Can Regional Transportation and Land-Use Planning Reduce GHG Emissions?

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INTRODUCTION

The Intergovernmental Panel on Climate Change’s fifth assessment report estimates that greenhouse gas (GHG) emissions must be cut 40%-70% by 2050 from 2010 levels to prevent a greater than 2°C temperature rise; a threshold that may avoid the most severe climate impacts (IPCC, 2014). The transportation sector accounts for 27% of U.S. GHG emissions, and transportation’s share is growing relative to other sectors (EPA, 2015). Reducing transportation GHG emissions is therefore critical to mitigating severe climate change risks.

Prior research has evaluated the GHG abatement potential of various vehicle technologies, transportation fuels, and strategies for reducing travel demand or shifting demand to less carbon intensive modes. The results of these studies consistently find that more efficient vehicles and lower carbon fuels are essential for achieving significant reductions in GHG emissions (Brisson et al., 2012; Lutsey and Sperling, 2009; McCollum and Yang, 2009; Melaina and Webster, 2011; Yang et al., 2009). Land-use and pricing policies also help, and are generally deemed necessary to meet GHG reductions goals aimed at keeping global temperature rise below 2°C, but appear to offer relatively less abatement potential.

The large abatement potential estimated in previous studies assumes that the federal government, or a large state, will be able to adopt the necessary policies to improve vehicle efficiency and increase the use of low carbon fuels. The required policy changes are generally not something a smaller state or an individual metropolitan region can pursue on its own since they do not have a large enough market share for new technology and fuels and with the exception of California are not allowed to adopt their own fuel economy and other vehicle standards (though other states can adopt California standards). So if federal climate policy fails, what can a regional transportation agency do to reduce GHG emissions from the transportation sector?

At the regional level, the options are largely confined to travel demand management, land-use planning, and encouraging alternative modes of transportation. Several prior studies have evaluated the potential to reduce GHG emissions at the regional level or through land-use policies alone. They have generally found that a combination of land-use planning, transit investment and pricing strategies can led to large reductions, but often not enough to create the GHG reductions necessary to avoid severe climate change impacts (Barbour and Deakin, 2012; Brisson et al., 2012; Ewing et al., 2007; TRB, 2009). In this study we evaluate if a mid-sized U.S. metropolitan area can hold GHG emissions to at least today’s levels through strategies that it can reasonably adopt.

APPROACH

We evaluate this question in a case study of the Albuquerque, New Mexico metropolitan area. The Albuquerque metropolitan area was the location of a recently completed climate change scenario planning project sponsored by the U.S. Department of Transportation and led by the Mid-Region Council of Governments (MRCOG). The authors worked with MRCOG to develop a modeling framework for evaluating the GHG abatement potential of different land-use and transportation planning strategies that the region could adopt (Lee et al., 2015). The aim was identifying strategies that could be included in MRCOG’s 2015 regional transportation plan. Neither the City of Albuquerque, MRCOG, nor the state of New Mexico has a GHG reduction goal or any type of climate change policy; therefore, the goal was
achieving the greatest GHG abatement possible while meeting other regional land-use and transportation planning goals.

Our study is being conducted in two phases. In the first phase we consider the GHG reductions from on-road sources that the region could achieve through strategies that are currently being considered, have been used elsewhere or that have been suggested in the literature. This first phase represents the typical approach of estimating the effectiveness of various strategies and was completed as part of the US DOT climate change project.

In the second phase, which are now completing, we flip the question around, and ask what strategies would be required to hold on-road GHG emissions at today’s level? With this aim in mind we investigate with our modeling system what land-use policies and transportation system changes would be required to meet this goal regardless of political feasibility or cost. We expect the results of this analysis to illustrate just how different the future may have to look form our current plans to achieve meaningful GHG emission reductions from the transportation sector.

Phase I

Transportation and Land-use Scenarios

MRCOG developed several land-use and transportation strategies based on input from municipal governments, meetings with regional stakeholders, scenario planning workshops and public meetings. Several initial scenarios were developed and through a series of additional workshops eventually narrowed down to three final scenarios: a trend and two alternatives that included strategies aimed at increasing the diversity of land-use, density of housing and employment, and transit mode share.

Each of the scenarios assumed a 52% increase in population and a 46% increase in employment between 2012, the base year, and 2040, the planning horizon. The trend scenario included the current land-use zoning in each municipality in the region, full build out of the highway projects included in the region’s previous transportation improvement program (TIP), and no changes to public transit except for the addition of a planned bus rapid transit line. The “preferred” and “constrained” scenarios changed zoning to allow denser residential and more mixed use development near transit stops and activity centers and increased commercial density at existing commercial centers, reduced allowable density in flood and fire risk areas, changed zoning to allow development of surface parking lots, and provided development incentives for parcels located in existing activity centers and transit corridors. The “preferred” scenario included the full build out of highway projects on the TIP and transit improvements that include several new express routes, new BRT lines and cut existing bus route headways in half on most routes. The “constrained” scenario assumed that there would be less funding available than currently predicted and therefore had fewer highway and transit investments. The constrained scenario excluded highway projects on the periphery of the region, new express bus routes, and less improvement in existing bus headways.

The changes to land-use zoning policies in the alternative scenarios are believed to represent the largest changes that municipal governments in the region are currently willing to accept. Similarly, the package of highway and transit projects reflect the region’s budget and political constraints.

Integrated Land-Use, Travel Demand and Emission Modeling System

Each of the land-use and transportation planning scenarios were evaluated with an integrated land-use/travel demand/emission model. The first step in this analysis uses UrbanSim, an agent based land-use model, to determine the future population, employment, and land-use mix in each transportation analysis zone (TAZ). UrbanSim predictions are driven by estimates of land and housing values that depend on accessibility, land-use regulations (e.g., zoning), land availability, and the expected population and employment growth in the region. For example, parcels with greater accessibility are more attractive but will also tend to be more expensive; UrbanSim considers these types of dynamics in determining the probability of development for each parcel in the region.
Zonal population and employment output from UrbanSim become input for MRCOG’s trip based (4-step) travel demand model that is used to forecast VMT and average travel speeds on each roadway link as well as mode share. UrbanSim and the travel demand model work together to model the interaction between land-use and transportation systems. UrbanSim requires base year zone to zone travel times that are produced by the travel demand model to initialize its year by year land-use simulation. The travel demand model uses future year population and employment predictions from UrbanSim to forecast future year travel demand. Future zone to zone travel times from the travel demand model are fed back into UrbanSim during an intermediate time period, 2025, so that future land-use decisions respond to changes in travel time.

The United States Environmental Protection Agency’s (US EPA) Motor Vehicle Emission Simulator (MOVES) model is used to create a GHG emission factor look-up table that provides gram per mile emission rates for a range of speeds and roadway types. These emission factors are matched to link level VMT estimates forecasted by the travel demand model and aggregated to estimate a regional GHG emission inventory for each scenario.

**Additional GHG Abatement Strategies**
Several additional GHG abatement strategies were considered on top of those included in the scenarios created by MRCOG. These were strategies that could not be modeled in the integrated modeling environment (bicycle infrastructure, adaptive signal control) or were not considered politically viable (growth boundary, higher gas tax, new VMT tax).

**Phase II**
In Phase II, we are using the same modeling system described above to investigate changes to either the transportation system, land-use plans or some combination of both that would be required to hold GHG emissions at 2012 levels. The main difference in our analysis approach in Phase II is that we no longer constrain our analysis to what is generally considered politically or financially feasible. So, for example, we are investigating scenarios with much greater density than what exists today, large reductions in roadway capacity, and significant transit system expansion and level of service improvements. The aim of this analysis is to evaluate the size of the gap between current plans and what would likely be required.

**PHASE I RESULTS**
Per capita GHG emission decline from 12.7 kg/day in the 2012 base year to 10.4 kg/day in the 2040 trend scenario and 10.1 in each of the alterative 2040 scenarios. While per capita emissions decline by up to 20% from current year 2012 levels, total GHG emissions increase in each of the future scenarios due to population growth (Figure 1). Applying each of the additional GHG abatement strategies with the exception of a very high VMT tax is still not able to hold GHG emissions at today’s levels (Figure 1).
The results in Table 1 and Figure 1 also illustrate that by only adopting the relatively popular and low cost GHG mitigation strategies, GHG emissions in the region will still grow higher than today’s level. Achieving GHG mitigation that reduces emissions from the 13,352 tons/day expected under the preferred scenario in 2040 to today’s level of 11,358 tons/day requires adopting a VMT tax between 6 and 8.4 cents per mile. The lower VMT tax rate corresponds to a scenario where all other strategies are also adopted while the higher tax corresponds to scenario where only a VMT tax is adopted. A growth boundary would significantly reduce GHG emissions but would still not be enough to hold GHG emission at today’s level.

**Table 1 GHG reductions from the 2040 Trend Scenario**

<table>
<thead>
<tr>
<th>Strategy</th>
<th>CO2-eq Reduction from Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred</td>
<td>706</td>
</tr>
<tr>
<td>Constrained</td>
<td>539</td>
</tr>
<tr>
<td>Growth Boundary</td>
<td>512</td>
</tr>
<tr>
<td>VMT Tax 0.005 per mile</td>
<td>107</td>
</tr>
<tr>
<td>VMT Tax 0.03 per mile</td>
<td>780</td>
</tr>
<tr>
<td>VMT Tax 0.12 per mile</td>
<td>2,384</td>
</tr>
<tr>
<td>Bicycle Infrastructure</td>
<td>29</td>
</tr>
<tr>
<td>Traffic Signal Enhancement</td>
<td>28</td>
</tr>
</tbody>
</table>
SUMMARY
In Phase I, we consider changes to the road network, transit investments, congestion relief measures, bicycle network investments, growth boundaries, and higher taxes on vehicle use. We also assume that in all scenarios that the vehicle fleet becomes more efficient overtime as newer, more efficient, vehicles replace older vehicles. The only strategy that we identify as likely to stop the growth in transportation sector GHG emissions requires imposing a relatively high VMT tax (6 cents per mile) or significantly increasing the gasoline excise tax ($1.24 per gallon). Not only is this tax strategy politically unpopular, it is also something that municipal and regional planning agencies have no control over. The other strategies can make significant contributions to reduce regional GHG emissions but even when pooled together they do not go far enough. Furthermore, many states have adopted GHG emission reduction targets far below today’s levels, and in these cases GHG reduction strategies would need to be even more aggressive.

In Phase II, which we are currently completing we will identify what land-use and the transportation system would have to look like to hold GHG emission at today’s level. The results of this analysis will be used to measure the gap between what is currently planned and what would likely be required under this relatively weak GHG emission target. The results can then be used to frame the climate change planning discussion differently. For example, how do we transition from the infrastructure and land-use we have today to what we expect will be needed in the future. This differs from the usual approach of evaluating plans that are generally created to improve mobility while minimizing GHG emissions. We will present our initial Phase II results along with our Phase I results at the conference.

REFERENCES