Greenhouse Gases, Transportation and Urban Development

A placed-based approach for understanding and mitigating greenhouse gas emissions from transportation in urban areas

Rob Neff
Department of Geography
and
Center for Integrated Regional Assessment
The Pennsylvania State University
USA

Prepared for presentation at the Open Meeting of the Global Environmental Change Research Community
Montreal, Canada, 16-18 October, 2003
Justification for a place-based approach

- National-scale solutions are politically burdensome
- Gasoline taxes are regressive and would require complete restructuring of the tax code
- Price controls and command-and-control approaches improve efficiency, but vehicle miles traveled (VMT) continue to increase (over the long term)
- Transportation emissions are the result of local decisions made in response to local circumstances
- The character of regional transportation networks varies greatly across the nation and the world

Many people think that due to its extremely decentralized nature, transportation is an issue that requires a national-scale solution, such as a gasoline or carbon tax. However, there are several problems with that approach, as described in this slide.

Evidence for the first two points is abundant in the United States. During the previous administration, a 4-cent gasoline tax was enacted and repealed over the span of approximately 3 months. Economic analysis at the time showed that repealing the tax had no impact on the economy. This occurred during the summer preceding the presidential election of 1996. The current political climate in Washington, DC is even more hostile towards increases in gasoline taxes.

Historical data show that while price increases and command-and-control options such as national efficiency standards do in fact improve efficiency and reduce total gasoline consumed per capita, VMT continued to increase during the same time span, contributing to urban sprawl, which in turn helps drive GHG emissions, as this paper will help to demonstrate.

Finally, transportation emissions are the result of local decisions made in response the condition of the transportation network at the local and regional scales, as well as personal preferences, economic limitations, etc. These factors vary greatly from place to place.
Outline

- Research Approach
- Study Area
- Transportation Modeling Results
- Data requirements for duplication
Research Approach

- Mixed Methods Approach
  - Traffic Modeling
  - Demographic analysis
  - Archival research
  - Field work

- The goal: To not only describe the pattern of emissions, but to understand the impact of past decisions on that pattern, and to inform speculation about potential mitigation options

Both quantitative and qualitative methods are used in order to more fully understand the traffic system as it exists today, and as it has developed over time.

Traffic Modeling tells us how many commuters travel between various origins and destinations.

Demographic analysis tells us who these people are (at least in part)

Archival research and field work tell us how the transportation network has evolved over time; Who were the decision makers, what decisions did they make (and why), and how have those decisions impacted the transportation network? Equally important are questions about who were absent from the decision-making process, and who (if anyone) has been marginalized by the planning process.

However, the time available for this particular presentation does not allow me to show the results of all this research, so I am limiting my discussion of the results of my qualitative research. I am only able to discuss these findings when discussing and explaining the results from the traffic assignment model, which is necessarily the first step of this approach.
**Traffic Model**

- Tightly integrated with ArcMap interface
- Origin-Destination data taken from the US Census Transportation Planning Package
- All-Or-Nothing (AON) traffic assignment over the network of major highways
- Results are normalized by area, then interpolated to a 1-km grid
- Results displayed by origin and destination

ArcMap is a geographic information system (GIS) developed by ESRI. It was chosen because of the ability to code Visual C++ and Visual Basic .dll's that can be integrated with its interface, and because it is a dominant GIS in the marketplace.

The Census Transportation Planning Package (CTPP) is a rich dataset describing people's residences, workplaces, mode of transportation, and demographic characteristics. Implementing this research approach in other countries may require the collection of primary data. At a minimum, origin-destination data of some sort would be required.

There are many other heuristics available for traffic assignment, but this was chosen as a logical first step, because most of the other heuristics have AON assignment embedded within them. AON assignment is likely to underestimate emissions, because travelers are not re-routed to minimize the effects of congestion.
The Philadelphia Metropolitan Area.

Mercer county is not typically included in the metro area, but it is included here because it contains significant commuter activity that is linked to the rest of the metro area. Grey polygons are transportation analysis zones (TAZs), which are comparable in size to US Census blockgroups. The centroid of each TAZ was used as the origin and destination point in the traffic assignment model.
Results

- Identification of “hotspots” (i.e. Destinations associated with higher than average emissions)
- Emissions for each destination are mapped, showing the emission-shed of each hotspot

This slide describes the results that are displayed on the next 7 slides.
Center City (Philadelphia’s Central Business District) is shown to be a major source of emissions, as are several suburban areas. In particular, please note West Chester, King of Prussia and Abington – these places will be examined in greater detail in the next few slides.
A close-up of the hotspot map, focusing on Philadelphia itself. Note the relative intensity of emissions from Center City compared with the rest of the city.
Summary of Top Hotspots

<table>
<thead>
<tr>
<th>Workplace</th>
<th>Total Distance Driven (1000's Km Per Day)</th>
<th>MTCE</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center City</td>
<td>13,410</td>
<td>95.39</td>
<td>68.08</td>
</tr>
<tr>
<td>North Philadelphia</td>
<td>891</td>
<td>6.34</td>
<td>4.52</td>
</tr>
<tr>
<td>University City</td>
<td>690</td>
<td>4.91</td>
<td>3.50</td>
</tr>
<tr>
<td>Fairmount</td>
<td>610</td>
<td>4.34</td>
<td>3.09</td>
</tr>
<tr>
<td>West Chester</td>
<td>450</td>
<td>3.20</td>
<td>2.29</td>
</tr>
<tr>
<td>South Philadelphia</td>
<td>436</td>
<td>3.10</td>
<td>2.21</td>
</tr>
<tr>
<td>King of Prussia</td>
<td>336</td>
<td>2.39</td>
<td>1.70</td>
</tr>
<tr>
<td>Bryn Maw</td>
<td>295</td>
<td>2.10</td>
<td>1.50</td>
</tr>
<tr>
<td>Lansdale</td>
<td>239</td>
<td>1.70</td>
<td>1.21</td>
</tr>
<tr>
<td>Juniata Park</td>
<td>235</td>
<td>1.67</td>
<td>1.19</td>
</tr>
<tr>
<td>Germantown</td>
<td>174</td>
<td>1.24</td>
<td>0.88</td>
</tr>
<tr>
<td>Fairmount Park</td>
<td>172</td>
<td>1.23</td>
<td>0.88</td>
</tr>
<tr>
<td>Newtown</td>
<td>157</td>
<td>1.12</td>
<td>0.80</td>
</tr>
<tr>
<td>Richmond</td>
<td>154</td>
<td>1.09</td>
<td>0.78</td>
</tr>
<tr>
<td>Abington</td>
<td>152</td>
<td>1.08</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Center City accounts for 68% of the total GHG emissions in the Philadelphia metropolitan area – no other place even comes close. However, when the other places are summed, they account for 32% of emissions, and therefore cannot be ignored.

This emissions pattern is interesting, given the distribution of commuters in the Philadelphia metropolitan area – Philadelphia is a typical US metropolitan area in that roughly 1/3 of all commuters are traveling to the CBD, 1/3 are reverse commuting (commuting from the city itself to the suburbs), and 1/3 are engaged in suburb-to-suburb commuting. This means that Center City is responsible for more than double its “fair share” of emissions. This becomes particularly relevant during examination of the next few slides.
At first glance, these maps might paint a compelling argument for improving the public transportation system that carries commuters into Center City, particularly in light of the fact that it is responsible for an overwhelming share of emissions.

Looking at these maps from bottom to top, we note that most of the commuters who work in Center City in fact reside in or very near the city of Philadelphia, as opposed to the suburbs. Since improving public transit in an urban environment is much more feasible than improving the network serving a dispersed group of suburbs, this seems positive – We should be able to improve the public transit system, reduce emissions, and better serve a significant portion of the urban population.

However, the top map shows that most of the people who reside in the city already use the public transit network (or other alternate modes of travel, such as bicycles) to travel to work in Center City. This is particularly true when those residing in the Pennypack area (the Northeast portion of Philadelphia in red) are considered suburban rather than urban. This is more appropriate because development in this area is more suburban in nature than it is urban, and is very separate from the rest of the city.

Finally, the center map shows that suburban commuters are responsible for the vast majority of Center City emissions. Thus, a small group of affluent commuters are responsible for a large proportion of the emissions generated during the commute to Center City, and of the total GHG emissions for the metropolitan area.
West Chester is a suburb of Philadelphia that at one time was a separate urban center with its own industry and central business district (albeit much smaller than Philadelphia). It still has a vibrant downtown area, as well as busy industrial complexes. Development is much more concentrated in West Chester than it is in most typical US suburbs.

These maps show that there are two commuting patterns playing out in West Chester – Suburb-to-suburb commuting occurs (and is responsible for most of the emissions), and there is a sizable proportion of the total commuters who live in the city and “reverse” commute to West Chester (bottom figure). The top two figures show that this results in very little emissions, however, as most of the reverse commuters get to West Chester by bus, often transferring two or three times along the way. Their commute can be anywhere from 1 ½ hours to 2 ½ hours (one-way), depending on their precise place of residence and the relative location of the rest of the public transit system. These commuters have some of the lowest incomes in the metropolitan area, and often are unable to find full-time employment at one place of work.
King of Prussia is a more typical US suburb than West Chester, but shows similar emissions patterns. Development is much more spread out, and the primary employers in the area are malls, strip malls, office parks and industrial parks, all of which are served only by bus, or often by employer-run shuttles that connect with the bus lines.

These maps show that there are two commuting patterns similar to West Chester. Suburb-to-suburb commuting occurs (and is responsible for most of the emissions), and there is a sizable proportion of the total commuters who live in the city and “reverse” commute to King of Prussia (bottom figure). The top two figures show that this results in very little emissions, however, as most of the reverse commuters get to King of Prussia by bus, often transferring two or three times along the way. Their commute can be anywhere from 1 ½ hours to 2 ½ hours (one-way), depending on their precise place of residence and the relative location of the rest of the public transit system. These commuters have some of the lowest incomes in the metropolitan area, and often are unable to find full-time employment at one place of work.
Abington is a much more affluent suburb than either West Chester or King of Prussia, and the employers are largely in the information or financial industries. There is a Penn State campus there, as well as numerous corporate campuses and banks. Abington is a striking example of nearly exclusive suburb-to-suburb commuting.
Summary

- Emissions come disproportionately from suburb-to-city commuting, despite typical commuting patterns
- Public transit riders are either close to their workplace or poor
- Significant enhancements to public transportation are difficult due to sprawl and edge city conditions
- Public transit is unlikely to be used by the most significant emitters
- Public transit improvements aimed at the most significant emitters would be terribly unfair
- A more credible solution would be to alter the development patterns of the city, but this takes time.

The flip side to the first two points is that the primary emitters of GHG gases are the more affluent members of the metropolitan area, and are much smaller in number than the less affluent and lower-emitting populations. Thus, improving the public transportation system is unlikely to be effective as a GHG mitigation option in Philadelphia, and would be grossly inequitable. If improvements to the public transit system are to be made, those improvements should benefit the poorer populations that spend a great deal of their time sitting (or standing) on busses to reach low-paying, part-time jobs, and those who are most likely to actually use the public transit system.

A more credible solution is to change the development patterns of the metropolitan area, but this requires in-fill development and takes time. There are also numerous social, cultural, and institutional barriers to altering the current development patterns. While these barriers are outside the scope of this paper, they are related to other social and economic problems that are being faced by communities in the area, and thus points to the need to address issues of social and economic equity as part of efforts to reduce GHG emissions from transportation in the Philadelphia Metropolitan Area.
Data Requirements

- Spatial data describing the transportation network
  - For integrated model, must be compatible with ESRI data models
  - Loosely coupled version also exists, but needs further refinement
- Reliable estimates of commuter behavior (origin, destination, mode of transit)
- Willingness (and sufficient resources) to engage in archival and field research

This slide briefly describes the data that would be required to duplicate this study in urban areas outside the United States.