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Research Needs Statements for Climate Change and Transportation

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Research Needs Statements for Climate Change and Transportation

Special Task Force on Climate Change and Energy

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Introduction

The objective of this effort was to develop a series of specific research needs statements on climate change and transportation for distribution to universities, students, research organizations, government agencies, and other interested parties for consideration in conducting and funding research in this important area.

In pursuing this objective, the participants drew from the work that has been done to identify the broad research themes on the mitigation of transportation's impact on climate change and on the adaptation of transportation to climate change. The effort was sponsored by the following TRB groups:

- Special Task Force (STF) on Climate Change and Energy (lead);
- Standing Committees in Transportation Energy, Alternative Transportation Fuels and Technology, and Transportation and Sustainability; and
- Joint Subcommittee on Climate Change.

STEPS IN THE DEVELOPMENT OF RESEARCH NEEDS STATEMENTS

During 2008, the STF developed a road map of activities to pursue on transportation, climate change, and energy. One of the identified activities was to develop a collection of peer reviewed research needs statements on climate change and transportation. These statements would supplement the relatively few statements on transportation and climate change already contained in the TRB Research Needs Statements database. They would also provide more specifics on the themes that would eventually be included in a parallel TRB effort that resulted in the publication of *Special Report 299*: *A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy*.

The STF initiated the project in early 2009. The resources that were reviewed and employed included

- Members of the STF;
- Volunteers from cosponsoring TRB committees on energy, alternative fuels and technology, sustainability, and the joint subcommittee on climate change;
- Participants in January 2010 workshop;
- TRB Research Needs Statements database;
- TRB Research in Progress database;
- TRB Climate Change web page;
- Selected reports from TRB and other sources, including
  - TRB *Special Report 290: The Potential Impacts of Climate Change on U.S. Transportation*;
  - TRB *Special Report 299*: *A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy*;
  - *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*; and

– *Environmental Research Needs in Transportation 2002 Conference Report* (chapter on Sustainability, including Climate Change: Cause and Effects).

Appendix A summarizes the general steps and time frames for this STF effort.

TRB SPECIAL TASK FORCE ON CLIMATE CHANGE AND ENERGY

Initiated in January of 2008, the STF coordinates activities and facilitates communications related to climate change and energy among TRB standing committees. It conducts activities to augment the work of existing committees on climate change and energy topics, and maintains a road map for ongoing and potential TRB activities in those areas.

The STF reports directly to the TRB Technical Activities Council. STF membership is drawn from representatives of 15 TRB committees with strong interest in climate change and energy issues, supplemented by 15 at-large members, including subject matter specialists from constituencies outside TRB whose expertise provides needed perspectives.

The STF has

1. Developed a road map for TRB activities in global climate change and energy;
2. Facilitated communications among all TRB standing committees having an interest in energy and climate change;
   – Conducted surveys of all standing committees and shared results and
   – Involved representatives of a cross section of committees from almost all groups on STF activities, who in turn reported back to their committees;
3. Coordinated the development of sessions that comprised the energy–climate change spotlight theme for the 2009 TRB Annual Meeting;
   – Delivered spotlight theme that included more than 60 sessions and
   – Initiated new process of surveying all committees on anticipated spotlight theme related sessions, and shared results to facilitate collaboration in session planning (nearly 100 committees);
4. Developed sessions for TRB summer conference and other meetings;
5. Submitted articles and proposed a future special theme issue for the TRB bimonthly magazine, *TR News*;
   – Sponsored development of article on climate change in November–December 2008 issue and
   – Prepared outline and initiated the development of theme issue on climate change. (Energy and Sustainability committees currently preparing content for issue to be published in mid-2010);
6. Developed volumes of the *Transportation Research Record* on climate change and energy;
7. Established and conducted a series of TRB webinars;
8. Prepared primer on climate change mitigation issues for each transportation mode to be published as a TRB e-circular;
9. Reached out and coordinated with other organizations;
   – U.S. Department of Energy (DOE), U.S. Environmental Protection Agency

(EPA), and U.S. Department of Transportation (U.S. DOT) all have representatives on STF who have been actively involved in TRB activities and

– Coordinated activities with AASHTO, ITS America, ITE, STPP, Bipartisan Policy Center, and others;

10. Contributed to TRB technical and policy studies;

– Provided names of individuals to serve on TRB policy study committees and cooperative research panel and

– Provided comments on white papers that led to TRB *Special Report 299: A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy*; and

11. Prompted the development of a website for tracking climate change activities across TRB divisions.

ACKNOWLEDGMENTS

The development and refinement of the research needs statements contained in the following section was truly a collaborative effort that involved members of the STF and cosponsoring committees, authors of the statements, those who provided comments on the statements through the collaborative website, and the January 2010 workshop participants. Special thanks to Marcy Schwartz, Ed Weiner, and Mark Norman, who led the planning for this activity; group leaders Marianne Mintz, Jonathan Rubin, Joyce Wenger, Louis Neudorff, Gary Maring, Edward Beimborn, David Suits, and Nathan Brown; and Mariah Vanzeer, who authored the comparison between TRB *Special Report 299* and the research needs statements produced through this activity (see Appendix C, p. 87).

Policy Research Needs Statements

DEVELOP A COMPREHENSIVE EVALUATION FRAMEWORK FOR CLIMATE CHANGE ANALYSIS IN TRANSPORTATION

Problem

The transportation sector is vital to the economy of the United States. It provides the critical links between industries and their customers and it is the network for individual mobility. It is also a primary contributor to greenhouse gas (GHG) emissions. The transportation sector currently accounts for about 30% of the total U.S. GHG emissions, and this is expected to grow in the future as population and economic growth coupled with GHG emissions reductions in other sectors (e.g., electric power, housing, and industry) will focus concern on all modes of the transportation sector.

All current motorized modes of transportation rely on burning petroleum fuels for propulsion. As populations grow and economies expand, the demand for transportation, and thus petroleum, also grows. This growth in transportation activity will increase GHG emissions without changes in modes, fuels, and other decisions. In order to slow or reverse this trend, public policy has been addressing three components of the link between transportation and GHG emissions. The three components are

- Efficiency of vehicles: the rate at which they consume energy. This includes, for each transportation mode, both the vehicle or person miles per gallon and the operating characteristics that affect the actual amount of fuel consumed during on-and off-road use. Therefore, mitigation options include items ranging from new vehicle technology improvement [corporate average fuel economy, (CAFE)] to transportation systems management that improves vehicle efficiency by reducing congestion;
- Carbon content of fuels: the fuel source for each mode and the amount of carbon released in the combustion process. Included are current conventional fuels, improved conventional fuels and alternative fuels such as alcohol, natural gas, propane, electric power, and hydrogen; and
- Travel activity: the use of all vehicles to provide transportation service. Included programs discourage the use of vehicles that use high carbon fuels, programs promoting transportation alternatives, and those encouraging increases in vehicle occupancy rates. This area also includes changes in land use planning that leads to a lower reliance on low energy efficiency vehicles for transportation.

Options in all three areas may be needed to achieve the stated GHG reduction goals contained in Climate Change Action Plans now adopted by about half the states and numerous regional and local government entities. It is unclear which options will be supported by the public and their elected representatives. The CAFE standards to improve fuel efficiency seem popular, but continued vehicle efficiency improvements will require some modification of consumer’s expectations for new vehicles.

At the same time, government and industry analysts are evaluating options to minimize the adverse impact of expected climatological change such as sea-level rise and severe storm events. Trade-offs between adaptation and mitigation policies must be understood, and consistent analytic methods will need to be applied to correctly inform public decision making.

The transportation sector has sought to apply uniform standards for economic analysis of transportation projects and programs across states. One effort was the AASHTO-sponsored development of a guidebook and software for the application of economic analysis in transportation programs. The so-called AASHTO Red Book, *A Manual of User Benefit Analysis for Highways, 2nd Edition*, was developed by a previous NCHRP Project #02-23. One possibility for the current study is to produce an addendum to the Red Book that would serve as a key reference source for the application of economic analysis to climate change mitigation and adaptation evaluation.

Objective

The objective of this research is to identify and explore the methods currently employed to evaluate GHG emissions mitigation and adaptation options. From this research, the study team will develop a set of guidelines and methods for economic analysis of transportation policies and programs that address climate change. The research should address the following questions:

- How have the federal government, state and local governments, nonprofit organizations, and private sector evaluated public policy and program actions in the transportation sector to mitigate the impacts and adapt to changing conditions brought about by climate change?
- How have policy and program actions in other sectors been evaluated and are these techniques equivalent to those identified in the transportation sector?
- What data are currently available to carry out these analyses and what new data may be required for a full and comprehensive analysis? Who should be responsible for collecting and making these data available to all?
- What level of economic analysis, including benefit–cost, micro- and macroeconomic impact, cost effectiveness, and other techniques are appropriate?
- What analysis is required to address price or market instruments, such as cap-and-trade or efficient pricing strategies?

Transportation analysts should be able to look to a common reference for analytic methods to evaluate these transportation responses to GHG emissions and climate change. These methods should reflect the state of the science in policy and program analysis and be accessible to all and reproducible. The range of analysis should cover all modes (including nonmotorized), all traditional forms of economic analysis (both internal and external costs), and indirect impacts such as those identified from land use.

Key Words

Climate change, benefit–cost analysis, comprehensive planning, greenhouse gas emissions mitigation, greenhouse gas emissions adaptation, economic analysis

Related Work

Selected related work includes that of NAS; TRB National Cooperative Research Program reports on climate change and transportation studies; National Surface Transportation Policy Commission Report; AASHTO Red Book; U.S. DOT/U.S. Geological Survey (USGS) Gulf Coast Climate Study; and reports by EPA, state, regional, and local agencies. Studies sponsored by nonprofit organizations such as the Urban Land Institute's *Moving Cooler* or private sector studies such as the McKinsey & Company study, *Pathways to a Low Carbon Economy*, also provide additional data and methods.

Urgency–Priority

The research would inform ongoing policy discussions such as

- What are the likely economic costs to government, industry, and households from the transportation policies under consideration to mitigate and adapt to climate change?
- What is the appropriate role and responsibility of the public sector at all levels of government to provide transparent and supportable economic analysis of transportation policies and programs to mitigate and adapt to climate change? Can we expect such analysis to be uniform at all levels of government and across all states?
- How should federal transportation programs and agencies—through the upcoming surface transportation, energy, and climate change legislation as well as through other national or state transportation programs and policies—be charged with conducting comprehensive analysis of all proposed climate change policies and programs that impact transportation of people and goods?

Estimated Cost

$650,000

- Phase I: $450,000 literature review, workshop, development of methods and
- Phase II: $200,000 development of guidebook and software for climate change transportation analysis.

User Community

U.S. DOT (all modes), EPA, DOE, AASHTO, state DOTs, metropolitan planning organizations (MPOs), and other transportation and land use authorities

Implementation

Findings will be used as guidelines for the implementation of climate change action plans by federal, state, and local agencies.

Effectiveness

The research will shape understanding of the issues and opportunities facing transportation analysts as they provide critical information to decision makers and the public about potential changes in the delivery of transportation infrastructure and services. This analysis and guidebook will form part of a critical set of literature that will shape the nation's response to climate change, with broad and far-reaching societal impacts.

DEVELOP A COLLABORATIVE DECISION-MAKING FRAMEWORK FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

Problem

Numerous organizations at the federal, state, and local levels have a stake in developing strategies to mitigate GHG emissions and adapt to climate changes. These organizations need to have supportive policies and collaborative approaches to improve their effectiveness in developing and implementing climate change strategies. There is a need to communicate, cooperate, and collaborate in efforts so that they are not duplicative or counterproductive.

Objective

This project will develop a greater understanding of decision making and policy processes related to climate change and long-range planning within the transportation sector. The project will consider key decision points for developing strategies and addressing critical mitigation and adaptation issues within a collaborative decision-making framework. It will develop a variety of concepts or constructs that would support federal, state, and local agencies working together to assure that each had appropriate input into policy development, and alternative strategies to mitigate climate change and adapt to any changes linked to multimodal, multijurisdictional, and multisector issues (including multimodal travel and goods movement). This may include assessing the potential for interagency cooperation and analyzing societal trends toward a preference for more sustainable and environmentally friendly development practices. It will identify materials already produced in the planning process and develop new materials to fill gaps.

This project will be informed by the results of SHRP 2 C01 and SHRP 2 C09. Project C01 resulted in the development of a Collaborative Decision-Making Framework for the transportation planning and project development process, which has been posted online as a tool for state DOT and MPO staff to access and use. The final tool is called "Transportation for Communities-Advancing Projects through Partnerships." Project CO9 attempts to determine how the consideration of GHG emissions is, or could be, integrated into traditional transportation planning and project development processes. This research proposal builds on both of these projects, but the main difference is that the primary focus of this research will be the development of a collaborative decision-making framework for climate change decision making at the federal, state, and local levels, with transportation issues and impacts considered as part of that framework.

Key Words

Institution cooperation, planning process, climate change

Urgency–Priority

It is important to establish institutional cooperative and collaborative strategies so that the funds and efforts of federal, state, and local agencies are not wasted or advancing counterproductive strategies to mitigate climate changes and strategies to adapt to climate changes.

Cost

$200,000

User Community

U.S. DOT, EPA, DOE, AASHTO, Association of Metropolitan Planning Organizations (AMPO), National Association of Regional Councils (NARC)

Implementation

The results of this project could be used to improve institutional communication and collaborative efforts to address climate change mitigation and adaptation strategies and make the efforts of these agencies most cost effective.

Effectiveness

The results of this project could reduce the cost of efforts to mitigate climate changes and strategies to adapt to these changes. It could reduce the staff hours and increase the effectiveness of various agencies' efforts by reducing duplication and integrating their efforts.

EXAMINE CAP-AND-TRADE AND TRANSPORTATION SECTOR–SPECIFIC POLICIES

Problem

How would pursuing transportation sector–specific policies in conjunction with a cap-and-trade system change the price of allowances, alter the share of emissions reductions from transportation, and impact costs and benefits in the transportation sector?

Objective

Draft climate change legislation includes measures specific to the transportation sector as well as establishing an economywide cap-and-trade system. The rationale is that without complementary measures, most GHG emission reductions would come from other sectors because a cap-and-trade system would only increase gasoline costs by about 20 cents per gallon. This is not a problem inherently, because if there are more cost-effective GHG reductions to be made in other sectors, then it is more efficient for the economy as a whole for the reductions to come from those other sectors. However, if there are market failures that reduce the reaction to higher prices, then pursuing additional measures can lower implementation costs by compensating for market failures.

There is evidence that some aspects of transportation, as well as other sectors, may exhibit market failures. For instance, consumers tend to undervalue fuel savings in vehicle purchase decisions. That leads to the conclusion that a cap-and-trade system can serve as the central policy to guide cost-effective GHG reductions, while complementary policies (additional policies that work with the main cap-and-trade policy) also may be pursued to lower implementation costs by compensating for market failures when they exist.

Tighter fuel economy standards, GHG standards, biofuel incentives, funding for vehicle research, and transportation planning requirements are all types of policies that are under discussion to be pursued in conjunction with cap and trade. How would pursuing transportation sector–specific policies in conjunction with cap and trade change the price of allowances, alter the share of emissions reductions from transportation, and impact costs in the transportation sector? Universities, government agencies, and other researchers have used complex economic models to estimate allowance prices and GHG reductions from other sectors. Examples include EPA's ADAGE model. However, researchers have not included complementary transportation measures in these models.

Key Words

Transportation, greenhouse gas emissions, climate change, cap and trade

Related Work

- EPA and DOE analyses of Waxman–Markey and Lieberman–Warner and
- MIT analysis.

Urgency–Priority

Draft transportation reauthorization legislation and climate change legislation are currently being considered in Congress. Information on how transportation sector–specific policies would interact with cap and trade is important for cost-effective public policy.

Cost

$300,000

User Community

The research could be carried out by universities, consultants, government agencies, nonprofits, or other researchers. The audience for the research would be Congress, the federal government, state and local governments, and MPOs.

Implementation

The research could help inform national policy.

Effectiveness

The project would help the transportation sector reduce GHG emissions, a very important goal because transportation accounts for about a third of U.S. carbon emissions, and science indicates that emissions must be reduced substantially to avoid dangerous climate change impacts.

EXAMINE GHG REDUCTION STRATEGIES AS POTENTIAL "OFFSET CREDITS"

Problem

Current climate change legislation before the U.S. Congress includes provisions for a cap-and-trade program, where the government guarantees emissions reductions by setting a mandatory cap on aggregate emissions below the existing pollutant levels, and providing sources covered under the cap emission allowances equal to the cap that can be bought or sold (traded). The emissions cap declines over time until the desired aggregate emissions cap is achieved. Such cap-and-trade programs typically include an offset feature that allows covered sources to meet their mandatory cap by using emission offset credits. An emissions offset is a credit for "additional" emission reductions not required by an emission cap or any regulatory program.

Several strategies have been identified for reducing GHG emissions resulting from mobile transportation sources (e.g., improving operational efficiency, reducing vehicle miles traveled (VMT) and travel demand via pricing, increasing transit usage, promoting modal shifts, freight operations and enforcement). Some of these strategies, and the associated systems and infrastructure improvements, might be appropriate as offsets that entities (e.g., utility companies) operating under the cap-and-trade program can "purchase," thereby providing a potential funding source for these transportation strategies.

Objective

This research will investigate the processes, procedures, and information required for transportation improvements to qualify as emission offsets. In general, to qualify as an emission offset, the reduction must be real, permanent, quantifiable, enforceable, and in addition to any cap or regulatory requirement. The necessary protocols, appropriate models for estimating the GHG reductions, and the technologies for monitoring and measuring the GHG reductions will also be examined, along with the overall cost-effectiveness of having a transportation project qualified as an offset.

Key Words

Cap and trade, climate change, funding

Related Work

- Cap-and-trade programs as defined in Waxman–Markey (House) and Kerry–Boxer (Senate),
- European Union Emission Trading Scheme,
- *Moving Cooler* report, and
- NCHRP 20-24 (59) *Strategies for Reducing the Impacts of Surface Transportation on Global Climate Change: A Synthesis of Policy Research and State and Local Mitigation Strategies*.

Urgency–Priority

Depending on the final form of the climate change legislation, the results of this effort could be very important and useful in documenting the necessary procedures and protocols for identifying appropriate projects and then qualifying these transportation projects as offset credits, thereby providing additional funding sources for deploying and operating transportation improvements.

Cost

$200,000

User Community

FHWA; AASHTO; APTA; state and local DOTs; MPOs; ITS America; International Bridge, Tunnel and Turnpike Association (IBTTA)

Implementation

The results of this project would be used by owners of transportation infrastructure and systems, in cooperation with MPOs and trade associations, to identify transportation projects that might qualify as offset credits in the carbon markets, to determine the cost-effectiveness of pursuing this option, and to follow the necessary protocols and procedures for qualifying such projects as credits.

Effectiveness

This research would promote a greater understanding in the transportation community regarding cap-and-trade mechanisms and the potential of promoting transportation improvement projects as offset credits. Given the potential complexity of the protocols and procedures in qualifying projects as offset credits, coupled with the uncertainty of carbon market pricing (e.g., cost per metric ton of CO_2), such information would be critical before pursuing this potential funding source.

ASSEMBLE A COMPILATION AND ANALYSIS OF COURT DECISIONS ON GHG EMISSIONS

Problem

The regulation of GHGs is in its infancy in the United States, with piecemeal programs promulgated by the states and nascent regulations proposed and finalized by EPA. As is often the case, when regulatory agencies struggle to establish standards for particularly controversial environmental problems, courts fill in the gaps. This is happening now with respect to GHG emissions. U.S. courts have begun issuing decisions about the adequacy of GHG analyses in a number of different situations, including environmental review documents, endangered species listings, and Clean Air Act permitting decisions. Given the still developing regulatory scheme covering GHGs, these various court decisions provide useful insight as to how future federal, state, and local agency decisions can best incorporate and include information regarding GHG emissions and climate change. To date, there has been no comprehensive attempt to gather and analyze these court decisions.

Objective

This project requires the compilation and analysis of the various court decisions that have been issued regarding the adequacy of federal, state, and local GHG and climate change analyses. The research would attempt to cull lessons or standards from those opinions to guide future decision makers in their climate change and GHG analyses.

Key Words

Climate change, environmental impact assessment, endangered species, greenhouse gas emissions

Related Work

We are not aware of any similar work, although there have been attempts to simply catalog decisions of this nature.

Urgency–Priority

The U.S. transportation sector is responsible for 30% of the country's GHG emissions. As a result, transportation agencies are constantly confronted with the need to perform GHG analyses. In the absence of a comprehensive regulatory scheme or even any policy or guidance concerning the methodology or standards for such analyses, agencies are forced to use a case-by-case piecemeal approach. This approach has meet with modest success when agency actions are challenged in U.S. courts. A research paper such as that proposed in this research needs statement would be extremely valuable in providing transportation officials and the consulting community some degree of guidance and standards in how to confront this pressing need.

Cost

$150,000

User Community

AASHTO, APTA, FHWA, FTA, FAA, National Association of Environmental Professionals, and individual members of similar professional associations

Implementation

This research would be used by local, state, and federal transportation agencies across all modes to help guide them in the scope of GHG and climate change analyses they need to comply with the National Environmental Policy Act (NEPA), ESA and Clean Air Act analyses and decision documents. The research also would be used by the consulting community that supports government agencies in these endeavors.

Effectiveness

Despite the best efforts of transportation officials, litigation cannot be avoided in all instances. Especially with respect to a controversial environmental concern such as the appropriate methodology to assess and address GHG impacts, litigation is inevitable. The cost of program delays resulting from successfully challenged administrative actions is tremendous. Agencies and environmental professions are constantly seeking ways to minimize litigation risk, and more importantly, to reach the best decisions for their transportation proposals. This research will be most effective if it provides a framework for future permitting and environmental reviews based on successes and failures coming out of the U.S. judicial system.

INVESTIGATE POTENTIAL FOR EDUCATIONAL MATERIALS LINKING CLIMATE CHANGE AND TRANSPORTATION

Problem

Among both the public and many elected leaders there is an insufficient understanding of climate change as well as a lack of understanding of the relationship between climate change issues and transportation. There is also a lack of understanding about consumer awareness of the link between climate change and transportation and about what motivates and affects “socially responsible” behavior. In addition, it is not clear what key decision factors elected leaders at the local and regional levels use to make policy decisions related to climate change and transportation.

Thus, there is a need for a better understanding of consumer awareness and motivation and of the factors used in decision making about climate change and transportation and consequently for developing effective messages and educational materials that can be used to reach out to those audiences.

Objective

This project will determine the actual state of awareness of the general public and local and regional decision makers about the link between transportation and climate change based on existing research and discussions with major transportation and climate change stakeholders. It will identify the key factors (age, income, education, geography, etc.) that could allow development of targeted information to more fully inform the public.

The project will investigate what messages and educational materials would be effective in educating the public and elected officials about the relationship between climate change and transportation. Subsequently, educational programs and materials will be developed focusing on the benefits, costs, and consequences, with the aim of creating more informed voters, politicians, and transportation users and consumers.

The educational programs and materials developed will provide detail at appropriately varying levels of complexity based on the various audiences involved in contributing to climate change or addressing related policy decisions.

Key Words

Communications, outreach, greenhouse gas, social responsibility, consumer awareness

Urgency–Priority

This research is urgent because policy decisions are being made now regarding climate change and transportation, and they should be made based on a stronger understanding of the issues, benefits, and costs.

Cost

$150,000

User Community

FHWA, FTA, FRA, U.S. DOT’s Office of the Secretary, AASHTO, APTA, DOE, EPA

Implementation

The communication and educational materials developed through this research could be provided to the various organizations of the user community to reach the largest audience.

Effectiveness

The societal impacts of this research would be improved policies regarding climate change and transportation. Early relevant measures of effectiveness would be the quantity and quality of legislation at federal, local, and regional levels that specifically addresses climate change as it relates to transportation.

DEVELOP A FRAMEWORK TO ENABLE MULTIPLE AGENCIES TO DEVELOP POLICIES RELATED TO CLIMATE CHANGE AND INFRASTRUCTURE PROTECTION

Problem

Different agencies will continue to develop policies related to climate change and to transportation infrastructure protection. While these two topics, and thus their related policies, often affect each other, policies are not typically developed through the joint efforts of the various agencies that may ultimately be affected or that may have valuable input for the decision-making process.

Objective

This research will develop a variety of concepts or constructs that would enable U.S. DOT, Department of Homeland Security (DHS), and local agencies to work together to assure that each had appropriate input into policy development related to climate change and protecting our critical transportation infrastructure. As the transportation infrastructure is multimodal and multijurisdictional, and relates to multisector issues (including multimodal travel, goods movement, and security, for example), numerous agencies could be involved in collaborating for ensuring the best and most balanced policies.

This research will include assessing the potential for interagency cooperation and analyzing societal trends toward a preference for more sustainable and environmentally friendly development practices. It will consider other concepts under discussion regarding potential DOTs of the future, new roles for U.S. DOT, new roles for metropolitan planning organizations, etc., and address how these new structures or organizations might best be designed to also consider and address climate change, critical infrastructure protection, and their relationship.

This research should also consider institutional structures needed for climate change mitigation policy and program implementation.

In addition to assessing the organization issues, this research will also assess and then develop a greater understanding of the decision and policy process related to climate change and long-range planning that may support or conflict with critical infrastructure protections and security. This research will develop strategies for addressing climate change and critical infrastructure protection at key points in the Collaborative Decision-Making Framework (related to SHRP 2 project). It will identify materials already produced in the planning process and develop new materials to fill gaps.

This research will also assess the flexibility within current federal regulations (e.g., regulations on spending federal funds) to address transportation needs regarding climate change and critical infrastructure protection.

To support eventual implementation of the ideas generated in this research, the final task would be for the research team to support a workshop to not only share the ideas developed, but to also apply some of the strategies to address a specific “test” scenario through a tabletop exercise.

Key Words

Policy development, collaboration, decision making

Related Work

The capacity focus area of the SHRP 2 is developing approaches and tools for integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity. Its Collaborative Decision-Making Framework provides an adaptable approach, with principles, guidelines, and procedures for a variety of projects and contexts, and could be used as a basis for decision making and policy development beyond highway capacity.

Another TRB document with possible ideas on which to build is entitled *Crosscutting Techniques for Planning and Analysis 2007*.

Urgency–Priority

Since there are so many ways in which transportation, climate change, and infrastructure protection relate to each other, and as various organizations have various responsibilities for each, it is imperative that we better understand organizational collaboration and devise improved constructs and processes for improved collaboration and decision making.

Cost

$100,000

User Community

AMPO, AASHTO, FHWA, APTA, DHS, DOE, EPA

Implementation

TRB could share the results of this research with various stakeholders, support the proposed workshop, and build on the workshops to deal with additional critical scenarios.

Effectiveness

Collaborative decisions to the issues connecting climate change and transportation infrastructure protection should inherently be better than stove-piped decisions and policies. A possible measure of effectiveness of the impacts of this research would be seeing multiple stakeholders work together for collaborative decisions or seeing them with a positive attitude about the "compromise" decisions and policies.

EXPLORE ADAPTATION AS A DEFENSIVE STRATEGY TO ADDRESS CLIMATE VARIABILITY IMPACTS ON CRITICAL TRANSPORTATION INFRASTRUCTURE

Problem

In some locations, particularly the U.S. Gulf, transportation infrastructure will remain at risk due to persistent weaknesses in natural systems, such as sea-level rise coupled with shoreline subsidence and barrier island erosion. One way of avoiding repeated hardening and reconstruction costs is to move the infrastructure to where it is less at risk—this is a kind of adaptation to climate variability.

Objective

This research would build on the U.S. DOT study, *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study* (2008). The objective would be to quantify the risk to existing infrastructure in its present form and location, and undertake a cost–benefit analysis geared toward balancing the cost of hardening and reconstruction with the cost of moving it to where the damage from climate variability will not be so great. Significant cost could be avoided by planning the relocation of such infrastructure where the anticipated rate of depreciation and catastrophic destruction (as with the bridge of Highway 1A during Katrina) is high. If planned sufficiently in advance, such projects could be undertaken in a way that would minimize disruption to the existing network, while providing a concrete example of an adaptation strategy.

Key Words

Infrastructure, hardening, relocation, cost–benefit

Related Work

Central to this work would be the 2008 U.S. DOT study, *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure*, which examined all aspects of transportation infrastructure in the U.S. Gulf from Houston to Mobile, including surface and air transportation, as well as pipelines. The work involved a geographic examination of how far inland the sphere of influence of climatic variability would reach, taking into account sea level rise, subsidence, barrier island erosion, and salt marsh diminution. The study also indicates whether conclusions reached may be applicable to similar locations elsewhere in the United States. Several cities in Kentucky, Virginia, Iowa and Alaska have already taken steps to relocate as a result of persistent flooding. A considered plan to relocate critical infrastructure to enhance its useful life would be a logical outcome.

This research would also directly support other infrastructure-related research statements presented in this circular: Examine the Relationship of Climate Change and GHG Mitigation with Transportation Infrastructure Security; Constructs to Enable Multiple Agencies to Develop Policies Relating Climate Change and Critical Transportation Infrastructure Protection; or Collaborative Decision-Making Framework for Climate Change Mitigation and Adaptation.

Urgency–Priority

The need to preserve and protect our critical infrastructure has already been clearly presented in other policy statements. This research supports that mission by addressing the potential weaknesses inherent in the location of specific infrastructures in at-risk geography due to climate variability.

There are areas along all the coast of the United States where infrastructure is present in abundance, which presents a huge asset base that needs to be protected. In some locations, the damage potential of severe storms and erosion is minimal, so hardening will be sufficient. However, in the U.S. Gulf or in locations above the Arctic Circle, hardening will not be sufficient. Subsidence, storm surge, and large scale erosion will destroy even hardened infrastructure.

Cost

Referencing the cost of the U.S. DOT study, this research should not exceed $750,000, because it should be based in large part on the existing DOT information and the results of other security-oriented research efforts. The analysis will be partly geospatial and partly cost–benefit.

User Community

The user community should include U.S. DOT, FHWA, FTA, and state public works and transportation agencies, who ultimately "own" this infrastructure. Particularly, the U.S. Army Corps of Engineers should be included, due to their involvement in flooding issues and mitigation plans.

Implementation

The findings could result in a national program to harden or relocate key infrastructure. One outcome could be a multistate dialogue about adaptation to implement the recommendations of such a study in an at-risk region such as the U.S. Gulf. Alternatively, the study could result in a recommendation on how infrastructure should be hardened with no need to be moved at all.

Effectiveness

The societal effects of this research will be highly sensitive. The presence and location of specific infrastructure is an economic necessity for businesses of all sorts, as well as an attractor for new economic development. It adds the fundamental value to countless homes and businesses. Any plan to relocate such infrastructure will face an uphill battle. However, the potential societal benefit from having hardened, secure, and sustainable infrastructure is significant. The cost of hurricanes Katrina and Rita was in excess of $100 billion. This was due in part to the potency of the storms, but it was also due to the significant amount of infrastructure that was present.

Energy and Alternative Fuels Research Needs Statements

ASSESS DIRECT AND INDIRECT LIFE-CYCLE GHG IMPACTS OF ADVANCED FUELS AND VEHICLES

Problem Statement

There are mounting regulatory and market pressures that would encourage a transition of the ground transportation system toward advanced fuels and vehicles. In the United States, EPA and NHTSA have begun a joint rulemaking process that coordinates GHG emission standards and CAFE standards. The European Union has committed to a 20% reduction in GHG emissions (relative to 1990 levels) by 2020. By 2020, Canada has committed to reduce its GHGs by 20% from the 2006 level, and by 2050 expects to achieve a 60% to 70% reduction from the 2006 level. The American Clean Energy and Security Act has moved through the House of Representatives. It sets the goal of a 17% reduction of GHGs below 2005 levels by 2020. The latest Senate draft bill (Boxer–Kerry) would change that goal to a 20% reduction. At the same time, EPA is developing regulatory proposals under the existing Clean Air Act.

Many countries are tightening regulation of vehicle fuel economy and GHG emissions. China announced in May 2009 that it would require automakers to improve fuel economy by an additional 18% by 2015; raising fuel economy to approximately 42 mpg. China has increased taxes on large engine vehicles (over 4 liters) to 40%, increased taxes on vehicles with engines between 3 and 4 liters to 25%, and decreased the tax on small engine vehicles (1 to 1.5 liters) to 1%. In April 2009, the European Union adopted regulations requiring a reduction of CO_2 emissions from new passenger cars from 159g/km (in 2006) to a maximum of 130g/km by 2015, corresponding to a fuel economy of 48.9 mpg. The European Union also set a target for 2020 emissions of 95 g/km (subject to review prior to becoming a standard). Japan has set a fuel economy target of 48 mpg by 2010. Australia will increase fuel economy standards to 34.4 mpg by 2010. Most EU countries currently have carbon emissions–based taxes on cars, and those EU members that currently do not have committed to do so.

The challenge for research is to quantify the direct and indirect life-cycle GHG impacts of the advanced fuels and vehicles that will be necessary to meet these tightening automotive standards and to determine whether they will, on net, contribute to total GHG emissions reductions from all sources. An assessment of direct impacts on life-cycle GHG emissions from a particular fuel or vehicle technology is complex, even assuming no change in upstream or downstream markets. Modeling impacts on prices and quantities in upstream and downstream markets is the key to assessing indirect impacts. For example, increasing the use of biofuels could shift agricultural production toward more GHG-intensive technologies for producing both biofuels and food.

Objective

This project will assess the direct and indirect technical and market channels through which advanced fuels and vehicle technologies are likely to affect overall GHG emissions by

- Reviewing previous work in this area with particular attention to analysis by EPA of renewable fuels standards;
- Identifying the upstream and downstream markets likely to be affected and the likely qualitative impacts on them;
- Including agricultural products, electricity, fuel feed stocks (e.g., natural gas use by chemicals industry), automotive components and materials, fueling and road infrastructure, driver behavior and VMT, labor markets, and investment markets;
- Identifying strengths and weaknesses of alternative modeling approaches, including computable general equilibrium, agent-based, and dynamic nonlinear systems models;
- Quantifying impacts of advanced fuels and vehicles in terms of life-cycle (direct and indirect) GHG emissions and market costs of related or affected products and services;
- Making a quantitative assessment of key strategic alternatives, including a comprehensive sensitivity analysis of each model's parameters; and
- Identifying the parameters that are most important for further research.

Key Words

Fuel transitions, life cycle, well-to-wheel, farm-to-wheel, market impacts, sustainability impacts, transportation safety impacts, electric vehicle, plug-in hybrid electric vehicle, hybrid electric vehicle, fuel cell vehicle, life-cycle analysis, computable general equilibrium, agent-based model, dynamic nonlinear systems model

Related Work

Delucchi, M. A. *A Lifecycle Emissions Model (LEM): Lifecycle Emissions from Transportation Fuels, Motor Vehicles, Transportation Modes, Electricity Use, Heating and Cooking Fuels, and Materials*. University of California, Davis, 2003, p. 444.

Delucchi, M. A. *Conceptual and Methodological Issues in Lifecycle Analyses of Transportation Fuels*. Institute of Transportation Studies, University of California, Davis, 2004, p. 25.

Gurgel, A. C., J. M. Reilly, and S. Paltsev. *Potential Land Use Implications of a Global Biofuels Industry*. Massachusetts Institute of Technology Joint Program on the Science and Policy of Global Change, Cambridge, Mass., 2008.

Heywood, J., P. Baptista, I. Berry, K. Bhatt, L. Cheah, F. de Sisternes, V. Karplus, D. Keith, M. Khusid, D MacKenzie, and J McAulay. *An Action Plan for Cars: The Policies Needed to Reduce U.S. Petroleum Consumption and GHG Emissions*. Report No. MITEI 2009-01 RP. MIT Energy Initiative, Sept., 2009.

World Energy Outlook 2006, International Energy Agency, Paris, Policy Research Working Paper No. 4682, p. 69, 2006.

Mitchell, Donald. *A Note on Rising Food Prices*. World Bank, July 2008.

National Research Council. *Water Implications of Biofuels Production in the United States*. National Academies Press, Washington, D.C., 2007.

Searchinger, T., R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T.-H. Yu. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change. *Science*, Vol. 319, No. 5867, Feb. 29, 2008, pp. 1238–1240.

Spatari, S., M. O'Hare, K. Fingerman, D. Kammen, and A. E. Farrell. *Sustainability and the Low Carbon Fuel Standard*. Energy and Resources Group 2, Goldman School of Public Policy University of California, Berkeley, 2008.
Tilman, D., J. Hill, and C. Lehman. Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. *Science*, Vol. 314, No. 5805, Dec. 8, 2006, pp. 1598–1600.
Technical Challenges of Plug-In Hybrid Electric Vehicles and Impacts to the U.S. Power System. Task 1: Technological Barriers for Acceptable PHEV Performance and Cost; Task 2a: Plug-in Hybrid Electric Vehicles (Consumer Survey); Task 2b: PHEV Marketplace Penetration, An Agent Based Simulation; Task 2c: Market Models for Predicting PHEV Adoption and Diffusion; and Task 3: Impact of PHEVs on the Reliability of the Electric Grid. University of Michigan, Ann Arbor, and National Renewable Energy Laboratory, Washington, D.C., 2009.
University of Michigan; Rochester Institute of Technology; University of California, Berkeley; University of California, Davis; and Northwestern University. Environmental Policy, Auto Design, and Materials Flows. National Science Foundation, MUSES, ongoing project.
World Bank, *World Development Report 2008*: *Agriculture for Development*. Report 41456. Washington, D. C., Oct., 2007.
World Bank, *World Development Report 2010*: *Development and Climate Change*. Washington, D. C., Sept. 2009.

Urgency–Priority

The proposed research will contribute to the ongoing debate on the relative merits of advanced fuels and vehicle technologies in advancing the goal of reducing overall GHG emissions.

Cost

$900,000

User Community

RITA, EPA, NHTSA, DOE, U.S. Department of Agriculture (USDA), state DOTs, state DAs, energy offices and environmental agencies, original equipment manufacturers (OEMs) and their suppliers, energy suppliers and their trade associations [power producers, Electric Power Research Institute (EPRI), NHA, etc.], agricultural biofuels suppliers and their trade associations

Implementation

The desired project outcome is a final report outlining the channels of indirect impacts and qualitative and quantitative assessments under key strategic scenarios. The report should include a critical comparison of alternative modeling approaches, a comprehensive sensitivity analysis of model parameters, and directions for future research.

Effectiveness

This research will refine the understanding of channels of indirect impacts of advanced fuel and vehicle technologies on GHG emissions.

EXPLORE LIFE-CYCLE ANALYSIS OF ALTERNATIVE FUELS FOR TRAINS, PLANES, AND SHIPS

Problem Statement

The life-cycle analysis (LCA) of transportation fuels is a critical step when comparing the energy and environmental attributes of conventional and alternative fuels. LCA accounts for the energy use and environmental impacts that occur during the production, transportation, distribution, and use of different fuels. LCA tools allow analysts and decision makers to evaluate more completely the impacts of using conventional fuels, biofuels, and electric vehicles, to name a few.

Most LCA tools have focused on applications in the light-duty vehicle (LDV) sector. With only a few exceptions, LCA has ignored other modes (such as trucks, trains, ships, and planes). Yet these modes are gaining prominence in our transportation emissions inventories, and fuel consumption in these modes is likely to grow faster than in the LDV sector in the coming decades. In addition, alternative fuel markets have extended beyond the LDV sector; for example, biofuels, electric power, natural gas, and other alternative fuels are now being considered and used for air, rail, and water transport.

Objective

This project will design and develop a suite of LCA models that can be used to evaluate life-cycle energy and emissions for conventional and alternative fuels used for non-LDV modes of transport. The project entails

- Reviewing LCA models previously developed for LDVs [e.g., the Greenhouse Gas and Regulated Emissions and Energy Use in Transportation (GREET) model];
- Reviewing LCA models previously developed for non-LDV modes [e.g., the Total Energy and Emissions Analysis for Marine Systems (TEAMS) model, and the Lifecycle Emissions Model (LEM), which includes rail and marine modes];
- Identifying gaps in the availability of tools for non-LDV modes;
- Building non-LDV modules or stand-alone LCA tools to evaluate energy use and emissions from fuels used in non-LDV modes. The LCA tools should account for regional variations (and appropriate regional aggregations) with respect to fuel-cycle analysis;
- Conducting analyses using these LCA tools to evaluate alternative fuel options for non-LDV modes; and
- The LCA should cover the fuels specific to the end use and their performance in the vehicle. Can the existing engine technologies use the alternative fuels? Safety and engine durability issues involved with switching fuels, especially in shipping, should be covered.

Key Words

Alternative fuels, total fuel cycle analysis, life-cycle analysis

Related Work

Corbett, J. J., and J. J. Winebrake. Emissions Tradeoffs among Alternate Marine Fuels: Total

Fuel Cycle Analysis of Residual Oil, Marine Gas Oil, and Marine Diesel Oil. In *Journal of the Air and Waste Management Association*, Vol. 58, No. 4, April 2008, pp.1–5.

Wang, M. Fuel Cycle Analysis of Conventional and Alternative Fuel Vehicles, *Encyclopedia of Energy*, 2004, pp. 771–789.

Wang, M. Q. Development and Use of the GREET Model to Estimate Fuel-Cycle Energy Use and Emissions of Various Transportation Technologies and Fuels. Center for Transportation Research, Energy Systems Division, Argonne, Ill., 1996.

Winebrake, J. J., J. J. Corbett, and P. E. Meyer. Energy Use and Emissions from Marine Vessels: A Total Fuel Cycle Approach. In *Journal of the Air and Waste Management Association*, Vol. 57, No. 1, Jan., 2007, pp. 102–110.

Urgency–Priority

The proposed research will provide tools necessary for conducting analyses of conventional and alternative fuels in non-LDV modes. Given the role of the non-LDV sectors in overall energy use and emissions inventories, this project should receive high priority.

Cost

$800,000

User Community

DOT, EPA, DOE, state DOTs, energy offices and environmental agencies, OEMs, energy suppliers and their trade associations, academics

Implementation

The desired project outcome is a set of LCA models (either integrated or stand alone), that can be used to evaluate total fuel cycle energy use and emissions impacts associated with using conventional and alternative fuels in planes, trains, trucks, and ships (i.e., non-LDV modes).

Effectiveness

This research will help inform key decision making related to non-LDV modes, such as new policies to incentivize alternative fuel use for trucks, trains, ships, and planes.

ASSESS INTERCITY PASSENGER AND INTER- AND INTRA-CITY FREIGHT TRANSPORT ENERGY AND GHG INTENSITIES

Problem Statement

Energy intensity values (energy use per unit of activity) are basic data for forecasting, policy analysis, planning, and monitoring progress toward energy and environmental goals. They are essential for predicting the impact of changes in the structure of passenger and freight transportation over time and in response to technology advances and policy initiatives. Because greenhouse gas emissions are closely linked to energy consumption, energy intensities are also key variables in modeling climate change impacts of transportation activities. In general, however, only the most aggregate energy intensity values are readily available (e.g., energy use per total revenue passenger-mile for air travel, energy use per vehicle-mile for automobile travel, etc.), and for some modes (e.g., truck freight) even the most basic estimates of energy use per unit of activity are not available. GHG intensity values are similarly lacking.

The lack of detailed, comprehensive, consistent, and objective measures of modal energy and GHG intensities handicaps a range of analyses. In many cases, analyses must rely on generic estimates based on total activity and fuel use developed by or for agencies like DOT's FHWA, EPA's MOVES model, and DOE's Energy Information Administration (EIA). The most recent comprehensive study of passenger and freight energy intensities is now more than 30 years old.

Objective

Developing a consistent set of comprehensive and objective energy and GHG intensity estimates will require a substantial research effort. This research should survey all modes, but the primary focus should be on intercity passenger and inter- and intra-city freight transport energy and GHG intensities. The research should make distinctions, where possible, of different spatial scales (e.g., national, regional, metropolitan). The level of detail should reflect analytical needs as well as the availability of reliable and accurate data. Detail is important to ensure valid comparisons across modes and functions and to improve the accuracy of derived estimates, such as GHG emissions. Specific tasks will include

- Reviewing U.S. and international literature, both to obtain modal energy intensity estimates for comparative purposes and to identify data sources and methods;
- Surveying the literature and relevant agencies to identify and evaluate the most important uses of energy intensity numbers;
- Covering gaps in scattered data and representative driving cycles that do not exist;
- Determining modal, functional, and spatial structure of intensity estimates to be derived based on the availability of data, the identified needs and uses for energy intensity estimates, and relevant parameters; and
- Selecting methods and data sources for developing the estimates and implementing them in a computer model (e.g., a spreadsheet) so that estimates can be made for both the past and future, according to the availability of data.

Key Words

Energy efficiency, fuel efficiency, fuel economy, greenhouse gas intensity

Related Work

Davis, S. C., S. Diegel, and R. G. Boundy. *Transportation Energy Data Book*, Ed. 28. Report ORNL-6984. U.S. Department of Energy and Oak Ridge National Laboratory, Oak Ridge, Tenn., 2009.

Rose, A. B. Energy Intensity and Related Parameters of Selected Transportation Modes: Freight Movements. Report ORNL-5554. Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1979.

Rose, A. B. Energy Intensity and Related Parameters of Selected Transportation Modes: Passenger Movements. Report ORNL-5506. Oak Ridge National Laboratory, Oak Ridge, Tenn., Jan. 1979.

Urgency–Priority

The proposed research will contribute to the ongoing dialogue on climate change strategies, policies, and investments by providing a consistent, objective basis for comparing alternative technology and policy options.

Cost

$500,000

User Community

DOT (FHWA, FTA, FAA, FRA, etc.), EPA, DOE, MPOs, state DOTs, state energy offices, and trade associations (APTA, United States Council for Automotive Research, ATA, etc.)

Implementation

The desired project outcome is a final report and a computer model, together with instructions for its operation, to be used by a range of federal, state, and local agencies, operating authorities and user groups.

Effectiveness

If successful, this research will refine the understanding of the relationship between energy intensity and various technical and operational parameters and provide an enhanced capability to compare alternative technological and policy options.

ANALYZE SOCIAL COSTS AND BENEFITS OF ADVANCED BIOFUELS AND OTHER LOW-CARBON FUELS

Problem Statement

Policy interest in low-carbon fuel standards (LCFS) as a means of reducing GHG emissions is growing rapidly. California governor Arnold Schwarzenegger signed an executive order on January 18, 2007, that initiated a low-carbon fuel standard to reduce the carbon intensity of fuels for light-duty vehicles. The standard limits the life-cycle weighted average carbon intensity of transportation fuel. Several bills that would establish a similar national LCFS were introduced in the 110th Congress. None were adopted, and one was discussed on the Senate floor. In the 111th

Congress, an LCFS was in the original draft of the Waxman–Markey bill, but removed from the version that passed the House. The American Clean Energy and Security Act may include a national LCFS.

There is an urgent need for an objective, scientific analysis of the social costs and benefits of the advanced biofuels and other low-carbon fuels that would be required under a national LCFS.

Objective

This project will conduct a comprehensive social benefit and cost analysis of a national low LCFS by

- Reviewing previous related efforts from the University of California, the University of Minnesota, and others;
- Consulting several proposed guidelines for benefit and cost analysis, including the OMB's guidelines;
- Developing an economic model that permits the prediction of private and social costs and benefits of LCFS. The model should distinguish between tangible and intangible elements. An example of a tangible component of private cost would be the incremental increase in the cost of producing fuel. An example of an intangible component of private cost to the consumer would be any loss of vehicle performance associated with the LCFS. The social costs and benefits should include quantifiable market and nonmarket impacts;
- Developing an accounting framework that delineates the appropriate dimensions and boundaries of the social costs to be considered. Such a framework should capture impact disparities and equity concerns among affected stakeholders;
- Measuring and normalizing incremental costs in terms of appropriate functional units (e.g., $/tonne GHG avoided, $/Btu, etc.) to facilitate comparison of fuel alternatives. Additionally, total (nonnormalized) costs should be estimated to assess overall impacts to affected stakeholders; and
- Identifying several scenarios for a national LCFS along a number of dimensions
  - Establishing the baseline for the analysis, including, if appropriate, GHG and CAFE standards under the EPA and NHTSA joint rulemaking and the Renewable Fuels Standards 2;
  - Conducting a comprehensive sensitivity analysis for the parameters in the model, consulting experts and establishing 90% to 95% ranges of plausibility; and
  - Establishing GHG benefits of LCFS implementation by 2050 and beyond.

Key Words

Low-carbon fuel standards, benefit–cost analysis of regulation, biodiesel, ethanol, biofuels, social costs, social benefits, private costs, private benefits

Related Work

Farrell, A. E., D. Sperling, A. R. Brandt, A. Eggert, B. K. Haya, J. Hughes, B. M. Jenkins, A. D. Jones, D. M. Kammen, C. R. Knittel, M. W. Melaina, M. O'Hare, and R. J. Plevin. *A Low-Carbon Fuel Standard for California Part 2: Policy Analysis.* University of California, August 1, 2007.

Hill, J., E. Nelson, D. Tilman, S. Polasky, and D. Tiffany. *Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels*. University of Minnesota, June 2, 2006.

Holland, S. P., J. E. Hughes, and C. R. Knittel. Greenhouse Gas Reductions under Low Carbon Fuel Standards? *American Economic Journal: Economic Policy 2009,* Vol. 1, No. 1, pp. 106–146.

Monetary Valuation per Dollar of Investment in Different Performance Measures, NCHRP 8-36-61. National Cooperative Highway Research Program. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36%2861%29_FR.pdf. Accessed April 13, 2009.

Yacobucci, B. D. *A Low Carbon Fuel Standard: State and Federal Legislation and Regulations*. Congressional Research Service, December 2008.

Urgency–Priority

The proposed research will contribute to the current debate on a national LCFS.

Cost

$900,000

User Community

U.S. DOT, EPA, DOE, state DOTs, energy offices and environmental agencies, fuel producers and their trade associations, and OEMs

Implementation

The desired project outcome is a final report of social costs and benefits. Social costs and benefits should include quantifiable market and nonmarket impacts; detailed explanation of the model; all assumptions and data files used; and a detailed discussion of the sensitivity analysis (identifying the parameters with such uncertainty that they would change the results).

Effectiveness

This research will refine the understanding of the social costs and benefits of a national LCFS and provide guidance for policy.

ASSESS THE LIMITS OF ADVANCED BIOFUEL SUPPLY ON TRANSPORTATION

Problem Statement

Advanced (second- and third-generation) biofuels include a range of renewable liquid or gaseous fuels produced from nonfood sources such as woody grasses, agricultural residues, and organic waste. Processes include conventional anaerobic digestion, as well as advanced bioreactors and gasification and fermentation technologies. In addition to the mandates for advanced biofuel production established under President Bush, a new round of renewable fuel standards, California's low-carbon fuel standard and the possibility of GHG caps are making second- and third-generation biofuels an increasingly important part of the fuel pool. However, as with first-generation biofuels, there may be practical limits to these fuels' contribution to U.S. fuel supplies. These limits include the volume of resources likely to be available, competition with other end-uses (e.g., electricity generation, natural gas for stationary use), competition for arable land to produce biomass resources, production costs, limitations on blend percentage (e.g., vapor pressure limitations for ethanol in gasoline, cold-flow performance for some types of biodiesel), limitations on production incentives, and availability of vehicles that can use the fuel (e.g., flexible fuel vehicles that can use E-85). Options for increasing biofuel quantities include expanding the resource base that can be used, developing advanced production technologies and supplementing supplies with imports from foreign countries.

Objective

The contribution that advanced biofuels can make to the U.S. transportation fuel market shall be estimated. The maximum practical production potential for ethanol, biodiesel, and other potential biofuels will be estimated, taking into account the existing resource bases for each, the economics of competing uses, and a range of incentives. Long-term potential (20 years or more from now) for biofuels production and use will be estimated, including consideration of additional resources, advanced technology production processes, the impact of global climate change on the resource base, and the potential for imports from foreign countries. A sensitivity analysis will be conducted of the factors affecting biofuels production. Technical limitations on the use of biofuels in vehicles shall be taken into account when estimating the total amount that could be used as fuel. This should include an assessment of whether production incentives can lead to future production that is self-sufficient.

Key Words

Renewable fuel, second-generation biofuel, third-generation biofuel, advanced biofuel, cellulosic ethanol

Related Work

Biomass Research and Development Board. *Increasing Feedstock Production for Biofuels Economic Drivers, Environmental Implications, and the Role of Research*. 2009. http://www.afdc.energy.gov/afdc/pdfs/increasing_feedstock_revised.pdf. Accessed Oct. 2009.

Biomass Research and Development Board. *National Biomass Action Plan*. 2008. http://www.afdc.energy.gov/afdc/pdfs/nbap.pdf. Accessed Oct. 2009.
Early, J., and A. McKeown. *Red, White and Green: Transforming U.S. Biofuels*. Worldwatch Report 180. Worldwatch Institute, Washington, D.C., January 2009.
Perlack, R., et al. *Biomass as Feedstock for Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, Oak Ridge National Laboratory for U.S. Department of Agriculture and U.S. Department of Energy, April 2005.

Urgency–Priority

The proposed research will contribute to the ongoing dialogue on renewable fuel strategies, policies, and investments by providing a consistent, objective context for evaluating competing claims by technology and project developers.

Cost

$400,000

User Community

DOT (FHWA, FTA, FAA, FRA, etc.), EPA, USDA, DOE, state DOTs, state energy offices, fuel suppliers and their trade associations (API, RFA, etc.)

Implementation

The desired project outcome is a final report with forecasts of potential advanced biofuel supplies by type.

Effectiveness

This research will refine our understanding of the feasibility of meeting renewable fuel goals and the potential of various advanced technologies to contribute to that effort.

ANALYZE INFRASTRUCTURE AND SUPPLY CHAIN REQUIREMENTS TO SUPPORT THE TRANSITION TO HIGH-EFFICIENCY, LOW GHG–EMITTING LIGHT-DUTY VEHICLES

Problem Statement

An ever-growing interest in the promise of high-efficiency, low GHG–emitting vehicles has led to a variety of efforts to accelerate their commercial introduction. All the major original OEMs are in various stages of developing fuel cell, electric and plug-in hybrid electric vehicles (PHEV). Honda has already launched the Clarity, a first-generation fuel cell vehicle. General Motors has announced that the Volt, a fully electric vehicle, will be available by year-end 2010. Toyota is planning a plug-in version of its popular Prius. Nissan and Ford are developing plug-in hybrids and battery electrics. Government efforts include the DOE's long-standing support for R&D and fleet deployment of fuel cells for light-duty vehicles, the activities of the California Fuel Cell Partnership (CAFCP) to deploy fuel cell vehicles and infrastructure, and numerous state programs to assist in infrastructure deployment (some of which have obtained additional assistance from Recovery Act funds). The utility industry is also heavily involved, through the efforts of the EPRI and major power providers. The sum of current and planned private and public sector investment in electric, fuel cell and PHEV technologies is significant. To maximize the return on this investment a comprehensive assessment of pathways to full-scale deployment of these vehicles is essential.

Clearly, electric, biofuel hybrid electric vehicle (HEV), fuel cell and PHEV technologies have the potential to lessen dependence on foreign oil and reduce pollution and GHG emissions. However, achieving this potential is no small task. Developing and deploying these vehicles will be a formidable undertaking. Early vehicles may achieve greater success in niche markets as opposed to the mass markets served by conventional vehicles. Coordinating infrastructure development with deployment is likely to be a particular challenge. Conventional highway fuels are distributed by means of what may be termed a petroleum model. Product terminals receive various grades of petroleum from refineries via tankers or pipelines and truck it to local refueling facilities. Depending on the feedstock and conversion process, hydrogen supply infrastructure would be very different, as would the recharging infrastructure for electric and plug-in hybrids. Questions like the availability of "spare" capacity to accommodate growing market demand and the evolution of supply infrastructure are not idle musings. Unless resolved at the outset, these issues are likely to pose formidable barriers to the transition to high-efficiency, low GHG–emitting vehicles.

Objective

This project will conduct a comprehensive assessment of pathways to the successful mass market commercialization of high-efficiency, low-GHG-emitting vehicles in North America by

- Reviewing previous related efforts from NAS, CAFCP, DOE, University of California, Davis, Oak Ridge National Laboratory, Argonne National Laboratory, etc.;
- Examining the potential for electric, biofuel HEV, fuel cell and PHEV technologies to penetrate niche and other markets including fleets, trucks, stationary applications (e.g., residential, portable and mobile power including forklifts and utility vehicles);
- Evaluating options for the early introduction of electric, biofuel HEV, fuel cell, and PHEV technologies in transportation applications, including transit buses (FTA, CAFCP, European demo program) and niche markets;
- Evaluating transition options—natural gas for gaseous fuel, hybrid electric for electric drive;
- Evaluating the narrowing advantages of fuel cell vehicles against competing technologies—conventional gasoline and diesel, hybrid electric, and alternative fuels; and
- Evaluating infrastructure requirements for electric, biofuel HEV, fuel cell and PHEV technologies;
- Describing prospective pathways with associated costs, benefits, and potential barriers.

The work will be divided into two phases, the first identifying components of one or more end-state infrastructures, and the second detailing potential transitions to those end states.

Key Words

Fuel transition, electric vehicle market penetration, fuel cell vehicle market penetration, plug-in hybrid electric vehicle market penetration

Related Work

Greene, D., P. Leiby, and D. Bowman. *Integrated Analysis of Market Transformation Scenarios with HyTrans.* Oak Ridge National Laboratory, Report ORNL/TM-2007/094, June 2007, http://www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2007_094.pdf. Accessed Oct. 2009.

Lin, Z., C. Chen, Y. Fan, and J. Ogden. *Optimized Pathways for Regional H2 Infrastructure Transitions: The Least-Cost Hydrogen for Southern California*. Research Report UCD-ITS-RR-08-02. Institute of Transportation Studies, University of California, Davis, 2008.

National Research Council. *Transitions to Alternative Transportation Technologies: A Focus on Hydrogen*. National Academies Press, Washington, D.C., 2008.

Stephan, C., et al. Modeling the Transition to a Hydrogen-Based Personal Transportation System. *Frontiers in Transportation,* Amsterdam, Netherlands, Oct.14–16, 2007.

Urgency–Priority

The proposed research will contribute to the ongoing debate on the relative merits of electric, fuel cell and PHEV technologies and potential pathways to their widespread adoption.

Cost

$600,000

User Community

RITA, EPA, DOE, state DOTs, energy offices and environmental agencies, OEMs, energy suppliers and their trade associations (power producers, EPRI, NHA, etc.)

Implementation

The desired project outcome is a final report outlining alternative pathways for the introduction and market development of electric, fuel cell, and PHEV technologies. Analysis will include an assessment of the role of niche markets and various policy instruments in achieving market success.

Effectiveness

This research will refine the understanding of pathways to achieve market success in deploying electric, fuel cell and PHEV technologies, and the role of various policy instruments in achieving that goal.

ASSESS THE IMPACT OF LEAKAGE ON THE EFFECTIVENESS OF A LOW-CARBON FUEL STANDARD

Problem Statement

A LCFS sets a target to reduce the GHG intensity of transportation fuels. Fuel providers must reduce the GHG intensity of their fuels, measured on a life-cycle basis. Concerns for the leakage problem raise doubts about the effectiveness of the LCFS. There are at least two types of the leakage problems that can occur: first, regulated parties will have incentives to export high-carbon fuels to non-LCFS countries or not import high-carbon fuels. Thus, a national LCFS could limit the flow of high-carbon fuel, such as oil sands, into the United States. But instead of reducing the consumption of high-carbon fuels globally, the majority of the oil sands exports might be diverted elsewhere, such as to the Asian market. Thus the marginal benefit would be close to zero. Similar problems can also exist for other fuels, such as high-carbon bunker fuel and aviation fuel. Not only fuel providers can deliver high-carbon bunker fuel and aviation fuel to other markets, ships or airplanes, or can plan their fueling routes and refuel at ports or airports where high-carbon fuels are sold at lower price. The second type of leakage is the indirect land use change issue associated with the large-scale production of low-GHG biofuels. Indirect emissions occur when biofuels production on agricultural land displaces agricultural production and causes additional land use change elsewhere that leads to an increase in net GHG emissions. Few studies have examined the impacts of leakage on the effectiveness of the LCFS.

Objective

Studies are needed to examine the type of conditions under which leakage may occur and the extent of leakage that could affect the effectiveness of a national LCFS. More robust assumptions and alternative scenarios will be needed to give a better picture of the impacts of a national LCFS on global oil and commodity markets and vice versa. The cost of mitigation options, such as the ability of companies to switch to low-GHG fuels, the cost of reducing the carbon intensity of high-carbon fuels and the potential for second-generation biofuels to mitigate the competition for land that will be used to produce biofuels and the type of land (marginal versus cropland) likely to be used for energy crop production at a county-specific level for the United States. This research should also consider the potential for interstate and interregional leakage from the California Low-Carbon Fuel Standard and the proposed Northeastern States Low-Carbon Fuel standard.

Key Words

Oil sands, unconventional oil, shuffling, indirect land use change

Related Work

Difiglio, C. Analysis of a Federal LCFS (Sec 121 of Waxman–Markey Discussion Draft). Presented at Twelfth Biennial Asilomar Conference on Transportation and Energy Policy, at Pacific Grove, Calif., 2009.

Holland, S. *Taxes and Trading versus Intensity Standards: Second-Best Environmental Policies with Incomplete Regulation (Leakage) or Market Power*. Center for the Study of Energy Markets, University of California Energy Institute, Berkeley, 2009.

Urgency–Priority

The research will contribute to the understanding of the effectiveness of the LCFS and inform policies to develop strategies to reduce leakage and shuffling outside of the unregulated market (which is a common problem for any low-carbon policy, including the cap-and-trade).

Cost

$500,000

User Community

EPA, USDA, DOE, fuel suppliers and their trade associations (API, RFA, etc.), U.S. DOT, Canadian government, and the International Maritime Organization (IMO)

Implementation

The desired project outcome is a final report evaluating the potential impacts of leakage affecting the effectiveness of an LCFS, and policy recommendations to effectively reduce the leakage from occurring.

Effectiveness

This research will have many implications for a broad set of carbon policies (perhaps extending to policies to achieve a set of sustainability goals) that will be needed to deal with leakage at the domestic and international level. Reducing the potential leakage will help to improve the efficiency of policies, minimize unintended consequence, and promote the production of low-GHG fuels.

ASSESS COSTS ASSOCIATED WITH HYDROGEN AS AN ALTERNATIVE FUEL

Problem

Hydrogen has been proposed as a feasible alternative fuel for vehicles. However, the ramifications of such an approach to transportation have not been fully assessed. These include the emissions due to energy required to produce and distribute hydrogen, the cost of infrastructure for fuel (pipelines, fueling stations) and fuel cells (sales, service), and the safety issues associated with hydrogen containment and handling.

Objective

A comprehensive assessment of all costs (net GHG, economic, safety) associated with use of hydrogen as an alternative fuel for surface transportation is required. These costs should be compared with the alternative investment in a new surface transportation system that can serve local, mid-range, and long-range needs.

Key Words

H_2, infrastructure, distribution, fuel cell

Related Work

None identified

Urgency–Priority

Assignment of priority to this research should be based on the amount currently being spent on hydrogen fuel system R&D. The sooner such an analysis is conducted, the more money can be saved if indeed the presumed conclusion is true.

Cost

$50,000

User Community

The audience that should receive this research problem statement includes AASHTO, DOE, NHTSA, and EPA.

Implementation

The finding of the proposed research would feed into current proposals to further study and develop hydrogen and fuel cell systems for transportation.

Effectiveness

Societal benefits of the research would be savings in R&D money currently being spent on hydrogen transportation, and a comprehensive assessment of the true costs and safety issues associated with hydrogen.

ASSESS POTENTIAL EMISSIONS REDUCTIONS FROM LINEAR MOTOR SYSTEMS

Problem

Current surface transportation systems depend on century-old internal-combustion technology that produces millions of tons of GHGs and other emissions annually. Highway vehicles produce emissions while idling in traffic and in drive-thru windows, aircraft produce emissions while taxiing and during takeoff and landing, and most trains in the United States produce emissions on unpowered railways. These emissions could be eliminated through deployment of existing, linear-motor technology.

Objective

Research would provide a comprehensive assessment of potential emissions reductions from deployment of linear-motor transportations systems for highway, train, and aircraft:

- For highways, linear motor stators could be buried in one or more lanes, and existing vehicles could be retrofitted with aluminum plates;
- For electric vehicles, essentially unlimited range could be afforded, with recharge while in transit;
- For aircraft, linear motors in taxiways would eliminate need to burn jet fuel during taxiing; aircraft could be retrofitted with retractable aluminum plates or, alternatively, linear motor–propelled taxi vehicles could be used;
- For runways, incorporated linear motors could provide takeoff and landing assist to reduce fuel consumption and emissions, with added benefits of regenerative braking and noise reduction; and
- For trains, linear motors could be installed in railways to reduce fuel consumption and emissions in yards, as well as for long-distance travel.

Assessment must include estimates regarding continued increased deployment of renewable power generation, and distributed-grid systems that could be utilized by linear motor systems.

Key Words

Electric, induction, cars, highways, aircraft, airports, trains, rail

Related Work

Gurol, H. General Atomics Linear Motor Applications: Moving Towards Deployment. *Proceedings of the IEEE,* Vol. 97, No. 11, Nov. 2009.

Meeker, D., and M. J. Newman. Indirect Vector Control of a Redundant Linear Induction Motor for Aircraft Launch. *Proceedings of the IEEE,* Vol. 97, No. 11, Nov. 2009.

Thornton, R., et al. *Linear Motor Powered Transportation, Proceedings of the IEEE,* Vol. 97, No. 11, Nov. 2009.

Urgency–Priority

Assigning priority of this assessment must consider any near- and long-term plans to improve or further develop 20th-century internal-combustion transportation infrastructure, rather than investing in new technologies for the 21st century.

Cost

$50,000 for comprehensive analysis of proposed work

User Community

The proposed audience for this research needs statement should include AASHTO, APTA, FHWA, NHTSA, FRA, FAA, DOE, and EPA.

Implementation

Research findings would be implemented by dissemination to transportation agencies at all levels, including those cited above. Objective costs and benefits, including long-term savings, would be included.

Effectiveness

Societal benefits of such research would be an objective, comprehensive picture of how transitioning transportation in the United States to linear motor–based systems could improve both the environment and the economy through lower emissions, high fuel efficiency, and low-maintenance vehicles and infrastructure. Although initial deployment costs of such systems are high, these costs might be outweighed by the long-term savings in fuel and maintenance, as well as environmental benefits.

Planning and Environment Research Needs Statements

DEVELOP STANDARDIZED PROCESS TO INCORPORATE CLIMATE CHANGE INTO THE PLANNING PROCESS

Problem

State DOTs and MPOs are facing requirements at the state and regional level, and emerging direction from the federal level, to address climate change in statewide and metropolitan transportation plans. However, there are no standardized approaches to measure and analyze GHG emissions, analyze emission reduction strategies, perform tradeoffs with other planning factors and goals, or determine how to incorporate technology assumptions into long-range transportation planning. In addition, very little information exists on how to effectively analyze the potential impacts of climate change and incorporate adaptation strategies into the long-range transportation plans.

Objective

The objective of this research would be to develop a standardized transportation planning process to incorporate climate change activities (both mitigation and adaptation) into statewide and metropolitan planning. This standardized process would include

- Measurement of GHG emissions from transportation and establishment of an emissions baseline;
- Effectiveness of various GHG reduction strategies;
- Appropriate assumptions for incorporating vehicle and fuel technology assumptions into the planning process;
- Ways of comparing GHG reductions with other transportation goals;
- How to effectively incorporate climate modeling into adaptation planning; and
- A standardized adaptation approach, including how adaptation strategies can be incorporated into the long range transportation plan.

Key Words

Transportation planning; climate change

Urgency–Priority

High priority

Cost Estimate

$500,000

User Community

State DOTs, MPOs, resource agencies, clean air agencies, AASHTO, AMPO

Implementation

The standardized process could be immediately translated into guidance for implementation at state DOTs and MPOs.

Effectiveness

This research would be focused on guidance that would be immediately effective for MPOs and state DOTs struggling with this requirement.

DEVELOP CLIMATE CHANGE INDICATORS AND MODEL OUTPUTS TO MITIGATE GHG EMISSIONS FROM TRANSPORTATION

Problem

States and MPOs are developing and evaluating transportation plans and programs on an ongoing basis. At the same time, many of them are also developing climate action plans and GHG reduction targets that frequently call for a reduction in GHG emissions from the transportation sector. However, it is difficult to assess the GHG emissions reduction potential of various transportation projects and policy alternatives because of a lack of effective analytical tools. This project is designed to address this need.

Objective

The objective of the project is to develop analytical tools that planners can use to assess the GHG impacts of transportation projects and policies. These tools should enable planners to identify transportation projects or policy alternatives with the greatest GHG mitigation potentials that also meet other project goals. Analytical tools should consider the impacts of transportation projects on such factors as fuel consumption, land use, land cover, and materials consumption, among others. Analytical tools should also allow for regional variation in inputs such as temperatures, fuel mix, mode split, and average fleet fuel efficiencies. These tools should be able to use the outputs of existing models to produce GHG impact information for long- and short-range planning for both passenger and freight demand.

Key Words

Climate change mitigation, long-range planning, short-range planning, demand modeling, freight demand; passenger travel, environmental impacts

Urgency–Priority

In order to develop transportation plans and programs that seek to reduce GHG emissions, planners need to be able to estimate the GHG impacts of various transportation projects and policy alternatives and compare them. Planners need to have the ability to perform these analyses as soon as possible.

Cost

$500,000

User Community

EPA, DOE, FHWA, FTA, FAA, FRA, AASHTO, APTA, AMPO

Implementation

These methods would be used by transportation planners to evaluate the GHG emissions and climate impacts of transportation plans, policies, and projects.

Effectiveness

The development and application of these methods will allow planners to identify and select the transportation projects and policies that will most effectively mitigate the emission of GHGs and reduce the transportation sector's impact on climate change.

IDENTIFY AND DEVELOP CLIMATE CHANGE MODELING OUTPUTS AND CLIMATE SCENARIOS TO SUPPORT TRANSPORTATION AGENCIES IN ASSESSING CLIMATE RISKS AND ADAPTATION STRATEGIES

Problem

States and MPOs are developing and evaluating transportation plans and programs on an ongoing basis. There is increasing awareness that future climate conditions may affect the resilience of the transportation infrastructure and services envisioned in these plans. However, it is currently difficult for transportation agencies to incorporate information about potential changes in climate into transportation planning and investment processes.

While there are a range of institutional and process barriers to effectively using climate projections in transportation decisions, one major obstacle is the lack of information and model outputs for potential climate scenarios. To be useful in the transportation planning process, climate projections need to be available at an appropriate geographic scale and include information on the probability and severity of potential impacts. Further, transportation planners need to develop risk-analysis approaches to use these inputs appropriately, using a probabilistic framework that incorporates both the likelihood of impacts as well as the significance of the infrastructure or service component that may be affected by the climate effect.

The capacity of climate scientists to provide region-specific, “downscaled” climate scenarios is rapidly advancing, but collaboration between the climate science community and the transportation practitioners who need this information is at a very early stage. This project is designed to address the gap in climate information and methodologies confronting transportation decision makers as they seek to make sound transportation plans and investment decisions today, while providing a framework for future advancements in this critical area.

Objective

The objective of this project is to advance the state of practice in incorporating climate information into transportation decision making. The research will

- Identify existing modeling tools that provide climate data and projections at a resolution and scale sufficient to support regional and subregional transportation decision making, including both information on long-range climatic change and information about the likelihood and extent of extreme events;
- Develop methods to use the outputs of existing models to produce climate change impact information for long- and short-range planning for both passenger and freight demand;
- Develop a risk-assessment approach to enable transportation agencies to plan and manage transportation networks incorporating a range of potential climate futures, levels of uncertainty, and prioritization of adaptation responses; and
- Identify gaps in existing modeling capabilities to inform climate researchers on needs of the transportation user community and recommend interdisciplinary approaches to develop a next generation of climate models that will address transportation needs.

Key Words

Long-range planning, short-range planning, climate impact and adaptation, risk assessment, asset management, climate modeling, environmental impacts

Urgency–Priority

High. In order to develop transportation plans and programs that seek to reduce the climate change impacts of transportation projects and policies, planners urgently need the capability to estimate climate change impacts of their various alternatives in order to perform their analyses.

Cost

$500,000

User Community

State DOTs, MPOs, transit agencies, EPA, DOE, FHWA, FTA, FAA, FRA, AASHTO, APTA, AMPO, National Oceanic and Atmospheric Administration (NOAA), USGS, USC

Implementation

These methods would be used by transportation planners to evaluate the risks of climate change impacts to transportation infrastructure and services, and incorporate this information into transportation plans and programs.

Effectiveness

The development and application of these methods would allow the planners to improve the resiliency of the transportation system to potential future climate impacts and severe events, and to prioritize adaptation strategies to address the most significant risks to system performance.

EXPLORE THE ENERGY AND CLIMATE IMPACTS OF ALTERNATIVE MODES OF TRANSPORTATION

Problem

Transportation planners are seeking to evaluate alternative approaches to reduce energy consumption and climate impacts of transportation plans and strategies. If progress is to be made in addressing these issues, planners will need techniques and methods to carry out impacts analyses of transportation plans and polices. At present, planners are struggling with such analysis. There is a need to develop a standard method for calculating fuel cycle (i.e., well-to-wheels) GHG emissions for various alternatives in transportation planning exercises. Achieving this objective will require a significant research undertaking to understand the parameters of what might be included within this analytical framework.

Objective

As a first step in establishing a comprehensive analysis framework, this study should strive to understand the components that must be included. As an example, should the GHG emissions of construction be considered and how should the long-term life-cycle costs be considered? How does the analysis consider other effects and related GHG emissions (e.g., parking requirements, land use changes)? This project should establish a reasonable framework that identifies the range of elements that should be included in such an analysis, together with potential research needs to further explore identified elements. The study should include the institutional frameworks within which such an investment prioritization might occur, including other key considerations such as safety, mobility, economic impact, and broader environmental consideration. This study is not intended to develop analytical tools but rather establish a framework of key elements that should be included and additional research that should be undertaken to enhance our analysis of effective strategies to reduce GHGs with transportation investment decisions.

Key Words

Climate change mitigation; energy conservation, modal energy intensiveness

Urgency–Priority

High

Cost

$200,000

User Community

AMPO, NARC, AASHTO, FHWA, FTA, APTA

Implementation

The results of this project will be used to inform transportation planners and analysts in their assessment of climate change impacts of transportation plans and strategies. It will be used to frame a larger research effort that will enhance analytical frameworks to identify effective transportation investment decisions.

Effectiveness

The results of this project will allow transportation planners and analysts to better assess the climate change impacts of various modes of transportation and to develop more effective climate change and energy strategies. It will be used to frame a larger research effort that will enhance analytical frameworks to identify effective transportation investment decisions.

ANALYZE THE EFFECTS OF DRIVING AND THE BUILT ENVIRONMENT

Problem

TRB's *Special Report 298: Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions* recommended specific research on the effects of land use patterns and the form and location of more compact, mixed-use development on VMT, energy use, and GHG emissions are needed to implement compact development more effectively.

Objective

The objective of the research is to provide analysis of the impact of the built environment on driving with the goal of assisting transportation and land use policy makers in decision making.

This research builds upon and expands from the TRB study. It includes the following key areas in which more research would be productive:

- Longitudinal studies to help isolate the effects of different types of development patterns on travel behavior;

- Studies of how different development patterns and policies (including road pricing, parking pricing, insurance pricing, public transit quality, carsharing availability, etc.) affect travel activity as well as fuel consumption, emissions, and pollution exposure;
- Studies of changes in metropolitan areas at finer levels of spatial detail to help inform the needs and opportunities for policy intervention;
- Careful before-and-after studies of policy interventions to promote more compact, mixed-use development to help determine what works and what does not work;
- Studies of threshold population and employment densities to support rail and bus transit and walking and bicycling, which would update old references and help guide infrastructure investments as well as zoning and land use plans;
- Studies of changing housing preferences and travel patterns of an aging population, new immigrant groups, and young adults to help determine whether future trends will differ from those of the past; and
- Development of recommendations for how the results of the above studies can be incorporated into transportation models for better assessing policy and planning decisions.

Key Words

Climate change, greenhouse gas emissions, compact development, smart growth, driving, vehicle miles traveled, land use, planning, policy

Related Work

Special Report 298: Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions. TRB, National Research Council, Washington, D.C., 2009.

Special Report 299: A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy. Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 24–25.

Urgency–Priority

Draft transportation reauthorization legislation and climate change legislation being considered in Congress would require states and metropolitan planning organizations to set transportation GHG reduction targets and develop strategies to meet these targets. Solid information on the impact of land use strategies on reducing transportation GHGs is crucial to the ability to develop these strategies.

Cost

$500,000

User Community

The research could be carried out by universities, consultants, government agencies, nonprofits, or other researchers. The audience for the research would be state and local governments, the federal government, and metropolitan planning organizations.

Implementation

States and metropolitan planning organizations could use analysis produced by the research in developing transportation plans that include GHG reduction strategies.

Effectiveness

The project would help the transportation sector reduce GHG emissions, a very important goal because transportation accounts for about a third of U.S. carbon emissions and science indicates that emissions must be reduced substantially to avoid dangerous climate change impacts.

Design and Construction Research Needs Statements

EXPLORE THE EFFECTS OF ASPECTS OF CLIMATE CHANGE ON TRANSPORTATION INFRASTRUCTURE

Problem

It is anticipated that future changes in climate will bring with it rising temperatures, increased precipitation events, permafrost, increasing sea levels, etc. Transportation infrastructure is likely to be affected adversely by any one, or the combination of all of these. For the aviation sector, the impacts of climate change could affect existing and future aviation infrastructure—for example, many U.S. airports are located in coastal areas. A better understanding of these impacts, vulnerabilities, and adaptation needs for the aviation system is needed. This is true for other sectors, including highways, railroads, port, and transit infrastructure. Furthermore, the implications of increased absolute surface temperatures as well as expanded temperature differentials (daily and yearly) will likely affect rail infrastructure; design, installation, maintenance, repair, and inspection. In addition to the obvious issues, this topic could include focus on implications for utilization of maintenance of way equipment on lines with traditional movement of equipment from south to north in the winter months and the issue of changing subgrade support (thawing permafrost) in Alaska and portions of western Canada.

Objective

This project would address the impacts of the various aspects of climate change on transportation infrastructure design, construction, maintenance and operations. In some instances, the facilities can be protected from the effects of climate change. In other instances, it may be necessary to construct alternatives to the existing facilities. Looking into the future, new standards need to be developed for the construction of transportation facilities to reduce the danger of adverse impacts due to climate change. Moreover, approaches need to be developed for the construction, maintenance, and operation of transportation facilities to minimize these impacts. Development of best practices on risk assessment and cost trade-offs for the items in the previous statement need to be accomplished.

Key Words

Climate change; transportation infrastructure design; transportation operations; transportation maintenance; standards

Urgency–Priority

A substantial number of transportation facilities are located in areas that are in danger of increased precipitation events and from rising water levels as the earth's temperature rises. In addition, rising temperatures can affect the operations and maintenance of other transportation facilities. It is critically important to minimize the adverse impacts of these phenomena on intrastate transportation. Furthermore, new design standards are needed to assure that the construction of future infrastructure projects avert problems from rising temperature and water levels.

Cost

$400,000

User Community

AASHTO, APTA, FHWA, FTA, FAA, MARAD, FRA

Implementation

The results of this project could be used to decrease the vulnerability of existing transportation infrastructure to the adverse effects of the various aspects of climate change and to avert such problems in the design of future infrastructure projects.

Effectiveness

The results could be used to reduce the cost and operational difficulties due to climate change. Furthermore, the results could be used to avert operation problems and disruptions on the movement of passengers and goods.

QUANTIFY AND INCORPORATE ENVIRONMENTAL BENEFITS INTO LIFE-CYCLE COSTING MODELS FOR COMMON ROADWAY CONSTRUCTION PRACTICES

Problem

Common roadway construction practices impact our environment. Impacts to streams and rivers have been monitored and are considered in the design and construction process. Efforts have been made to reduce other impacts of roadway construction such as dust, noise and emissions. However, the benefits of reducing each of these environmental impacts have not been measured. There is no readily available means of evaluating roadway construction practices that are more environmentally sound than conventional construction practices. Development of a baseline for environmental impacts is required in order to measure and quantify the benefits of impact reduction.

Sustainable pavement practices include reusing and recycling materials to construct roads that remain safe and durable while reducing emissions, energy use, and waste. With quantifiable environmental benefits, new technologies that support sustainable pavement practices can be measured. The measured benefits provide the most value when incorporated into a decision support tool for the selection of new roadway construction and rehabilitation alternatives.

The decision support tool is life-cycle costing. Many pavement life-cycle cost models focus on the economic aspect of the alternatives but fail to consider the social and environmental impacts. There is a need to develop a more comprehensive life-cycle costing model to evaluate the relative costs and environmental benefits of the material and processes used. In order to effectively guide decisions on pavement alternative selections to improve environmental performance, it is essential to develop research on quantifying and incorporating the environmental benefits associated with road building into the current life-cycle costing models.

Objective

The objective of this project is to identify key environmental impacts of common roadway construction operations and quantify each impact to establish a baseline; measure the influence that reduced levels of impact have in relation to proximity from the roadway; and develop a mechanism to quantify and incorporate environmental benefits associated with common roadway construction practices into agency life-cycle cost models.

Key Words

Environmental impacts, roadway construction, sustainability, pavement design alternatives, recycling materials, and life-cycle costs

Related Work

There is limited data and research material available related to quantifying environmental impacts. The context of the proposed study is to develop a common mechanism that can be applied by all agencies. Lewis, Rasdorf, Frey, Pang and Kim discussed the impact of diesel engines on mobile source air pollution and issues associated with measuring this impacts (ASCE, 2009). Surahyo and El-Diraby developed a scheme for environmental and social costs of highway projects that included three case studies (ASCE, 2009). Huang, Bird and Bell considered emissions from maintenance equipment in comparison to disrupted traffic using life-cycle cost comparison (2009). Life-cycle cost assessment of warm mix asphalt was presented by Hassan (TRB, 2009). He noted a 24% reduction in air pollution. Caltrans is currently measuring emissions from heavy-duty construction equipment. Each of these studies contributes to the overall issue but does not address the spectrum of environmental impacts.

The first step is to establish a quantitative baseline of key environmental impacts. The second step is to develop a common system to measure the environmental benefits based on various environmentally friendly processes and techniques. The final step is to utilize these quantified environmental benefits and incorporate them into a life-cycle cost model.

Currently there are a few "green rating" systems being developed to quantify the environmental benefits of transportation engineering:

- Green Roads developed by University of Washington in partnership with LEED^{TM} (development of the second generation),
- NYSDOT GreenLites Project Design Certification Program (completed),
- Alberta–Stantec Green Guide for Roads (under development),
- Transportation Association of Canada (TAC) Green Guide for Road Task Force (under development), and
- Ontario Ministry of Transportation (MTO) Green Pavement Rating System (under development).

These “green rating” systems all follow the same principle and objective, which is to quantify the environmental impacts of road construction projects, but each system is different. For example, the Ontario MTO Green Pavement Rating System focuses on the pavement alternatives during design and construction, whereas Green Roads, developed by University of Washington, focuses on design and construction as well as various other aspects of road building such as mobility and safety.

Most current research studies emphasize quantification of environmental benefits, but they have not taken a step forward to incorporate these results into a decision model. Ontario’s MTO Green Pavement Rating System is unique in that it is proposing to quantify and incorporate the environmental benefits into life-cycle cost models by applying a discounted cost adjustment. This concept is currently under development, but the framework is readily available to serve as a backbone of this study.

Urgency–Priority

There is a national sense of urgency regarding both global warming and congestion mitigation, but the road construction industry lacks a benchmark and a methodology to address these two key social issues. Without a methodology and a baseline, environmental impacts cannot be measured and compared with improvements to equipment and processes used in common roadway construction practices.

Quantifying and incorporating environmental benefits into a life-cycle cost model is an overarching topic where the demand on our practitioners is significant. Sustainability in transportation infrastructure has a huge impact to our society, and every effort to improve the effectiveness of environmental performance is essential. Consequently, the Climate Change Task Force Committee has assessed and selected this topic for a research needs statement submission.

Cost

$500,000 recommended for a research period of 24 months

User Community

AASHTO, FHWA, Transportation Association of Canada (TAC)

Implementation

The outcome of the research is a baseline measurement of environmental impacts and a mechanism to quantify the environmental benefits that can be incorporated into life-cycle costing models for roadway construction activities. This built-in environmental component in the life-cycle cost model would be transferable and could be implemented by any agency that carries out life-cycle costing.

Effectiveness

Sustainability considers social, economic, and environmental (SEE) impacts. The research will provide a decision support tool to minimize SEE impacts of a project.

The research will be successful if key environmental impacts are identified, best practices for measuring these impacts are described, and data are collected from a variety of locations to provide baseline data.

The research will enhance the existing roadway life-cycle costing models by incorporating an environmental component, which leads to an alternative decision based on SEE impacts. The environmental component is assessed through quantifying sustainability, which includes context-sensitive design, materials and resources, energy and atmosphere, etc. The quantification of environmental benefits will also serve as a mechanism for designers to be aware of the opportunities to incorporate sustainability into their projects.

Operations and Maintenance Research Needs Statements

ANALYZE THE IMPACT OF IMPROVED OPERATIONAL EFFICIENCY ON GHG EMISSIONS

Problem

One of the approaches for reducing transportation-related GHG emissions is to improve the operational efficiency and reliability of the surface transportation network, specifically through the implementation of transportation systems management and operational (TSMO) strategies and the supporting intelligent transportation systems (ITS) technologies. Moreover, such strategies are most effective when implemented on a regional basis.

Recent studies have shown that such operational improvements can reduce GHG emissions, but the estimated reductions vary widely between studies. Additionally, information on the effectiveness of individual strategies [e.g., ramp management, transit priority and bus rapid transit (BRT), speed and lane control or active traffic management, managed lanes, incident management, coordinated signal control, integrated corridor management, automated fleet inspections] and the supporting technologies is sparse, particularly in various combinations and under different conditions and scenarios.

Currently, little is known about how changes in traffic flow affect the carbon emissions from new vehicle propulsion technologies, such as hybrids, plug-in hybrids, electric vehicles and fuel cells. For example, the lifetime of a battery may differ based on its discharge cycle, which may or may not be influenced by changes in traffic flow conditions. These issues will become increasingly important to fully understand how operational improvements ultimately affect GHG emissions e.g., some evidence suggests hybrid vehicles are more efficient in slow stop-and-go traffic, when compared with free-flowing conditions).

A related issue is the carbon footprint resulting from the deployment, operation, and maintenance of these transportation management systems [e.g., power supply for Transportation Management Center (TMC), central equipment and field devices, transportation by staff to or from TMC, maintenance activities].

The ability to accurately estimate GHG reductions resulting from operational improvements (e.g., reduced congestion, improved reliability) is expected to become a critical need in the near future. For example, current draft legislation before the U.S. Congress requires states and MPOs to develop a transportation GHG reduction plan and prioritized list of projects to support the plan, including "surface transportation system operation improvements, including intelligent transportation systems or other operational improvements to reduce long-term GHG emissions through reduced congestion and improved system management." Moreover, the development of these strategies is to "be based on emission models and related methodologies."

Objectives

This project would

- Analyze and identify the reasons why recent studies show such different results in the potential reduction in GHG emissions resulting from the implementation of ITS and operational strategies (e.g., strategies considered, geographic area of analysis, time frame, models and analytical tools used, assumptions about latent demand, and TSMO carbon footprint);

- Identify and analyze the available tools, simulation models, and other analyses techniques for quantifying and estimating reductions in GHG emissions resulting from existing and planned TSMO programs including any features and limitations [e.g., which strategies can be modeled, inputs required (including information and linkages from other models), and comparison of results between models for similar strategies and a variety of scenarios]. This effort should include MOVES2010 (Mobile Vehicle Emission Simulator), EPA's new emission modeling system for estimating emissions for on-road and off-road mobile sources. Identify how and the extent to which these models and tools incorporate vehicle age and different types of vehicles [e.g., light-duty (gas and diesel), trucks and other heavy-duty (gas and diesel), hybrid, electrical, vehicle age], within the traffic flow in varying combinations, recognizing that different types of vehicles (and vehicle ages) will have different curves relating grams of CO_2 per mile to vehicle speed. The manner in which these models and tools account for the impacts of acceleration and deceleration on emissions should also be addressed;
- Analyze and estimate the reduced GHG emissions from various TSMO strategies and supporting ITS technologies—individually and in combination—for various scenarios (e.g., levels of traffic flows, location characteristics, with and without managed lanes, freight operations, and transit vehicles); and
- Define components of the TSMO–ITS carbon footprint, identify tools for its calculation, and recommend practices for reducing it.

Key Words

Climate change, transportation systems management and operations, intelligent transportation systems, modeling, carbon footprint, planning for operations

Related Work

Barth, M., and K. Boriboonsomsin. Real-World Carbon Dioxide Impacts of Traffic Congestion. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2058*, Transportation Research Board of the National Academies, Washington, D.C., 2008.

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009.

NCHRP Project 20-24/Task 72: Maximizing Highway Operational Strategies to Reduce Greenhouse Gas (GHG) Emissions. (Note: This is a recently-approved project that might address some of the items proposed in this research statement. The stated objectives of this research are to "support efforts to maximize operational strategies to reduce highway GHG, by *(a)* documenting a full range of operational strategies to reduce highway GHG, *(b)* indicating the circumstances and locales where these strategies could be most effective in reducing GHG, *(c)* providing quantitative estimates of their GHG reduction potential, both individually and in combination; *(d)* estimating their costs and cost-effectiveness; *(e)* identifying collateral benefits and dis-benefits; and *(f)* identifying policies and actions that could be taken to maximize their GHG reduction effect.")

Reducing Transport GHG Emission: Opportunities and Cost. International Transport Forum, Paris.

U.S. Environmental Protection Agency. MOVES (Motor Vehicle Emission Simulator). http://www.epa.gov/otaq/models/moves/

Urgency–Priority

The results of this effort are very important in terms of identifying the most appropriate models and analysis tools for use by states and MPOs in developing transportation GHG reduction plans and prioritized lists of projects to support the plans (as required by proposed federal legislation).

Cost

$450,000

User Community

FHWA, AASHTO, state DOTs, MPOs, ITS America, EPA

Implementation

The findings of the proposed research could be implemented in several ways by local and state transportation agencies and MPOs, including

- Analyzing and selecting operational strategies and supporting ITS technologies for inclusion in transportation GHG reduction plans and the prioritized lists of projects to support the plans [and subsequently integrated into transportation initiative plans (TIPs)];
- Reducing the carbon footprint of current and future transportation management systems; and
- Identifying current and future operational improvements and quantifying the reduced emissions as possible “offset credits” under a cap-and-trade system.

Effectiveness

This research would promote greater understanding in the transportation and environmental communities and among the public of the linkage between operational strategies and technologies—resulting in improved roadway and surface transit efficiency and reliability—and GHG emissions. It would provide transportation planners and system owners with a more rational basis for selecting cost-effective transportation systems management and operations strategies with the goal of reducing GHG emissions. TSMO strategies and supporting technologies could be more readily and evenly compared with other approaches (e.g., VMT reduction via congestion pricing and taxation) for addressing climate change.

EXPLORE INDUCED DEMAND FROM OPERATIONAL EFFICIENCY AND ITS IMPACT ON GHG EMISSIONS: PART 1—SYNTHESIS

Problem

Induced demand—also referred to as latent demand—is the phenomenon of more of a good being consumed after its supply increases. In economic terms, the demand for use of a transportation facility is a function of the overall price to use that facility. The largest element of that price, or "generalized cost," is travel time, when the travel time to use that facility—and by extension, the price to use it—is reduced. A common indicator is "demand elasticity," which is an economic measure of how much demand changes when the price changes.

The induced demand resulting from additional roadway capacity (e.g., new roads, added lanes to existing roads) has been well documented, with estimated long-term travel time elasticities for travel demand ranging from 0.4 to as high as 1.0, suggesting that the offsetting impacts of additional induced traffic may be significant. What is not well known is whether improved efficiency and reliability of the roadway network—particularly that resulting from transportation systems management and operational strategies and the supporting ITS technologies—also induces additional demand. While such operational improvements do not add capacity, per se, they can reduce travel time (and costs) of the trip, or enhance reliability that allows travelers to retime trips nearer to their preferred time. This improved efficiency and decrease in travel times likely does induce additional demand, thereby resulting in an increase in vehicles miles traveled and offsetting (over time) some of the GHG emission and energy consumption benefits of the traffic flow improvements and increased efficiency. However, the context and user perception of operational improvements as compared to capacity increases may be very different, resulting in different elasticities.

Objective

Two phases are envisioned for this project. The initial phase—the subject of this needs statement—is synthesis of existing information, including the following:

- Summarize existing research and assumptions regarding the issue of induced demand, examining the differences between additional lane miles and reduced travel time (and the associated elasticities) when addressing induced demand. This effort should investigate whether induced demand from operational improvements and ITS does exist, to what extent (i.e., the elasticity of traffic demand to improved efficiency and reliability), and under what circumstances (e.g., does the level of latent demand differ depending on the type of strategy and the type of congestion targeted by these strategies). Both short-term and long-term impacts should be considered. This review should include a consideration of how operational improvements affect both travel time and travel reliability and
- Identify how operational strategies and ITS technologies may be configured and managed (e.g., reduced free-flow speed limits as part of active traffic management, integrated multimodal traveler information), and combined with other GHG reduction approaches (e.g., pricing) to minimize any induced demand.

Key Words

Latent demand, climate change, transportation systems management and operations, intelligent transportation systems modeling, demand elasticities

Related Work

Barth, M., and K. Boriboonsomsin. Energy and Emissions Impacts of a Freeway-Based Dynamic Eco-Driving System. *Transportation Research Part D: Transport and Environment*, Vol. 14, No. 6. 2008, pp. 400–410.

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009. This study incorporates induced demand in the analysis of "System Efficiency Strategies."

Eno Tranportation Foundation. Working Together to Address Induced Demand. Washington, D.C., Feb. 22–23, 2001.

Reducing Transport GHG Emission: Opportunities and Cost. International Transport Forum, Paris. This document indicates that "traffic management will induce additional traffic in many circumstances, but even overall traffic increases, overall emissions may still be less than before if operating speeds are more efficient."

Urgency–Priority

Many assumptions have been made about latent demand resulting from improved operational efficiency. Moreover, there exists within some segments of the environmental community a belief that reducing congestion is not a viable approach for addressing climate change; that the latent demand resulting from reduced congestion and improved reliability will, in the long term, increase VMT so that the net effect of reducing congestion will be to increase GHG emissions overall.

The results of this effort are very important in terms of accurately estimating the long-term reduction in GHG emissions resulting from the deployment of transportation systems management and operational strategies, and subsequently in developing transportation GHG reduction plans and prioritized lists of projects to support the plans (as required by proposed federal legislation). The information will also be useful in working with EPA to promote transportation systems management, operational improvements, and the supporting ITS as part of the overall solution for reducing GHG emissions.

Cost

$50,000

User Community

FHWA, AASHTO, state DOTs, MPOs, ITS America, EPA, ITE

Implementation

The findings of the proposed research could be implemented in several ways by local and state transportation agencies and MPOs, including

- Analyzing, selecting, and justifying operational strategies and supporting ITS technologies for inclusion in transportation GHG reduction plans and the prioritized lists of projects to support the plans (and subsequently integrated into TIPs) and
- Identifying current and future operational improvements and quantifying the reduced emissions as possible offset credits under a cap-and-trade system.

Effectiveness

This research would promote greater understanding in the transportation and environmental communities of the relationship (if any) between operational strategies or ITS technologies and induced demand resulting from improved roadway efficiency and reliability and the long-term impact on GHG emissions. It would provide transportation planners and system owners with a more rational basis for selecting cost-effective transportation systems management and operations strategies—perhaps in concert with other transportation strategies—with the goal of reducing GHG emissions.

EXPLORE INDUCED DEMAND FROM OPERATIONAL EFFICIENCY AND ITS IMPACT ON GHG EMISSIONS: PART 2—ANALYSIS

Problem

With induced demand (or latent demand), more of a good is consumed after an increase in its supply. In economic terms, the demand for use of a transportation facility is a function of the overall price to use that facility. The largest element of that price, or “generalized cost,” is travel time, when the travel time to use that facility—and by extension, the price to use it—is reduced. A common indicator is “demand elasticity,” which is an economic measure of how much demand changes when the price changes.

The induced demand resulting from additional roadway capacity (e.g., new roads, added lanes to existing roads) has been well documented, with estimated long-term travel time elasticities for travel demand ranging from 0.4 to as high as 1.0, suggesting that the offsetting impacts of additional induced traffic may be significant. What is not well known is whether improved efficiency and reliability of the roadway network—particularly that resulting from transportation systems management and operational strategies and the supporting ITS technologies—also induces additional demand. While such operational improvements do not add capacity, per se, they can reduce travel time (and costs) of the trip, or enhance reliability that allows travelers to retime trips nearer to their preferred time. This improved efficiency and decrease in travel times likely does induce additional demand, thereby resulting in an increase in vehicles miles traveled and offsetting (over time) some of the GHG emission and energy consumption benefits of the traffic flow improvements and increased efficiency. However, the context and user perception of operational improvements as compared to capacity increases may be very different, resulting in different elasticities.

Objective

Two phases are envisioned for this project. The initial phase is a synthesis of existing information and is addressed in a separate research needs statement. This second phase involves an analysis of actual implementations of operations strategies and ITS and their impact on inducing additional vehicle travel. Activities include the following:

- Develop a method to empirically analyze how ITS and operations projects may have had an impact on inducing additional vehicle travel. This effort would include identification of data collection sites, development of a data collection and analysis plan, data collection (e.g., field data, behavior surveys), and analysis;
- Implement the methodology. This likely would involve collecting and analyzing data from near-term system deployments (e.g., ICM Pioneer Sites, urban partnership agreements, ATM implementations) to identify and calculate the elasticities between improved travel times, reliability, and increased demand and VMT. This likely would mean collecting detailed data both before and after project implementation; and
- Identify methods for incorporating latent demand considerations (if any) into models and other analytical tools for estimating and quantifying GHG reductions resulting from transportation systems management and operation strategies and technologies.

Key Words

Latent demand, climate change, transportation systems management and operations, intelligent transportation systems, modeling, demand elasticities

Related Work

Barth, M., and K. Boriboonsomsin. Energy and Emissions Impacts of a Freeway-Based Dynamic Eco-Driving System. *Transportation Research Part D: Transport and Environment*, Vol. 14, No. 6. 2008, pp. 400–410.

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009. This study incorporates induced demand in the analysis of “System Efficiency Strategies.”

Eno Tranportation Foundation. Working Together to Address Induced Demand. Washington, D.C., Feb. 22–23, 2001.

Reducing Transport GHG Emission: Opportunities and Cost. International Transport Forum, Paris. This document indicates that “traffic management will induce additional traffic in many circumstances, but even overall traffic increases, overall emissions may still be less than before if operating speeds are more efficient.”

Urgency–Priority

Many assumptions have been made about latent demand resulting from improved operational efficiency. Moreover, there exists within some segments of the environmental community a belief that reducing congestion is not a viable approach for addressing climate change; that the latent demand resulting from reduced congestion and improved reliability will, in the long term, increase VMT so that the net effect of reducing congestion will be to increase GHG emissions overall.

The results of this effort are very important in terms of accurately estimating the long-term reduction in GHG emissions resulting from the deployment of transportation systems management and operational strategies, and subsequently in developing transportation GHG reduction plans and prioritized lists of projects to support the plans (as required by proposed federal legislation). The information will also be useful in working with EPA to promote transportation systems management, operational improvements, and the supporting ITS as part of the overall solution for reducing GHG emissions.

Cost

$750,000 (Phase 2)

User Community

FHWA, AASHTO, state DOTs, MPOs, ITS America, EPA, ITE

Implementation

The findings of the proposed research could be implemented in several ways by local and state transportation agencies and MPOs, including

- Analyzing, selecting, and justifying operational strategies and supporting ITS technologies for inclusion in transportation GHG reduction plans and the prioritized lists of projects to support the plans (and subsequently integrating them into the plans) and
- Identifying current and future operational improvements and quantifying the reduced emissions as possible offset credits under a cap-and-trade system.

Effectiveness

This research would promote greater understanding in the transportation and environmental communities of the relationship (if any) between operational strategies or ITS technologies and induced demand resulting from improved roadway efficiency and reliability and the long-term impact on GHG emissions. It would provide transportation planners and system owners with a more rational basis for selecting cost-effective transportation systems management and operations strategies—perhaps in concert with other transportation strategies—with the goal of reducing GHG emissions.

System Users Research Needs Statements

EXAMINE THE PROMOTION OF ECO-DRIVING TO REDUCE GHG EMISSIONS

Problem

According to the *Moving Cooler* report, “eco-driving strategies can achieve cumulative GHG reductions by changing the efficiency of individual driving behavior, if widely embraced and practiced”. The *Moving Cooler* report indicates cumulative GHG reductions between 1.1% and 2.7% from the baseline through 2050 are possible. The preliminary findings from the International Transport Forum indicate that “reducing CO_2 emissions through the promotion of smoother driving styles can reduce emissions by up to 15%, though the impact of these measures decrease over time without additional training.”

Eco driving programs are underway in Belgium, United Kingdom, Spain, Norway, and Iceland through voluntary training programs. The website www.ecodrivingusa.com identifies the following best practices for green driving:

- Believe you can reduce fuel use and emissions,
- Avoid rapid starts and stops,
- Keep on rolling in traffic (maintaining a constant speed),
- Ride the “green wave” (synchronized traffic lights),
- Maintain an optimum highway speed for good mileage,
- Use cruise control,
- Navigate to reduce carbon dioxide,
- Avoid idling,
- Buy an automated pass for toll roads,
- Use the highest gear possible,
- Drive your vehicle to warm it up, and
- Obey your check-engine light.

In light of the various social, economic, and transportation network differences between Europe and the United States, how can the eco-driving experience in Europe be successfully translated and implemented in the United States?

Objective

This project would

- Analyze the training methods and effectiveness of eco-driving in other countries;
- Identify and recommend best practices and approaches to promote eco-driving in the United States, including training measures, processes and guides. Identify, as may be appropriate, different practices and approaches for various types of drivers (e.g., individuals driving their own vehicles, professional drivers of fleet and transit vehicles, and individuals driving rental or other fleet vehicles);

- Address how transportation systems management and operational strategies and the supporting ITS technologies can be deployed and operated to promote eco-driving (e.g., synchronized traffic signals, speed management and harmonization via Active Traffic Management, navigation via traveler information and green routing, Intellidrive and other in-vehicle devices, and intelligent speed adaptation); and
- Address how to promote eco-driving beyond climate change considerations (e.g., saving fuel and money, reducing traffic fatalities).

A second part of this effort would involve the definition and setup of a pilot program to quantify the benefits and effectiveness of the recommended eco-driving training and related practices.

Key Words

Green Driving, training, transportation systems management and operations, intelligent transportation systems

Related Work

Barth, M., and K. Boriboonsomsin. Energy and Emissions Impacts of a Freeway-Based Dynamic Eco-Driving System. *Transportation Research Part D: Transport and Environment*, Vol. 14, No. 6. 2008, pp. 400–410.

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009.

Information available at various eco-driving websites (e.g., http://www.ecodrivingusa.com/; http://www.ecodrive.org/).

Reducing Transport GHG Emission: Opportunities and Cost. International Transport Forum, Paris.

Urgency–Priority

The results of this effort could result in a very cost-effective approach for reducing GHG emissions from mobile transportation services. It could also prove useful in promoting selected transportation systems management and operational strategies in support of eco-driving, which in turn would be incorporated into transportation GHG reduction plans and prioritized lists of projects to support the plans (as required by proposed federal legislation).

Cost

- $125,000 (not including the pilot program) and
- $300,000 (pilot program)

User Community

FHWA, AASHTO, state DOTs, MPOs, ITS America, EPA, state Departments of Motor Vehicles

Implementation

The findings of the proposed research could be implemented in several ways by local and state transportation agencies, departments of motor vehicles, and MPOs, including

- Developing driver education and training programs to promote eco-driving and
- Analyzing and selecting operational strategies and supporting ITS technologies that encourage and support eco-driving for inclusion in transportation GHG reduction plans and the prioritized lists of projects to support the plans (and subsequently integrating them into TIPs).

Effectiveness

This research would promote greater understanding of eco-driving and the best ways to promote this concept in the United States, including driver education and training, the deployment of transportation systems management and operational strategies, and support of ITS technologies for eco-driving.

ASSESS THE POTENTIAL FOR A CLIMATE CHANGE TRUTH-IN-ADVERTISING INITIATIVE FOR THE TRANSPORTATION SECTOR

Problem

Currently, transportation goods and services are marketed, promoted, and sold with very little information related to their carbon footprint or other possible impacts to the climate. For example, the life-cycle footprint of a new car, bus, or train includes the embodied energy involved in making the vehicle, its shipping, all the fuel and maintenance materials used during its life, and its impact when disposed of at the end of its life. A similar calculation can be made for a single trip made on any mode. The potential exists to standardize how these calculations are made, incorporate the information into how the goods are services are labeled or otherwise marketed, and make the information available to the consumer at the time of purchase. This would result in a more informed public regarding how their purchases could impact climatic changes.

Objective

Assess the feasibility and benefit of a climate change truth-in-advertising policy for transportation goods and services, similar to those used for food nutritional information, prescription drugs, or other consumer goods. Ensuring customer awareness of facts about climate change impact of goods and services would be mandatory for the purveyor of those goods and services. Calculations would be made with valid, science-based, peer-reviewed data. This research would assess the potential for such an initiative and identify opportunities, barriers, and other issues associated with its implementation.

Key Words

Goods, services, consumer, advertizing, marketing, transportation, carbon footprint

Related Work

None identified

Urgency–Priority

Given current concern about the transportation sector's influence on climate change as well as the current efforts to reduce U.S. dependence on fossil fuels and promote more efficient transportation, this research project would be timely. It would help determine whether the consumer mindset regarding transportation choices and behavior—and the resulting impact on the climate—would change, given appropriate information about those impacts.

Cost

$100,000

User Community

The audience that should receive this research problem statement includes AASHTO, APTA, NHTSA, FCC, and EPA.

Implementation

The findings of the proposed research could facilitate the implementation of an initiative to increase public awareness of the impact to climate change of transportation-related goods and services.

Effectiveness

Societal impacts of this research include, at a minimum, greater public understanding of how transportation goods and services impact climate. At best, this assessment could influence development of more sustainable transportation alternatives.

Aviation Research Needs Statements

DEVELOP STRATEGIES FOR UNDERSTANDING AND REDUCING THE CONTRIBUTION OF LANDSIDE TRAFFIC TO GHG EMISSIONS AT AIRPORTS

Problem

Landside vehicles—including private automobiles, taxis, limos, shuttles, delivery trucks, and other vehicles that travel to and from the airport—often contribute a significant proportion of an airport's GHG emission inventory. For example, in the case of Dallas Fort Worth International Airport (DFW), landside vehicle GHG are estimated at 13% of the total. A fundamental element of good airport design is the enabling of efficient movement to and from the airport; minimizing congestion and travel time; maximizing convenience and (by extension) minimizing energy use, pollution, and GHG emissions. Among the strategies that have been developed to do this are

1. Roadway design to minimize congestion and facilitate efficient vehicle movement,
2. On-site airport parking facilities and policies (including automation and priority parking for clean vehicles),
3. Public transit links to and from airports (where it makes sense), and
4. Consolidated rental car facilities that reduce airport access road congestion.

Further development in this area, including improved understanding of the dimensions and dynamics of landside traffic, the volume of GHG generated, and the integration of a range of strategies to reduce them, will help to further reduce GHG at airports.

Objective

Research should examine landside activity from the perspective of GHG emissions reductions, while focusing on improving knowledge and developing and integrating strategies to maximize energy efficiency and to reduce GHG emission resulting from trips to and from the airport. Improvements in the understanding of the dynamics of landside traffic, geography, population density, and incentives can enable planning organizations and airport operators to improve landside planning, parking policies, transit links, and other actions to reduce GHG emissions related to aviation activities.

Key Words

Airport, landside, surface vehicles, planning, greenhouse gas, emissions, transit, traffic, congestion

Related Work

ACRP has released a guidebook on airport GHG emission inventory preparation. There are also ongoing ACRP studies on airport facility planning and the identification of measures for airport operators to reduce and mitigate their GHG.

Urgency–Priority

Aviation activity is projected to increase over the next decade, and, in the absence of mitigating actions, aviation's environmental impacts will also grow. In some cases U.S. airports currently face local and state action to reduce GHG emissions. In addition, national legislation to implement a cap-and-trade program is under consideration in the U.S. Congress. The development of strategies to reduce emissions associated with airports and aviation activity is needed.

Cost

$200,000 (approximate annual budget for project)

User Community

Researchers, airport planners, airport environmental consultants, airport operators, Airports Council International–North America, American Association of Airport Executives

Implementation

Research results could be used to improve airport planning and operation to maximize energy efficiency and reduce GHG emissions resulting from trips to and from the airport.

Effectiveness

Aviation provides valuable services to society and drives significant economic activity. However, current and projected environmental impacts of aviation (and energy use, more generally) are driving regulatory actions to limit or reduce climate change impacts. Improved understanding of means to reduce emissions resulting from travel to and from the airport (landside vehicles) can help to increase efficiency and reduce a crucial element of aviation activity impacting climate change.

EXAMINE THE IMPACT OF NON-CO_2 EMISSIONS FROM JET AIRCRAFT

Problem

Aircraft condensation trails (contrails), cirrus clouds, and other non-CO_2 emissions such as NO_x impact the climate at altitudes but are poorly understood and quantified. There is a need to better quantify the impacts of non-CO_2 aircraft emissions (with reduced uncertainties) and develop metrics to interrelate these impacts among themselves as well as those of CO_2 alone. This will help develop better understanding of impacts due to tradeoffs among emissions resulting from different policy or technology solutions.

Objective

The research will better link aviation emissions and climate impacts with specific attention to the following focused study areas:

- Isolation and improvement of the magnitudes of individual components of aviation emission-induced climate impacts on global and regional scales and
- Development and evaluation of aviation climate impacts metrics (including change in surface temperature) to better compare non-CO_2 aviation climate impacts with each other and with CO_2 on various time horizons.

Key Words

Aircraft, aviation, greenhouse gas, emissions, non-CO_2 emissions, aviation, contrails, cirrus clouds, metrics

Related Work

The FAA-sponsored Aviation Climate Change Research Initiative (ACCRI) is funding ongoing work to address this issue. ACCRI's objective is to support aviation-specific climate change research that is policy-relevant and solution-focused as well as to coordinate and link research needs and activities with national and international climate change research efforts. More details on the research program and recent publications can be found at http://www.faa.gov/about/office_org/headquarters_offices/aep/aviation_climate/. A research report identifying detailed research needs and gaps is available at http://www.faa.gov/about/office_org/headquarters_offices/aep/aviation_climate/media/ACCRI_Report_final.pdf.

Urgency–Priority

Aviation activity is projected double or triple over the next two decades. In the absence of mitigating actions, aviation's environmental impacts will also grow dramatically. Cap-and-trade legislation under consideration in the United States and planned regulation of international aviation under the European Union's Emissions Trading Scheme (ETS) address CO_2 emissions that represent only a partial picture of the climate change impact. Non-CO_2 emissions at cruise altitude are understood to have significant climate impacts but are poorly quantified. CO_2 mitigation strategies for aviation have the potential to exacerbate non-CO_2 emissions due to interdependencies in their generation. For this reason, reducing the uncertainty around the climate impacts of non-CO_2 emissions and their relationship to CO_2 impacts is necessary to ensure optimal and balanced decision making regarding mitigation policies.

Cost

$200,000 (approximate annual budget for each of multiple focused studies)

User Community

Universities, research institutions, NASA, NOAA, United States Climate Change Science Program

Implementation

Research results that reduce uncertainty around aircraft non-CO_2 emissions impacts on climate change will improve decision making and inform balanced technology choices, policy measures, and the development of policies and emissions standards to mitigate aviation’s climate impacts.

Effectiveness

Aviation provides valuable services to society and drives significant economic activity. However, current and projected environmental impacts of aviation (and energy use, more generally) are driving regulatory actions to limit or reduce climate change impacts. By helping to provide sufficient scientific knowledge to inform effective policies, this research can lead to a reduction in aviation’s climate change impacts and the concomitant impacts on the natural ecosystem—while also supporting the maintenance of the value that aviation activity provides to society.

Freight, Marine, and Rail Research Needs Statements

IDENTIFY STEPS TOWARD ACHIEVING CLEAN FREIGHT CORRIDORS

Problem

Freight movement accounts for approximately 20% of GHG emissions from transportation and is expected to increase in its share. The logistical challenges of freight transportation, which involve multiple modes and transfer operations, add to the complexity to determine the carbon footprint for shipping a particular good as well as to develop solutions for reducing the GHG emissions from freight transportation. By identifying critical corridors of freight transportation and analyzing them and their key multimodal supply chains, strategies, technologies, and practices can be developed to address GHG emissions from freight transportation, while at the same time promoting safety and mobility and reducing other forms of pollution.

This project is focused on a top-down look at key transportation corridors to assess key governmental actions that can be taken to try to achieve carbon neutral corridors.

Objective

The objective for this research is to examine one or more freight corridors for the potential to reduce GHG emissions while addressing key goals such as economic efficiency and safety. Results could be used to guide future clean freight corridor initiatives.

Key Words

Freight, transportation, climate change, greenhouse gas emissions, pollution, multimodal, freight corridor

Related Work

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009.

Cambridge Systematics, Inc. *National Rail Freight Infrastructure Capacity and Investment Study.* Association of American Railroads, Sept. 2007.

I-95 Corridor Coalition. *A 2040 Vision for the I-95 Coalition Region: Supporting Economic Growth in a Carbon-Constrained Environment*. Dec. 2008.

Urgency–Priority

Freight and climate change issues have been somewhat overlooked in the rush to develop strategies and policies to reduce emissions from passenger transportation modes. Freight transportation is much less understood by planning agencies and therefore often not considered in Climate Change Action Plans.

Cost

$500,000

User Community

State and local planning agencies, manufacturing industries, rail industry, vessel operators, port managers, trucking industry, FMCSA, FRA, FHWA, NHTSA, MARAD, EPA, state law enforcement, shippers, consumers

Implementation

Findings could be used in implementing technologies and polices to produce model clean freight corridors, including those selected by U.S. DOT as Corridors of the Future. They might also be used in creation of a federal clean freight corridors program.

Effectiveness

This research would assist state and multistate transportation entities to better incorporate freight and climate implications into their transportation plans and programs.

ASSESS POTENTIAL EMISSIONS CAUSED BY PROPOSED INCREASE IN FREIGHT TONNAGE

Problem

An increase in allowable freight tonnage on U.S. highways has been proposed. Such an increase in truck weight could affect GHGs and other emissions, as well as the mix of shipments by highway versus rail. Such an increase could also impact the aging highway infrastructure and affect highway fatalities due to increase in relative mass ratios.

Objective

The objective of this research is to provide an objective and comprehensive assessment of environmental impact of increasing highway freight tonnage limits, including the potential impact on GHG emissions that could result from implementation of the proposed change.

Key Words

Greenhouse gases, trucks, highway, regulation

Related Work

None identified

Urgency–Priority

Because decisions regarding the proposed change are imminent, this assessment should be considered priority.

Cost

$50,000 for a short-term assessment

User Community

Agencies and organizations that should receive this research problem statement include AASHTO, FHWA, NHTSA, FMCSA, and EPA.

Implementation

Implementation of findings would be directly applicable to decisions regarding the proposed change to freight regulations.

Effectiveness

Societal considerations include impacts on emissions (GHG, particulates, etc.) due to the proposed change.

EXAMINE CARBON FOOTPRINT OF SUPPLY CHAINS

Problem

Supply chains are designed for the processing, staging, and carriage of goods to market. Design choices are determined by sourcing decisions, production and competitive requirements, logistical economies, product characteristics, land uses and values, construction and input costs, multiple technologies, infrastructure networks, and still other influences. Choices have material consequences for GHG emissions, and render aspects of them variable or fixed for periods of time. Many companies have made carbon footprint measurements for their individual supply chains, just as many freight operators have measured their particular contributions. Nevertheless, lacking is systematic research into the overall carbon footprint of supply chains for key industrial sectors of the economy, first for assessment of their relative GHG impacts and the gains available from improvement, and second for estimation of the comparative consequence of supply chain designs and components.

This research would perform case studies of at least five multimodal supply chains, representative of major segments of national economic activity. The study would seek cooperation of industry to identify mutually beneficial strategies for the public and private sectors. Each study will develop calculations of the total GHG emissions of the chain and provide an accounting of component elements, including consideration of energy efficiency. It would particularly highlight the transportation components of the supply chains where significant improvements may be made. Cross-sector comparisons then will be prepared for the set of studies, analyzing the reasons for differences and their susceptibility to change and identifying carbon reduction opportunities.

Objective

The objective is improved understanding of a) the GHG emission profiles of major supply chains in the national economy; b) the primary contributors to those profiles; and c) the opportunities and obstacles toward improvement.

Key Words

Greenhouse gas emissions, logistics, staging, freight, goods movement, multimodal transportation, energy efficiency

Related Work

Carbon footprints of production and distribution processes have been estimated in various industries in the United States and overseas and are reported or referenced in industry sources or in proceedings such as those of the Council of Supply Chain Management Professionals. For example, Wal-Mart, the largest U.S. containerized importer, has several initiatives underway to help improve climate and energy impacts of its supply chains. It has set a goal of doubling the fuel efficiency of its truck fleet to 13 mpg by 2015. Further, it is requiring suppliers to implement RFID technology to improve the efficiency and sustainability of their supply chains.

EPA's SmartWay program has looked extensively at fuel efficiency of freight carriage as a route to carbon efficiency and has begun to explore these factors in the larger context of supply chain structures.

Urgency–Priority

GHG management in the freight sector is being pushed forward by the actions of individual supply chain companies to improve their carbon footprints, both for their own purposes and to be ahead of the effects of probable federal legislation. Objective review of supply-chain issues is needed as an aid to public policy on GHG in transportation, economic development, and environmental management.

Cost

$500,000, covering at least five industry sector studies (e.g., retail, manufacturing, agriculture)

User Community

State and local planning, development, and environmental agencies; supply-chain companies in production and distribution; commercial property developers and managers; logistics operators, multimodal freight carriers, and ports; logistics technology providers; logistics industry associations such as CSCMP, NASSTRAC, and NITL; government agencies such as EPA, AASHTO, AMPO, and FHWA

Implementation

Depiction of the carbon footprints of major forms of supply chains and their significant components can lead to improvements in supply-chain design, commercial development policy, properties, operating forms and technology options, and transportation policies, programs, and performance management.

Effectiveness

The carbon profile of freight transportation is substantially determined by supply-chain structures, so that improvements in the former partly depend on opportunities in the latter. Moreover, the GHG implications of industrial processes, buildings, and geographic staging patterns lay on top of the direct movement of goods. The combined result is a material component of national emissions that intersects with public policy at a variety of points. The effectiveness of this research would be demonstrated by the breadth of opportunities for GHG reductions it uncovers or suggests, and their probable magnitude in the economy.

IDENTIFY AND EXPLORE THE IMPLICATIONS OF CLIMATE CHANGE FOR RAIL AND BARGE FREIGHT DEMAND, SERVICES, AND NETWORKS

Problem

The climate-change literature projects that weather conditions and weather patterns could change significantly enough to trigger shifts in land use, economic activity, and trade, which would lead to substantial changes in transportation demand, services, and networks. Researchers have started exploring the implications of these changes: for example, studying the effects of sea-level rise on coastal communities, evaluating changes in precipitation and temperature on agricultural production, assessing the potential of more frequent and severe weather events on roadbed and bridge design, and modeling the effectiveness of pricing and regulation to reduce GHG emissions. This work should be extended to better understand the implications for freight transportation demand, services, and networks, especially for rail and barge freight transportation which could be disproportionately impacted by climate and energy shifts. Environmental policies often encourage shifts to rail and barge modes but, ironically, climate change may negatively affect the viability of these modes (e.g., substantial reduction of coal use could have major impact on rail revenue).

The premise for the research is that rail and barge freight transportation demand, services, and networks will shift as a result of future climate change, but little is known about the potential magnitude, duration, incidence, and significance of the effects. For example

- Coal accounts for about half of the total tonnage hauled by rail and a quarter of railroad revenues. If the production of coal is curtailed or electric-power generation is shifted closer to mine mouths, what are the physical and financial impacts to rail industry? How would the rail industry adapt?
- It is anticipated that climate change will make some areas less hot and drier, others cooler and wetter, leading to a redistribution of growing areas. Grain, other farm products,

lumber, pulp and other wood products account for about 15% of rail tonnage and revenues and an even larger share of barge revenues. If the locations of growing areas shift, how might rail service and rail infrastructure be relocated or realigned? What would be the impact on the barge system?

- Much of the nation's chemical stocks are produced in the Gulf Coast region, which is at risk from sea rise and severe storms. Chemicals account for about 12% of rail tonnage and revenue, with rail tank cars used extensively to transport and store liquid fertilizer near growing fields. What is the probability that chemical production and associated rail transportation facilities will be relocated away from the Gulf Coast? Over what time period? What would be the impact on rail and barge services?
- Intermodal rail transportation (e.g., doublestack container trains) is a critical link in international trade, carrying imported merchandise from the Pacific Rim and West Coast ports to Midwestern and East Coast markets. Revenues from intermodal rail traffic now make up nearly a quarter of total railroad revenues. How might climate change shift trade partners and trade routes, or force the relocation of ports?

Objective

The objective of this research is to identify and explore the implications of climate change for rail and barge freight demand, services, and networks. The research should address the following questions:

- How might climate change affect the demand for rail and barge freight services? The research should review the climate change literature, identifying, excerpting, and organizing information on the range of likely changes and their interactions;
- What is the likely magnitude, duration, incidence, and significance the changes for rail and barge transportation? The research should trace out the implications of the changes for rail freight demand, services, and networks;
- What is the capacity of the rail road and barge industries to adapt and adjust to the changes? The research should draw on the lessons learned from the evolution and restructuring of the freight rail system to assess the technical, financial, and institutional capacity of the rail industry (and the public sector) to adapt and adjust; and
- What policies and programs might be considered to enable the rail and barge systems to better anticipate and react to climate change impacts? The research should consider both private and public sector roles and responsibilities.

Key Words

Climate change, freight transportation, rail freight, barge freight, rail and barge freight demand, rail and barge freight services, rail freight networks

Related Work

TRB climate change and transportation studies, NCFRP reports, National Surface Transportation Policy Commission Report, U.S. DOT/USGS Gulf Coast Climate Study, American Association of Railroads National Rail Capacity Study

Urgency–Priority

The research would inform ongoing policy discussions such as

- How much investment is needed in the transportation system generally and the rail freight transportation system specifically to support U.S. economic growth and competitiveness in world trade?
- What is the appropriate role and responsibility of the public sector in the private sector, but regulated, railroad industry? Barge industry?
- How should federal transportation programs and agencies—through the upcoming surface transportation legislation as well as through other national or state transportation programs and policies—be reorganized to deal with today's much larger, more complex, and tightly integrated multimodal freight transportation system.

Cost

$350,000

User Community

American Association of Railroads, American Short Line and Regional Railroad Association, U.S. DOT/OST, FRA, EPA, AASHTO, FHWA, National Industrial Transportation League, freight community

Implementation

Findings will be implemented as policy, program, and investment decisions by federal, state, and local agencies and by railroads, businesses, and the investment community.

Effectiveness

The research will shape understanding of the issues and opportunities facing freight rail transportation and investment. It will form part of a critical set of literature that will shape the nation's response to climate change, with broad and far-reaching societal impacts.

EXPLORE REDUCING GHG EMISSIONS FROM FREIGHT MOVEMENTS THROUGH COMPREHENSIVE PORT AND GATEWAY PLANNING

Problem

There are several steps in the freight processing system, from warehousing, manufacture, and distribution that generate trips, usually by truck, between these stages. Often import material is in a disaggregated state when it lands in the United States. The freight is then taken to a facility for warehousing or manufacture, where the product will then often move to a distribution facility for a final trip to a store or to another warehousing facility as back stock. Ports and other gateway areas are usually not planned effectively to accept and accommodate the needs of freight in these many steps in product transfers. This inefficiency leads to many trips in, through, and around the major metropolitan areas. In order to reduce the contribution of GHG emissions from the freight sector, there is a need to effectively plan for both the landside needs for off terminal freight movement and for the aggregation and distribution needs of products in conjunction with transportation planning and investment decisions. The research should evaluate MPO's and states' efforts to address these needs, by working with both inland and coastal ports and other major gateways to create comprehensive port and gateway plans that are integrated into LRTPs, and evaluate how those needs have been understood and accounted for in development and transportation planning and operations. The research will evaluate and identify the data gaps and barriers to integrating port gateway plans into LRTPs, and their full implementation.

Objective

Identify best practices to accommodate landside freight movements and system efficiencies to achieve GHG emission reductions.

Key Words

Freight, transportation, climate change, greenhouse gas emissions, pollution, ports, gateways, multimodal, land use, comprehensive planning

Related Work

The proposed research would complement and build on work from the freight logistics, planning and environmental fields, including

- NCFRP 15: Understanding Urban Goods Movements;
- NCFRP 16: Representing Freight in Air Quality and Greenhouse Gas Models;
- NCHRP 25: Freight Trip Generation and Land Use; and
- NCFRP 27: Promoting Environmental Goals in Freight Transportation through Industry Benchmarking.

Urgency–Priority

This is an underexamined topic and the issue has significant implications for the management of freight and reducing GHG emissions.

Cost

$500,000

User Community

State DOTs, MPOs, manufacturing industries, rail industry, vessel operators, port managers, trucking industry, FMCSA, FRA, FHWA, NHTSA, MARAD, state law enforcement, shippers, consumers

Implementation

Findings will serve as a guide for best practices in freight flow management and land use planning for freight services.

Effectiveness

This report has the potential to improve the way metropolitan areas conduct planning and decision making for freight and material flows in and around major gateways, resulting in more effective GHG reduction strategies. Success will be achieved if state and local transportation and planning officials use the findings to better coordinate and cooperate with the private sector and industry on comprehensive port or gateway planning.

Public Transportation Research Needs Statements

EXAMINE THE ROLE OF PUBLIC TRANSIT SERVICE AS A GHG EMISSIONS REDUCTION STRATEGY

Problem

Early federal transit-related GHG efforts such as the American Recovery and Reinvestment Act's (ARRA) Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) grants enable transit agencies to reduce GHG emissions through the purchase of more fuel-efficient vehicles among other capital investment strategies. However, these strategies do not address the more critical fact that even a fuel-inefficient diesel bus produces dramatic GHG savings over the same number of passengers in private automobiles (assuming reasonable levels of ridership).

- While the notion of public transit as a "green" or more environmentally friendly mode of transportation is established in the popular consciousness, this idea tends to be most directly associated with rail service, and particularly with extremely capital-intensive new rail investments;
- Although there is an important role for rail investments, less capital-intensive solutions, such as providing higher levels of service on existing bus routes along with ancillary enhancements to the transit experience, may offer opportunities for even more significant environmental benefits. For example, service with 20-minute headways will be much more attractive to discretionary riders than service with hourly headways. However, it will also be more costly in the short run (in terms of operating costs) while ridership develops. If short-term operating costs can be overcome, a dense network of high-quality, frequent bus routes can have significant impacts in terms of changing trip patterns, reducing local vehicle miles traveled, and supporting transit-friendly development; and
- Research may find that expanding fleets and enabling higher levels of service (while absorbing short-term operating deficits) may be more cost-effective in reducing GHG emissions from the transportation sector than greening transit vehicles. In this case, it would be more effective for federal transportation dollars seeking GHG benefits to be spent in this way. Such an investment program may form an important element of broader federal climate change policies and investments.

Objective

This project would explore the nexus between transit service and regional GHG emissions, with the aim of establishing a simple yet rational method for estimating and comparing the GHG impacts of various operations investments. As envisioned, this project would have two main components. First is the development of a method to explore the efficacy of the proposed concept (i.e., is it more climate-friendly to expand fleets with additional standard buses, or to replace existing fleets with highly fuel-efficient buses?). The second component would be an exploration of the data needs and method for this trade-off to be calculated at the local or regional scales, in conjunction with the establishment of proposed funding formulas and performance measures. To be viable, the proposed funding framework should balance robustness with simplicity in order to be manageable by transit agencies, state DOTs, and MPOs of all scales.

Key Words

Transit, formula, greenhouse gas reduction, climate change

Related Work

Davis, T., and M. Hale. *Public Transportation's Contribution to Greenhouse Gas Reduction,* American Public Transportation Association, 2007. This study was conducted for APTA with funding provided through TCRP Project J-11/Task 2.

Urgency–Priority

The proposed research is timely in order to contribute to the ongoing congressional and federal dialogue on new climate change strategies, policies, and investments.

Cost

$300,000

User Community

APTA, FTA, transit agencies, MPOs, state DOTs

Implementation

The desired project outcome would

- Refine an understanding of the linkage between public transit and GHG emissions for policymakers and members of the public;
- Define ways to estimate a GHG value for pounds of CO_2 per passenger mile traveled, considering local factors. This would contribute to the definition of performance measures and help to rationalize operational investments within the broader context of climate change policy (such as cap-and-trade markets);
- Review the existing literature on life-cycle analysis (LCA) protocol to assess its viability in the modeling process for transit GHG impact documentation;
- Establish a framework for making GHG-smart service investments (i.e., routes where buses are full and there is demonstrable additional demand; BRT-like route enhancements to attract discretionary riders and maximize mode shift);
- Detail alternatives for how GHG-related operating assistance could most effectively be provided at the state, metropolitan, or transit agency levels, and establish suggested alternatives for funding sources (and linkages with other climate change programs) as well as performance measures for funding received; and

- Result in an outline for the establishment of new federal formula-based operating assistance in the context of broader federal climate change policies.

Effectiveness

This research will refine an understanding of the relative GHG benefits of greening transit fleets versus modernizing, optimizing, and selectively expanding operations. The resulting project report will blueprint how, through optimizing existing resources, route planning, improved client services, and investments in operations and maintenance, a transit agency can establish an operational baseline that will result in lower GHG generation per passenger mile traveled (PMT).

Drawing on that baseline, the report will suggest best practices for green system investments that will help federal agencies to make GHG-related transit investments in a more cost-effective way.

EXPLORE TRANSFORMATIVE PUBLIC TRANSPORTATION SOLUTIONS FOR REDUCING GHG EMISSIONS

Problem

Most studies to date have relied on annual percent increases from baseline transit ridership in order to project the GHG emission reduction potential of transit investments. This study would take the opposite approach: looking at transit achieving a significant mode share in particular markets, what that would mean for emissions, and what it would take to get there.

Objective

The objective of the research is to provide scenario building and analysis of localized, transformative public transportation solutions. Important analysis areas include thresholds at which transit serves a large enough number of destinations and offers service at equal or better travel times than driving to achieve a significant market share. The research would take a market segmentation approach, focusing on specific markets that offer the best opportunities. The research would also examine particular U.S. or international cities that have gone through a transformation from auto-dominant to multimodal transportation. The research would seek to determine what factors led to success in these cities, including factors such as political decision-making processes, implementation, public opinion, economy, etc.

Key Words

Public transportation, greenhouse gas emissions, climate change, planning

Related Work

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009.

TCRP Report 93: Travel Matters: Mitigating Climate Change with Sustainable Surface Transportation. Transportation Research Board of the National Academies, Washington, D.C., 2003. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_93.pdf.

TCRP Synthesis J-07/Topic SH-09, Greenhouse Gas Emissions Savings from Transit (forthcoming).

TCRP Report 97: Emerging New Paradigms: A Guide to Fundamental Change in Local Public Transportation Organization. Transportation Research Board of the National Academies, Washington, D.C., 2003. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_97.pdf.

Urgency–Priority

Draft transportation reauthorization legislation and climate change legislation being considered in Congress would require states and metropolitan planning organizations to set transportation GHG reduction targets and develop strategies to meet these targets. Solid information on impacts of combined strategies on reducing transportation GHGs is crucial to the ability to develop these strategies. The study would also inform the federal government's livability initiative.

Cost

$300,000

User Community

The research could be carried out by universities, consultants, government agencies, nonprofits, or other researchers. The audience for the research would be state and local governments, the federal government, metropolitan planning organizations, and transit agencies.

Implementation

States and metropolitan planning organizations could use analysis produced by the research in developing transportation plans that include GHG reduction strategies. Communities could also use the analysis to help them achieve successful public transportation solutions.

Effectiveness

The project would help the transportation sector reduce GHG emissions, a very important goal as transportation accounts for about a third of U.S. carbon emissions, and science indicates that emissions must be reduced substantially to avoid dangerous climate change impacts.

DEVELOP IMPROVED MODAL OPERATING PROFILES FOR COMPARISONS WITH TRANSIT

Problem

There would be value in discerning a realistic auto operating context or profile to use in comparison with transit travel. We tend to compare mean characteristics of the modes when it comes to energy and climate analysis, and yet we know quite a bit about the context for the typical transit trip. In simple terms, this might give us a better profile reflecting temporal and geographic distribution of transit travel in urban areas and identifying the probable auto operating performance in the same context for comparison purposes.

The transit network is less dense and hence more circuitous than the roadway network, depending upon the density and design of the transit network. Thus, a transit trip between a given origin destination is likely to be somewhat longer than the roadway trip. At the same time, an auto trip may involve search for parking spaces or an alternative destination, which could add to its emissions. In addition, a transit trip is more likely to occur in a dense urban environment during peak travel periods when auto performance would be more likely to be compromised by stop-and-go travel. These differences should be factored into comparisons between modes. There has been little analysis to calculate comparative efficiency measures as a function of such things as roadway or transit network density comparisons and geographic and temporal travel locations. Thus, this analysis would likely lead to some adjustment in the relative model efficiencies and could provide more precise information for specific project or corridor level analyses.

A related element would be to explore the mileage by mode for non-service uses. This is easily determined within transit as deadhead miles for getting vehicles to and from service and for use in training and other purposes. For auto travel there may be value in exploring the availability of data to support estimates of the amount of mileage for supportive actions such as trips exclusively for fuel or maintenance or vehicle support functions.

Objective

The objective of this project would be to develop realistic operational profiles of travel by alternative modes between the same origin and destination. Such profiles should take into account indirectness of the trip, access characteristics, as well as the actual travel portion of the trip.

Key Words

Transit, formula, vehicle operating profiles, greenhouse gas reduction, climate change

Related Work

There are a number of overall energy efficiency estimates by mode, and there are some project levels simulation model-based findings on vehicle performance; however, the proposers are not aware of any systematic treatment of these issues for use in longer range planning or policy formation contexts.

Urgency–Priority

The proposed research is timely in order to contribute to the ongoing congressional and federal dialogue on new climate change strategies, policies, and investments.

Cost

$300,000

User Community

APTA, FTA, transit agencies, MPOs, state DOTs

Implementation

The desired project outcome would

- Refine an understanding for the comparison of GHG emissions and energy use of alternative modes for policy makers and members of the public;
- Define ways to estimate a GHG value for pounds of CO_2 per passenger mile traveled, considering local factors. This would contribute to the definition of performance measures and help to rationalize operational investments within the broader context of climate change policy (such as cap-and-trade markets);
- Review the existing literature on modal profiles to assess its viability in the modeling process for transit GHG impact documentation;
- Establish a framework for making GHG-smart service investments (i.e., routes where buses are full and there is demonstrable additional demand; BRT-like route enhancements to attract discretionary riders to enhance and maximize mode shift); and
- Detail alternatives for how GHG-related operating assistance could most effectively be provided at the state, metropolitan, or transit agency levels, and establish suggested alternatives for funding sources (and linkages with other climate change programs), as well as performance measures for funding received.

ANALYZE SYNERGIES BETWEEN TRANSIT, LAND USE, AND PRICING STRATEGIES TO REDUCE GHG EMISSIONS

Problem

Evidence suggests that there are synergies between transit, land use, and pricing strategies that enhance the GHG reduction effect of each when implemented together. However, more detailed information on the magnitude and characteristics of these synergies is not available. Research in this area would help local and state governments, metropolitan planning organizations, transit agencies, and others estimate the potential GHG reduction impacts of pursuing such strategies in conjunction with one another.

Objective

The objective of the research is to examine interactions between transit, land use, and pricing strategies. The types of questions to answer include

- What is the magnitude of the synergistic effects? What are the co-benefits?
- What is the impact of pursuing strategies jointly on the cost-effectiveness of the strategies?
- What do case studies of metropolitan areas implementing strategies jointly teach us?

- How can strategies combine to make travel alternatives competitive with driving?
- How can these strategies be best implemented in an economic downturn with tight budgets?
- Can pricing strategies cover the costs of transit investments? Who pays and who benefits? How are public agency budgets affected and how are household budgets affected?
- What are the operational implications of pursuing transit-oriented development without funding available to expand transit service to meet increased demand?
- How do different types of transit modes, such as bus, bus rapid transit, and rail impact the outcomes from these combined strategies?
- Are there thresholds that can be reached at which costs decrease (for instance, levels of regional accessibility at which households can conveniently reduce automobile ownership)? At which residential and employment density levels are different types of transit service more cost-effective?
- What variations of strategies are most appropriate for different types of communities?

Key Words

Public transportation, land use, pricing, greenhouse gas emissions, climate change, planning

Related Work

Cambridge Systematics, Inc. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute, Washington, D.C., 2009.

TCRP Report 128: Effects of TOD on Housing, Parking, and Travel. Transportation Research Board of the National Academies, Washington, D.C., 2008.

Special Report 298: Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions. TRB, National Research Council, Washington, D.C., 2009.

Urgency–Priority

Draft transportation reauthorization legislation and climate change legislation being considered in Congress would require states and metropolitan planning organizations to set transportation GHG reduction targets and develop strategies to meet these targets. Solid information on the impacts of combined strategies on reducing transportation GHGs is crucial to the ability to develop these strategies.

Cost

$300,000

User Community

The research could be carried out by universities, consultants, government agencies, nonprofits, or other researchers. The audience for the research would be state and local governments, the federal government, metropolitan planning organizations, and transit agencies.

Implementation

States and metropolitan planning organizations could use analysis produced by the research in developing transportation plans that include GHG reduction strategies.

Effectiveness

The project would help the transportation sector reduce GHG emissions, a very important goal because transportation accounts for about a third of U.S. carbon emissions, and science indicates that emissions must be reduced substantially to avoid dangerous climate change impacts.

APPENDIX A

Time Frame for Development of Research Needs Statements

	Steps
May 2009	• STF conference call: STF reviewed and approved overall approach
June 2009	• Spreadsheet of climate change projects contained in Research in Progress and Research Needs Statements TRB databases developed • Group and category team leaders assigned – Categories generally corresponded to TRB standing committee group structure – Team leaders worked with group to develop initial list of potential research topics
July 2009	• TRB Standing Committees in Transportation Energy, Alternative Transportation Fuels and Technology, and Transportation and Sustainability, Joint Subcommittee on Climate Change agreed to cosponsor this effort • STF meeting in Asilomar, California – STF reviewed, revised, and prioritized list of potential research topics – High priority topics assigned to team leaders – STF reviewed and approved collaborative website, January 2010 workshop, and schedules
August 2009	• Team leaders selected authors to prepare drafts of research needs statements (RNS) for high priority topics • TRB staff provided STF members with RNS templates, instructions, and access to collaborative website • Team leaders provided RNS authors with templates, instructions, and access to collaborative website
October 2009	• RNS authors posted drafts of potential research needs statements on collaborative website by mid-October • STF members provided any initial comments on draft RNS by October 31 using collaborative website
November 2009	• Members of cosponsoring committees invited to submit comments on draft RNS through collaborative website • Speakers, members of cosponsoring committees, and selected others invited to January 2010 workshop, and access provided to collaborative website
December 2009	• Team leaders reviewed comments and other input received and made any necessary revisions and additions to draft RNS • Side-by-side comparison of draft RNS and TRB *Special Report 299: A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy* prepared
January 2010	• One-day workshop held on Saturday, January 9th, immediately preceding TRB Annual Meeting – Opening presentations – Summaries by team leaders – Breakout groups prioritized RNS in each category, recommended needed edits, and identified remaining gaps – Appendix B contains workshop agenda • Team leaders arranged for edits and revisions to be incorporated into RNS
February–March 2010	• E-circular prepared • RNS statements added to TRB database and distributed to others

APPENDIX B

Climate Change Research Needs Workshop Agenda

DATE AND TIME: Saturday, January 9, 2010; 8:30 a.m.–4:30 p.m.

LOCATION: Delaware Room, Marriott Wardman Park Hotel, Washington, D.C.

OBJECTIVES:
- Understand context of ongoing and planned climate change research activities;
- Review, prioritize, and refine Research Needs Statements prepared for the workshop; and
- Determine next steps for finalizing workshop product.

Time	Agenda Topic	Presenter
8:30	**Welcome and introductions** • Agenda review and • Self introductions.	Marcy Schwartz, CH2M HILL; Chair, TRB Special Task Force (STF) on Climate Change & Energy
9:00	**Status of ongoing and completed studies on transportation and climate change**	Emil Frankel, Bipartisan Policy Center; Chair, TRB Committee for a Study of Potential Energy Savings and Greenhouse Gas Reductions from Transportation
9:30	**TRB *Special Report 299: A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy***	Mike Meyer, Georgia Institute of Technology; Chair, TRB Committee for Study on Transportation Research Programs to Address Energy and Climate Change
10:00	**Break**	
10:15	**STF Research Needs Statements** • Overview of statements, • Relation to *SR 299*, and • Discussion and gap identification.	Marcy Schwartz Mariah Vanzeer, CH2M HILL Breakout group coordinators
11:30	**Lunch (on your own)**	
12:45	**Research Needs refinement** • Comments/revisions to existing statements, • New statement(s) needed to fill gaps, • Prioritize statements, • Recommend next steps to finalize product, and • Prepare small group report.	Breakout groups
3:30	**Group Reports and Next Steps**	Marcy Schwartz Breakout group leaders
4:30	**Adjourn**	

APPENDIX C

Gap Analysis of Research Needs Statements Compared with TRB *Special Report 299*

NOTE: The analysis contained in the following memorandum was prepared prior to the January 9, 2010, workshop. It therefore does not reflect some changes made during and following the workshop to the collection of proposed research needs statements.

TRB *Special Report 299: Recommendations for Use with STF Research Need Statements*
PREPARED FOR: TRB Special Task Force on Climate Change and Energy
PREPARED BY: Mariah Vanzerr, CH2M HILL
DATE: December 2, 2009

Introduction

The TRB Special Task Force on Climate Change has been preparing a series of Research Need Statements to help the transportation community develop the body of knowledge needed to address the challenge of climate change. Concurrently, the TRB Executive Committee has been preparing *Special Report 299*: A Transportation Research Program for Mitigating and Adapting to Climate Change and Conserving Energy. In this recently released report, the Executive Committee recognizes that transportation is likely to be affected by legislation regulating greenhouse gas emissions in the near future and that new research and policy analysis will be needed to meet potential future reduction targets. The report provides an overview of climate change issues related to transportation, identifies needed research topic areas, and recommends a national research program to address them. The purpose of this memorandum is to better understand how *Special Report 299* relates to the Research Need Statements developed by the Special Task Force on Climate Change and Energy, how the two pieces of work complement each other, and where they diverge. The memorandum begins with a brief overview of *Special Report 299*, followed by a discussion of similarities and differences, and ends with a recommendation for how *Special Report 299* and the Research Need Statements can be used together.

SR 299

Special Report 299 contains a synthesis of the current literature on the transportation and climate change field. The report includes specific proposals for research as well as a recommendation for the creation of an overarching comprehensive research program to coordinate and organize needed research in the future. The report notes that improvements in technologies and fuels alone may not be able to reduce transportation energy consumption and GHG emissions the 60% to 80% below current levels by 2050 recommended by the IPCC and widely embraced by decision makers across the nation. The report authors recognize that efforts to reduce future travel demand or shift demand to more fuel-efficient modes may be necessary to reach these targets.

To address these concerns, *Special Report 299* recommends a national research program that would provide guidance to officials responsible for policies that affect the use of the surface transportation system, its operation, maintenance, and construction. Research results would assist decision makers by helping them select the most effective and beneficial strategies that will also help to minimize potential harmful side effects to economic and social welfare. An investment of $41.7 million a year over an initial 6-year period ($10 million for adaptation research, $31.7 million for mitigation research), is recommended to start the research program. The report also aims to help officials begin to adapt transportation infrastructure to climate changes that are already occurring and that are expected to occur in the next several decades.

The specific topic areas suggested for research in *Special Report 299* are preliminary and include the recommendation that expert and practitioner stakeholders refine the topics early in the research program. The report recommends that research conducted under the auspices of the program should be

- Directly relevant to the needs of federal, state, and local transportation policy makers;
- Awarded on the basis of open competition and a merit review by peers; with results evaluated by expert and practitioner stakeholders;
- Flexible so that program managers can shift the areas of investment as knowledge develops; and
- Evaluated on an ongoing basis by an independent group that would directly report to Congress.

Specific recommendations included in *Special Report 299* include the Congressional authorization of funding for the collection of data that are adequate to meet the needs of federal, state, and local governments as they develop climate change policy and plan mitigation and adaptation strategies. Additional recommendations include the development of a mileage fee to supplement or replace taxes on fuels that currently generate revenues for highway and transit infrastructure. Notably, *Special Report 299* does not address research needs concerning motor vehicle fuels and propulsion systems, since these topics are being addressed by other National Research Council (NRC) activities.

Similarities–Differences

Overall, TRB *Special Report 299* and the Special Task Force's Research Needs Statements are highly complementary. *Special Report 299* outlines the need and framework for a comprehensive research program on transportation and climate change and begins to identify several topic areas where research is needed. However, the report stops shy of including discrete research need statements. Rather, the report notes that expert and practitioner stakeholders need to be involved to develop specific research proposals.

The TRB Special Task Force on Climate Change and Energy's Research Need Statements, on the other hand, comprise approximately 36 discrete research proposals, each with complete problem statements, objectives, and estimated costs. Though organized a bit differently, these research need statements could be seen as a beginning to the work recommended in *Special Report 299*.

The primary differences between TRB *Special Report 299* and the Special Task Force's Research Needs Statements involve the way the needed research topics are organized. As shown in Appendix B, the Special Task Force has organized its research topics primarily by transportation mode in accordance with the TRB committee structure, whereas the TRB Executive Committee has organized their research topics primarily into broad cross-modal policy arenas. Additionally, *Special Report 299* does not include research proposals concerning motor vehicle fuels and propulsion systems, whereas the Research Need Statements do include research proposals that address various alternative fuel technologies. The Special Task Force Research Need Statements also include modal-specific projects that address needs in the fields of aviation, freight, marine, rail, and public transit.

However, many of the research topic areas identified in the two efforts match in subject area and content. For example, both pieces of work identify the need for research in the following areas:

- Assessing data needs and gaps,
- Costs and benefits,
- Life-cycle GHG analysis,
- Travel behavior,
- Land use and VMT modeling,
- Transportation infrastructure,
  - Construction,
  - Operations, and
  - Maintenance,
- Policy analysis,
- Program evaluation, and
- Adaptation to climate impacts.

Summary

While the Special Task Force Research Need Statements go more into depth on a few topics, TRB *Special Report 299* outlines a broad array of research topics intended to be more fully developed by experts and practitioner stakeholders in the future. These two pieces of work are complementary in the sense that *Special Report 299* outlines a broad research program framework that the Special Task Force Research Need Statements can fit into nicely. However, to avoid confusion and to highlight the complementary nature of the two efforts, it is important to understand how they can be nested together. Toward this end, Appendix C suggests where the Special Task Force Research Need Statements might fit within the broader categories outlined in *Special Report 299*.

APPENDIX D

Comprehensive List of Proposed Research Topics: Special Task Force on Climate Change and Energy and TRB *Special Report 299*

STF Research Needs Statements (organized by mode)	**SR 299 Research Topic Areas** (organized by policy arena)
Aviation	**Policy Guidance and Outreach**
Understanding and reducing the contribution of landside traffic to greenhouse gas (GHG) emissions at airports	Life-cycle GHGs
Impact of non-CO_2 emissions from jet aircraft	Cost-effectiveness, including cobenefits and costs
Design & Construction	Low-hanging fruit
The effects of rising temperatures on transportation infrastructure	Land use and VMT
Quantify and incorporate environmental benefits into life-cycle costing models for roadways	National and local data gaps
Research needs on construction pollution	Educational outreach for policy makers and practitioners
Energy and Alt Fuels	New tools and technologies
Analyzing social costs and benefits of advanced biofuel and other low carbon fuels	**Measurement and Estimation**
Analyzing pathways for the transition to high efficiency/low GHG emitting vehicles	Cost-effectiveness of individual mitigation strategies and combinations of strategies
Alternative fuel life-cycle analysis for trains, planes, and ships	Life-cycle analysis for modal comparisons
Assessing modal energy intensities	Full social cost accounting
Assessing the limits of advanced biofuel supply for transportation	Co-benefits and costs
Assessing (direct and) indirect life-cycle GHG impacts of advanced fuels and vehicles	**Travel Behavior and Modeling**
Assessing the effectiveness of a low carbon fuel standard in a world of international leakage	Individual, household, and life-cycle activities

STF Research Needs Statements (organized by mode)	**SR 299 Research Topic Areas** (organized by policy arena)
Freight Marine & Rail	Demographic changes
Climate impacts of supply chains	Urban goods movement
Rail impacts of climate change	Land use interactions
Clean freight corridors	New, cost-effective approaches to data collection and dissemination
Port gateway planning for freight, climate, and energy	Next-generation trip generation models
Operations and Maintenance	Opportunities for passenger and freight mode shift
Transportation performance measures for climate change	Potential for trip substitution
Improved operational efficiency and the impact on GHG	Incorporating uncertainty in models used for policy analysis
Induced demand from operational efficiency–GHG impact	**Policy Analysis**
Planning and Environment	Successes and failures of past transportation interventions to meet federal air quality standards
Land use models	Lessons from abroad
The energy and climate impacts of alternative modes of transportation	Implementing user charges
Develop climate change modeling outputs	Integrated vehicle–fuel scenarios: for assessments of the potential of alternative vehicles and fuels to meet GHG emission reduction targets.
Policy	Equity
Comprehensive evaluation framework	Institutions: research on how to harmonize institutions at the regional scale
Compilation and analysis of court decisions regarding GHG emissions	Benefits of new investments in less energy-intensive modes
Examine the relationship of climate change and GHG mitigation with transportation infrastructure security	Program evaluation
Constructs to enable multiple agencies to develop policies relating climate change and critical transportation infrastructure protection	National-level analysis
Educational materials linking climate change and transportation infrastructure protection	

STF Research Needs Statements (organized by mode)		SR 299 Research Topic Areas (organized by policy arena)	
	Policy *(continued)*		**System Management and Operations *(continued)***
	Collaborative decision-making framework for climate change mitigation and adaptation		Speed management, real-time travel info, freeway access management, special event management
	GHG reduction strategies as potential "offset credits"	**Materials, Maintenance, and Construction**	
Public Transit			Sustainable pavements, street lighting, low-impact maintenance practices, low-energy construction practices
	Improved modal operating profiles	**Structure**	
	Role of public transit service as a GHG emissions reduction strategy		Research program structure and design
Safety and System Users		**Adaptation**	
	VMT traffic safety impacts		Identification of vulnerable assets and locations
	Vehicle fleet turnover and purchaser responses to market changes		Identification of opportunities for adaptation of specific facilities
	Promoting eco-driving to reduce GHG emissions		Understanding changes in the life span of facilities caused by climate change
Proposed New Statements			Understanding the modes and consequences of failure
	Transportation-related data collection best practices		Assessing the risks, costs, and benefits of adaptation
	Adaptation as a defensive strategy to address climate variability impacts on critical transportation infrastructure		Models and tools to support decision making
	Relative contributions of ridership, technology, and fuel choice to meeting GHG targets in transit		Monitoring and sensing

APPENDIX E

Combined *Special Report 299* and STF Topics

The following list shows the research topic areas in *SR 299* [bulleted headings (•)] with the discreet research proposals put forth by the Special Task Force [starred headings in color (*)] inserted under the *SR 299* headings where they fit best. The original STF category for each discrete research proposal is noted after it in parenthesis). To merge the tables successfully, there are certain cases where the *SR 299* headings were interpreted broadly. These cases are noted in parenthesis after the appropriate heading. There were also a few cases where specific research need statements could fit under more than one *SR 299* heading. In these cases, the best fit was selected, with the alternates noted in parentheses.

1. Policy Guidance and Outreach

- Life-Cycle GHGs
- Cost-Effectiveness (of individual strategies), Including Co-benefits and Costs
- Low-Hanging Fruit
- Land Use and VMT
- National and Local Data Gaps
  - * **Transportation-Related Data Collection Best Practices (STF Category: Policy)**
- Educational Outreach for Policy Makers and Practitioners
  - * **Educational Materials Linking Climate Change and Transportation Infrastructure Protection (STF Category: Policy)**
- New Tools and Technologies (guidance documents, etc.)

2. Measurement and Estimation

- Cost-effectiveness of individual mitigation strategies and combinations of strategies
  - * **GHG Reduction Strategies as Potential Offset Credits (STF Category: Policy) (This topic is related to the heading in terms of the potential to receive funding for specific GHG mitigation strategies.)**
- Life-cycle analysis for modal comparisons (this category is interpreted broadly to include research pertaining to the GHG impacts of various modes at various stages in the life cycle in order to create a complete picture)
  - * **Understanding and reducing the contribution of landside traffic to GHG emissions at airports (STF Category: Aviation)**
  - * **Impact of non-CO_2 emissions from jet aircraft (STF Category: Aviation)**
  - * **Alternative Fuel Life-Cycle Analysis for Trains, Planes, and Ships (STF Category: Energy and Alternative Fuels)**
  - * **Assessing Modal Energy Intensities (STF Category: Energy and Alternative Fuels)**
  - * **Assessing (Direct and) Indirect Life-Cycle GHG Impacts of Advanced Fuels and Vehicles (STF Category: Energy and Alternative Fuels). (This topic could also fit under the "Integrated vehicle–fuel scenarios" heading under Policy.)**
  - * **Climate Impacts of Supply Chains (STF Category: Freight, Marine, and Rail)**

  - * **Clean Freight Corridors (STF Category: Freight, Marine, and Rail)**
  - * **Port Gateway Planning for Freight, Climate, and Energy (STF Category: Freight, Marine, and Rail)**
  - * **The Energy and Climate Impacts of Alternative Modes of Transportation (STF Category: Planning and Environment)**
  - * **Role of Public Transit Service as a GHG Emissions Reduction Strategy (STF Category: Public Transit)**
- Full social cost accounting (valuing externalities)
  - * **Analyzing Social Costs and Benefits of Advanced Biofuel and Other Low Carbon Fuels (STF Category: Energy and Alt Fuels)**
  - * **Comprehensive Evaluation Framework (STF Category: Policy)**
- Co-benefits and costs (This category is interpreted broadly to include all co-benefits of GHG mitigation strategies)
  - * **Quantify and Incorporate Environmental Benefits into Life-Cycle Costing Models for Roadways (STF Category: Design and Construction)**

3. Travel Behavior and Modeling

- Individual, household, and life-cycle activities
- Demographic changes
- Urban goods movement
- Land use interactions
  - * **Land Use Models (STF Category: Planning and Environment)**
- New, cost-effective approaches to data collection and dissemination
- Next-generation trip generation models
  - * **Improved Modal Operating Profiles (STF Category: Public Transit)**
- Opportunities for passenger and freight mode shift
- Potential for trip substitution
- Incorporating uncertainty in models used for policy analysis
  - * **Develop Climate Change Modeling Outputs (STF Category: Planning and Environment)**

4. Policy Analysis

- Successes and failures of past transportation interventions to meet federal air quality standards
- Lessons from abroad
  - * **Promoting Eco-Driving to Reduce GHG Emissions (STF Category: Safety and System Users)**
- Implementing user charges
- Integrated vehicle–fuel scenarios (i.e., the potential of alternative vehicles and fuels to meet GHG emission reduction targets)
  - * **Analyzing Pathways for the Transition to High-Efficiency, Low GHG Emitting Vehicles (STF Category: Energy and Alternative Fuels)**
  - * **Assessing the Limits of Advanced Biofuel Supply for Transportation (STF Category: Energy and Alternative Fuels)**

- ∗ **Assessing the Effectiveness of a Low Carbon Fuel Standard in a World of International Leakage (STF Category: Energy and Alternative Fuels)**
- ∗ **Vehicle fleet turnover and purchaser responses to market changes (STF Category: Safety and System Users)**

- Equity
- Institutions: Research on how to harmonize institutions that affect travel behavior
  - ∗ **Constructs to Enable Multiple Agencies to Develop Policies Relating Climate Change and Critical Transportation Infrastructure Protection (STF Category: Policy)**
  - ∗ **Collaborative Decision-Making Framework for Climate Change Mitigation and Adaptation (STF Category: Policy)**
- Benefits of new investments in less energy-intensive modes
- Program evaluation
  - ∗ **Transportation Performance Measures for Climate Change (STF Category: Operations and Maintenance)**
- National-level analysis (This heading is interpreted to include both national strategies and national level analysis of policy that affects GHG emissions and transportation.)
  - ∗ **Compilation and Analysis of Court Decisions Regarding GHG Emissions (STF Category: Policy)**
  - ∗ **Examine the Relationship of Climate Change and GHG Mitigation with Transportation Infrastructure Security (STF Category: Policy)**

5. System Management and Operations

- Speed management, real time travel info, freeway access management, special event management
  - ∗ **Improved Operational Efficiency and the Impact on GHG (STF Category: Operations and Maintenance)**
  - ∗ **Induced Demand from Operational Efficiency - GHG Impact (STF Category: Operations and Maintenance)**

6. Materials, Maintenance, and Construction

- Sustainable pavements, street lighting, low-impact maintenance practices, low-energy construction practices
  - ∗ **Research Needs on Construction Pollution (STF Category: Design and Construction)**

7. Structure

- Research Program Structure and Design

8. Adaptation

- Identification of Vulnerable Assets and Locations
  - ∗ **The Effects of Rising Temperatures on Transportation Infrastructure (STF Category: Design and Construction)**
  - ∗ **Rail Impacts of Climate Change (STF Category: Freight, Marine, and Rail)**

- Identification of Opportunities for Adaptation of Specific Facilities
  * **Adaptation as a Defensive Strategy to Address Climate Variability Impacts on Critical Transportation Infrastructure (STF Category: Proposed New Statements)**
- Understanding Changes in the Life Span of Facilities Caused by Climate Change
- Understanding the Modes and Consequences of Failure
- Assessing the Risks, Costs, and Benefits of Adaptation
- Models and Tools to Support Decision Making (uncertainty of climate impacts)
- Monitoring and Sensing

APPENDIX F

Review of Remaining Gaps and Observations from January 2010 Workshop

GAPS IN RESEARCH NEEDS STATEMENTS

Participants in the January 10, 2010 workshop listed the following additional topics for which research needs statements should be developed:

- Improvements to travel demand models;
- Evaluation of past interventions;
- Effects of various pricing approaches;
  - Involvement of private sector and
  - Tax policies;
- Impacts of telecommunication improvements;
- Lessons from abroad;
- Monitoring—before and after studies;
- Macroeconomic impacts of mitigation strategies;
- Improving understanding of equity impacts of policies and how they should be addressed;
- Regional climate forecasting;
- Impact on battery life (plug-ins) resulting from congestion versus free flow;
- Coordination of roadway and transit operations (e.g., integrated corridor management);
- More adaptation–performance measures for asset management;
- Institutional barriers to implementation of multimodal climate change policies and strategies;
- Global integration of climate change strategies—learning from international efforts;
- Incorporation of disaster planning methods to climate change;
- Determining effectiveness of pricing on modal choice;
- Developing data for improving urban goods movement; and
- Development of technical assistance and dissemination (handbooks, webinars, etc.).

OBSERVATIONS: LOOKING BEYOND THE TRANSPORTATION SECTOR

Participants in the January 10, 2010 workshop made a number of observations regarding the roles that other sectors could take that could affect climate change and transportation. Some of these included

- Data needs are critical, but broader than our scope of work;
- Energy storage and delivery systems for hydrogen and electricity need to be considered as part of the transportation infrastructure. This may include smart metering, grid

connectivity, load management, and local utility rate regulation. This will require a collaborative inter-agency, inter-industry program with broad public involvement;

- We need a much better understanding of the behavior of consumers and inventors and innovators of new technologies. We also need to better understand the potential of new media, social networking, crowd-sourcing, cloud computing, and other information technologies to dramatically change consumer behavior independent of price;
- The United States incentivizes and mandates fuel efficiency and low carbon fuels; and attempting to offset the losses of fuel tax revenue by introducing VMT taxes could have unintended consequences;
- The energy and climate change community at large has yet to embrace and champion the dramatic cuts in GHG that will be necessary by 2050. Incremental improvements will be insufficient; and
- Public outreach and communications to raise awareness of climate change and address barriers to public acceptance of climate action strategies will be needed.

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