SUSTAINABLE TRANSPORTATION:
FINDINGS FROM AN
INTERNATIONAL SCANNING REVIEW
AND IMPLICATIONS FOR THE U.S.

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Submitted for review for PUBLICATION ONLY - this paper was presented at the 2001 Annual Meeting of the Transportation Research Board but was not submitted for publication at that time.

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Acknowledgments

The work presented here was supported in part through an international scanning tour funded by the US Department of Transportation. The group that conducted the scanning tour contributed ideas throughout this study. They are: Team Leader Susan Petty of the Federal Highway Administration, Peter Markle, FHWA, Charles Howard, Washington DOT, Ysela Llort, Florida DOT, Frances Banerjee, City of Los Angeles Transportation Dept., Alex Taft, Assn. of Metropolitan Planning Organizations, David Pampu, Denver Regional Council of Govts., and Jean Jacobsen, National Assn. of County Officials.

The work also draws upon a paper by the author prepared for the Transit Cooperative Research Program, plus earlier papers by the author on transportation demand management and transportation-land use strategies.

Abstract

This paper examines sustainable transportation issues, drawing upon the literature as well as on evidence from a study tour of Sweden, Germany, the Netherlands, and Scotland. Greenhouse gases have been the initial motivation for most sustainable transportation initiatives, but broader social, economic, and environmental concerns now figure into the idea of sustainability. In the US, barriers to sustainability include uncertainty about the problem and the best ways to address it, as well as uncertainties about public support. Nevertheless, many efforts are underway locally in the US to promote sustainable development and sustainable transportation. The European organizations visited are using many of the same strategies as are US planners, but can rely on strong policy commitments, government incentives, and new planning processes putting an emphasis on collaboration and performance measurement to support their efforts.
1. Introduction and Overview

Concerns about the sustainability of development practices are increasingly being voiced in the US, Europe, and other developed countries as well as in the developing world. Early discussions of sustainable development focused largely on environmental damage (especially global warming) from land development and transportation, but increasingly, disparities in economic development and in the choices available to different nations and social groups for housing, jobs, services, and overall quality of life are among the matters of concern. Although the current Administration has rejected the Kyoto Protocol, efforts are underway to find other ways to reduce greenhouse gases, and concern about the broader quality of life issues remains strong.

Interest in sustainable development is motivated by a number of factors. There is a desire to reduce carbon loading of the atmosphere to avoid or reduce the impact of the greenhouse effect and its possibly catastrophic global consequences. There is also worry about a host of other environmental harms, ranging from the effects of deforestation on ecosystems and biodiversity to the impacts of fishery depletion on seacoast economies and ocean health. In both developed and developing countries, the effects of growing dependence on the automobile, rapid urbanization, and sprawl development are major motivations for considering sustainability. There also is interest in maximizing the productivity of infrastructure investment and controlling costs. Desires to preserve farmland, wild land, and other open space, improve urban amenity, redevelop brownfields, and make the suburbs more interesting are additional factors in current
discussions. Finally, the social equity of current patterns of consumption domestically and internationally, the necessity of economic growth and development in the less developed nations, and the relative contributions of the “haves” and the “have-nots” to environmental damage and to its potential restoration are additional issues that have entered into the debate over sustainable development.

Proposals that aim to promote sustainable development are as wide-ranging as the problems that motivate them. They include carbon taxes and fuel pricing strategies, new fuels and new vehicle technologies, strategies phase out fossil fuel power generation, and industrial strategies focusing on efficiency gains. They also include local and regional growth management and urban revitalization efforts, transit investments and traffic calming programs. The umbrella is wide enough to cover such US Federal and state programs as brownfields initiatives, Enterprise Zones, Location-Efficient Mortgage experiments, and Livable Communities programs, as well as programs to promote the use of recycled materials in construction and reconstruction, to implement intelligent transportation (ITS) systems, and to formulate new processes of context-sensitive design.

In the US and in other developed countries, transportation is a major focus of sustainable development inquiries for the simple reason that transportation is so prominent in the many problems that sustainable development aims to address. The US produces some 30% of the world’s total greenhouse gas emissions, transportation accounts for 25% of those emissions. Strategies that do not address transportation would fail to address a large share of total emissions.

Specific transportation measures that have been proposed in sustainable development discussions include the following:
• Electric and other alternative-fueled vehicles
• High efficiency gasoline, diesel, and hybrid vehicles
• Traffic operations and logistics improvements using information technologies and ITS
• Deployment and promotion of alternative modes such as rail freight transportation and transit, biking, and walking for personal transport
• Land use strategies that reduce auto dependence by focusing development around transit and in pedestrian-oriented areas
• Land use strategies that shorten trips and encourage transit use, walking and biking through compact, higher density, mixed-use development
• Telecommuting and other telecommunications substitutions for travel.

Although interest in these strategies is high, barriers to their successful implementation also are substantial. Technological alternatives are costly, take time to deploy, and do not always perform well. Alternative modes are frequently neither as convenient nor as inexpensive – in time or dollars – as the auto. Developers and lenders question the costs and profitability of infill and believe that high-density urban or town-center living is a specialized and limited market niche. Government officials note that funding for these strategies is limited and worry about public costs increasing along with densities. Institutional issues also are significant, with technological development, transportation infrastructure, and land use planning falling to different agencies with different approaches and missions.

Nevertheless, efforts are underway to try to overcome the barriers to sustainable development, often focusing in particular on sustainable transportation and land use.
State, regional and local governments and agencies are increasingly working on sustainability issues, sometimes on their own, sometimes in cooperation with local businesses, developers and community-based organizations. Many of the efforts rely on leveraged investments and involve both public and private partners. From the more successful experiences, a new planning style is beginning to emerge, emphasizing networks and coalitions of common interest, locally crafted solutions, experimentation, and rewards for accomplishment.

For some, however, sustainability is best treated with skepticism. The concept seems too vague to be useful. To some, it seems anti-growth. Some states have rejected the approach outright; others find it controversial.

Despite these sensitivities, the US transportation community has shown an increasing interest in sustainable transportation and its linkages to land use and urban development patterns, economic growth, environmental impacts, and social equity. Federal, state and local agencies as well as private organizations are working to translate the broad goals of sustainability into specific transportation policies, objectives, and programs. They are re-examining their policies, planning approaches, and evaluation methods and are considering changes to every aspect of practice, from the materials and designs used in construction to the kinds of alternatives considered for implementation.

Their efforts are known by a variety of names. Some are developing plans or programs for "smart growth" or "livable communities." Some have conducted a "visioning" process. Others emphasize one or another aspect of sustainable development: infill, compact growth, transportation alternatives, habitat preservation, revitalization of established neighborhoods and shopping districts, expansion of affordable housing
opportunities. Still others have placed great emphasis on programs to improve public safety, access to jobs, and educational opportunities. Funding has sometimes been entirely local; sometimes it has been supported by grants obtained through the Federal Transit Administration’s Livable Communities program, HUD’s Enterprise Zone community revitalization efforts, or EPA’s Brownfields Redevelopment demonstrations. What all these efforts have in common is a desire to meet current needs in a fashion that both improves social, economic and environmental conditions while preserving good options for future generations.

Because of the growing interest in sustainability issues, a review was carried out to examine how other developed countries are addressing sustainable transportation issues. Through the literature, Sweden, Germany, the Netherlands and the United Kingdom were identified as having several years’ experience in addressing sustainable transportation issues. Visits to each country were arranged and a set of questions was prepared and provided in advance to the European participants. A study group, composed of representatives from the US Department of Transportation, the American Association of State Highway and Transportation Officials, metropolitan transportation organizations, city and county governments, and academia, traveled to the four European countries.

In each country, the US group met for two to three days with officials engaged in sustainable transportation efforts. The topics covered included 1) the context in which planning and decision making for transportation and development occurs; 2) definitions of sustainability, 3) the policies and planning practices used in pursuit of sustainability, 4) sustainable transportation and sustainable development strategies, and 5) case studies and
implementation examples. Following the site visits, additional materials were provided by some of the organizations visited.

In each country, the study group noted differences in context that must be considered in assessing the potential for adoption of similar policies and practices in the US: slower growth than in many US metropolitan areas, relatively homogeneous populations, higher development densities, more extensive and more heavily utilized transit systems. Still, many similarities were noted, including growing auto ownership and use, suburban development, and public interest in community amenity and quality of life. The differences suggest that some translation for American settings will be necessary, while the shared concerns and objectives point to opportunities for mutual exchange and learning.

This paper examines the issues raised by sustainable development and sustainable transportation, drawing upon the literature as well as on the four European examples. The paper first presents some background on greenhouse gases, the initial motivation for most sustainable transportation initiatives, and then examines transportation strategies that have been used in transportation. The discussion then turns to key issues or uncertainties that arise in discussions of sustainable transportation. Sustainable transportation as an emerging strategy in the US is then considered, followed by findings from the European study. The final section of the paper assesses possible strategies that could be implemented in the US.
2. Background on Greenhouse Gases

Scientists generally agree that increasing concentrations of greenhouse gases (water vapor, CO2, methane, nitrous oxide, halocarbons) in the atmosphere are causing the average temperature of the earth to rise. The timing, magnitude, and consequences of this temperature increase are not fully understood or agreed upon, but most analyses have predicted that warming could be on the order of 1–4 degrees Celsius within a century. Average temperature increases of this magnitude could produce marked changes in precipitation patterns, with accompanying disruptions in other natural systems. It is also possible that the frequency and violence of storms could increase. (NOAA, Fall 1997.) The resulting changes could be rapid enough that neither natural systems nor social systems would be able to adapt easily. Some system changes appear to be underway already, including increased global mean surface temperatures and rising sea levels (IPCC, 1996.)

In response to this potential threat to social, economic, and environmental wellbeing, a series of international conferences have been held to develop a plan of action. The Kyoto Protocol, hammered out in 1997, aimed to be step toward the reduction of greenhouse gas emissions over the next decades. The Protocol sets out targets for industrialized nations averaging out to about 5% below 1990 levels by the 2008-2012 period. For the US, the target level was proposed to be a 7% reduction, a difficult target to meet considering that emissions have continued to grow each year. Unlike most advanced industrial states, the US Congress did not ratify the agreement, however, leaving the US comparatively uncommitted to action.
Finding ways to achieve significant reduction in greenhouse gas emissions is a major challenge, particularly in light of the fact that, absent strong new action, emissions are projected to continue to increase substantially over the next several decades. In the US transportation sector, for example, CO2 emissions could nearly double by the middle of the next century unless technological changes are vigorously introduced or transportation demand is sharply curbed. Either type of reduction strategy could have large economic, social, and environmental consequences far beyond the immediate greenhouse gas effects, so careful evaluation of the alternatives seems wise.

While most greenhouse gases occur naturally, anthropogenic emissions the major source of the buildup of these gases in the atmosphere. The buildup occurs because emissions are being produced at rates that exceed natural absorption cycles. In particular, atmospheric CO2, the most common of the greenhouse gases other than water vapor, is increasing by about one-half percent per year. (NOAA, Fall 1997). CO2 is emitted by a large number of human activities, including the burning of fossil fuels and the manufacture of cement. CO2 concentrations also are increased by deforestation, which reduces the ability of the earth to reabsorb emitted CO2.

The United States, the largest energy user in the world, is also the largest emitter of CO2, currently accounting for almost one-quarter of the total. US CO2 emissions come from transportation activities, residential and commercial activities, and industrial processes in roughly even shares. US transportation activities, which have been estimated to be the largest single source of greenhouse gas emissions in the world (EPA, Spring 1998), include both motor vehicle emissions and other transportation emissions (e.g., from jet aircraft); however, surface transportation alone is 25% of the US total. Three
quarters of that 25%, about 16% of US greenhouse gas emissions, currently are from motor vehicle use.

Understanding of the effects of greenhouse gases is still evolving, as scientists refine means of measuring and forecasting atmospheric changes over time, further study the roles played by the earth’s oceans and forests in carbon absorption and recycling. In addition, the likely spatial consequences of change are not completely understood or agreed upon. Furthermore, since greenhouse gas emissions are a worldwide phenomenon, forecasts must deal with likely changes in activity in both developed and rapidly developing countries. This adds a substantial additional component of uncertainty to the analyses, as the pace of development and the choices made could greatly affect forecasts.

Debate also continues over the range of options that might be used to address greenhouse gas emissions. Market approaches, regulatory changes in technologies, and restraints on energy demand and use are all under discussion. Some favor market approaches as a more cost-effective strategy, especially in the short run. For example, developed countries might pay for technological improvements, or perhaps for forest preservation, in less developed nations as a more cost-effective alternative than immediate technological change or demand suppression at home. Others believe that a multi-pronged strategy will be necessary both to accomplish the needed reductions and to assure a modicum of equity. Consensus has yet to emerge in the US on the paths to follow toward sustainability, though new insights emerging from ongoing research may eventually provide direction.
3. Transportation Strategies for Reducing Greenhouse Gas Emissions

Table 1 presents a partial list of the strategies that have been suggested for reducing greenhouse gas emissions. The strategies are grouped into several categories based on the component of the transport system addressed: vehicles, roadways, operations, demand.

The first category of strategies would reduce greenhouse gas emissions through technological change in vehicles and fuels. In the short run, this would most likely be accomplished by improving the efficiency of conventional vehicles, and in the longer run through the introduction of new vehicle technologies and new fuels. Innovations emerging from manufacturer innovations could be put to use in reducing greenhouse gas emissions, for example. If, due to demand-side incentives or changes in public attitudes, consumers began to demand vehicles that are low emitters of greenhouse gases, suppliers would likely respond by offering consumers that choice. Alternatively, government could provide incentives to manufacturers to produce low-emissions vehicles, or could mandate the same through regulatory interventions. Corporate Average Fleet Efficiency (CAFE) standards, research and development partnerships, taxes, rebates, and subsidies are specific options to consider, and could operate for both passenger vehicles and trucks.

A second category of strategies to reduce greenhouse gas emissions would involve improvements to roadways and vehicle operations. Again, different approaches might be used in the short run and over the longer term. Conventional traffic flow improvements such as traffic signal timing, ramp metering, flow metering, and bottleneck removal all have the potential to reduce greenhouse gas emissions by smoothing the flow of traffic and reducing fuel-wasting stop-and-go travel. Driver education could reduce
emissions by training drivers to avoid heavy accelerations and decelerations and to be mindful of the fuel consequences of high speeds. Scheduling trips outside of the peak periods could reduce congestion and thereby cut emissions.

Improved methods of accident/incident management and improved logistics and fleet management, both relying increasingly on advanced technologies for vehicle location and communication, also have substantial promise for increased efficiency of operations. Information technology-enhanced routing and scheduling can reduce the fuel needed for transport of both passengers and freight. Technological innovations currently under development offer the potential for significantly larger gains: these include the more advanced aspects of intelligent transportation system improvements such as smart highways and smart vehicles.

Demand management is a third category of strategies for reducing greenhouse gas emissions. Several subcategories of demand management are in use: modal substitution, telecommunications substitution, pricing, and land use strategies all can be thought of as forms of demand management.

Modal substitution means, for example, replacing car trips with transit, paratransit, ridesharing, biking and walking for personal travel and substituting rail for truck and air freight. This can be accomplished by providing better modal options (offering services and improving their quality in order to attract travel to alternative modes), or through incentives for the use of the alternative modes (e.g., subsidies for users of preferred modes). Regulatory requirements (trip reduction ordinances requiring employers to obtain commute mode shares of no more than 50% by drive-alone, for example) are also a possible way to induce modal substitution.
Telecommunications substitutions for travel also can be considered a form of demand management. Telecommuting, teleshopping, teleconferencing, and distance learning are varieties of telecommunications substitutes for travel.

Pricing incentives and disincentives could be used in the short run to reduce demand and encourage the use of alternative modes or the substitution of telecommunications for travel. In the longer run vehicle technology improvements would likely be induced by the higher prices. Gas tax increases are the pricing strategy most commonly used in the US and abroad; fees and taxes that affect vehicle ownership, such as sales taxes and registration fees, also are common. Variations that base taxes and fees on fuel efficiency, emissions, and expected vehicle life could specifically target the reduction of greenhouse gases, as could "fee-bate" variations offering tax reductions for efficient, low emissions vehicles along with surcharges for high emitters. Or pricing strategies could base emissions or fuel surcharges on measured or estimated use (VMT/VKT). Finally, rather than use pricing to restrain emissions directly, pricing could take the form of subsidies for preferred modes or for telecommunications substitutes.

Land use and urban development strategies alter demand by reducing trip length (by providing a choice of close-by destinations) or by making alternatives to the auto more competitive and cost-effective. (These strategies also may reduce emissions associated with building heating and cooling, service provision, etc.) For example, compact development, mixed use development, and higher development densities can reduce trip lengths and make transit, pedestrian, bike use practical and affordable. In some cases compact development also may facilitate better management of urban freight transport (shipment consolidation, delivery scheduling, etc.)
This list of strategies will sound familiar to most transportation professionals. The same list has been used for many years in the search for strategies to reduce air pollution emissions and to manage traffic congestion, and many of the strategies have been used for decades. The federal government established CAFE standards to induce fuel efficiency in vehicles in the 1970s. Federal and state gas taxes are in place and are periodically increased. Highway departments and local traffic engineering offices routinely use traffic operations strategies to increase capacity and reduce environmental impact. Transit services and ridesharing programs are offered throughout most metropolitan areas and in rural ones as well. Land use strategies promoting infill, compact development, and mixed use are promoted in numerous cities and suburbs.

The widespread use of many of the listed strategies is both an advantage and a drawback. It is an advantage because it means that established programs are in place to offer evidence of efficacy and potentially to serve as a base for further expansion or innovation. It is a drawback because it means that many of the strategies will already be fully deployed where they are cost-effective, with their benefits already captured. Further deployment in these circumstances could produce limited results and in some circumstances could even produce disbenefits. (As an example, consider the impacts of deploying fixed route bus service in low density areas where the service is little utilized: emissions and fuel use per passenger carried can be higher than would occur by using autos or taxis to serve the trips.) Hence the issue is whether market niches cans still be found to which these strategies might effectively be applied.

For some of the strategies, many would respond that there are indeed more markets to be served. For example, traffic signal timing and other operations
improvements are in common use, but many localities have lacked the resources to upgrade equipment or to retune their signals on a regular basis. They could benefit from a funded traffic signal management program. Similarly, few localities have had the resources to fully implement bicycle networks, pedestrian improvements, and traffic calming programs, and funds for such strategies are oversubscribed. Transit operators and ridesharing service providers often have lists of unfunded improvements and few have even begun to explore the possibilities for shuttle services, subscription buses, and other innovations. Not all of these strategies would necessarily be cost-effective from a greenhouse gas reductions perspective, but some surely would be.

Other strategies remain in the early stages of deployment and a strategic effort to implement them might produce meaningful results. This is the case, for example, for many of the strategies involving advanced technologies for highway and transit operations. It also may be the case for certain vehicle and fuel technology strategies, where the wider implementation of experiments and demonstration projects could be useful.

Land use strategies have recently begun to capture the attention of many interest groups and studies and small programs to test these strategies’ transportation effectiveness are underway. Here, too, wider experimentation and systematic evaluation could be useful.

Pricing strategies are still highly controversial in most parts of the country, although some local governments and private operators are successfully managing parking pricing and projects with variable tolls and “value pricing” are underway on a handful of US highway facilities. Proposed gas tax increases, “fee-bates,” emissions fees,
and the like have been evaluated in major studies, but so far implementation has not occurred due to concerns about equity and opposition to any strategy that looks like a tax. Nevertheless, there is enough interest in these strategies to consider a larger effort toward their implementation than has occurred to date.

How effective would the various transportation strategies be in reducing greenhouse gas emissions? The Transportation Research Board investigated this topic in a 1997 report. Four scenarios were tested: one emphasized demand management and land use planning, the second focused on improvements in vehicle efficiency, the third emphasized fuel price increases, and the fourth assumed the introduction of new vehicle technologies. Drawing upon evidence in the literature from modeling studies and field experiments, estimates of greenhouse gas reductions were produced for each scenario. The results, which are for the US, were as follows (TRB Special Report 251, 1997):

- From aggressive demand management and land use planning strategies: 6% reduction by 2020, 15% by 2040
- From a 1.5% annual increase in average new vehicle fuel efficiency: 15-20% reduction by 2020, 35% by 2040
- From higher fuel prices amounting to a 3% increase per year: 20% reduction by 2020, 40% by 2040
- From the introduction of new low-emissions vehicles (5% of fleet by 2020, 35% by 2040): no significant change by 2020, 30% reduction by 2040.

Assuming that these results are approximately correct, no one strategy by itself offers a “silver bullet” for the greenhouse gas emission problem. Furthermore, considerable uncertainty about implementation feasibility attaches to each of the
scenarios, strengthening the conclusion that thorough consideration of the full range of options is a prudent approach.

4. Key Issues on Transportation and Greenhouse Gas Reductions

We turn next to some of the issues that would have to be addressed in designing and carrying out an invigorated search for transportation strategies to reduce greenhouse gases. Key issues include: uncertainties about the nature and severity of the greenhouse gas problem; questions about the extent to which transportation strategies should be used in attacking greenhouse gas concerns, and debates over which transportation strategies are most pragmatic and efficacious.

Uncertainties About the Problem: Important uncertainties remain about the nature and severity of the greenhouse gas problem. Although most scientists agree that the Earth is warming, there is less agreement about the causes and cures. Uncertainties coupled with the high stakes involved make it hard to muster the political support needed for action.

Sectoral Responsibility for Greenhouse Gas Emissions Reductions: Analyses often assume, as did the discussion in the previous section, that transportation would aim to reduce greenhouse gases proportional to the transportation sector’s contributions. However, this is not necessarily the most efficient nor the most effective way to reduce the emissions. Because proportional reductions could be attained only through major departures from current transport policies, it is reasonable to look at other possible sources for emissions reductions. Reductions in greenhouse emissions could for example
be obtained by helping developing countries limit or reduce their production of greenhouse gases (emissions trading). Or a higher-than-proportional share of US reductions might be sought from other sectors of the economy, notably power generation (about 36% of total US emissions.)

Both of these strategies are problematic. In the Kyoto negotiations and subsequent talks, other countries have objected to US proposals relying heavily on marketable emissions strategies for greenhouse gases. The Protocol does permit emissions trading, but specifies that it is to be "supplemental to domestic actions." In the case of power generation, seen by some as the sector most reachable by government policy, the issue (as in transportation sector) is how much reduction can actually be achieved, given heavy demand, high costs of new plants, and limits to the reach of regulation.

In short, there appears to be no simple solution that would alleviate all pressure for change in the transportation sector. Emissions trading may well reduce the magnitude of needed transportation emissions reductions, and other sectors may present options that are more cost-effective or simpler to implement than certain transportation strategies. A better understanding of the full range of alternatives and the tradeoffs they involve would be valuable, but a continued search for transportation solutions also seems necessary.

**Technology Change and its Implications:** Technological advances in the automotive industry and other sectors of the economy have considerable potential to reduce greenhouse gas emissions and, for that matter, other externalities that are broader concerns about sustainability. Aggressive technology deployments, whether in the form of changes in conventional vehicles or through the introduction of radically different
vehicle and fuel technologies, could produce substantial greenhouse gas reductions over
the next several decades.

To many, the prospect of “invisible” technological change is far more inviting than the
prospect of higher prices or other demand reduction strategies. However, such technology
deployments are by no means assured, and may emerge in forms that are not as attractive
as currently envisioned – considering price, availability, and performance characteristics.
Another issue is that in the absence of public policy direction, the technological changes
that do emerge may or may not be directed to greenhouse gas emissions. For example, at
present many advances in automotive technology are being applied to increase
acceleration and performance or strengthen vehicle bodies, not to boost efficiency. A
variety of interventions could change this, directly or indirectly – higher CAFÉ standards
and higher gas taxes are but two of many possibilities – but would certainly themselves
be controversial. Thus both market studies and studies of potential supplier and consumer
incentives or disincentives for technological change would be valuable.

Public Opinion and Support for Action: Reductions in transportation greenhouse gas
emissions, as well as broader actions to move toward greater environmental, social, and
economic sustainability, likely will depend on changes in consumer preferences. While
polls generally find widespread support for environmental protection and enhancement,
they also suggest that many consumers are not yet ready to alter their travel behavior or
consumer purchases because of the threat of global warming. (See, e.g., Stoffer,
12/22/97). For example, suburban utility vehicles and trucks remain popular despite their comparatively low fuel economy, and drive-alone mode shares are increasing.

Many analysts believe that changes in pricing policy, such as higher fuel taxes or full-cost pricing for parking, could substantially change consumer choice. However, public opposition to such measures continues to make their implementation doubtful. Changes in public attitudes might be forthcoming as public understanding of greenhouse gas issues increases, but so far there is little evidence that this is occurring.

Changes in travel behavior also could be generated through changes in land use and location, modes offered and chosen, and overall activity patterns. Here, too, however, the changes would depend on public support for policy changes, along with individual, household, and business decisions consonant with those changes. The interest in “livable communities” and “sustainable development” suggests some sentiment in favor of policy reform, but the vast majority of households continue to settle in conventional suburbs and to rely on the auto as their main means of transport.

**Barriers to the Development of Action Plans:** A number of studies have developed and tested plausible scenarios for reducing transportation greenhouse gas emissions. However, moving forward from scenario testing to the development and implementation of action plans has been a slow process that is hampered by two major barriers: the lack of a mandate, and the lack of a funding source.

First, there is no mandate for state, metropolitan, or local agencies to develop greenhouse gas reduction strategies or broader sustainable development plans; nor are there earmarked funds for such planning efforts. As a result, most greenhouse gas
reduction initiatives must either piggyback onto other, ongoing planning efforts, or must compete with those efforts for funding. The lack of a clear mandate for action, coupled with the lack of an eligible, dedicated funding source, deters many agencies from taking on the greenhouse issue - especially when they consider that the topic is likely to be multi-faceted and controversial.

In addition, analysis approaches and performance indicators in common use are geared to the analysis of large scale highway and transit investment, not the vehicle, fuel, operations, and land use changes that form a large part of the toolkit for sustainable transportation. Hence planning methods themselves are less than fully useful for this task.

5. Sustainable Transportation: An Emerging Strategy

As the previous sections have discussed, most of the measures being proposed for greenhouse gas reductions have been considered before; some are widely implemented, while others – particularly those involving pricing and land use – have been touchy subjects more often rejected than pursued. What then are the opportunities for action? One possibility is that interest in the broader notion of sustainable development could serve as a vehicle for change.

As a variety of definitions of sustainable development have been put forward; a few are presented in Table 2. Increasingly the idea of sustainability has come to be understood as a collective process for considered decision-making and action and not simply a particular end-state or outcome. There is growing consensus that sustainability must include economic betterment and social equity, not just a narrow technical focus on greenhouse gases or other aspects of the natural environment. Planning for sustainable
development increasingly involves strategic coordination of efforts along all of three dimensions.

In the last several years sustainability initiatives have been undertaken in a number of cities and regions here and abroad. Recent undertakings include the Maryland Smart Growth Initiatives, the Portland OR 2040 Plan, Sustainable San Francisco, Sustainable Toronto, Sustainable Seattle, and The Bay Area Alliance for Sustainable Development. Examples from the Netherlands, France, and Germany, and from Brazil, Argentina, and Indonesia also are well known. These efforts largely follow upon the 1987 report of the World Commission on Environment and Development (commonly called the Brundtland Commission report) and in the US, on the President’s Council for Sustainable Development (PCSD) report, “Sustainable America – A New Consensus”, which argued that sustainable development can only be achieved by building sustainable communities.

Reflecting the recommendations and action items in those precedent documents, the local and regional efforts typically focus on the interrelationships among transportation, housing and employment trends and policies, and the resulting consequences for the environment (especially air quality), energy use, economic prosperity, and social equity. They often are developed through a process involving a wide range of interests (business leaders, environmentalists, social justice advocates, etc. as well as public officials and agency staff members). Often, they involve the negotiation of procedural agreements as well as the development of performance indicators and specific actions to be undertaken.
Table 3 lists some of the strategies that are proposed in sustainable development plans. As the table shows, the strategies range from land use planning to transportation, housing, and economic development, and linkages and overlaps are strong.

Supporters of the strategies and initiatives believe there is considerable potential for important gains through sustainable development planning. Most admit, however, that the US is behind many other countries in its efforts. Hence a closer look at sustainability initiatives in other developed countries should provide valuable insights and examples.

6. European Experiences: Findings from an International Scanning Review

The European study tour to Sweden, Germany, the Netherlands, and Scotland was designed to examine how other developed countries are addressing sustainable transportation issues. Visits to each country provided the opportunity to conduct extended discussions with policy makers and practitioners and to more closely examine these countries' experiences.

Definitions of Sustainability

All of the countries visited use some variation of the Brundtland definition of sustainability - meeting the needs of the present without compromising the ability of future generations to meet their own needs – as the starting point for their efforts on sustainable development. CO2 reduction, as called for in the Kyoto Protocol and other agreements, is an important objective. However, sustainability is seen as a much broader concept having economic and social as well as environmental dimensions. Sustainable development is viewed as development that improves the standard of living and quality
of life, while at the same time protecting and enhancing the natural environment and honoring local culture and history.

In this context, sustainable transportation is safe, high quality, and accessible to all, ecologically sound, economic, and a positive contributor to regional development. Specific goals for sustainable transportation include improved service quality, safety, air quality, water quality, noise reduction, protection of habitat and open space, historic preservation, and reduced carbon emissions, plus local goals consistent with the overall objective.

Policies and Practices

The policies and practices used to pursue sustainability recognize the importance of collaboration, both as a means of reaching agreement on specific goals and objectives and as a way to pursue specific strategies. The countries visited are using collaborative strategic planning to identify and evaluate ways to move toward sustainability, and are devising performance measures with which to assess progress. Collaborations involve the different levels of government, different agencies, citizens and the private sector.

Both the EU and each country back the commitment to CO2 emissions reduction with policies for accomplishing that end. At the same time, they recognize that local governments and the general public typically have more immediate transportation concerns, including mobility needs and noise, speeding, and traffic problems. However, initiatives to address local concerns often reduce CO2 emissions as well, thus contributing to a larger sustainability strategy. European policies therefore encourage and reward such local initiatives. Practices include: 1) Offer local governments incentives for
aligning their policies and practices with national objectives; 2) Lead by example – show good practices in government first; 3) Support local projects that move in the direction of greater sustainability, to build local understanding and support; and 4) Try new ideas and see what works.

What makes sustainable transportation planning different from past practice is that social and environmental objectives are an integral part of sustainable transportation planning, rather than constraints or the focus of mitigation efforts. European policies on sustainability have made transport agencies directly responsible for the social, economic, and environmental performance of their systems. This is leading to a changed set of priorities, emphasizing access and exchange rather than trips per se, giving greater attention to the less environmentally damaging modes, optimizing the use of existing capacity, and encouraging improvements in vehicle technology. Sustainability considerations are reflected in the types of projects pursued, in project location decisions, in the quality of design and landscaping, in the choice of materials used.

Specific Strategies for Sustainable Transportation

A variety of specific strategies are being pursued to increase the sustainability of the transport system. The overall approach was described as “doing a number of small things as part of a larger, strategic program.”

Land use-transportation strategies are one component of the overall effort and are used to reduce trip lengths and facilitate the use of transit, biking and walking. Specific actions include revitalization of existing centers, infill and brownfields redevelopment,
focusing high density development near transit, encouraging development in and contiguous to existing centers already served by transit, and planning for compact, mixed-use suburban development which is both walkable and sufficiently dense to support transit services. Policies discouraging single use, stand-alone developments such as shopping malls also are in place or are being considered.

Transit improvements are a second element of the European strategy for sustainability. Subsidies have been reduced in recent years but are still provided as a matter of social and environmental policy. Specific strategies to improve transit service include the development of extensive systems of priority lanes for buses, high quality architecture and landscaping at transit stations and stops, planning for door to door service (including walk and bike access planning as part of transit planning), improved intermodal transfers, and high-quality customer information services.

Bicycling and walking are a third key strategy for sustainability. Extensive systems of bikeways and bike parking exist in each of the countries we visited, and bikes can be taken on many transit systems. High quality pedestrian spaces are plentiful and more are being created by widening sidewalks, calming traffic, creating vehicle-free or vehicle-restricted zones, and bulbing out intersections to facilitate pedestrian crossings.

While considerable emphasis is given to alternative transport modes, highways and the automobile are recognized as an essential mode of travel in every country, and most efforts focus on sound management rather than on disincentives. Efforts do attempt to educate the public about the impacts of auto use, and to encourage trip chaining and scheduling to reduce harmful effects.
Streets and highways are being built and rebuilt to reduce negative impacts, in some cases by undergrounding the facilities. Parking also is placed underground in many instances, and is priced according to cost. Joint development of air rights and partnerships with developers and owners of nearby properties are being used to help finance these costly projects.

Biodiversity is being protected through good planning, location, design, and maintenance practices, for example, providing animal crossing corridors and maintaining shoulders and medians as habitat. Bioengineering is used to create environmentally sound, aesthetic structures, and recycled materials are selected reduce environmental impact.

Logistics and operations improvements and ITS technologies are increasingly being applied to maximize the capacity of existing facilities, thereby reducing congestion, improving safety, and cutting down on the need for new facilities. Traffic calming is widely used in residential areas and on major streets in shopping districts; the installations are made of high quality materials and are well designed and landscaped. Both speed management and traffic calming are part of programs aimed at a goal of zero highway deaths.

Car sharing programs are being tried as ways of providing households the convenience of occasional access to an automobile without necessitating ownership or costly rentals. Alternative fuels are being tested both for transit and for personal cars, to reduce pollution and carbon emissions. In addition, ITS technologies are being promoted to help drivers plan trips more effectively, avoid bottlenecks, and travel at speeds that
reduce congestion and improve safety. Improvements in truck technology are being sought, and incentives for truck emissions reduction include both emissions pricing and restrictions on the use of 'dirty' trucks in sensitive areas.

Road pricing is discussed as a way to properly reflect the social and environmental costs of auto use, but it is being approached with considerable caution because there is not much public support for it. Fuel taxes are already several times those in the US, but are not hypothecated; instead, funds are allocated to reflect government policies and priorities.

Tables 3-7 list specific strategies being used by each of the four countries visited in the study tour, as well as the overall approaches being taken.

7. Summary of Findings and Implications for the US

1. The US is the world's largest producer of greenhouse gas emissions, currently generating about one-quarter of the world total. This share is projected to decline over the next two decades due primarily to faster growth in emissions in other nations, but per capita emissions will still be the highest in the world.

2. The US transportation sector produces about one-third of greenhouse gas emissions, with motor vehicles responsible for about 25%. US transport shares are higher than in many other countries because of the US's higher dependence on motorized transport.
3. At current rates of growth, the US transportation sector’s emissions of greenhouse gases could increase by a third over the next two decades and could nearly double by the middle of the next century.

4. Although the current Administration has rejected the Kyoto protocol, strategies to reduce transportation greenhouse gas emissions nevertheless are being actively considered in the US and include:
   - improvements to current motor vehicle technologies
   - introduction of new vehicle technologies
   - use of alternative fuels
   - increased efficiency in transportation operations
   - increased use of less energy intensive modes
   - reduced demand for transportation, though pricing, altered land use patterns, or voluntary changes in activities and lifestyles.

5. Since most of the strategies being considered for greenhouse gas reduction have been around for a while, they are either fairly well implemented or face significant implementation barriers. What would it take to change this situation and increase implementation success? Current planning processes focusing on transportation sustainability are one possible strategy. Sustainable development planning is underway in a number of US cities and regions and abroad. These new efforts typically take a broad view of sustainability, defining it to include social and
economic issues and considerations of community and equity as well as environmental and energy considerations specific to climate change issues. This broader perspective allows for a more balanced discourse over policy issues and permits better balance and tradeoffs. Transportation is an important element in many of the plans and is often coordinated with housing, brownfields cleanup, and jobs strategies.

6. European countries are actively pursuing sustainable development and sustainable transportation, and are trying a number of strategies might be considered for implementation in the US. These include policy approaches and planning procedures as well as specific transportation measures or actions that emphasize land use-transportation coordination to shorten trips and facilitate the use of walking, bike and transit modes.

7. The European emphasis on policy consistency and cooperative problem solving among agencies with somewhat different objectives has potential applicability to the US. Policy harmonization efforts being undertaken at the EU, national, state/province, and local levels show promise: These efforts identify policy conflicts and then turn to negotiations to remove them, following up with new policies and practices as necessary. This approach is potentially useful as a way to resolve transportation-environmental conflicts and speed attainment of environmental goals in the US.
8. European practice matching operating responsibility for transit and highway systems with control over funding for those systems often assigned to local or regional agencies, may be a logical extension of TEA-21 devolution policies.

9. Planning approaches that might be adopted in the US include visioning processes to develop shared goals, strategic planning for both the long term and mid-term, and backcasting to test to see what strategies would be needed to meet goals. Another policy item with high potential for the US is the use of performance standards along with monitoring and reporting on progress. This could be coupled, as it is in the countries visited, with fiscal incentives for actions supportive of adopted goals.
Table 1. Strategies for Reducing Transportation Greenhouse Gas Emissions: A Partial List

Vehicle / Fuel Technological Changes:
1. Improved Efficiency of Conventional Vehicles
   - Manufacturer Innovations / Supplier Offerings
   - Responses to Consumer Demand
   - Responses to Government Regulation and Incentives: CAFÉ Standards, R&D Partnerships, Taxes, Rebates, Subsidies
2. New Vehicle Technologies
3. New Fuels

Road / Vehicle Operations Improvements:
1. Conventional Traffic Flow Improvements
   - Traffic Signal Timing
   - Ramp Metering
   - Flow Metering
   - Bottleneck Removal
2. Intelligent Transportation System Improvements
   - Smart Highways
   - Smart Vehicles
3. Accident / Incident Management
4. Routing and Scheduling Enhancements
5. Driver Education
6. Improved Logistics and Fleet Management

Demand Management:
1. Modal Substitution
   - Transit, Paratransit, Ridesharing, Walking, Biking Improvements and Incentives
   - Rail Substitutes for Truck
2. Telecommunications Substitutions
   - Telecommuting
   - Teleshopping
   - Teleconferencing
   - Distance Learning
   - Information Technology-Enhanced Routing and Scheduling (Passengers, Freight)
3. Pricing Incentives / Disincentives
   - Gas Tax Increases
   - Vehicle Sales Tax Based on Fuel Efficiency and Expected Life
   - Vehicle Registration / License Fee Based on Fuel Efficiency, Use (Measured or Estimated)
   - Other Impact Fees Based on Use
   - Subsidies for Preferred Modes, Telecommunications Substitutes, Etc.
4. Land Use –Transportation Strategies
   - Compact Development
   - Mixed Use Development
   - Higher Development Densities
   - Transit, Pedestrian, Bike Friendly Development

Table 2. Definitions of Sustainability, Sustainable Development, and Sustainable Transportation
Sustainability: Meeting the needs of the present without compromising the ability of future generations to meet their own needs
- World Commission on Environment and Development 1987

Sustainability: Relationship between human economic systems and larger dynamic, but normally slower-changing ecological systems, in which (1) human life can continue indefinitely, (2) human individuals can flourish, and (3) human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system.
-Constanza 1991

Sustainable Development: a process of change in which exploitation of resources, the direction of investments, the assumptions of technological development, and institutional change are all in harmony and balance and enhance both current and future potential to meet human needs and aspirations
- World Commission on Environment and Development 1987

Ecological sustainability: refers to ecosystems and maintenance of their integrity.
Economic sustainability: refers to the market-based perspective that is premised on the fundamental assumption of maximizing rather than foregoing growth and consumption.
Social sustainability: refers to the ability of people to take collective actions to strive for fair access to the benefits of human progress
- Berke and Kartez, 1995

Sustainable Transportation: Transportation that does not endanger public health or ecosystems and meets mobility needs consistent with use of renewable resources below their rates of regeneration, and use of non-renewable resources at below the rates of development of renewable substitutes
- OECD, 1994

Sustainable Transportation: Allows the basic access needs of individuals and societies to be met safely, and in a manner consistent with human and ecosystem health, and with equity within and between generations; is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; limits emissions and waste within the planets ability to absorb them, minimized consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.
- Centre for Sustainable Transportation (Canada), March 1998

Table 3. Strategies for Sustainable Development

Land Use and Community Development
- Preservation, Rehabilitation, and Redevelopment of Central Cities and High Density Inner Suburbs
- Infill in Cities and Suburbs - Increased Density, Mixed Use
- Reusing Brownfields, Recycling Buildings
- TODs and PODs as the Paradigm for New Developments
- Quality of Life: Attention to Crime/Schools/Services/Amenities
- Recycling/Precycling/Composting Programs

Transportation
- Access vs. Mobility – Basic Concepts
- Bike- and Pedestrian-Friendly Cities
- Transit, Paratransit, Ridesharing
- Telecommuting/Teleconferencing
- New Technologies for Improved Efficiency: evs, Traffic Control Systems, Transportation Information Systems,…
- Prices and Subsidies Aligned with Sustainability

Housing and Other Building Designs
- A Range of Choices
- Energy efficient buildings
- Edible Landscaping
- Natural/Indigenous plants

Business/Job Creation
- Business Leadership
- Community Economic Development
- Clean/Safe technologies

Social Equity
- Aligning Taxes and Subsidies with Sustainable Development
- Equitable Distribution of Resources
**Table 4. EU Environmental Policy**

- Precautionary principle: better prevention than cure
- Early consideration of environmental effects
- Avoid resource exploitation that causes significant damage – use but don’t abuse
- Avoid spillovers in other countries
- Polluter pays principle
- Promote world-wide environmental policy
- Improve scientific knowledge on environment
- Share responsibilities for environmental actions
- Assign responsibility for action to the appropriate level of government – as close to citizens as possible
- Environmental education

Source: Treaty of Rome, Articles 235 and 100, and Single European Act, as reported in Haq, 1997
Table 5. Germany - Berlin

Overall Strategies for Sustainability:
- Work within EU framework, apply local regulations (no overall package of measures for country)
- Qualitative vision and quantitative criteria – noise, air quality, acidification, CO2 reduction, etc.
- Multimodal planning and least cost planning
- Avoid trips, shift to less damaging modes, optimize road capacity, improve vehicle technology, deploy telecommunications and ITS
- Land use strategies – German City Assn.: density and mixed use, corridor and wedge, reinforce existing centers, discourage or ban greenfield stand-alone malls; focus development at crossing of transit lines
- Education and research
- User fees to reflect full cost (not yet supported by public except perhaps for trucks)

German Examples of Sustainable Development and Sustainable Transport:
- Truck impact management– vehicle taxes, fuel taxes, time restrictions
- Rail and sea emphasis for freight
- Logistics and ITS to manage freight movements
- Speed advisories to avoid congestion
- no new roads, but upgrade and some widening
- In longer term, highway management using ITS
- Traffic calming
- Federal regulations on urban development – aim for compact growth, pedestrian, bike, and transit access
- Coordinated land development and transport improvements
- Emissions standards for vehicles
- Alternative fuels for vehicles
- Intermodal improvements including use of tunnels
- Transit emphasis
- Dedicated bus lanes
- Transit connection to airport
- Bicycle facilities well connected to rail
- Construction logistics to reduce adverse impacts
- Recycled materials in construction and reconstruction
Table 6. Scotland – Edinburgh

Overall Strategies for Sustainability:
- Regional strategies for development and transport; integrate transport and land use
- Central city vitality
- Public transport competitive and attractive
- Compact and contiguous suburban development
- Emphasis on exchange, not movement

Scottish Examples of Sustainable Development and Sustainable Transport:
- Travel Wise program – try to educate public - think before you travel, chain trips, walk or bike, etc.
- Extensive green lane system for bus priority
- Parking pricing
- Car club experiment
- Traffic calming
- Bike streets, bike ways
- Wider sidewalks (also good for business)
- Lower speeds in some zones
- Speed enforcement by camera
- Recycled materials in construction
Table 7. Sweden - Stockholm

Overall Strategies for Sustainability:

- Strategy is "lots of small things" but done in collaboration and put together into an overall strategy
- Access, quality service, safety, good environment economic development all objectives for transportation plans
- Transportation providers must meet social and environmental objectives, are evaluated on social and environmental performance
- Collaborative efforts to identify and remove conflicts, pursue areas of agreement
- Strategic planning, performance measures, monitoring, evaluation and feedback to strategic plan
- Environmental goals integrated with planning processes
- Accelerate attainment rather than change direction
- Lead by example – show good practices in govt. first
- Try things out and see what works – e.g., fossil fuel-free community
- Recognize that general public is not so concerned or knowledgeable about global issues, but are concerned about local ones such as too much traffic – build upon local understandings, expand understanding and educate.

Swedish Examples of Sustainable Development and Sustainable Transport:

- Emphasis on making transit work – performance goals
- Subsidy reduced but more efficient service
- Customer orientation – market surveys, info systems at stops, remove barriers, etc.
- Quality architecture and landscape design in stations, stops
- New towns at walkable densities, near transit, etc.
- Redevelop centers – recognize cultural and social importance.
- Build and rebuild to reduce negative impacts, e.g., Underground roads, traffic calming
- Biodiversity protected through good planning, design, and maintenance
- Remove barriers for animals
- Careful choice and use of road materials; recycled materials used
- Alt. fuels; hybrids for buses and govt. fleets; Zeus project
- Truck improvements being sought – incentives for cleanup
- Rail improvements for freight
- Zero deaths safety plan – grade separation, traffic calming, in-vehicle protection, education
Table 8. The Netherlands – the Hague, Rotterdam

**Overall Strategies for Sustainability:**
- Get prices right
- Access as focus – land use as well as transport
- Support existing centers
- Provide multimodal transport in line with sustainable policies
- Quality services door to door
- Quality design – including undergrounding
- Public-private land use-transport solutions

**Dutch Examples of Sustainable Development and Sustainable Transport:**
- manage demand by using pricing to appropriately reflect full costs
- ABC policy – focus development where there is greatest access
- Development contiguous to existing cities and towns, mixed use
- Infrastructure policies aligned to support sustainable development (including water, sewer, etc.)
- Limit stand-alone shopping malls etc.
- Traffic calming
- Preserve Green Heart of the region
- Plan for whole trip chain not mode by mode (e.g., bike storage at apt., bike lane to train station, storage or on-board option, etc.)
- Truck logistics
- Plan for technological change in vehicles, ITS, etc. – focused on safety and congestion relief (getting 10% less congestion)
- Prohibit cell phone use while driving unless hands free
- Driverless people mover (but it didn’t move us!!!)
- Public-private partnership to help pay for high cost items
- undergrounding roads, rail, parking