

Transportation Practices and Strategies for Sustainable Development

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Abstract: The transportation as a system is an important component of social and economy sustainable development. Sustainable development of transportation requires consideration, not only its own economic results, but also positive and negative effects of transportation. On one hand, the transportation has promoted the economic development and the progress of the society while on the other hand it has also brought a lot of negative effects. The existing problems in the respects of resources consuming (the land, energy), air pollution, noise, traffic jam, traffic accident, etc. are the key to realize the sustainable development of the transportation. In order to effectively reduce the adverse impact of existing transportation systems new development patterns must be adopted. Overall, the concept of transportation sustainability should be defined through three major factors: social equity, economic efficiency and environmental responsibility. Strategies for transportation sustainability include demand management, operation management, improvements of vehicle technology, pricing policy and integrated land use and transportation planning. This paper deals with importance of transportation for sustainable development and presents some sustainable transportation practices and strategies in the United States and Europe.

Key words: Transportation, Sustainable Development, Practices, Strategies

Introduction

Sustainability, in general, is creating a balance between the economy, social needs and environment. Transportation, as a core component supporting the interactions between economy, social activities and environment should be balanced. Virtually all human activities have an impact on our environment, and transportation is no exception. While transportation is crucial to our economy and our personal lives, as a sector it is also a significant source of greenhouse gas (GHG) emissions. Today's transportation is facing the most significant issue – climate change. The reality of climate change is broadly accepted by international recognized scientific organization and governments. Rising global temperatures pose two major challenges for the transportation community: (1) preservation of transportation systems by minimizing affect of climate change and (2) reduction of greenhouse gases emissions produced by transportation systems. The transportation sector accounts for more than two thirds oil consumption and transportation vehicles emit 28% of the total greenhouse gas emissions. Since 1990 transportation sector emissions have grown more in absolute terms than any other sector. Forecasts of emissions, or estimates of future emissions, assist with the development of policies and actions that can be taken to establish reduction goals and reduce GHG emissions over the long term. While technological change is essential to reducing GHG emissions there is also a role for strategies that help to limit the growth in travel demand. Sustainable development of transportation requires consideration, not only its own economic results, but also positive and negative effects of transportation. On one hand, the transportation has promoted the economic development and the progress of the society; while on the other hand it has also brought a lot of negative effects. The existing problems in the respects of resources consuming (the land, energy), air pollution, noise, traffic jam, traffic accident, etc. are the key to realize the sustainable development of the transportation.

Transportation Sustainability

The concept of sustainability can be defined through three major points: social equity, economic efficiency and environmental responsibility (Figure 1). Social equity relates to conditions favoring a distribution of resources among the people upon comparative levels of their productivity. This should not be

confused with welfare programs because welfare is not equity, but redistribution. Economic efficiency relates to higher levels of economic efficiency in terms of resource and labor usage. Economic efficiency focuses on competitiveness, flexibility in production and providing goods and services that supply a market demand. Environmental responsibility assumes using natural capital (the sum of nature’s resources) at a rate at which they can be replenished naturally. This includes the supply of resources (food, water, energy, etc.) and numerous forms of wastes. The existing problems in the respects of social equity, economic efficiency and resources consuming (the land, energy, etc.) are the key to realize the sustainable development of the transportation. The transportation infrastructure, mode of transportation and logistics systems are the major areas of transportation sustainability concentration which would contribute to the sustainability in general. Table 1 summarizes the key issues that should be balanced and integrated.

The next an important question is: how to evaluate presented transportation sustainability issues? Sustainable transportation indicators are an important tool for better transportation planning. There is currently no standard set of transportation sustainability indicators. It would be very desirable to develop standardized baseline indicators of transportation sustainability.

The quantity of oil consumption and greenhouse gas (GHG) emission are directly related and they have influence on all three categories of transportation sustainability issues. The basic information on oil consumption and GHG emission are presented in the following paragraphs.

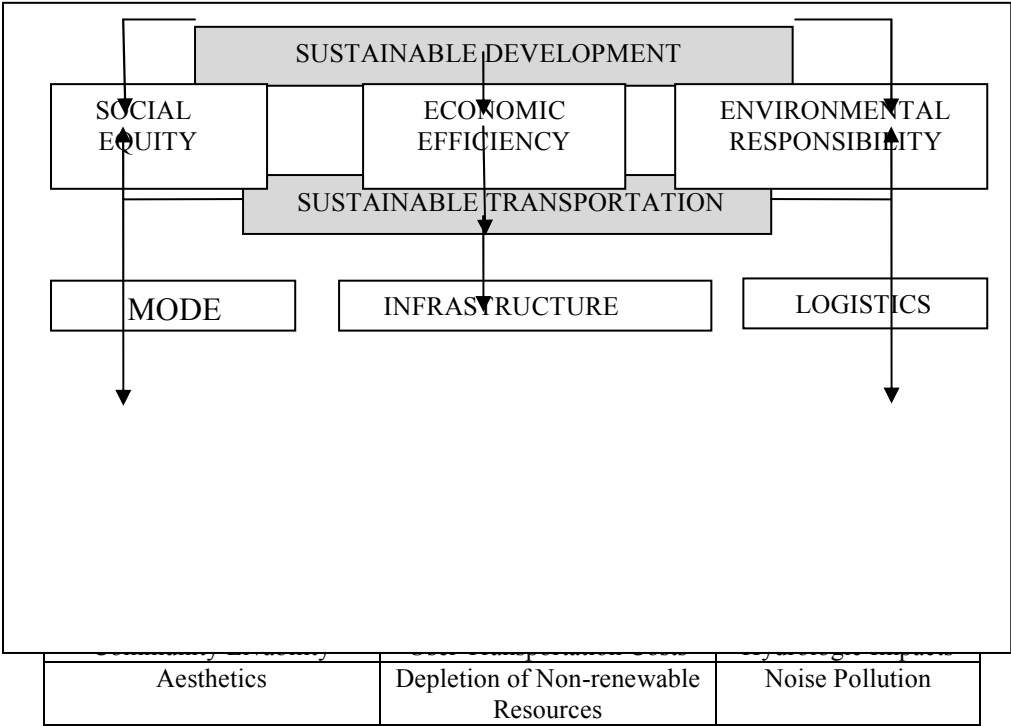


Table 1: Transportation Sustainability Issues (Source: Victoria Transport Policy Institute)

Oil Consumption

The industrialized countries are the largest consumers of oil, but until 1998 had not been the most important growth markets for some years. The countries of the Organization for Economic Cooperation and Development (OECD), for instance, account for almost 2/3 of worldwide daily oil consumption. In contrast, however, oil demand in the OECD grew by some 11 percent over the 1991-97 periods, while demand outside the OECD (excluding the Former Soviet Union) grew by 35 percent. The Former Soviet Union presents a special case. The collapse of the Russian economy that accompanied the collapse of Communism led to a decline in oil consumption of more than 50 percent over the 1991-98 periods. The developed economies use oil much more intensively than the developing economies. The United States and Canada stand almost alone in their consumption of oil per capita. For instance, oil consumption in the United States equals 10.8 liters per day per

capita. The difference is this country transportation sector, with its dependence on private vehicles to travel relatively long distances. Oil consumption in the rest of the OECD equals 5.3 liters per day per capita. Outside of the OECD, oil consumption equals 0.76 liters per day per capita. Table 2 shows consumption of oil per day per capita in the USA, European Union and some European Countries with the rank of those countries in total oil consumption per day among 213 world's countries.

Country	Oil Consumption per Day per Capita [Liters/Day/Capita]	Total Oil Consumption per Day [Liters/Day In Millions]	Rank in Total Oil Consumption per Day
USA	10.8	3288	1
European Union	4.6	2288	2
Germany	4.7	390	7
Croatia	3.6	16	76
Serbia and Montenegro	1.3	13.5	82
Slovenia	4.3	8.6	94
Bosnia and Herzegovina	1.1	4.4	111
Macedonia	1.7	3.4	119

Table 2: Oil Consumption (Source: Energy Statistics, Oil Consumption, Nation Master.com)

Regionally, the largest consuming area remains North America (dominated by the United States), followed by Asia (with Japan the largest consumer), Europe (where consumption is more evenly spread among the nations), and then the other regions. Asia was the region with the fastest demand growth until the 1998 economic crisis in East Asia. The region's economic upheaval is a central reason for the oil price collapse of 1998. The United States and Canada use oil more for transportation than for heat and power, but the opposite pattern holds for most of the rest of the world: most regions use more oil for heat and power than for transportation. As a result, global demand for oil is highest in the Northern Hemisphere's cold months. There is a swing of 3-4 million barrels per day (some 5 percent) between the 4th quarter of the year, when demand is highest, to the 3rd quarter, when it is lowest. Demand for crude oil is derived from the demand for the finished and intermediate products that can be made from it. In the short-term, however, demand for crude oil may be mismatched with the underlying demand for petroleum products. This misalignment occurs routinely as a result of stock changes: the need to build stocks to meet seasonal demand, for instance, or the desire to reduce stocks of crude oil for economic reasons. In the longer term, blending non-petroleum additives into petroleum products (such as ethanol or other oxygenating agents into gasoline) can also reduce crude oil demand relative to demand for finished products.

Greenhouse Gas Emission

Based on current GHG emission reporting guidelines, the transportation sector directly accounted for about 28 percent of total U.S. GHG emissions in 2006, making it the second largest source of GHG emissions, behind only electricity generation (33 percent). Nearly 97 percent of transportation GHG emissions came through direct combustion of fossil fuels, with the remainder due to carbon dioxide (CO₂) from electricity (for rail) and hydro-fluorocarbons (HFCs) emitted from vehicle air conditioners and refrigerated transport. Transportation is the largest end-use sector emitting CO₂, the most prevalent greenhouse gas. Estimates of GHG emissions do not include additional "lifecycle" emissions related to transportation, such as the extraction and refining of fuel and the manufacture of vehicles, which are also a significant source of domestic and international GHG emissions. Figure 1 shows Greenhouse Gas emission in the USA.

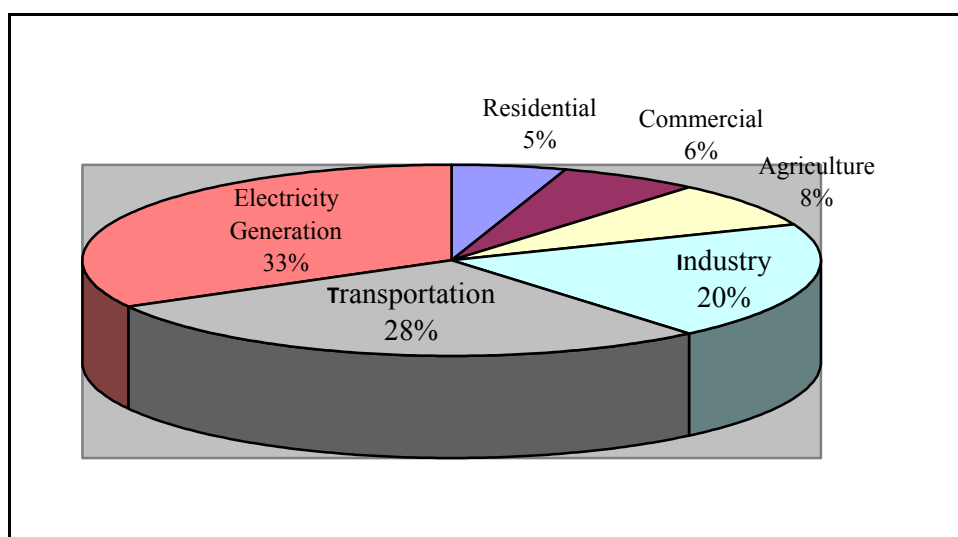


Figure 1: Greenhouse Gas Emissions in USA

Sustainable Transportation Practices and Strategies

A number of practices and strategies are being carried out in many countries in Europe and United States. Some of those practices which found to be effective are listed and described in the following paragraphs.

Land Use Strategies

The decisions related to land use have significant impact on transportation and vice versa. The number and purpose of trips generated by certain type of land use would influence size and spatial distribution of transportation infrastructure and different mode of transportation. The most beneficial land use strategy is people living close to work, shopping centers and basic services. Providing public transportation and space for walking and biking are the next best actions. Defining urban growth boundaries, minimum density development and comprehensive planning are effective land use strategies that reinforce sustainable transportation. The policy of the state, region or municipality should be development of transportation plan that implement the goals previously adopted by the state, region or municipality. The objective of this policy is to provide the needed level of mobility while minimize number of trips taken by automobile. It is anticipated that adequate transportation demand management would reduce greenhouse gas emissions in the USA by 6% by 2020 and 15 % by 2040. The land use strategies could be summarized in the following four practical development actions: compact development, mixed use development, higher development densities and transit, pedestrian, bike friendly development. Current transportation planning practices tend to favor road automobile-oriented investments and designs over alternatives. Transportation planning practices often evaluate transportation primarily in terms of vehicle movement, which skews decisions toward automobile improvements at the expense of other forms of access. Transportation professionals should shift their focus from only on level of service for motor vehicles or road users to the users of other travel modes. **Technology**

The new technologies offer many opportunities to improve efficiency of goods and passenger transportation and ability to access information. Application of Intelligent transportation systems in many areas of transportation field already brought significant benefits. The gas-electric hybrid vehicles are widely available on the market. Hybrid vehicles, which combine an internal combustion engine with a battery-powered motor, are significantly more fuel efficient than regular gasoline powered vehicles. For example the 2008 Toyota Prius hybrid has a combined city/highway fuel economy of 5.1 liter per 100 kilometers, while non-hybrid Toyota Corolla, which is comparable in size, is rated at 8.8 liters per 100 kilometers in city and 6.8 liters per 100 kilometers on highway. The ‘plug-in –hybrids’ are designed to operate mainly as limited range electric vehicles, with a small gasoline engine to extend range and recharge batteries if needed. They are expected to reach the fuel economy of 2.4 liters per 100 kilometers. The electricity consumed from the grid is not included in this measure. This technology is still several years from widespread deployment as the battery systems that operate the vehicles are extremely expensive and not yet sufficiently reliable for commercial use. An alternative fuel, most generally defined, is any fuel other than the traditional selections, gasoline and diesel, used to produce energy or power. The emissions impact and energy output provided by alternative fuels varies, depending on the fuel source. Examples of alternative fuels include biodiesel, ethanol, electricity, propane, compressed natural gas, and hydrogen.

Transportation Planning Strategy

While technological change is essential to reducing GHG emissions there is also a role for strategies that help to limit the growth in travel demand. Transportation planning strategies can be implemented through the transportation planning process and are usually initiated by transportation agencies. These include Travel Demand Management (TDM), transit investment, changes in land-use patterns and bicycle/pedestrian projects. The vehicle-kilometer traveled (VKT) has grown much faster than population growth for the past several decades, but appears to have slowed considerably in the past two years, perhaps in response to sharply rising fuel prices and global economic crisis. There are many factors that can affect the future growth rate of VKT. Among most important factors are economic trends and demographic forces, which are largely beyond the influence of government policies. Expanding transit services and other alternatives to single-occupant vehicle travel and encouraging land use that minimize the number and length of auto trips can significantly help to reduce GHG emission. An average private vehicle emission rate is about 0.3 kg of CO₂ per kilometer. An automobile driven by single person 20 kilometers round trip to work will emit 6 kg of CO₂. Thus, savings by using existing public transportation services would be about 6kg of CO₂ per day. Over the course of a year an individual could potentially reduce their CO₂ emissions by more than 1440 kg (assuming 240 days of transit travel per year). The possible opportunity to reduce growth in VKT is providing incentives and logistical support for telecommuting. Telecommuting, which has been doubled in the 1980-2000 period, is likely to be highly cost-effective strategy for reducing GHG emissions. A high level of motor vehicle travel is not sustainable. Therefore sustainable transportation requires mobility management (strategies that change travel behavior) to increase transportation system efficiency rather than just vehicle efficiency.

Transportation Systems Operations Strategies

Transportation systems operations strategies are designed to reduce vehicle delay, improve traffic flow, and avoid unnecessary emissions. These include incident management, traveler information, and freeway management. Traffic congestion contributes to GHG emissions because vehicle engines operate less efficiently and therefore produce higher emissions per kilometer when they are driven at low speeds in stop-and-go traffic. The optimal speed for motor vehicles with internal combustion engines is about 70 km/h. At lower speeds, CO₂ emissions per kilometer are several times higher than at 70 km/h. At higher speeds, CO₂ emissions per kilometer increase as well, but somewhat less sharply.

Pricing Strategies

The significant component of GHG emissions, as much as 22 percent, results from inefficient operation of motor vehicles. These inefficiencies could result from factors beyond the driver’s control, such as traffic congestion, and also could reflect a driver’s own behavior, such as high speed driving, vehicle maintenance, and tire pressures. The concept of road pricing has received increased attention primarily as a means of managing congestion and generating additional funding for transportation. If implemented on a broad scale road pricing system could change driver behavior. Driver education and other policies could help to promote more efficient vehicle operations, which would help reduce GHG emissions. Pricing strategies are recognized as efficient for congestion reduction. The methods vary from toll roads to peak period congestion pricing. Congestion pricing

charges the owner or operator of a motor vehicle a fee for using certain roadways during periods of high congestion. The way in which congestion pricing is implemented depends upon type of technology selected and the type of pricing preferred by policymakers. Increase fuel cost can help promote alternative modes of transportation and investments. Transportation Research Board (TRB) estimates that increasing fuel prices by a rate of 3 percent per year would result in a 20 percent in global warming by 2020 and 35 percent reduction by 2040. Also TRB estimates that a 1.5 percent annual increase in average new vehicle fuel efficiency would result in a 15 to 20 percent reduction in global warming by 2020 and 35 percent by 2040.^[1] Distance-based car insurance and distance-based car registration fees convert insurance and registration fees to a variable cost related to annual kilometers driven. This would reduce driving by about 9 percent and would reduce travel during peak hours motivated by consumer savings resulting from the lower, off-peak charges.

Education, Community and Consumers Involvement

The sustainability considerations are affecting people's travel patterns and involve changes in citizen behavior and community design. In order for sustainability to be effectively achieved, citizens need to be informed and educated. Transportation demand management involves educating individuals and communities about changing travel behavior, including shifts in travel time, route, mode and destination. An efficient market must provide consumers with a variety of options from which they can choose the combination of quantity, quality and price that best suits their needs. Consumers must also have accurate information about their options. Only with viable options can consumer decisions reflect their true preferences. The value of some types of consumer transportation options is widely recognized. For example, many people argue that competition in vehicle manufacturing, fuel production and distribution, and airline services tends to increase efficiency and service quality in these markets. However, there is less recognition of the importance of competition between modes. For example, transit service improvements can benefit both motorists and non-motorists if it allows some motorists to shift and therefore reduces congestion and dependency on petroleum producing monopolies. Improving other modes, such as walking, cycling and ridesharing, can have similar benefits, both to people who change modes, and so benefit directly from having diverse options to choose from, and those who benefit indirectly through reduced congestion and increased market competition.

Conclusions

Transportation is a core component of sustainable socioeconomic systems development. Planning for sustainability requires changing the way we think about transportation and solve its problems. Transportation is one of largest contributors of greenhouse gas emissions and a major contributor to global warming. A balance between economic, social and ecological objectives is necessary. Improving vehicle gas consumption efficiency and reducing number of trips by private automobile are two most beneficial actions. However, these actions require manufacturer innovations/supplier offerings and development of new, more efficient modes of transportation. Improved travel choices supported by pricing incentives, technological innovations, intelligent transportation system implementation and better integration of land use and transportation planning provide basic framework for sustainable transportation policy and actions. A high level of motor vehicle travel is not sustainable. Therefore, sustainable transportation requires mobility management (strategies that change travel behavior) to increase transportation system efficiency rather than just vehicle efficiency. Sustainable transportation indicators are an important tool for better transportation planning. It would be very desirable to develop standardized baseline indicators of transportation sustainability.

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