# SAVING OIL AND REDUCING $CO_2$ EMISSIONS IN TRANSPORT: OPTIONS AND STRATEGIES

**Lewis Fulton**

*International Energy Agency, Paris*

*Office of Energy Efficiency and Renewable Energy*

*Division of Energy Technology Policy*

***Abstract***: *Transport is the fastest-growing energy sector world-wide. This paper summarizes a new IEA book that examines the multiple policy approaches being taken by IEA Member countries to reduce transport-related carbon emissions. These include improving fuel economy in new cars and trucks, as well as reducing fuel consumption by vehicles already on the road. Also covered are the use of alternative fuel sources and ways to cut the growth in travel, such as by improving transit systems and using new technologies to reduce congestion. Finally, energy-saving options in freight transport are explored, including how to make trucks and trucking systems more efficient and how to move more goods by rail and water-borne transport.*

*In the book, more than twenty different approaches are developed, including some which have been neglected by most IEA countries. Five of the most promising options are summarized here. The study discusses the benefits and costs of each option, as well as obstacles it faces, and quantifies the effect of each in reducing oil use and $CO_2$ emissions. Success stories from IEA countries are presented, as well as some stories of failure.*

## Introduction

In the transportation sector, total energy use, oil use and emissions of carbon dioxide are closely linked. Petroleum fuels still account for more than 95% of energy use in transport in nearly every IEA country, and oil combustion is a major source of $CO_2$ emissions. Transport has become the dominant oil-consuming sector in most IEA countries; oil use in the sector has increased steadily over the past 30 years and now represents nearly two-thirds of total IEA oil consumption (Figure 1). Thus, the oil dependence problem is largely a transport problem.

Emissions of $CO_2$ from road transport increased more than in any other subsector between 1990 and 1999 (Figure 2), for several reasons. The distance traveled by passenger cars and other light passenger vehicles has steadily increased over the period in virtually all IEA countries. Further, the fuel economy of new light-duty vehicles did not improve in any IEA country between 1985 and 1995. (Since 1995 it has sharply

improved in European countries and Japan, but not in North America). Although the technical efficiency of light-duty vehicles has improved steadily over the last 20 years, consumer preferences for larger, heavier, and more powerful models have offset most of the efficiency gains, yielding little change in fuel economy. Because strong growth in travel is expected to continue in the future, the light-duty vehicle sector constitutes one of the biggest challenges for reducing oil use and reducing $CO_2$ emissions. Without new initiatives for the transport sector, we estimate that light-duty vehicle fuel consumption and $CO_2$ emissions in IEA Member countries will likely rise to 30% above 1990 levels by 2010.

**Figure 1 Trends in Total and Transport Oil Consumption in IEA Countries**

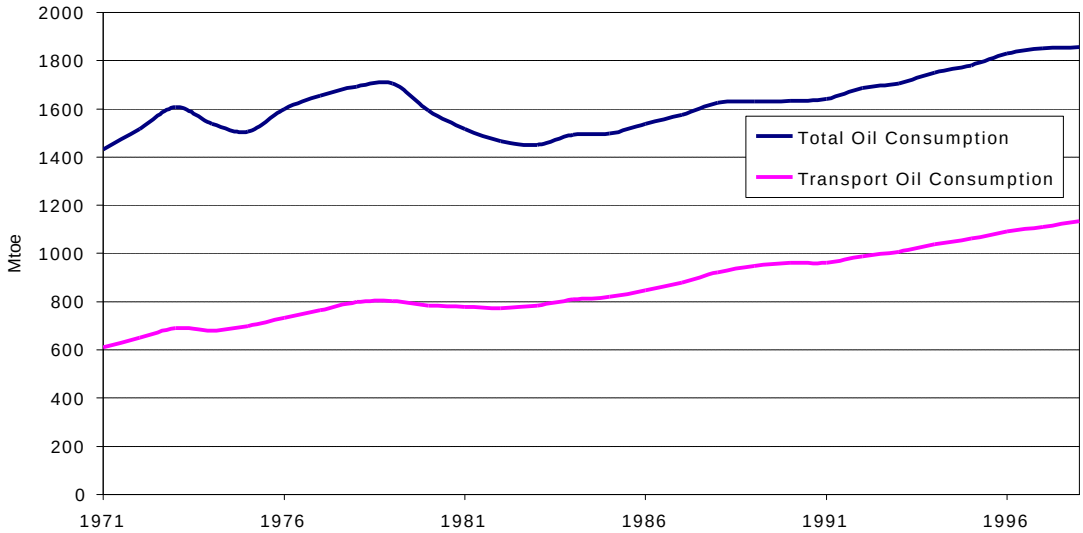
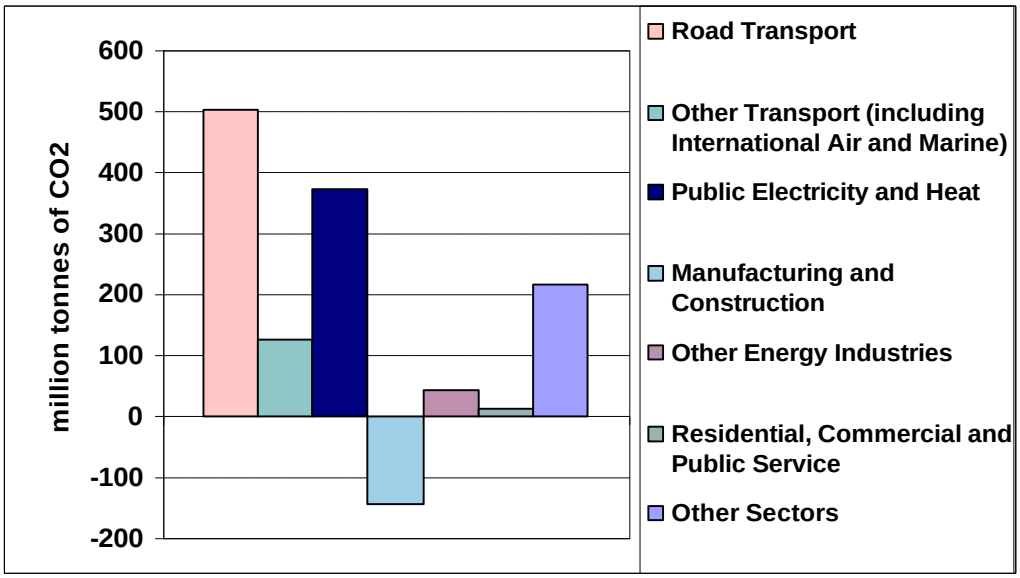
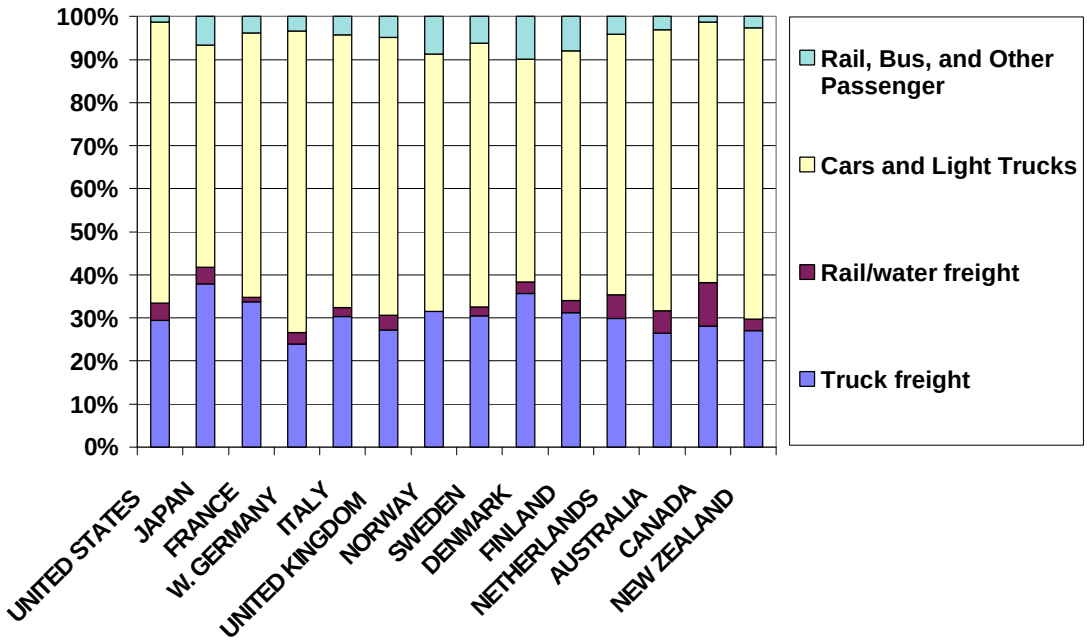



**Figure 2 Change in $CO_2$ Emissions by Sector in IEA Countries, 1990-1999**



This paper summarizes a new IEA book of the same name, that takes a fresh look at potential options and strategies for saving oil and reducing $CO_2$ emissions in transport. It addresses light-duty vehicle and other surface passenger and freight transport modes, with a particular emphasis on road transport, because it represents such a large share of energy use within the transportation sector -- up to 90% in some countries. (This study does not include air travel.) As Figure 3 shows, cars and passenger light trucks account for 50%-65% of transport energy use, freight trucks for 25%-40%, and rail, bus, and water-borne passenger and freight travel for less than 15%, among surface modes of transportation in IEA countries. Accordingly, a 10% decline in fuel use in light-duty vehicle passenger travel is equal to a 6%-7% reduction for the entire transportation sector in most countries; for freight it yields about a 3%-4% reduction and for a small subsector such as passenger or freight rail it results in less than a 1% reduction. Policies that target only the small subsectors must achieve dramatic reductions to cut energy use by more than a negligible amount. Therefore, this paper and the book focus on road transport and address water and rail transport only in terms of the energy-saving possibilities of shifting the movement of goods from truck to rail and water.

**Figure 3 Surface Transport Energy Use Shares by Mode and Purpose, 1995**




## Overview of Analysis

A variety of options and strategies for reducing oil consumption and emissions of $CO_2$ in surface transport are examined in the book, and a selection of the most promising options are presented here. For most sectors and policies, the study has drawn on a review of the literature and descriptions of existing policies in IEA Member countries. However, the IEA conducted a considerable amount of original analysis, especially in

determining the potential for and cost of reducing fuel consumption and $CO_2$ emissions as a result of technical improvements to light-duty vehicles. In addition, more than 20 specific options and strategies were developed, based on recent research and examples of best practices, that might be considered as ideas for future use. For each policy example, we calculate how much it could reduce fuel consumption and $CO_2$ emissions in a typical IEA country, and where possible, we estimate its cost or at least some elements of its cost.

This paper includes projections for light-duty vehicle fuel economy, but does not develop a full set of projections or policy scenarios for all the measures discussed in the different chapters. A more thorough set of projections was recently included in the IEA World Energy Outlook 2000 (IEA, 2000). These projections included a reference case and alternative case for transport showing the potential impacts of selected measures on reducing fuel use and $CO_2$ emissions through 2020. In contrast, this volume focuses on providing policy makers with information on the potential for employing a variety of different measures in tackling transport fuel use and $CO_2$ reductions. However, the estimates presented here are consistent with those used to develop the alternative case projection in the World Energy Outlook 2000.

Most of the options and strategies presented in the book are not radical. They make small changes in the movement of people and goods for modest improvements in fuel efficiency. If well-designed groups of these options are taken together, they could reduce fuel consumption and $CO_2$ emissions by a substantial amount by 2010. Individually, however, only a few are likely to yield reductions of more than a few percentage points. (We highlight those especially promising individual and groups of policies below.) Although most options will not be easy to implement, they are still worthwhile. Most of them can be developed in a manner that is politically acceptable in many countries, or at least not unacceptable. Many measures appear to be inexpensive, or even of negative cost, taking into account the fuel savings and other direct benefits they provide consumers.

One obstacle to reducing oil use and $CO_2$ emissions in transport is the unresponsiveness of vehicle travel to changes in the travel environment or to the costs of travel. Evidence from past research indicates that a 10% increase in fuel prices usually results in only a 1%-3% decline in travel. Many individuals have few choices about how and how much they travel, once they choose their location of residence and work. If they do have a choice, fuel costs may be a small factor in their decisions. Fuel costs are usually a low percentage of variable travel costs, which also include parking, tolls and vehicle maintenance. (Variable costs can also affect travel, perhaps of a similar magnitude as changes to fuel costs.) Increases in fuel costs, however, may encourage the purchase of vehicles with better fuel economy or, possibly, switching to alternative fuel vehicles that can run on a less expensive fuel. Therefore, fuel consumption and emissions of $CO_2$ may be more responsive than travel to changes in fuel prices. We consider all of these factors in estimating the effect of the policy options on oil consumption and $CO_2$ emissions.

IEA's estimates of these effects and the costs of implementing the policy options are subject to considerable uncertainty. We do not attempt to estimate the full cost per ton for $CO_2$ reductions; instead we identify the types of costs and benefits of each policy. Cost components that are well known or easily calculated, such as for some technologies and for the value of fuel savings, are estimated. We point out cases where the fuel savings alone appear large enough to offset the direct costs of a measure. But such a comparison is incomplete, since almost all transport policies have important societal effects that are difficult to quantify: on safety, traffic congestion, travel time, emissions of air pollutants, and even on lifestyle. Estimating all of these effects, which vary from location to location, and country to country, has proven difficult and is the subject of debate and on-going research. Without taking them into account, however, any specific estimate of the cost of reducing fuel use and $CO_2$ emissions may be misleading. Conversely, since governments often implement transport policies primarily to have effects other than on oil use or $CO_2$ emissions (e.g., congestion reduction, economic development, air quality improvements), it is all the more important to quantify the potential impacts of such measures on fuel use and $CO_2$, since these impacts can be important.

The options and strategies are developed with national governments in mind, but recognize that many transport initiatives are best undertaken by regional or local governments. This is particularly true for the policies that aim to modify the patterns of urban passenger travel, for example through roadway design, provision of transit services, and support for non-motorized modes of transport like bicycles. For those options, we identify approaches that national governments can take to encourage action at a local or regional level. The IEA also takes the somewhat unconventional approach of avoiding discussion of one of the key energy-saving measures traditionally implemented by national governments in the transport sector: fuel taxes. This paper seeks to offer alternatives that can complement or substitute for fuel taxes, which are increasingly unpopular.

## Highlights: Promising Strategies

Of the strategies and options presented in the book, most offer modest oil and $CO_2$ reductions when implemented alone, typically in the range of 1% to 3%. A few offer bigger reductions. However, when properly combined, it is not difficult to construct a package of measures that can result in savings of 10% or more. This section reviews several of the most promising individual measures, and the next section covers how individual measures may be combined to best advantage.

**Improving Fuel Economy Through Technical Changes:** Much cost-effective technology exists that can be deployed on light-duty vehicles to improve fuel economy. This appears to be one of the few individual measures that can achieve large reductions in oil use and $CO_2$ emissions by 2010, and at potentially very low cost. IEA analysis

finds that these available cost-effective technologies could reduce average fuel consumption for new cars as much as 25%-30% by 2010 in most countries (compared to what it may be without new technologies) and probably by at least 20% in every country, even those with relatively low fuel prices such as the United States. A new book by the US National Research Council (NRC 2001) estimates a similar cost-effective potential improvement for the US. We estimate that by 2020, use of cost-effective technology plus aggressive adoption of advanced propulsion technologies such as hybrid-electric and fuel cell systems could reduce new car fuel consumption by more than 40%. Fuel economy for the total stock of light-duty vehicles would improve more slowly, as it is replenished by the new, higher efficiency models. By 2020, stock average fuel consumption and $CO_2$ emissions could be cut by up to 30%, and by more than 40% by 2030. Greater use of diesels could contribute yet another 5%-15% reduction in fuel use, especially in North America where the current diesel market share is quite low.

Policy intervention is needed, however, to encourage deployment of new technology at a maximum rate, and to ensure that its fuel savings are not lost through sales of larger, heavier, and more powerful vehicles – a fuel-hungry trend in most IEA countries over the past 15 years. Measures that can curb this trend include vehicle purchase fees, rebates, and other incentives based on fuel economy or the presence of particular advanced technologies. Even a modest fee would send strong price signals to both consumers and vehicle producers, predisposing them toward higher efficiency vehicles. Countries with vehicle purchase fees based on added value could replace some or all of this fee to one linked to fuel economy, rendering a new fee unnecessary.

**Promoting On-board Technologies that Improve Fuel Economy:** These technologies include diagnostic equipment that can identify and report vehicle problems to drivers, information systems that can assist drivers in maximizing fuel economy, and automated systems that can improve fuel economy by controlling certain vehicle functions. Advanced cruise-control systems can reduce fuel use and increase safety, not only by maintaining steady speeds but also through smoother acceleration and deceleration. Other technologies such as econometers, which report rates of fuel consumption to the driver in real time, send signals about which driving behaviors yield fuel savings. If governments require the technology or provide financial incentives to consumers, and car companies increase the availability of on-board devices, fuel consumption and emissions of $CO_2$ for light-duty vehicles could decline 3%-5% by 2010. The costs of these devices are likely to be more than offset by their fuel savings. The Netherlands has taken the lead in this area by offering financial incentives to manufacturers and consumers to add certain information systems to vehicles.

**Toll Rings and High Occupancy/Toll Lanes:** While most economists strongly support roadway pricing to efficiently reduce traffic congestion, most communities that have considered it have rejected this option. Drivers are not yet convinced of the benefits of tolls while the costs are all too apparent. Some innovative toll systems, however, may be more politically acceptable. These include toll rings and high occupancy/toll (HOT)

lanes. Toll rings are sets of tollways placed around a city periphery that charge for access to the center. They are an example of cordon pricing – charging for vehicle movement between different zones. The charge for access within the toll ring compels drivers to consider travel options other than single-occupant vehicles. The country with the most toll rings, Norway, has shown that they can be implemented in a manner acceptable to the public. Clearly linking revenue from toll rings to improvements to the transportation infrastructure and transit service can strongly increase public acceptance.

Although most analyses of road pricing and toll rings have not looked at their effects on fuel use or emissions, a European Commission modeling study found that cordon pricing systems for Athens and Lyon could result in a 14% decline in car travel and an 8%-10% decrease in $CO_2$ emissions. The IEA estimates that If governments adopt an incentive for all major metropolitan areas to implement cordon-pricing systems, they could reduce fuel consumption and emissions of $CO_2$ for light-duty vehicles nation-wide 3%- 6% by 2010.

High Occupancy/Toll lanes, or HOT lanes, have become popular in some parts of the United States to increase travel options for commuters and collect tolls on existing highways. So far, HOT systems have been created by adding electronic tolling to High Occupancy Vehicles (HOV) lanes, which are restricted to vehicles with at least two or three passengers. By paying a toll, low-occupancy vehicles gain access to the corridor. Adding tolling has not only increased the use of previously underutilized HOV roadways, but also more importantly has created a public sense that drivers can buy their way out of traffic congestion. Eventually, as the public becomes familiar with HOT lanes, adding tolls to other existing highways may become politically possible. Converting HOV to HOT lanes, or creating new HOT lanes, might not reduce $CO_2$ emissions immediately since they essentially increase roadway capacity and could reduce vehicle occupancy. Rather, conversion of HOV into HOT lanes could represent an important step towards building public acceptance of electronic tolling and roadway pricing in general.

**A National Parking Tax and Cash-out:** The availability and cost of parking are major factors in individuals' decisions to drive or choose another mode of travel. A change from free to priced parking, even a low price such as USD 1.00 per hour, adds more to the cost of many trips than big increases in fuel cost, and encourages a reduction in vehicle trips. Thus, parking pricing can be a powerful tool. Measures that restrict the amount of parking or that increase fines and enforcement also send strong signals to drivers. Parking measures receive strong public support in many cities, especially in places where parking revenue is earmarked for local community projects such as beautification. In some countries such as the United States, where free parking is abundant, pricing it may be politically and logistically difficult. One promising option is to encourage employers to offer employees the choice between free parking and a cash subsidy for other modes of commuting travel. By "cashing out" their free parking spaces, employees can save money and commute by other means such as carpooling or bicycling. In California, firms with cash-out programs measurably reduced car travel

and emissions of $CO_2$. A cash-out policy or increased parking fees could minimize the number of parking spaces needed in new buildings, which could increase land-use density and in turn also reduce travel. A national parking tax of USD 1.00 per hour (USD 3.00 maximum per day), combined with support for parking cash-out programs, could yield reductions in travel, fuel use and $CO_2$ emissions for light-duty vehicles of 4%-7% by 2010. This reduction might increase over time as people, businesses and localities factor the tax into decisions about location and land use.

**Low Greenhouse Gas Alcohol Fuels:** Chapter 5 shows that while a variety of alternative fuels could substitute for petroleum, relatively few also promise large reductions in greenhouse-gas emissions – aside from alcohol from cellulosic crops. Since they can run in conventional vehicles, alcohol fuels have other important advantages: they do not require major investments in new types of vehicles or in a new system of fuel stations. They can be blended with gasoline up to 15%-20% by volume and used in current vehicles, and can be distributed through the existing refueling system. Alcohol from cellulosic feedstocks – in contrast to most of today's alcohol fuel, produced from starchy crops – can take advantage of low-energy growing and conversion processes that substantially reduce its "full fuel cycle" greenhouse gas emissions, up to 90% lower than gasoline. The primary disadvantages are the vast amounts of land required for growing the crops, and the high price of growing and converting the crops to alcohol. In recent years, however, yields per acre have increased and costs have fallen, and research continues in these areas in IEA countries. While these fuels may never replace petroleum fuels completely, they could eventually replace up to 10% in some countries and thereby reduce $CO_2$ emissions by up to nearly 10% -- a larger reduction than for many other options. Alcohol probably can displace only a few percent of gasoline by 2010 in most IEA countries, but at least 5% by 2020 in many countries. For light-duty vehicles, this would yield a 3%-4% reduction in $CO_2$ emissions.

**Telematic Systems for Freight:** The increased availability of computer systems for more efficiently managing trucking and local freight delivery are creating new opportunities for saving fuel. These same technologies, however, have also allowed for "just-in-time" methods of inventory that have also led to increases in truck travel. To counteract that, trucking firms are just beginning to take advantage of scheduling and routing software to combine deliveries and reduce empty truck ("backhaul") travel.

Governments can help improve logistics systems for urban areas by encouraging, or directly investing in, advanced driver and network information systems, co-operative freight transport systems, and public logistics terminals. While national governments do not usually make direct investments in urban infrastructure, they often provide funding for important projects. It makes sense to fund and co-ordinate improvements in urban logistics nationally, in part to ensure that systems are compatible throughout a country.

Estimating the fuel savings resulting from better logistics management is difficult. If a strategy is developed that increases average truck load factors by 10% in major urban

areas, however, then average fuel use for freight trucks would decline 2%-3%. This can usually be achieved at a low or negative cost, since it comes nearly entirely from increased operating efficiency in the freight sector.

## Developing Policy Packages

A key aspect to developing effective fuel saving, $CO_2$ reduction transport policies is to integrate individual policies and measures into packages that benefit from a "synergistic" interaction among the components. It is also important to avoid implementing policies that work at cross purposes and negate the benefits of other policy elements.

Three types of promising policy packages are presented in Table 1. The basic approaches are: a) a focus on private vehicle travel reductions (and increased uses of transit and non-motorized travel modes), b) increased vehicle efficiency and use of non-petroleum and/or low-carbon fuels, and c) a combination of the first two that selects policies from each group that work well together. The policies mentioned in the table for each group serve to reinforce each other and in some cases provide synergistic benefits, with the net impacts adding up to more than the sum of the impacts of individual policies within the set.

As the table shows, one major difference between the three groups is the type of impact they have: policies to improve vehicle fuel economy will tend to increase travel levels (by lowering the cost of driving) and therefore, as a group, generally work in a different direction than policies that are directly targeted toward vehicle travel reductions. Further, policies that effectively increase roadway capacity or improve traffic flow may "induce" increased travel. However, it may be possible to eliminate the mixed signal by using pricing to maintain travel costs. For example, increases in fuel prices can be used to maintain the cost of driving in the case of increased vehicle efficiency, and increased fuel or roadway prices can be used to maintain the cost of travel in the case of traffic flow improvements or capacity expansion.

Estimating the impacts of specific packages is difficult and is for the most part outside the quantitative scope of the book, but one example policy including several travel reduction measures is provided in Chapter 3. This package, including transit improvements, parking restrictions and increased prices, and promotion of walking and bicycling, could provide up to a 16% reduction in light-duty vehicle fuel use and $CO_2$ emissions by 2010. A package of policies that adds significant amounts of low greenhouse-gas alternative fuel (such as cellulosic ethanol) to the fuel economy improvement measures mentioned above could reduce oil use and $CO_2$ emissions by over 30% by 2010. A well designed (and aggressive) combination of travel reduction and fuel economy improvement packages could therefore yield reductions on the order of fifty percent.

**Table 1 Grouping Policies for Reinforcing Effects: Three Possible Packages**

| Vehicle Travel Reduction | Reducing Vehicle Fuel Use / $CO_2$ Emissions | Mixed Approach |
|---|---|---|
| Policies that reduce vehicle travel demand and provide alternatives to vehicle travel, including:<br>• Pricing of vehicles, fuels, and roadway usage to discourage vehicle ownership and driving<br>• Land use changes and related measures that promote transit and non-motorized travel<br>• Improvements in transit service and incentives for increased transit ridership<br>• Provision of alternatives to driving through telematic measures such as incentives for telecommuting and teleshopping. | • Increased new car and light-truck vehicle efficiency through technical measures, including greater adoption of near-term and "next-generation" technologies<br>• Encouraging consumer purchases of the most efficient vehicles available and discouraging purchases of ever-larger, more powerful vehicles<br>• Optimizing on-road efficiency through capacity enhancements, traffic flow improvements, vehicle maintenance and driver education.<br>• Promoting alternative fuels that reduce oil use, increase overall energy efficiency, and reduce $CO_2$ (and other GHG) emissions. | Elements of the first two approaches that are complementary, i.e. measures that encourage both decreased personal vehicle travel and increased efficiency of travel. The mixed approach should also include:<br>• Fuel pricing increases that offset reduced cost-per-kilometre of travel from efficiency improvements. Differential price increases by fuel type can be used to simultaneously encourage selected alternative fuels.<br>• Avoiding roadway capacity enhancements, traffic flow improvements, and related measures that encourage more vehicle travel (the "induced demand" effect) |
| **Advantages:** Lower vehicle travel will reduce $CO_2$ as well as pollutant emissions, lower societal costs associated with vehicles (accidents, traffic law enforcement, etc.). Many argue that such an approach provides other societal benefits in terms of "livability" from communities less dominated by cars and roadway infrastructure. | **Advantages:** Relatively large reductions in fuel use and $CO_2$ emissions are possible from small increases in new vehicle and on-road fuel economy. Such reductions are often inexpensive since fuel savings offset much or all of the cost of the vehicle improvements. | **Advantages:** takes many of the best elements of first two approaches. Maximizes the synergistic and reinforcing impacts by removing the elements that run at cross purposes, or by building in elements to prevent this from occurring. |
| **Disadvantages:** Aggressive policies are needed to achieve significant reductions in travel. Travel responsiveness to price increases and other anti-car policies is quite low. Land use measures may take a long time to have an impact. Important opportunities for fuel savings and $CO_2$ emission reductions from vehicle efficiency improvements may be missed. | **Disadvantages:** Some technologies may require long lead-times to penetrate the market (e.g. fuel cells). All measures that improve fuel economy reduce the cost of travel and are likely to yield some "rebound effect", i.e. higher travel levels. Measures to increase capacity or traffic flow may also trigger more travel that could wipe out much of the energy savings / $CO_2$ benefit. | **Disadvantages:** May be difficult to implement a comprehensive package – transport policy is typically implemented in bits and pieces. |