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Economic Cooperation

Survey 2.0 of Policies and Programs that Promote Fuel-Efficient Transport in APEC Economies

The Alliance to Save Energy

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– Judith Barry
– Angela Morin-Allen

Abbreviations and Units

APEC	Asia Pacific Economic Cooperative
APU	auxiliary power unit
BRT	bus rapid transit
Btu	British thermal unit
CAFE	Corporate Average Fuel Economy
CBD	central business district
CNG	compressed natural gas
CO_2	carbon dioxide
CO	carbon monoxide
cc	cubic centimeters
ERP	electronic road pricing
EU	European Union
GDP	gross domestic product
GHG	greenhouse gas
HC	unburned hydrocarbons
HOV	high occupancy vehicle
ITS	intelligent transport system
L	liter
LPG	liquefied petroleum gas
km	kilometers
mpg	miles per gallon
NO_x	nitrogen oxides
psi	pounds per square inch
rpm	revolutions per minute
TOD	transit-oriented design/development
U.K.	United Kingdom
U.S.	United States
VKT	vehicle-kilometer traveled

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Executive Summary

This survey explores the range of policies and programs available to public sector decision makers to maximize the efficiency of the transportation sector in their jurisdictions. For purposes of this discussion, transportation energy efficiency encompasses approaches that either reduce the amount of fossil fuels used per vehicle-kilometer traveled (VKT) by road or rail, or which reduce the overall vehicle-kilometers traveled.[1] Since countless volumes have been written on these topics, it is the intent of this survey to distill the large amount of information into concise summaries that provide APEC policymakers and decision makers with an understanding of the range of proven options for improving transport efficiency. The authors summarize about 50 examples[2] of policies and programs undertaken by APEC economies to improve transportation energy efficiency.

Strategies for optimizing transport energy efficiency fall into two broad categories: those focused on vehicles, and those that address urban systems and transportation infrastructure. The latter include mass transit, toll pricing for road use and parking to discourage the use of single-occupancy vehicles in central business districts, and land use and zoning decisions that locate mixed uses at higher densities to help reduce the need to travel. A third category, taxes and pricing of gasoline and diesel fuel, can influence both the efficiency of vehicles (through buyer purchase decisions) and the use of vehicles. Examples of these proven approaches to transportation energy efficiency are summarized below in Figure 1.

Increasing Fuel Economy of New Vehicles

With regard to new vehicles, one of the most common policy instruments for improving fuel efficiency, and arguably the most effective option for central governments, is through fuel economy standards imposed on vehicle manufacture or sale. Apart from the European Union, all economies in the world with fuel economy standards are members of APEC: Australia, Canada, China, Japan, Korea, Chinese Taipei and the United States, while New Zealand has a fuel economy labelling scheme for new and used vehicles. With the exception of Australia, the standards are either already mandatory or—in the case of Canada and the EU—in the process of becoming mandatory.

Automobile manufacturers have a range of technological approaches – backed in several cases by government-sponsored research and development – for meeting increasingly rigorous standards, including hybrid-electric drive trains, stop-start technology that automatically shuts off the engine when the vehicle comes to a standstill, transmissions with more speeds and wider gear ratios, reduced weight through lighter materials, reduced drag through improved aerodynamic design of the body, low friction lubricating oil, and low rolling resistance tires. The improvements in

[1] This APEC survey addresses only surface transportation, not transportation by air or water modes. In only a few cases, where data are available, the opportunity to shift among modes (for example from road to rail for freight) is discussed. This survey does not examine shifts in fuels used for transport, which is the subject of a separate APEC study by the APEC Biofuels Task Force.

[2] The authors have endeavored to be as comprehensive as possible in showing the breadth and depth of proven policies and programs to improve energy efficiency in transportation in all APEC economies. It was not the authors' intention to attempt to catalog every example of each type of policy and program. Some relevant programs in APEC economies might not have been mentioned in order to avoid duplication or because information about such policies was not available to the authors. The authors welcome additional information from readers about examples of innovative programs that might not have made it into this survey.

efficiency due to hybridization vary greatly depending on the specific vehicle, but they are in the range of 25% to 50% over corresponding non-hybrid models.

In some cases, governments can also remove inefficient vehicles from the road through tailpipe emissions standards. This situation applies to two-stroke engines such as the three-wheelers used as taxis in many developing economies, and to motorcycles. Four-stroke engines are more fuel-efficient and less polluting than two-stroke, and so threshold emission standards can be set that are not practically feasible for two-stroke engines powered by gasoline or diesel. Emissions standards for greenhouse gas emissions can also improve fuel economy while reducing pollution that causes climate change.

Encouraging Purchase of Fuel-Efficient Vehicles

In countries that manufacture large numbers of vehicles, a common way for policymakers to increase the purchase of efficient vehicles is through a system that rates and labels vehicles according to their fuel efficiency. Labels and ratings are excellent tools for helping consumers make more fuel-efficient choices, and they could usefully be applied in all economies regardless of whether most vehicles are manufactured domestically or imported. New Zealand—which imports 100% of its vehicles—recently developed a labeling and rating system that converts the different standards used by different economies into a single efficiency rating on a scale from one to six stars. The system is applied to used vehicles as well as new, and can provide a useful example for other APEC economies.

Another common approach is to use taxes to encourage the purchase of efficient vehicles and discourage the purchase of inefficient ones. Such "green levies" or "feebates" are used in several APEC economies. The "feebate" approach provides buyers of efficient vehicles with a rebate, and imposes a surcharge or tax on the purchase of fuel inefficient vehicles, whereby the surcharge funds the rebate. Governments can also mandate requirements regarding the purchase, maintenance and operation of their own vehicle fleets, which is not only readily implemented since they have direct control over these fleet vehicles, but can help drive the market for efficient vehicles.

Awareness campaigns can help influence purchasing decisions by making vehicle buyers more conscious of the costs associated with operating a vehicle, and by calling attention to vehicle labels in economies where they exist. Campaigns also inform drivers about ways they can improve fuel economy through certain driving habits and vehicle maintenance.

Improving Operational Efficiency of Existing Vehicles

While fuel economy regulations combined with efficient technologies ensure that newly manufactured vehicles are more efficient, the efficiency of vehicles erodes over time if they are not properly maintained. At some point, the technology of older vehicles also becomes so dated that maintenance cannot cost-effectively keep them running cleanly and efficiently, and they should be removed from use altogether. This removal, called scrappage or accelerated retirement, may be voluntary or mandatory, and it may be triggered by failure to pass an emission inspection, or by the vehicle's age and level of use. Generally more efficient vehicles have lower emissions, but it is important that the new technologies optimize increases in fuel economy with decreases in emissions. An accelerated retirement program cannot be effective in the absence of a properly enforced, mandatory vehicle inspection program that maintains efficiency and, in many cases, also controls emissions over the life of the vehicle. Quite a few APEC economies have a mandatory annual vehicle inspection program, but the main challenge is to design it in such a way that certifications cannot be obtained fraudulently. The Mexico City example described in Chapter 3 provides

valuable lessons for other economies: prevent fraud by using regularly audited testing protocols and by keeping testing separate from repairs; measure emissions of nitrogen oxides (NO_x) using dynamometer testing to prevent vehicles from falsely passing the test, and use equivalent protocols and equipment of comparable quality in testing centers in overlapping jurisdictions.

Reducing Congestion

Traffic congestion increases fuel consumption through delays that keep motor vehicles on the road longer per VKT, and through the fuel inefficiency of stop and go driving. Reducing congestion encompasses a wide range of approaches that reduce the volume of vehicles on those roads prone to congestion, and that improve the flow of traffic to reduce or eliminate stop and go traffic. Some measures to reduce congestion – especially adding road capacity or allowing single-occupancy hybrids in restricted lanes – may *increase* total vehicle use and VKT, so it is important that policymakers consider the possible impact of increased VKT when choosing among approaches to reduce congestion. Strategies for reducing congestion often focus on encouraging workers to commute to work by means other than by solo driving, or at least to do less solo driving, and they can be divided into two broad categories. One targets the roads themselves with regulations or traffic management techniques such as high occupancy vehicle (HOV) lanes, tolls to discourage the use of roads during peak traffic times, and lane restrictions that optimize flow on surface roads in congested areas. The other category of intervention is to provide commuters with options that make it easier for them to reduce or eliminate their motor vehicle commuting, such as allowing employees to work from home full or part time (telework), providing employees with transit passes in lieu of a parking space, and car sharing programs that relieve urban dwellers from the need for vehicle ownership.

Boosting Efficiency and Use of Mass Transit

Motor vehicles are already overwhelming roads in urban areas in many APEC economies, and as these areas continue to grow throughout the 21st century they will be utterly incapable of handling the ever increasing travel demand. Mass transit is a critical component to any comprehensive approach to improving the fuel efficiency of surface transportation, and it often forms the backbone of that approach. Since fixed-rail mass transit lines often spur high density growth along them, mass transit is also a useful planning tool to direct economic growth and density to those areas where they make the most sense or where they are most needed. Japan, for example, strategically built its Tsukuba Express Line from Tokyo through undeveloped areas with the vision of having the line form the backbone of future urban development in these areas. Bus systems are an effective and affordable option, especially bus rapid transit (BRT) systems that provide higher quality service than regular bus service. However, bus lines – because they do offer flexibility to accommodate changing needs – may not have the same effect on shaping urban development and densities. Many cities throughout the APEC region rely on a combination of buses and urban rail (light and/or heavy), and sometimes vans.

Urban Design and Planning to Reduce Vehicular Transport

Smart, transit-oriented development harmonizes transportation energy efficiency goals with the zoning, permitting and regulations issued to developers. For example, in areas well served with mass transit, carefully crafted zoning laws can create high-density, mixed-use zones that combine business and housing, making it easy for people to walk or bike to work and to commercial amenities such as shopping and restaurants. Pedestrian and bicycle paths can be strategically located to facilitate non-motorized transport between home, work, shopping and dining. The powerful leverage available in parking can be exploited by restricting parking spaces in areas where the use of mass transit, biking and walking are practical options. Smart growth planning not only

improves transportation energy efficiency and reduces pollution and greenhouse gas emissions; it can also spur economic development and improve the quality of urban life.

Efficient Freight

The freight sector is a significant consumer of energy, and one in which the potential energy efficiency gains remain mostly untapped in APEC economies, although there are some encouraging examples of improvements. Fuel use can be reduced by about 25% from long-haul trucking operations through improvements in aerodynamics, tires, auxiliary power units that minimize engine idling, engine and drive train technologies, weight reduction, driver training, modal shifts (for example from roads to rail and sea in Japan), and freight logistics (for example, reducing empty return-trips). Government policies can help freight carriers take advantage of these opportunities through regulations, incentives or voluntary programs. Some firms are taking measures on their own due to rising fuel costs. For short distance city deliveries, for example, Coca-Cola in New York City found that hybrid-electric trucks are cost-effective in situations where the truck's internal combustion engine is rarely needed at the low speeds characterizing deliveries in urban areas.

Conclusions

A message delivered by many of the APEC examples described here is the need for a comprehensive approach that considers the interaction among policy measures. For example, a scrappage program to remove old, inefficient vehicles from the road cannot be effective without a well functioning emissions inspection program that is free of corruption. Smart growth design and planning is by definition comprehensive, starting with a vision for a better approach to urban living and then designing the transportation infrastructure to support that vision. In all APEC economies, regardless of their level of economic development, transportation energy efficiency policies need to address the realities of those with low incomes and the trends toward increased driving as incomes rise. Policies that will have the best results are those that improve access to cleaner, more sustainable and fuel-efficient mobility options, and that influence travelers to choose the more energy-efficient option available to them. In all approaches to improve transportation efficiency, it is vital that the public be made aware of the rationale for the policies and programs, and their benefits.

The many examples highlighted in this study demonstrate that economies throughout the Asia-Pacific region are taking constructive measures to optimize the efficiency of transportation. Many of these measures, especially those targeting vehicle efficiency and mass transit, span economies in varying levels of economic development. Implementation of other measures, most notably employee incentives to reduce single occupancy vehicles, congestion pricing, car-sharing programs, smart growth, and efficient freight systems, has so far only been documented in the most developed economies, but these measures are also within reach of less developed economies. Congestion pricing generates revenues that can be used to improve transportation systems and provide assistance to the poor. Smart growth planning and efficient freight necessarily involve the private sector and their resources, and car sharing programs are being run profitably around the world by the private sector. It is the authors' objective that the information provided by this *Survey of Policies and Programs in APEC Economies* will provide the knowledge of practical strategies being implemented by others in the region to inspire all APEC economies to adopt proven strategies for promoting energy efficiency in surface transport.

Figure i. Examples of Sustainable Road Transport Policies and Programs Highlighted in this Survey

APPROACHES	Australia	Brunei Darussalam	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papau New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	United States	Viet Nam
Vehicle Fuel Economy Standards	•		•		•			•	•			•						•		•	
Labelling Vehicles for Fuel Efficiency	•		•		•			•				•					•			•	
Incentives to Purchase Efficient Vehicles			•		•	•		•										•		•	
Emissions Standards & Inspections	•		•	•	•	•	•			•	•			•	•		•	•	•	•	•
Vehicle Retirement or Scrappage			•		•	•								•							
Government Fleets (efficiency in)			•												•					•	
Awareness Campaigns			•					•	•						•					•	
Efficent Vehicle Technology (R&D)			•		•			•												•	
Congestion Pricing			•						•								•	•		•	
Maximizing Flow in Highway Lanes																		•		•	
Car Sharing	•							•									•				
Employee Incentives to Reduce SOVs			•																		
Bus Rapid Transit	•		•	•	•		•	•			•	•		•	•			•	•	•	•
Light Rail			•	•	•			•	•						•			•	•	•	
Smart Growth and TOD			•									•						•		•	
Efficient Freight Initiatives			•					•				•								•	
Retail Gasoline (premium grade) Prices (US$/L)*	0.93	0.34	0.84	1.09	0.69	1.69	0.57	1.08	1.65	0.53	0.74	0.98	0.94	1.22	0.76	0.77	0.92	0.83	0.70	0.63	0.67
Retail Diesel Prices (US$/L)	0.94	0.21	0.78	0.86	0.61	1.06	0.44	0.9	1.33	0.4	0.52	0.7	0.64	0.86	0.67	0.66	0.63	0.71	0.65	0.69	0.53

* Average prices from November 2006.

1. Increasing Fuel Economy of New Vehicles

Transportation has a fundamental relation to many of the pressing challenges facing the APEC economies—including health, national security, the environment and prosperity—a topic that has been discussed at length in numerous publications.[3] Although APEC consists of onlyonly 21economies, the region is home to a large portion of the world's people: over half of the world's most populous 100 cities are in the APEC region with urbanization and demand for mobilization still on the rise in developing economies.[4] Not only does the APEC region represent a significant portion of the world's new and existing vehicle stock, but the region also *produces* many of the world's vehicles, placing it in a position to profoundly affect the efficiency of the world's vehicles in the future. Apart from the EU-27, which leads global vehicle production with 18.6 million in 2006, the next four largest vehicle manufacturing economies are Japan, the United States, China and Korea. These four economies make up almost half of the world's production of motor vehicles, and 62% of the world's vehicles originate from the APEC economies (Figure 1).[5] The main approaches to improving fuel economy of new vehicles are fuel economy standards, emissions standards and development of efficiency vehicle technology.

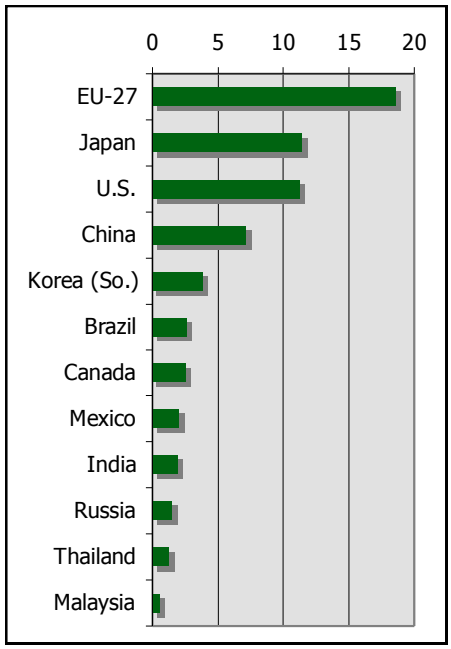


Figure 1. Vehicle production in top ten APEC producers, plus the EU-27 and Brazil (2006, millions). *(Source: ref. 6)*

Table 1. Overall average fuel economy for new vehicle fleets.

Economy	Miles per gallon (year)
Japan	37.9 (2004)
Korea	30.8 (2007)
China	28.4 (2006)
Canada	25.4 (2004)
U.S.	24.7 (2004)

Fuel Economy Standards for New Vehicles

The most universal policy instrument for improving the fuel efficiency of new vehicles, and arguably the most effective option at the level of central government, is through specific fuel economy standards imposed on vehicle manufacturers. Apart from the European Union, all economies in the world having fuel economy standards are members of APEC: Australia, Canada, China, Japan, Korea, New Zealand, Chinese Taipei and the United States. With the

[3] See for example: "Bellagio Memorandum on Motor Vehicle Policy Principles for Vehicles and Fuels in Response to Global Environmental and Health Imperatives: Consensus Document", June 2001, Energy Foundation (www.theicct.org/documents/bellagio_english.pdf); and "Urban Transport Energy Use in the APEC Region: Trends and Options", Asia Pacific Energy Research Centre, 2007 (www.ieej.or.jp/aperc/2007pdf/2007_Reports/APERC_2007_Urban_Transport.pdf).

[4] "The Principal Agglomerations of the World", Th. Brinkhoff, data as of 2007-09-30 (http://www.citypopulation.de).

[5] World Motor Vehicle Production by Country, International Organization of Motor Vehicle Manufacturers, http://oica.net/wp-content/uploads/2007/06/worldprod_country-revised.pdf.

exception of Australia, the standards in all of these economies are either already mandatory or—in the case of Canada and the EU—in the process of becoming mandatory.

One way of comparing the fuel efficiency of vehicles in different economies is through the overall average fuel economy for the entire fleet of vehicles manufactured in a given year, shown in Table 1 for five APEC economies. Looking at the overall fleet is useful because it represents the fuel efficiency of what was actually manufactured and sold, which can be more informative than a set of different standards for different classes of vehicles (e.g. passenger cars, light duty trucks, and heavy duty vehicles), especially since the classifications vary among economies.

Figure 2[6] looks at the situation differently, charting current and projected greenhouse gas emissions for new passenger vehicles that result from rising stringency of fuel economy standards, which are inversely related to greenhouse gas emissions.[7] The more stringent Japanese standards have not damaged the competitiveness of Japanese vehicles in the world market. In 2006, the top two Japanese makers (Toyota and Honda) combined produced 10.35 million cars (defined as up to 8 passenger seats in addition to the driver), compared to 9.5 million for the two largest U.S. manufacturers (General Motors and Ford), and Toyota and Honda continue to be competitive even during a world economic slowdown.[8]

[6] "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update, Feng An, Deborah Gordon, et al. The International Council on Clean Transportation", July 2007 (http://www.theicct.org/documents/ICCT_GlobalStandards_20071.pdf); "Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around the World", Feng An and Amanda Sauer, Pew Center on Global Climate Change, December 2004 (http://www.pewclimate.org/global-warming-in-depth/all_reports/fuel_economy); Updated 2009, Michael Walsh, International Council on Clean Transportation, May 2009.

[7] Accurate comparisons among economies require that all standards be normalized to one testing procedure used to measure fuel economy. The importance of the test cycle can be illustrated by comparing the fuel efficiencies calculated from different tests for a selected model. For example, a Toyota Corolla would rate at 32.4 mpg using the New European Drive Cycle (NEDC), 34.8 using the U.S. Corporate Average Fuel Economy (CAFE) procedure, and 27.6 using the new Japanese JC08 test cycle.

[8] "World Motor Vehicle Production Ranking of Manufacturers", International Organization of Motor Vehicle Manufacturers, 2006. (http://oica.net/wp-content/uploads/2007/07/ranking06.pdf)

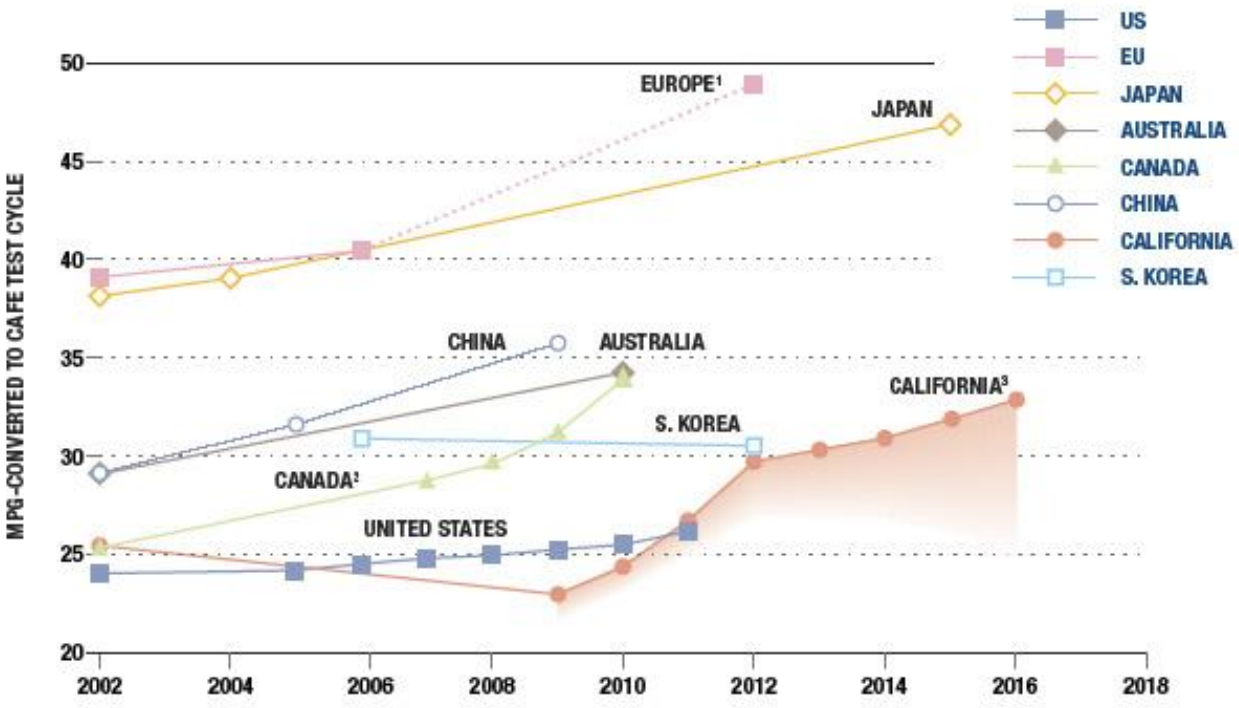


Figure 2. Actual and Projected Fuel Economy for New Passenger Vehicles by Economy, 2002–2018

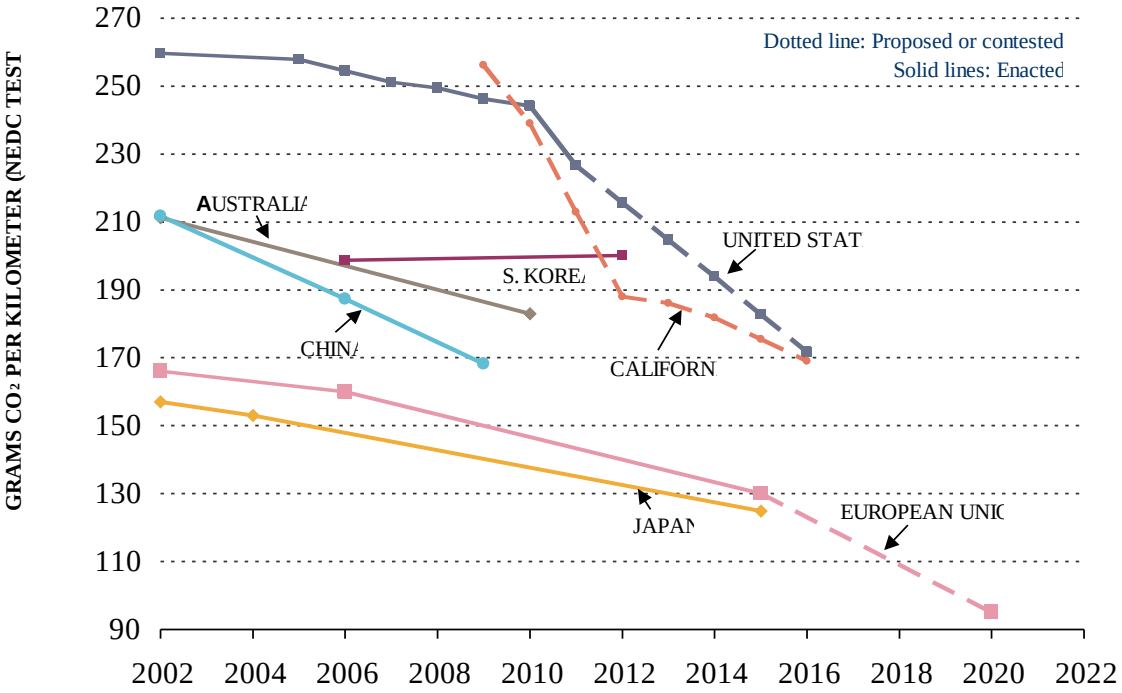
[1] The relative stringency of Europe's CO_2-based standards is enhanced under a fuel economy standard because diesel vehicles achieve a boost in fuel economy ratings due to the higher energy content of diesel fuel.

[2] For Canada, the program includes in-use vehicles. The resulting uncertainty of this impact on new vehicle emissions was not quantified.

[3] Shaded area under the California trend line represents the uncertain amount of non-fuel economy related GHG reductions (N_2O, CH_4, HFCs, and upstream emissions related to fuel production that manufacturers will generate from measures such as low-leak, high efficiency air conditioners, alternative fuel vehicles, and plug-in hybrid electric vehicles).

Source: "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update", Feng An, et al., The International Council on Clean Transportation, July 2007.

Actual and Projected GHG Emissions for New Passenger Vehicles by Country/Region, 2002-202



Source: *Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update*, ICCT. May 2009 update.

The United States' Energy Independence and Security Act (EISA) of 2007 increased the economy's fuel economy standards for the first time in thirty years. By the year 2020, new cars and light trucks must meet a fleet average of 35 mpg, and medium- and heavy-duty vehicles must make "maximum feasible" and "cost effective" fuel economy improvements. The EISA CAFE standards start to take effect in 2011 and are projected to achieve cumulative savings of carbon dioxide in the order of 700 million metric tons according to the Natural Resources Defense Council.[9]

On May 19, 2009, President Obama further proposed a national fuel efficiency plan to adopt uniform federal standards that regulate both fuel economy and greenhouse gas emissions to cover model years 2012-2016 that will move average fuel economy to 35.5 miles per gallon by 2016—making it more stringent than the statutory fuel economy standards passed in EISA 2007. This joint rule-making process between the U.S. Environmental Protection Agency (EPA) and the Department of Transportation (DOT) would result in a projected reduction in oil consumption of approximately 1.8 billion barrels during that period and reduce greenhouse gas emissions by approximately 900 million metric tons.[10] Furthermore, the plan provides the auto industry with uniformity and

[9] Barratt-Brown, Liz, "New fuel economy savings marred by tar sands," posted on Liz Barratt-Brown's Blog, 5 February 2008 (http://switchboard.nrdc.org/blogs/lizbb/beauty_new_fuel_efficiency_sta.html).

[10] White House Press Release, May 19, 2009 (http://www.whitehouse.gov/the_press_office/Fact-Sheet-and-Particpants-at-Todays-Rose-Garden-Event/).

certainty through 2016, by means of a national standard, while preserving the rights of states such as California to continue to set their own more stringent regulations if desired.[11]

China is also considering increased stringency in their fuel economy standards, which would require Chinese automakers to improve fuel economy by an additional 18% by 2015, with a possible average fuel economy of 42.4 miles per gallon in 2015.[12]

Efficient Vehicle Technology

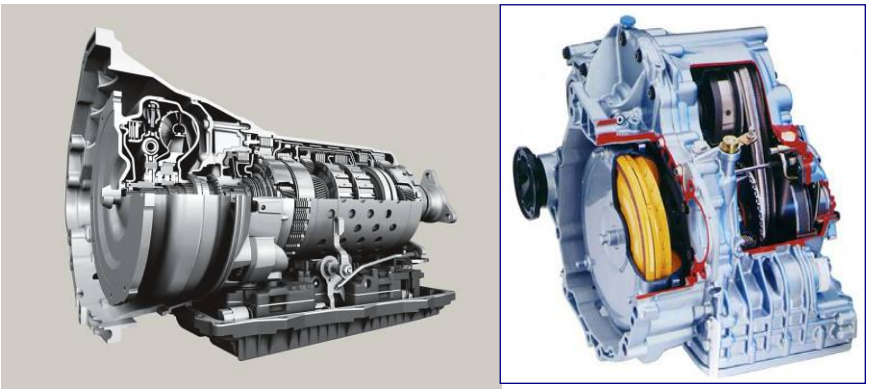


Figure 3. Efficient transmissions: an 8-speed automatic transmission at left and a continuously variable transmission, both by ZF. *(Photos from ZF Batavia LLC)*

The myriad of available technologies to optimize the efficiency of motor vehicles can fill volumes, and this paper will not attempt to do the topic justice. This section provides a brief overview of some of the recent efficiency innovations that are already being adopted by automobile manufacturers. It also references some of the research and development (R&D) programs within APEC that provide funding for the high-risk, pre-competitive research needed to create vehicles for the future. Fuel efficient technologies and R&D programs for heavy trucks are discussed in Chapter 7 on Efficient Freight.

Hybrid electric drive trains use an electric motor in conjunction with a petroleum-fueled internal combustion engine. The full hybrid system developed by Toyota, and now used by Ford and Chrysler as well, can drive the wheels of the vehicle with the engine or the electric motor, either in concert or separately. Power assist hybrids, also called medium hybrids, mainly rely on the engine. Most cannot run on electric power alone, although some can do so once the vehicle has reached a certain cruising speed. The improvements in efficiency due to hybridization vary greatly depending on the specific vehicle, but they are in the range of 25% to 50% over corresponding non-hybrid models. Yet another class of vehicle is variously known by phrases such as "mini hybrids," "micro hybrids" and "hollow hybrids." These are not hybrid vehicles because the electric motor does not provide additional torque to power the drive train, but they do use an electric motor to boost efficiency through regenerative braking[13] and by allowing the engine to automatically turn off when

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[11] Broder, John M., "Obama to Announce New Mileage and Emissions Standards," *The New York Times,* 18 May 2009 (http://www.nytimes.com/2009/05/19/business/19emissions.html).

[12] Bradsher, Keith, "China Is Said to Plan Strict Gas Mileage Rules," *The New York Times,* 27 May 2009 (http://www.nytimes.com/2009/05/28/business/energy-environment/28fuel.html?_r=1).

[13] Regenerative braking is now available in hybrid vehicles. It takes energy normally wasted during conventional braking and turns it into usable energy that is typically transferred into the vehicle's chemical storage battery that powers the car at city speeds. At slower speeds in stop-and-go traffic, the electric motors in hybrids help the vehicle stop by reversing their direction when the driver applies the brakes. The torque created by this reversal counteracts the vehicle's forward momentum and eventually stops the car. Traditional brakes, on the other hand, use friction to counteract a car's forward movement, creating excess heat energy that dissipates into the air and wastes up to 30 percent of a car's generated power.

the engine is not needed (i.e., when coasting, braking or stopped) then smoothly turn back on again. Efficiency improvements in the "mini hybrids" are on the order of 10%. Plug-in hybrids have the potential to further reduce fuel consumption and increase efficiency.

Idle stop or stop-start technology automatically shuts off the engine when the vehicle comes to a standstill, then starts it again when the accelerator is pressed. The resulting reduction in fuel

Figure 4. Coefficient of Drag (Cd) on Selected Vehicles. From left to right: Mercedes-Benz concept car (0.19), Toyota Prius (0.29), and Ford Ranger (≥ 0.4).
(Photos courtesy of DaimlerChrysler AG, Toyota Motor Corporation, and Ford Motor Company, respectively.)

consumption is in the range of 5% to 7%, although some manufacturers have claimed more compelling results. Daimler Chrysler, for example, claims that the idle stop feature in the 2008 micro hybrid version of the Mercedes Benz Smart Car improves fuel economy by up to 8% for a combination of highway and urban driving, but shaves up to 20% from fuel usage when driving is confined to the city.[14] Similar fuel savings are possible with electric regenerative braking—in the range of 5% to 10%[15]—so that vehicles combining regenerative braking and idle stop will see an improvement in fuel efficiency of at least 10%.

For a given engine size and type, one of the main opportunities for improving the overall efficiency of the drive train is in the transmission. There are two factors that can improve transmission efficiency: a larger number of speeds and a wider ratio transmission. Six-speed transmissions are rapidly becoming more common, and 7- and 8-speed automatic transmissions are now available in some luxury cars. The schematic in Figure 3 shows an 8-speed automatic transmission by ZF. The company cites a 14% improvement in fuel efficiency over a typical automatic 5-speed transmission.[16]

Another innovation in transmission technology is a long transmission ratio gearbox that provides greater spread between the low and high gears. This gives the engine a wider range of speeds (revolutions per minute, or rpm) in which to operate at its highest efficiency, providing improved fuel economy even at high speeds. General Motors finds that their six-speed automatic improves fuel economy up to 4% over a four-speed version, in part because it allows the engine to run at lower rpm at highway speeds, and in part because the overall transmission ratio is 6:1 rather than

[14] "Less Gas And More Style: Smart To Launch Exclusive For Two Micro Hybrid Drive Model," DaimlerChrysler AG, September 2007

[15] "Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards," National Research Council, National Academy Press, 2002 (http://www.nap.edu/openbook.php?record_id=10172&page=31).

[16] "The Automatic Transmission Development and Their Contribution to the Overall Emissions Reduction," Herbert Mozer, ZF Batavia LLC , March 2003. (ftp://ftp.arb.ca.gov/carbis/cc/techsem/final_presentations/mozer_autotrans.pdf)

the 4:1 ratio found in most four-speed automatics.[17] Making a relatively recent appearance in new vehicles is the continuously variable transmission, which has two features that optimize efficiency. One is that it transitions smoothly between gears to keep the engine at the optimal torque where it runs most efficiently, and the other is that it has a high transmission gear ratio, typically 6:1.[18]

Figure 5. Smooth Wheel Covers Reduce Drag
(shown on a GM Opel Corsa Eco)
(Photo courtesy of General Motors)

In the body of the car, there are two routes for improving fuel efficiency: reducing weight through lighter materials, and reducing drag through improved aerodynamic design of the body. In passenger vehicles, body shape is critical to reducing drag, as illustrated by Figure 4 showing three different body shapes and their corresponding coefficient of drag. Drag can further be reduced by streamlining the flow of air underneath and around the car and through the engine compartment, using underbody panels, smooth wheel covers (Figure 5), and modified air intakes on the grille, respectively. According to some manufacturers of advanced aerodynamic technologies, reducing drag of light trucks can increase fuel economy by up to 10%, saving about US$300 per truck per year in fuel costs; savings for heavy and medium trucks are estimated at 20% and US$10,000 annually.[19]

Finally, further gains are possible in the tires and oil. A field test of 2,116 passenger cars of 21 different models found that the use of low friction lubricating oil shaved 5.5% from fuel consumption.[20] Low rolling resistance tires also provide fuel savings, with estimates ranging from an average of 2% (conservatively) to 4%.[21] Greater savings in the range of 5% are possible with the lower speeds and frequent stopping and starting of city driving.[22]

By implementing such proven technologies, the total energy-efficiency gains that can be made in new vehicles are estimated by the Pew Center on Global Climate Change to be over 30% within the next decade and as much as 100% by 2030. As noted in a Pew Center report on transportation in the United States, it will take time before the older and less efficient vehicles are retired, so the average

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[17] "GM Pushing Hard on Six-Speed Automatics; Introduces Three More," Green Car Congress, June 2006 (http://www.greencarcongress.com/2006/06/gm_pushing_hard.html).

[18] "New Transmission Technologies," Shahed Hussain, Velocity Automotive Journal, April 2006 (http://www.velocityjournal.com/articles/2006/614.html).

[19] Wood, Richard M. "Advanced Energy Efficiency Technologies for the Transportation Industry," SOLUS – Solutions and Technologies LLC, presentation for The Commonwealth of Virginia Energy & Sustainability Conference, 16-18 October 2007, at Virginia Military Institute, Lexington, Virginia USA.

[20] Friedrich, Axel, "Addressing Energy Efficiency in the Transport Sector," GTZ, 2007 (http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1171658979314/3465102-1175712029532/Dr_Friedrich_Fuel_taxation260307.pdf).

[21] American Council for an Energy-Efficient Economy. "Tire Standards Would Save Energy Without Adversely Affecting Safety," July 2005 (http://www.aceee.org/transportation/tire.pdf).

[22] Friedrich 2007.

efficiency of all vehicles in use in 2015 will possibly increase by 10% to 15%, with corresponding reductions in GHG emissions of 11%.[23]

In a report published by a new initiative aimed at making cars 50% more fuel-efficient by 2050 worldwide, or the 50 by 50 Global Fuel Economy Initiative (GFEI), the initiative's founding partners, UN Environment Programme (UNEP), International Energy Agency (IEA), International Transport Forum (ITF) and FIA Foundation, cite numerous analyses demonstrating the potential to achieve up to 50% savings in fuel consumption per 100 km by 2030-2035 that can be achieved with the wider adoption of existing and commercially available technologies. Advanced technologies such hydrogen fuel cell vehicles can offer further efficiency improvements but should not be necessary to achieve 50% fuel economy improvement. In order to stay on track to achieving the 50 by 50 goal, the GFEI has set interim targets of 30% fuel economy improvement in new cars by 2020 and 50% by 2030, with the remaining efficiency improvements to be achieved in on-road and operational efficiency of existing fleets. [24]

Despite the growing awareness and attention surrounding hybrid vehicles, their market penetration remains relatively low. In the U.S. market, hybrid sales have risen from 1.6% of new vehicle sales in 2006 to a little over 2% in 2007 and 2008, with sales from January to June in 2009 totaling about 2.6% of new light-duty vehicle sales.[25] This relatively low level of market penetration for a highly-publicized vehicle type indicates the need for increased consumer awareness and efforts to overcome market barriers to spur adoption and market penetration of existing technologies -- while research, development, and innovation continues for advanced technologies that can move economies to a high-efficiency, low-carbon mobility.

Canada's ecoTECHNOLOGY for Vehicles Fund

In Canada, a new program called ecoTECHNOLOGY for Vehicles (eTV), is one of six initiatives under the Government of Canada's ecoTRANSPORT strategy. eTV funds testing and evaluation of emerging technologies for vehicles in Canada. The program aims to foster partnerships with the automobile industry to identify and overcome barriers to the introduction and adoption of advanced vehicle technology. eTV also engages in outreach to raise awareness for these technologies and provide Canadians with information that incorporates environmental impacts to better inform Canadians' decisions about vehicles they purchase.[26]

China's New R&D Centers for the Economy's Growing Automobile Industry

As a step toward fulfilling Chinese ambitions of designing and manufacturing cars that will not be tied to foreign intellectual property, China's largest automobile company – the Shanghai Automotive Industry (Group) Corporation (SAIC) – is in the process of establishing a technology R&D center in Anting, one of Shanghai's municipalities. In February 2008, Chinese automaker BYD Auto opened another R&D center in Shenzhen. The new center will be used to test core components

[23] Greene, David L. and Andreas Schafer, "Reducing Greenhouse Gas Emissions From U.S. Transportation," prepared for the Pew Center on Global Climate Change, May 2003.

[24] "50 by 50 Global Fuel Economy Initiative," Joint initiative of FIA Foundation, International Energy Agency, International Transport Forum, UN Environment Program, (http://www.fiafoundation.org/50by50/Documents/50BY50_report.pdf), 2009.

[25] Correspondence with Jennifer Watts, Senior Manager of Marketing & Communications, Electric Drive Transportation Association, 13 July 2009.

[26] "ecoTECHNOLOGY for Vehicles," Transport Canada, 20 Aug. 2009, (http://www.tc.gc.ca/programs/environment/etv/menu-eng.htm), Oct. 2009

of the automaker's electric vehicle. [27] Non-Chinese automakers, e.g. Toyota, Honda, GM, Peugeot Citroen, have also stated plans to open R&D centers in China in the near future. The center developed in partnership with GM is to focus on alternative energy and environmentally friendly technologies.[28]

Japan: Vehicle R&D Programs

The Japanese government has sponsored research on electric vehicles and other clean, energy-efficient technologies for over two decades. According to interviews that the U.S. Office of Technology Assessment conducted with Japanese ministries and auto industry engineers, the Japanese work on advanced technologies was allowed to lapse until the U.S. state of California adopted its zero emissions vehicle regulations that went into effect in 1998.[29] The reasons given for the lapse were the problems with achieving sufficient battery performance, and doubts that there would be broad consumer interest in electric vehicles. Furthermore, automobile manufacturers felt that the best environmental and efficiency gains would be made through more aerodynamic design, lighter vehicles, and intelligent vehicle-highway systems. [30]

Over the past decade, Japanese automakers have established strategic alliances directly with non-Japanese companies. For example, Toyota and GM have an agreement to exchange fuel cell technology, and Nissan is working with Renault on fuel cell vehicles running on gasoline. Toyota and GM have also teamed with Exxon-Mobil on the development of clean hydrocarbon fuel and reformers for fuel cell vehicles.[31]

United States: Vehicle Technologies Program[32]

Under its Vehicle Technologies Program, the U.S. Department of Energy (DOE) has established the FreedomCAR and Fuel Partnership to support and fund high-risk research that will help develop the technologies and fueling infrastructure needed to make affordable, clean personal vehicles that minimize pollution and the dependence on petroleum imports. The partners conducting the research examine new applications of the above-mentioned technologies, as well as the development of systems for fuel cells and hydrogen storage, for electric propulsion and electrical energy storage, as well as for advanced combustion and emission controls for internal combustion engines using a variety of fuels. While the partners – including the U.S. DOE, energy companies and the U.S.

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[27] Joanne Jiu, "BYD Auto opens R&D center in Shenzhen," Gasgoo.com, 22 February 2008 at http://www.gasgoo.com/auto-news/5797/BYD-Auto-opens-R-D-center-in-Shenzhen.html. BYD group is the world's largest manufacturer of batteries for cellular phones, and the company entered the automobile market in 2003.

[28] "GM Planning a Clean-Tech R&D Center in China," 29 October 2007 at http://www.edmunds.com/insideline/do/News/articleId=123214.

[29] Office of Technology Assessment, *Advanced Automotive Technology: Visions of a Super-Efficient Family Car*, September 1995, OTA-ETI-638, GPO stock #052-003-01440-8, p. 248. The OTA analysis did not offer an explanation as to why the California policy spurred the Japanese automakers to jump-start their R&D programs, or if the timing was coincidental. One could speculate that the policy change was viewed by the automakers as a way to stimulate the market for electric vehicles.

[30] Ibid.

[31] Avadikyan, Arman, et al, ed., *The Economic Dynamics of Fuel Cell Technologies*, Bureau d'Economie Théorique et Appliquée, Institut Française de l'Energie, Institut d'Economie et de Politique de l'Energie, Association Française de l'Hydrogène, 2003, p. 196.

[32] For more information see the Vehicle Technologies Program website for the U.S. DOE at http://www1.eere.energy.gov/vehiclesandfuels/.

Council for Automotive Research (USCAR)[33] – conduct research independently, they work jointly on road-mapping, setting priorities and monitoring activities needed to achieve the Partnership's goals. The road-mapping involves identification of barriers, setting technology-specific R&D goals and cost targets, and determining milestones for evaluating progress.

In June 2009, DOE and the National Renewable Energy Laboratory (NREL) launched TransAtlas, a comprehensive mapping tool to help industry and government planners implement alternative fuels and advanced vehicles. Sponsored by DOE's Clean Cities initiative, a government-industry partnership through the Vehicle Technologies Program which aims to reduce petroleum consumption in the transportation sector, the interactive Google Maps tool maps out alternative fueling stations (such as hydrogen, electric, CNG, or biodiesel), vehicle density, production facilities, and existing road infrastructure in a user-friendly and customizable format.[34] This tool can be used to assess current infrastructure, delivery capacity, and market penetration by vehicle type and region, providing a basis for future planning and expansion. Additionally, to facilitate adoption of alternative fuels, the Vehicle Technologies Program's Mobile Alternative Fueling Station Locator allows consumers to locate and navigate to their needed alternative fueling station on their cell phones at anytime.[35]

Emissions Standards for New Vehicles that Improve Vehicle Fuel Economy

While APEC economies with major automobile manufacturing industries stress fuel efficiency standards as a way of regulating vehicle efficiency, sometimes the same result can be obtained by regulating new vehicle emissions instead, which have the effect of forcing fuel economy improvements.[36] As presented in the following case study, Thailand set such strict criteria pollutant emissions standards on new motorcycles that it forced manufacturers to stop making motorcycles with two-stroke engines, which have poorer fuel economy than four-stroke engines. It is worth noting that the Thai approach combines two strategies: emissions standards and inspections. (A more detailed discussion about mandatory vehicle emissions inspections is found in Chapter 3.) Another example from Indonesia shows how emissions standards forced an Indian manufacturer and exporter of auto-rickshaws to use more efficient engine technology to make a model that runs more efficiently and use relatively cleaner fuel. These regulations were driven by the desire to

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[33] Energy companies are BP America, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, and Shell Hydrogen. USCAR partners are DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation.

[34] "Customizable Interactive Map Shows U.S. Alternative Fuel Data," National Renewable Energy Lab News Release, 9 June 2009 (http://www.nrel.gov/news/press/2009/697.html).

[35] "Alternative Fuel Station Locator Goes Mobile," U.S. Department of Energy, Energy Efficiency and Renewable Energy, 9 February 2009, (http://www.afdc.energy.gov/afdc/progs/ddown.php?afdc/WHATS_NEW/872/).

[36] It is worth noting that some of the newer vehicle technologies such as hybridization have a trade-off between fuel economy and emissions. Tests run and analyzed by the Argonne National Laboratory found that "hybridization without changing the engine size can increase fuel economy (18% in the example), but increase NOx emissions (25% in the example). However, if the engine had ideal characteristics for a hybrid vehicle with larger islands of high efficiency and low emissions (originally developed for the PNGV program), the result could be a fuel economy increase of about 13% accompanied by a NOx decrease of almost 40%." Source: Rousseau, Aymeric et al, "Trade-Offs Between Fuel Economy and NOx Emissions Using Fuzzy Logic Control With a Hybrid CVT Configuration," Center for Transportation Research, 2002. http://www.transportation.anl.gov/pdfs/HV/433.pdf.

reduce local air pollutants such as carbon monoxide and hydrocarbons, but they also resulted in greater vehicle efficiency.

Emissions standards are particularly important for jurisdictions (states, provinces, counties, municipalities, etc.) that have the desire and authority to regulate against polluting emissions, but do not have the authority to regulate new vehicle standards. For example, the U.S. state of California regulated vehicle emissions standards targeting carbon reductions even before the federal legislation passed in 2007 with its new fuel economy standards for the entire economy. California argues that CO_2 is a pollutant under the Clean Air Act because the Act defines an air pollutant as one "which may reasonably be anticipated to endanger public health or welfare," where the definition of welfare includes "weather" and "climate." Based on this, California issued regulations in September 2004 limiting the "fleet average greenhouse gas exhaust mass emission values from passenger cars, light-duty trucks, and medium-duty passenger vehicles." The standards take effect in 2009 and become more stringent every year until 2016, by which time the average efficiency of the fleet will be 30% better than that in 2009.

As of June 2009, at least fourteen other states had adopted California's vehicle standards with three other states in the process of adopting. The recent national fuel economy and emissions standards for passenger vehicles announced by President Obama in May 2009 also align with California's standards, moving the country to the same level of stringency by 2016. On June 30, 2009, the U.S. EPA granted California a waiver to allow the state to regulate vehicle tailpipe greenhouse gas emissions, permitting California and the other states which have adopted California standards to regulate emissions before and after the federal standard's 2012-2016 period of effectiveness.[37]

Indonesia: Emissions Standard Phases-Out Inefficient Auto-Rickshaws

The Indonesian State Ministry of Environmental Affairs enacted a new vehicle emissions policy in January 2005 that began phasing out Jakarta's ubiquitous *bajaj*, a noisy, inefficient, and high-polluting three-wheeled auto-rickshaw manufactured in India by the Bajaj Auto Company.[38] Under the new policy, which sets emissions standards equivalent to Euro II levels, the two-stroke combined gasoline or diesel fueled *bajaj* will have to be replaced over time (as they deteriorate beyond repair) by new, cleaner and more efficient alternatives that meet the new emissions standards. Initially, after implementing the new policy the primary new alternative to the *bajaj* was a locally manufactured, cleaner and safer four-wheeled, four-stroke gasoline vehicle called the *kancil* (see Figure 6).

However, many *bajaj* drivers still preferred the more nimble three-wheeled design of the *bajaj*, and eventually in 2006 Bajaj Auto released a new Euro II-compliant four-stroke compressed natural gas (CNG) *bajaj* model in the Indonesian market (see Figure 7).[39] Response to the CNG *bajaj* has been positive so far; many drivers and customers like both the quieter operation, fuel-saving potential, and reduced environmental impact. The government set a target to distribute 500 CNG-powered

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[37] See the Pew Center on Global Climate Change map that is regularly updated showing states with vehicle GHG emissions standards: http://www.pewclimate.org/what_s_being_done/in_the_states/vehicle_ghg_standard.cfm.

[38] "Jakarta's Bajaj taxis face ban," BBC News, June 2004 (http://news.bbc.co.uk/2/hi/asia-pacific/3833033.stm).

[39] "Bajaj Auto launches CNG three-wheelers in Indonesia", The Information Company Pvt Ltd (TIC), August 2006 (http://www.domain-b.com/companies/companies_b/bajaj_auto/20060809_Indonesia.html).

bajaj each month. However, Jakarta is falling short of that goal, and *bajaj* drivers are hampered from acquiring and obtaining the requisite licenses to operate the CNG *bajaj* by high taxes and cumbersome bureaucratic procedures. The government has recently increased the tax for the Indian-imported CNG *bajaj* from 30% to 45% while concurrently levying an additional 10% luxury tax. Furthermore, each new CNG *bajaj* has to undergo an evaluation, which takes at least three weeks, and obtain public transportation licenses and other documentation. These barriers create long delays (sometimes up to two years) between purchase and activation, and ultimately discourage drivers from purchasing the cleaner and more efficient vehicles. As of January 2009, the CNG *bajaj* fleet numbered 600, but at least 120 units were still pending due to procedural barriers.[40]

Figure 6. Four-wheel, four-stroke *kancil* in Indonesia, a cleaner alternative to the two-stroke gasoline- or diesel-powered *bajaj*.
(Photo: www.treehugger.com)

Figure 7. Three-wheel *Bajaj* rickshaw with a two-stroke engine powered by compressed natural gas.
(Photo: www.dinesh.com)

CASE STUDY
THAILAND: Using Emissions Standards and Inspections to Induce Shift from 2-Stroke to 4-Stroke Motorcycles

Purpose
To shift the sale of new motorcycles from 2-stroke to 4-stroke engines, and ensure the maintenance of existing motorcycles.

Summary of Actions
1) Increasingly rigorous emissions standards for new motorcycles
2) Public outreach
3) Mandatory inspections of motorcycles in use

Background

[40] Dameria, Olivia, "Drivers await for greener 'bajaj'," *The Jakarta Post,* 3 January 2009, (http://www.thejakartapost.com/news/2009/01/03/drivers-await-greener-039bajaj039.html).

Motorcycles in Bangkok account for about half of all motor vehicles on the city's notoriously congested roads. Until the government began a concerted effort in 1994 to address the issue, the majority of these—94% in Bangkok and 87% in Thailand as a whole—were powered with 2-stroke engines. Motorcycles with two stroke engines emit twice as many hydrocarbons (HCs) and suspended particulates as four–stroke cycles, they have inferior fuel economy, and they are noisier. Although they are comparably priced, two-stroke motorcycles were popular because they were smaller and lighter, and operated more smoothly than four-stroke models.[41]

Implementation

Emissions standards for motorcycles were tightened steadily over the course of 11 years from 1993 to 2004, and by 2001 the standards were strict enough to preclude the manufacture of 2-stroke motorcycles. Standards based on Europe were established in 1993 and 1995—ECE (Economic Commission for Europe) 40-00 and ECE 40-01—with an even stronger standard set in 1997. Since then, standards were tightened further in 2001 and 2004, to match the standards of Chinese Taipei. Emissions limits for *new* motorcycles are as follows: carbon monoxide (CO) ≤ 3.5 g/km; HCs + NOx (nitrous oxides) ≤1.8 g/km, an evaporative level of 2 g per test, and white smoke (opacity) ≤ 15%.[42] The government also passed a new standard for the lubricating oil used in two-stroke motorcycle engines, to reduce the emissions of white smoke.[43]

The regulatory improvements were complemented by a number of other measures. Public outreach and stakeholder involvement included television, video, pamphlets and leaflets; motorcycle clinics; a seminar for manufacturers, dealers and motorcycle users; and the distribution of manuals on motorcycle maintenance. Mandatory inspections are carried out in two ways. Roadside check-points staffed by traffic police were set up in 50 districts in Bangkok to measure the opacity of smoke, with a fine of 500 Baht (US$15.75) per violation (>30%). Other emissions are monitored through annual inspections by licensed private garages, where motorcycles registered before 1 July 2006 must have emissions of CO ≤ 4.5% and HCs ≤ 10,000 ppm (idling), and white smoke ≤ 30%. These standards were tightened to 3.5% CO and 2000 ppm HCs in 2006, and are set to tighten again in 2009, to 2.5% CO and 1000 ppm HCs. One weak link in the inspections chain, however, is ensuring that the police and private garages are properly performing inspections. One assessment[44] of the program found that some people viewed the random testing by police to be a matter of providing a bribe, since in cases where failure of the test would require repairs, the cost of the bribe was far lower than the cost of repairs.

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[41] "Shift from Two- to Four-Stroke Motorcycles in Bangkok", Asia-Pacific Environmental Innovation Strategies (APEIS) Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory, May 2004.

[42] As explained in the following paragraph, the fine for exceeding this limit does not kick in until opacity is over 30%, suggesting that the allowable limit for older vehicles is 30%.

[43] Royal Thai Government Pollution Control Department. "The Management of Motorcycles in Thailand," December 2006, www.cleanairnet.org/baq2006/1757/docs/SP6_4.ppt.

[44] "U.S.-Asia Environmental Partnership: Strategy and Program Design: Strategic Assessment Report" (http://epiq2admin.web.aplus.net/pubs/usaep_strategic_asmt.pdf, September 2004.

Results

Sales of 4-stroke motorcycles in Thailand steadily increased from 13% of the domestic Thai motorcycle sales in 1994 to more than 99% of all motorcycle sales in 2005 (see Figure 8).[45] These results were mirrored in Bangkok.

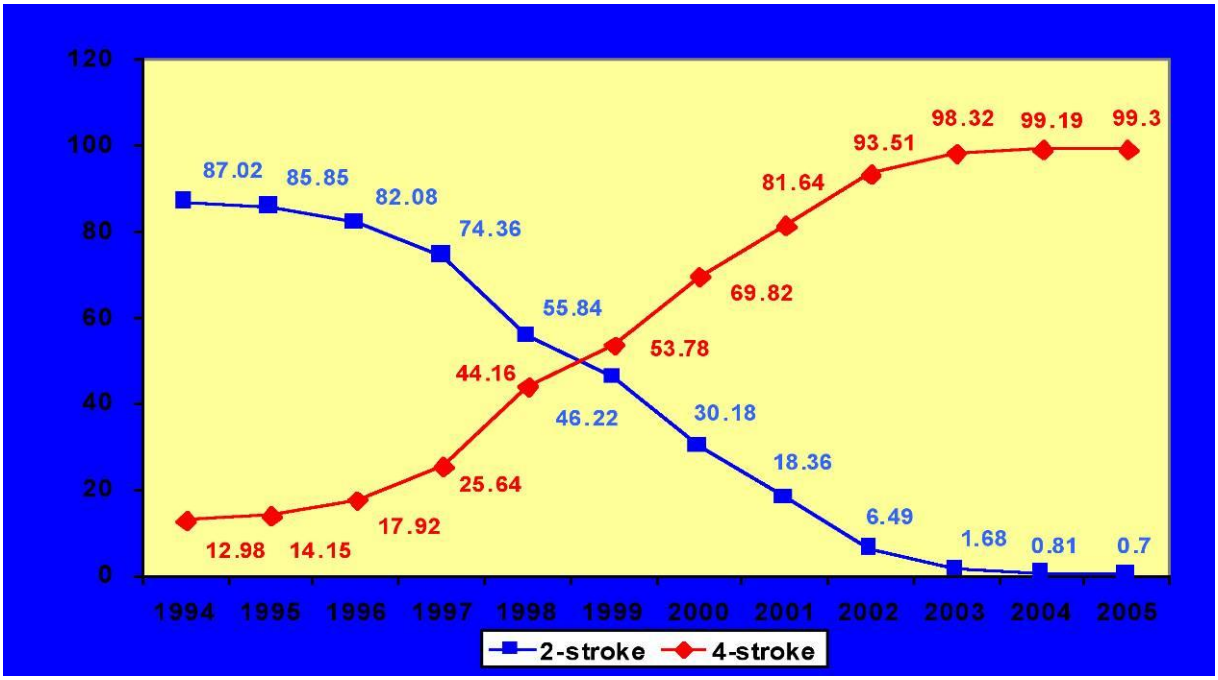

Figure 8. Motorcycle Sales in Thailand from 1994 to 2005

[Source: "The Management of Motorcycles in Thailand", Royal Thai Government Pollution Control Department, www.cleanairnet.org/baq2006/1757/docs/SP6_4.ppt, December 2006.]

Lessons Learned

More stringent regulations, steadily ramped up over the course of more than a decade, formed the backbone of this program. However, it was as successful as it was due to a comprehensive approach that used inspections to enforce the regulations, public education to build public support, and a stakeholder approach that engaged the manufacturers and dealers. Moving forward, regulators can continue to increase the stringency of the emissions standards while working to build appropriate institutional transparency and capacity for full implementation, especially in regards to inspection and maintenance programs.

[45] Royal Thai Government Pollution Control Department. "The Management of Motorcycles in Thailand," December 2006, www.cleanairnet.org/baq2006/1757/docs/SP6_4.ppt.

2. Encouraging Purchase of Fuel-Efficient Vehicles

Rising fuel prices give drivers a financial reason to buy more fuel-efficient vehicles. However, for a given vehicle class, most energy-efficient models have higher retail prices than models with low fuel economy when they are first introduced. Consumers need objective information and assurance that they will save enough money on reduced fuel expenditures to offset the higher cost of an energy-efficient vehicle. Approaches used by some APEC economies to convince buyers to purchase the more fuel-efficient options include vehicle efficiency labels, financial incentives, public awareness campaigns and the purchase of efficient vehicles for government fleets.

Vehicle Efficiency Labels and Ratings

Another way to encourage consumers to buy more efficient vehicles is to provide them, at the point of sale, with clear and convincing information about how much they are likely to spend on fuel costs for each vehicle on the market. In many economies, such information is not always readily available and easily deciphered. Energy-efficiency labeling programs that are widely used in industrialized countries and many emerging markets for white goods are gradually being designed for motor vehicles.

Vehicle labeling schemes targeting fuel economy have already been adopted within APEC in Australia, Canada, China, Japan, Singapore, the United States, and a new program is being introduced in New Zealand. Some labeling schemes only provide information about a vehicle model's performance rating within its class, rather than fuel consumption data. Japan and China use such a system and offer green labels to the most energy-efficient vehicles within each class (e.g. sedans, compact cars, etc.).

In the programs targeting fuel economy, the government-approved labels show basic information about a marketed vehicle's estimated fuel consumption and annual fuel cost. Some labels rank the vehicles as compared to other vehicles in the same class. Labels are typically affixed directly to the vehicle or to the price tag of the vehicle offered for sale.

Figure 9 shows examples of vehicle labels from selected APEC economies. An overview of some of the labeling schemes is provided below. Labeling might also be complemented by rating and rewards programs that call special attention to the most energy-efficient vehicles on the market.

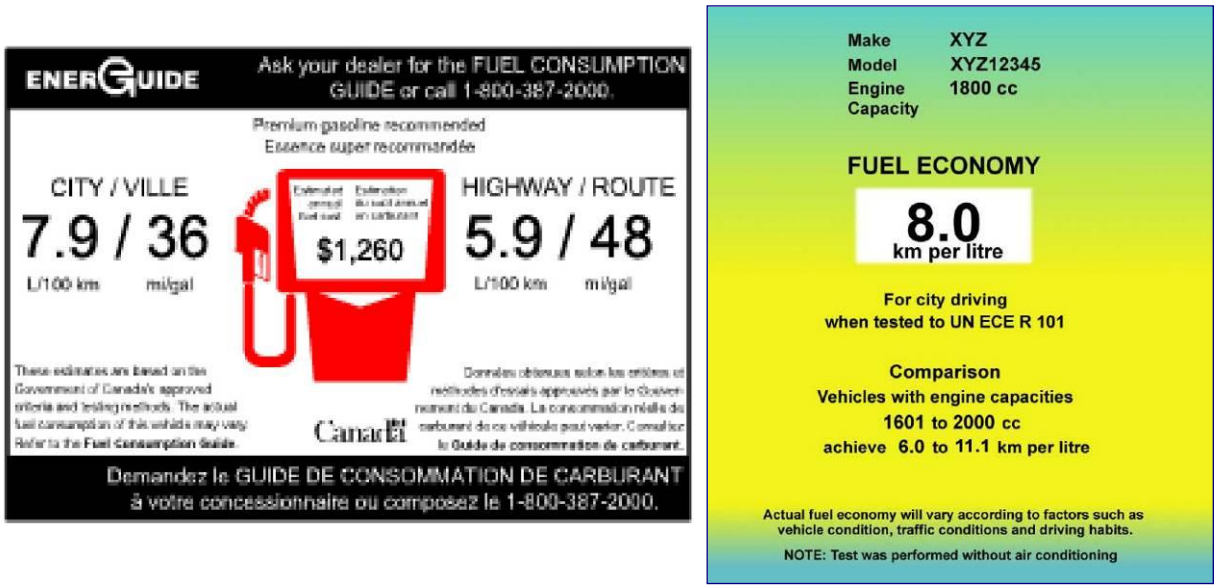

Figure 9. Vehicle fuel efficiency labels used in Canada and Singapore (cropped for Singapore).

Australia's Vehicle Efficiency Labeling and Rating Programs

Australia's most recent labeling system for new light vehicles was launched January 1, 2003 by the adoption of Australian Design Rule 81/01. Complementing this is the Green Vehicle Guide rating system launched in 2004. The labeling rule requires all manufacturers to affix a label to all vehicles weighing 3.5 tons or less, which broadens the scope of the rule from the previous threshold value of 2.7 tons.[46] The label provides the fuel consumption and carbon dioxide (CO_2) emissions data for the vehicle, using the United Nations Economic Commission for Europe (UNECE) emission standards for light vehicles for its rating and UNECE Regulation 101 as its test requirement. The label design is consistent with the energy labeling used in the economy for appliances and other products. The Rule is currently being considered for revisions in keeping with the latest version of UNECE Regulation 101.

For the Green Vehicle Guide rating system, vehicle emission certification data are converted into a simple five star rating of the vehicle's overall performance regarding air pollution and greenhouse gas emissions. Shoppers can use the tool at www.greenvehicleguide.gov.au to compare different models with respect to fuel economy, and emissions of CO_2 and ambient air pollutants. All new vehicles available on the Australian market and weighing up to 3.5 tons are rated, including passenger cars, off road vehicles, light trucks and vans. The web site currently includes about 1,600 models and is updated regularly as new vehicle models become available to the Australian market.

[46] According to Jon Real, who heads up the labeling program at Australia's Department of Infrastructure, Transport, Regional Development and Local Government, the shift to encompass vehicles weighing up to 3.5 tons occurred simply because the Australians moved from the U.S. EPA emission standards that defined light vehicles as 2.7 tons or less, to the UN ECE standards that categorized light vehicles as 3.5 tons or less. Vehicles in the 2.7 – 3.5 ton range include several models of heavier four-wheel drive sport utility vehicles, heavier utility trucks and large cargo vans. In Australia, light commercial vehicles comprise nearly 15 percent of the total road vehicle fleet and account for around 16 percent of all CO_2 emissions from road transport. Passenger vehicles, which include passenger SUVs, are responsible for about 60 percent of road transport CO_2 emissions.

Figure 10. New Zealand vehicle fuel economy label (minus the small print).

New Zealand – Vehicle Fuel Economy Labeling for New and Used Vehicles

A brand new mandatory labeling scheme was launched by the New Zealand government in April 2008 to enable buyers of both new and used vehicles to compare the fuel economy of different models. The system is easy for consumers, since it is based on the same sort of star rating system already in use for appliances, and easy for dealers because a free web service automatically fills in the labels with the correct information. Since New Zealand has no automobile manufacturing industry and imports all of its vehicles, the government Energy Efficiency and Conservation Authority developed an algorithm to convert the different standards used in different economies into a system that rates efficiency on a scale from one to six stars. It is the first vehicle fuel economy labeling scheme in the world to incorporate used as well as new vehicles into the same system.

Estimated annual fuel costs to operate the vehicle will also be on the label, in addition to a fuel consumption figure in liters per 100 km for new vehicles tested to the European standard (Figure 10). All of the information used in the labels can be found at www.fuelsaver.govt.nz, and another new site incorporates fuel economy, safety, and emissions: www.rightcar.govt.nz. The government estimates that annual fuel savings will exceed 6 million liters by the fifth year of the program, reaching 14 million liter per year by the tenth year.[47,48]

Canada's EnerGuide Labeling and Awards Program

The Canadian EnerGuide labeling program targets new light vehicles up to 3.8 tons (3,855 kg). The label shows average fuel economy for the given vehicle in the city and on the highway, as well as estimated annual fuel costs. Prospective buyers can consult the Fuel Consumption Guide, which is published annually and available online or at vehicle dealerships. The EnerGuide Awards program recognizes the most energy-efficient, climate-friendly vehicles on the market for each model year.

Incentives to Purchase Efficient Vehicles

Consumers do not always rank fuel efficiency among their top priorities when making vehicle purchasing decisions, even when fuel prices are high and rising. The most fuel-efficient models, at least initially, come in fewer varieties than vehicles with status quo fuel efficiency, and they may be more expensive than other models in the same class, so consumers often need additional incentives to purchase them. To shift consumer purchases from less to more efficient vehicles, "feebates" are

[47] Communication from Terry Collins, Energy Efficiency and Conservation Authority, November 2007.

[48] "Vehicle Fuel Economy", Government of New Zealand Energy Efficiency and Conservation Authority (http://www.eeca.govt.nz/transport/vehicle-fuel-economy/).

offered in a few APEC economies. This approach provides buyers of efficient vehicles with a rebate, and imposes a surcharge or tax on the purchase of fuel inefficient vehicles, whereby the surcharge funds the rebate. The following examples illustrate various ways that tax incentives and disincentives have been applied within APEC.

Canada's Green Levy for Poor Performers and Rebates for Efficient Cars and Light Trucks

Canada's ecoAUTO program, for example, offers up to C$2,000 in rebates to those who buy or long-term lease a fuel-efficient vehicle. The list of qualifying vehicles includes new cars with fuel economy of 6.5 L/100 km (36 miles per gallon) and new light trucks getting 8.3 L/100 km (28.3 mpg).[49]

In 2007 Canada also introduced a "Green Levy," which is an excise tax on certain classes of passenger vehicles with poor fuel economy. Natural Resources Canada rates and publishes weighted average fuel consumption for each new vehicle model on the market, and the amount of the tax is based on those weighted averages. The rates are based on estimated fuel consumption in the city (55 percent) and on the highway (45 percent). Vehicles with weighted average fuel consumption at or above 13 liters per 100 kilometers are levied C$1,000 for each additional full liter per 100 km up to 16 liters. In other words, weighted average fuel consumption of 13 to 13.9 L/100 km results in a levy of C$1,000, 14 to 14.9 L/100 km C$2,000, 15 to 15.9 L/100 km C$3,000, and 16 or more L/100 km C$4,000. The automobile manufacturer or importer must pay the levy when the vehicles are delivered to their purchasers (usually dealers or traders) or imported. One can safely assume that the levies are reflected in the purchasing price of the inefficient vehicles offered to buyers.

China Adjusted Taxes to Encourage the Purchase of Efficient Vehicles

In response to the dramatic rise in ownership of private cars and increased reliance on oil imports, China revised the tax structure in 2006 to encourage the purchase of vehicles with smaller engines.[50,51] This demand-side measure aims to strengthen China's new fuel economy rules (standard for mpg listed above). Similar to the feebate approach, purchasers of low-emission vehicles will be subject to lower excise taxes while purchasers of high-emission vehicles will have to pay a much higher excise tax. The government has also encouraged smaller car purchases by prioritizing them for taxi service instead of larger vehicles, and offering small car owners preferential oil prices and parking fees. As the Worldwatch Institute points out, "low-emission vehicles" and "economic vehicles" are vaguely defined, and low-emission cars are not necessarily economical, so clarification and perhaps further standards are needed.[52]

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[49] "Canada Introduces Measures to Encourage Fuel-Efficient Vehicle Purchases," in Green Car Congress, 21 March 2007. See also http://www.tc.gc.ca/programs/environment/ecotransport/ecoauto.htm for the ecoAUTO Rebate Program; and http://www.cra-arc.gc.ca/agency/budget/2007/excise-e.html and http://www.budget.gc.ca/2007/bp/bpc3e.html#levy for the "Green Levy" on fuel inefficient vehicles.

[50] "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update", by F. An, et al. July 2007, The International Council on Clean Transportation (http://www.theicct.org/documents/ICCT_GlobalStandards_20071.pdf).

[51] "Reducing China's Thirst for Foreign Oil: Moving Towards a Less Oil-Dependent Road Transport System", H.H. Oliver, Woodrow Wilson International Center for Scholars, 2006 (http://www.wilsoncenter.org/topics/pubs/CEF_Feature.3.pdf).

[52] "Government Encouraging Smaller Cars, Improved Fuel Efficiency," by Zijun Li, January 26, 2006, in China Watch online newsletter at http://www.worldwatch.org/node/3877.

Prior to this tax change, about half of the market share for light duty vehicles in China had engine sizes between 1.5 and 2.0 L, while about 20% of those sold had engines smaller than 1.5 L. The changes in excise tax were as follows, based on engine size:

- smaller than 1.0 L: stayed at 3%
- between 1.0 and 1.5 L: decreased from 5% to 3%
- between 1.5 and 2.0 L: remained the same
- between 2.5 and 3.0 L: increased by 4%
- between 3.0 and 4.0 L: increased by 7%
- larger than 4.0 L: from 8% to 20%

For small motorcycles with engines smaller than 250 cc, the tax was lowered from 10% to 3%.

Hong Kong, China's 30% Tax Credit for Purchase of Efficient Private Vehicles

Hong Kong, China enacted a new tax incentive program in April 2007 allowing a 30% discount on the first registration tax of new private petrol-powered vehicles that meet certain stringent emissions and fuel consumption standards. The standards require 40% better fuel economy compared to the average fuel economy for conventional Euro IV vehicles of the same vehicle weight class, while requiring HC and NO_x tailpipe emissions 50% below Euro IV levels. In order to ensure that the credit is available only to the most efficient vehicles on the market, the minimum standards are subject to annual review and revision. In the first five months after the incentive went into effect (through August 2007), nearly 2000 newly-registered vehicles were awarded this tax credit, accounting for 13% of all new private petrol vehicle registrations during that period. During this period there were 18 eligible vehicle models on the Hong Kong, China market for consumers to consider, an increase of 23% from those available before the tax incentive was put into effect. Hong Kong, China policy makers expect this growth trend to continue as manufacturers continue to bring more high-efficiency models to the Hong Kong, China market.[53,54]

Japan's Automobile Green Tax: Reduced Taxes for the Purchase of Efficient Vehicles

In addition to the strict fuel efficiency standards in Japan, in 2001 the government also began providing a set of tax incentives for consumers to purchase vehicles that are more efficient than required under the standards.[55] For passenger vehicles that surpass the existing fuel economy standards by 10%, the motor vehicle acquisition tax is reduced by 5% for private vehicles (about 7,500 yen) and 3% for light commercial vehicles (about 9,000 yen), while the annual motor vehicle tax is reduced by 25%. For vehicles that surpass the existing fuel economy standards by 20%, the savings are doubled. For a car with a 2000 cc engine, the annual savings in the motor vehicle tax is about 9,750 yen (~US$90) and 19,500 yen (~US$180) for vehicles that are 10% and 20% more efficient than the standards, respectively. In addition, the motor vehicle tax is halved for vehicles powered

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[53] Communication from K.C. Lo, Hong Kong Environmental Protection Department, October 2007.

[54] "Tax Incentives for Environment-friendly Petrol Private Cars", Hong Kong Environmental Protection Department, December 2007, (http://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/environment_friendly_private_cars.html).

[55] "Current Status of Measures Against Global Warming In Transport Sector", The Ministry of Land, Infrastructure and Transport, September 2007 (http://www.jama-english.jp/europe/news/2007/no_3/MrMiyazawa.pdf).

by electricity, natural gas or ethanol, and tax breaks are provided on qualifying hybrid vehicles. By way of *disincentive*, owners pay an additional 10% in the annual motor vehicle tax for vehicles with long service lives: over 11 years for diesel vehicles and over 13 years for gasoline and LPG.

Chinese Taipei Opts for Fuel Tax

Up until 2002, Chinese Taipei also used a tax scheme that encouraged purchase of more efficient vehicles. However, recognizing that the tax incentive did not encourage efficient *use* of vehicles once purchased, the government opted to adopt a fuel tax of about 50% on the base cost of gasoline. The rationale was that the revised tax system would influence consumers to both purchase more efficient vehicles and drive less.[56]

U.S. Tax Credits for Fuel-Efficient Vehicles

To motivate the market for fuel-efficient vehicles, consumers in the United States who buy qualifying cars and light trucks receive a tax credit. The tax credits are calculated based on two factors: the vehicle's fuel economy and energy savings. Cars and light trucks that exceed the 2002 model year city fuel economy standard for the respective vehicles' weight classes may be eligible for the fuel economy portion of the credit, starting at US$400 for fuel economy that is at least 125 percent better than the 2002 baseline, up to US$2,400 for an improvement of 250 percent or more. The conservation credit is determined by the estimated fuel savings over the purchased vehicle's lifetime, starting at US$250 for savings of at least 1,200 gallons of gasoline and going up to US$1,000 for savings of 3,000 or more gallons.[57]

Once a vehicle model meets the above-mentioned criteria, the corresponding automaker has to calculate the amount of the tax credit and apply to the U.S. Internal Revenue Service (IRS) for official certification. There are limits on the number of vehicles any single manufacturer may sell with the tax credit offer, so buyers are encouraged to act early. As soon as a manufacturer sells 60,000 certified vehicles, the amount of the tax credit decreases incrementally and is eventually phased out.

At the time of publishing this study, Toyota and Honda had already met their quotas, so purchasers of these automakers' IRS-certified vehicles were no longer eligible for the full or partial credit, depending on when the manufacturer met the quota.[58] The purpose of the quota is to protect domestic U.S. automakers that did not have a competitive selection of hybrid models to market at the time when the tax credit was enacted. The credits will be available through 2010 for certified vehicles whose manufacturers have not yet exhausted their quotas.

Efficient Government Fleets

Governments that want to encourage fuel economy can lead by example through improvements in the energy efficiency of government fleets. This can be done first on a small scale through pilot projects that demonstrate how cleaner fuels can replace traditional gasoline or diesel to power public buses and other vehicles, thus saving fuel and reducing pollution while maintaining or improving

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[56] Asia Pacific Energy Research Centre, "Energy Efficiency Programmes in Developing and Transitional APEC Economies," 2003, p. 17.

[57] Alliance to Save Energy http://www.ase.org/content/article/detail/2654#hybrid_vehicle, American Council for an Energy Efficiency Economy http://www.aceee.org/transportation/hybtaxcred.htm, and the Energy Policy Act of 2005.

[58] Alliance to Save Energy http://www.ase.org/content/article/detail/2654#hybrid_vehicle.

the quality of service. It can also be done through more comprehensive policies that require broad-based energy-efficiency improvements of entire fleets. Most APEC economies have utilized the former approach and a few (e.g. United States and Canada) have introduced the latter.

Canadian Government Programs for Greening Fleets

Canada supported a Federal Vehicle Initiative that ran from 1995-2007 and aimed to improve the fuel economy and capability of government fleets to operate on alternative fuels where cost-effective. By early 2008, Canadian federal departments had 1,400 alternative fuel and hybrid vehicles in use, amounting to about 5.3 percent of the total fleet.[59] Between 1995 and 2004, while the total federal fleet size increased by nearly 3% from 24,944 to 25,666 vehicles, its total fuel consumption declined by approximately 15% from 76.8 million to 65.0 million liters of gasoline equivalent.[60]

In 2007 a new program called ecoENERGY for Fleets was introduced in Canada, which targets primarily commercial fleets and includes driver training, fleet fuel management, and idling reduction. The estimated cost of the program is C$22 million over four years.

The Philippines' Regulations on Government Fleets

In October 2004 the Philippines President signed into law the Government Energy Management Program, which includes regulations governing the purchase and operation of government vehicles.[61] Engine size must be smaller than 1,600 cc for gasoline engines and less than 2,500 cc for diesel. Vehicle selection must be guided by the Department of Energy Fuel Economy Runs (refer to the following section on awareness campaigns for more detail on these "fuel economy runs"). Compressed natural gas vehicles should be purchased where feasible, and liquid fuels should be blended as appropriate with alternative fuels. For example diesel fuel should be blended with 1% of coco-methyl ester, also known as coco-biodiesel (according to Memorandum Circular No. 55), and gasoline should be blended with ethanol. All vehicles must be maintained regularly, including opacity emissions testing for diesels, and drivers must follow the efficient driving tips issued by the Department of Energy.

United States' Federal and State Level Policies to Green Fleets

In the United States, the Energy Policy Act (EPACT) of 1992 required that 75 percent of light-duty vehicles purchased by the federal government in metropolitan areas be alternative fuel vehicles. President Bill Clinton in the year 2000 issued Executive Order (E.O.) 13149: Greening the Government through Federal Fleet and Transportation Efficiency, requiring federal agencies to develop and implement a plan for a 20% reduction in their fleets' petroleum consumption by fiscal year (FY) 2005 compared to a FY 1999 baseline. Subsequently the amended EPACT of 2005 and E.O. 13423 (revoking E.O. 13149) modified the requirements. Alternative and flexible-fuel vehicles are required if the fuel is available within five miles or 15 minutes and its cost does not exceed gasoline costs by 15%. Federal agencies must reduce petroleum consumption by 2% a year from 2005 (the

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[59] Survey for purposes of this report's research completed by Natural Resources Canada, Office of Energy Efficiency. More information at http://oee.rncan.gc.ca/communities-government/transportation/federal/mandate.cfm?attr=16.

[60] Natural Resources Canada, *Improving Energy Performance in Canada – Report to Parliament Under the Energy Efficiency Act For the Fiscal Year 2005-2006*, online at http://oee.rncan.gc.ca/Publications/statistics/parliament05-06/appendix-a.cfm?graph=43&attr=0.

[61] Philippines Department of Energy, 2004 (www.doe.gov.ph/EE/IRR%20AO110-GEMP.pdf).

baseline of 1999 was reset to 2005), increase alternative fuel use by at least 10% compounded annually, and purchase plug-in hybrids when commercially available at reasonable cost.[62] Federal agencies must report their compliance by sharing data on vehicle acquisition and inventory, fuel economy and fuel use, using the Federal Automotive Statistical Tool (FAST). The U.S. Department of Energy tracks these data online http://fastweb.inel.gov.

Some individual U.S. states also have enacted policies to increase fuel economy of vehicles that they purchase. For example, under Connecticut's Public Act 04-231 (2004), the fleet average for cars and light-duty trucks purchased by the state must have an Environmental Protection Agency estimated fuel economy rating of at least 40 miles per gallon (mpg), and must obtain the best achievable fuel economy per pound of carbon dioxide emitted in its vehicle weight class. Since 2000, with the exception of vehicles used for law enforcement and special purposes, the state of Maine may not purchase or lease cars with estimated highway mileage ratings below 45 mpg or light-duty trucks with the same rating below 35 mpg. The state of New York's Executive Order 111 required that at least half of all new light-duty vehicles it purchased by 2005 be hybrids or alternative-fuel vehicles, and by 2010 all new vehicles must be hybrids or alternative-fuel vehicles.

Awareness Campaigns

While the above-mentioned programs target people or agencies who are looking to buy vehicles, such programs can be accompanied by more general public awareness efforts that address the need to drive more efficiently. Many public awareness campaigns have a component that discusses fuel economy in terms of both vehicle technology and driving behavior. The following example from the Philippines addresses a wide audience of drivers. Other types of awareness campaigns may include driver training (e.g., see Nippon Express in the Japanese policy case study in Chapter 7), celebrity public service announcements, publicizing achievements of government fuel economy initiatives.

The Philippines: Raising Public Awareness of the Fuel Economy of Popular Vehicles

In 1998, the Republic of the Philippines launched its "Road Transport Patrol" program to educate consumers on how they can optimize fuel efficiency and reduce air pollution through their choice of vehicles and the way they operate them.[63] Two types of audiences are targeted: the general driving public, and those who make their living driving, such as bus, "jeepney," taxi and truck drivers. The awareness campaign provides drivers with information on vehicle maintenance, driving tips to maximize fuel efficiency, and the fuel economy of different models of cars, buses and trucks. The program includes ongoing "fuel economy runs" conducted by the Department of Energy, a set of experiments where the fuel economy is measured for a variety of popular private, public, and commercial vehicles driven under normal conditions (and at times with different fuels, such as biodiesel). The results are kept in a database that provided consumers with real life fuel economy figures for use in buying vehicles.[64]

Figure 11. The Philippines "Road Transport Patrol"

[62] "Federal Fleet Requirements, EPACT and E.O. 13423: How Do Federal Fleets Comply?" Federal Energy Management Program Fact Sheet at http://www1.eere.energy.gov/femp/pdfs/41891.pdf.

[63] "The Philippines: making energy efficiency & conservation a way of life", F.A. Benito, Philippines Department of Energy, February 2005 (http://www.resourcesaver.com/file/toolmanager/O105UF1254.pdf).

***Republic of Korea: Energy Winner Award Program*[65]**

The Citizen's Alliance for Consumer Protection (CACPK) launched a broad-based consumer education and awareness program in 1995 that promoted energy-efficient consumption and production. Its initial focus on home appliances soon expanded to include cars, buildings, lighting, and program activities. Each year the independent CACPK Energy Advisory Committee evaluates all nominees for three main categories: Grand Prize of the Year, Energy Award of the Year (sub-categories: Energy Efficiency Award, Energy Innovation Award, Energy Conservation Award), and the Carbon Dioxide Reduction Award. The winners are allowed to use the award logo (Figure 12) on their products and promotional materials. The Energy Winner Award program is an example of how voluntary agreements between government and companies can be used to encourage demand and supply of more energy-efficient products and technologies.

Figure 12. Energy Winner Award Logo

***United States: Maine's Fuel Wise Campaign*[66]**

The example of the U.S. state of Maine's awareness campaign focuses mostly on driving behavior rather than technology, and as such is a segue into the next chapter. In 2006, the state enlisted the help of an Olympic gold medalist and popular humorist to spread the word about how the state's citizen's can save on transportation fuel costs. Maine's population is low-density and most people drive, so the most immediate way to reduce driving-related fuel consumption is to promote efficient driving behavior. The campaign featured 30- and 60-second radio spots where the celebrities shared fuel-saving tips: proper car maintenance (3 - 20% savings), carpooling (50% savings), observing speed limits (7 – 23% savings), and avoiding sudden stops and starts. A website provided further tips and visitors could enter contests to win prizes if they participated in surveys that will help the campaign directors determine driving habits.

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[64] "Philippines: Policies and Strategies for Developing and Promoting EE Technologies", Asian Development Bank, February 2005 (http://www.adb.org/Clean-Energy/documents/PHI-Policy-Report.pdf).

[65] Kim, Jai-Ok, "Raising Awareness and Participation of Manufacturers and Consumers: Energy Winner Award Programme of the Citizens' Alliance for Consumer Protection of Korea," chapter in *Guidebook on Promotion of Sustainable Energy Consumption: Consumer Organizations and Efficient Energy Use in the Residential Sector*, UN ESCAP 2007, http://www.unescap.org/esd/energy/publications/psec/guidebook-part-three.htm.

[66] For more information see http://maine.gov/tools/whatsnew/index.php?topic=Gov+News&id=22789&v=Article-2006.

3. Improving Operational Efficiency of Existing Vehicles

Advances in technology will have a profound impact on fuel economy and energy efficiency, but as outlined in the discussion of awareness campaigns above, there are also ways to improve fuel economy of existing vehicles. Information and tips for drivers and vehicle owners should be accompanied by enforceable, mandatory measures that ensure proper baseline maintenance and that get the least efficient, most polluting vehicles off the road.

Mandatory Vehicle Emissions Inspections

While regulations combined with efficient technologies ensure that newly manufactured vehicles are more efficient, the efficiency of vehicles erodes over time if they are not properly maintained. Eventually vehicles become so worn—especially those of older generation technology—that maintenance cannot cost-effectively keep them running cleanly and efficiently, and they should be removed from use altogether. Scrapping programs for old vehicles are discussed in the next section.

However, in between the beginning and end of the driving life of a vehicle, no program to improve air quality, stem greenhouse gas emissions, or reduce oil consumption can truly succeed unless mandatory vehicle inspections maintain efficiency and control emissions over the period that the vehicle is on the road. Quite a few of the APEC economies have mandatory annual vehicle inspection programs, some requiring inspections of all vehicles registered, while others do so only in the more polluted cities or—in the case of Canada—in certain provinces.

Inspection and Maintenance (I/M) programs can provide an important touch point with vehicle owners. The primary objective of I/M programs is to assure that vehicles are properly maintained and meet requisite performance, emissions, and safety standards, and to verify repairs for failed vehicles. In addition to improving vehicle maintenance, I/M programs are also strong deterrents to vehicle tampering and misfueling while providing a deployment platform and enforcement infrastructure for other strategies like alternative fuel retrofits.

Some challenges in implementing I/M programs result from a perceived "hassle factor" which discourages vehicle-owners from adequately complying with inspection requirements. Different results from varying test procedures such as idle testing or loaded testing also affect the stringency of the emissions inspections. Careful thought into establishing testing and standards is crucial to regulating tailpipe emissions of existing vehicles. Furthermore, successful I/M programs depend on proper training for inspectors and adequate oversight to ensure necessary repairs for failed vehicles and to discourage fraud.

For instance, combined testing and repair sites are subject to high instances of fraud due to conflicts of interest and lack of accountability, as illustrated in the case studies below. The solution is to decouple testing and repair which greatly reduces fraud but may increase the "hassle factor."

In short, nine elements of a well-designed I/M program include:[67]

1. Relative ease and simplicity of inspection and repairs
2. Public awareness to help overcome the "hassle factor"
3. Appropriate test procedures
4. Appropriate standards and norms

[67] Michael Walsh, "Improving Operating Efficiency of Existing Vehicles" presentation, 24 March 2009, (http://ase.org/uploaded_files/5342/apec_wppeet_walsh_2.pdf).

5. Inspector training
6. Consistent government oversight & auditing
7. Privatized system to ensure program efficiency and capacity
8. Strong enforcement
9. Centralized testing, preferably separate from repair sites

The following paragraphs describe the experience with programs in Malaysia, Mexico, the Philippines and Canada.

The case study below about Mexico City provides some useful lessons for economies interested in pursuing a new vehicle inspection program, especially with regard to designing a program that prevents emissions certifications from being obtained fraudulently. The Mexico City example also demonstrates the importance of measuring nitrogen oxide (NO_x) emissions from gasoline-powered vehicles in addition to carbon monoxide (CO) and unburned hydrocarbons (C_xH_x, or more commonly referred to as HC). CO and HC are signs of inefficiency because they result from incomplete combustion, whereas NO_x results from the reaction of the main components of air—nitrogen and oxygen—at the high temperatures and pressures that occur in the combustion chamber. NO_x is not a priority from a fuel efficiency perspective; however the rolling treadmill dynamometer testing procedure for NO_x prevents cheating on the test for CO and HC (see the Mexico City case study for details).

For more information on the design of vehicle emissions inspections programs, and the experience of economies around the world, see the 2004 comprehensive overview commissioned by the U.S. Agency for International Development.[68] Some APEC economies are among those examined in the report, including Australia; Canada; Chile; China; Hong Kong, China; Indonesia; Malaysia; Mexico; Peru; the Philippines; Singapore; Chinese Taipei; Thailand; United States; and Viet Nam.

Malaysia Vehicle Inspection Program

In July of 2007, Malaysia expanded its decades-old safety and emissions inspection program from only commercial vehicles to also include used private vehicles being sold to new owners. Commercial vehicles are inspected once every six months (except for new vehicles which are checked only annually for the first 2 years).[69] Vehicle owners cannot renew their Road Transport Department licenses without a sticker indicating that the vehicles they intend to drive have passed inspections. Effective July 2007, a new regulation requires used, private vehicles to be inspected also, before ownership of the vehicle can be transferred to a new owner.

All inspections are carried out by computerized inspection centers operated by a single private firm, Puspakom, which was awarded a franchise by the government to be the sole builder and operator of the centers. Each facility must be equipped with devices to measure opacity (for diesels) and CO and HC (for gasoline engines), and their mechanics are trained by the Malaysia Department of Environment, which audits the facilities annually. The "pass-fail" decision is computerized to eliminate human subjectivity and to prevent fraud. Contracting to private companies and allowing some profit incentives increase program efficiency while allowing inspection centers the flexibility to

[68] "Vehicle Inspection and Maintenance Programs: International Experience and Best Practices," Karl Hausker, U.S. Agency for International Development, October 2004 (http://pdf.dec.org/pdf_docs/PNADB317.pdf).

[69] "Vehicle Inspection and Maintenance in Malaysia", A. Ishak, Malaysia Department of Environment, November 2001 (http://www.cleanairnet.org/caiasia/1412/articles-37271_cq_15_ishak.pdf).

respond to market and policy demands relatively quickly. In Malaysia, Puspakom effectively doubled their capacity from 31 testing centers to 64 in 2007 to accommodate the increasing volume of private vehicle inspections stemming from new regulations requiring used vehicles to undergo inspection before transfer of ownership.[70] Almost half of the test centers are open until 20:00, and several located in especially busy areas are open on Saturdays.[71] In addition to verifying minimum safety and emissions standards, certifying used vehicles has the added benefit of preventing stolen and reassembled cars from entering the market, which can be a major problem in countries with a high influx of imported used vehicles. (In 2004, Puspakom seized 18 illegally reassembled cars between January and March of 2004.)[72]

A centralized and privatized inspection agency also offers a mechanism to implement new safety and emissions standards and regulations. In 2000, amendment regulations under Malaysia's Road Transport Act to require underrun bars on all commercial vehicles for road safety were enforced by Puspakom through their regular 6-month inspections.[73] Furthermore, such a centralized program also allows Malaysia's Road Transport Department direct access to consistent, reliable, and comprehensive data on in-use commercial and private vehicles.

Road-side inspections are a complement to the systematic regular inspections established by Malaysia's Road Transport Act. Since 1977, the government has used road-side inspections to check black smoke emissions from diesel vehicles. In 1995, they introduced the Area Watch and Sanction Inspection (AWASI) Program where Mobile Squads from the Department of Environment patrol streets to conduct visual checks on tailpipe emissions and may impose penalties such as issuing compound and prohibition orders on failed vehicles.[74] These spot checks greatly discourage tampering of vehicle engines after they pass inspection.

Lastly, the Malaysian I/M program engages in public education and awareness building with commercial vehicle operators through annual dialogues and providing "free" tests during Malaysia's annual Environmental Week Celebration in October.

In sum, the Malaysian I/M program incorporates many of the principles of a successful program including public awareness, inspector training, centralized testing, a privatized system, and complementary enforcement measures. For further improvements, the Malaysia Road Transport Department and Department of Environment continue to consider different test procedures such as a loaded dynamometer test rather than an idling test, broadening the scope of the program, and ensuring proper oversight and strong enforcement.

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[70] "Puspakom checks on used vehicles from today," *The Star,* 2 July 2007 (http://www.piam.org.my/news/insnews/ins_news.asp).

[71] "No Plans To Allow Workshops To Conduct Vehicle Inspection", *BERNAMA (Malaysian National News Agency)*, July 2007 (http://www.piam.org.my/news/insnews/ins_news.asp).

[72] "Consumers Told to Be Careful When Buying Used Cars," *BERNAMA (Malaysian National News Agency),* 4 June 2004 (http://www.piam.org.my/news/insnews/ins_news.asp).

[73] "Underrun bars on vehicles to be law," *New Straits Times,* 1 January 2000 (http://www.piam.org.my/news/insnews/ins_news.asp).

[74] "Vehicle Inspection and Maintenance in Malaysia", A. Ishak, Malaysia Department of Environment, November 2001 (http://www.cleanairnet.org/caiasia/1412/articles-37271_cq_15_ishak.pdf).

CASE STUDY
MEXICO: Vehicle Inspections Program in Mexico City

Purpose
To reduce air pollution in the Mexico City Metropolitan Area (MCMA) by keeping motor vehicles in the area properly maintained.

Summary of Actions
Mandatory annual inspections of all vehicles in Mexico City's two local jurisdictions, the Federal District (DF) and the State of Mexico (Estado de México, EM), with emissions tested for carbon monoxide (CO), oxides of nitrogen (NO_x) and unburned hydrocarbons (HC). High CO and HC emissions result from incomplete combustion, implying inefficient vehicle fuel use.

Background
Currently, 28 million people in Mexico live in urban areas with poor air quality. More than 70% of air pollution in metropolitan areas is caused by road vehicles.[75] The topography of the MCMA has much in common with the Los Angeles basin, which was famous for its smog thirty years ago. Both areas occupy large basins surrounded by mountains that trap air pollution, exacerbated by strong sun exposure that enhances the photochemical reactions that produce smog. Both areas are susceptible to thermal inversions, which occur when a high pressure system moves warm air over the basin, trapping cooler ground level air—with its pollution—until the high pressure system moves on and allows the cooler air to dissipate away from the ground. In the case of Mexico City the situation is further exacerbated by the high elevation—2200 meters above sea level—which enhances smog-forming photochemical reactions and makes combustion less efficient. During the 1990s the World Health Organization standard for ozone was exceeded on 90% of the days, and on 40 to 50 days the level of ozone was at least double the standard.[76] In 1992, Mexico City was declared by the United Nations as having the worst air pollution in the world. Most of the air pollution is produced by vehicles, numbering roughly four million today. When the mandatory inspections program for all vehicles began in 1992, many vehicles in the MCMA were operating inefficiently, due to age and/or poor maintenance.

Implementation
The local Mexico City government initiated a voluntary I/M program in 1982, and mandatory inspections for vehicles greater than five years old were instituted in 1988, and expanded to include all vehicles in 1992. In the early stages of the program, motorists had a choice between authorized test-only centers and—for greater convenience—independent test-and-repair garages. However, fraud at the test-and-repair facilities became increasingly widespread until an estimated half of all vehicles obtained their passing certificate by paying a bribe.[77] In January 1996 the system was completely overhauled, at some political risk because all 600 test-and-repair centers were shut down and the number of large, multi-lane, testing-only "macrocenters" called *Verifcentros*—first established in 1991— was increased from 26 to 33, totaling 180 test lanes (see Figure 13). As of 2005,

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[75] Lacy, Rodolfo, "The Challenge of Used Car Imports and Retiring Old Vehicles in Mexico," 23 March, 2009 (http://ase.org/uploaded_files/5342/apec_wppeet_rodolfo_lacy_2.pdf).

[76] "History of Mexico Air Quality Management and Some Recent Development", Luisa T. Molina, October 2006 (http://www.narsto.org/files/files/MexicoCity_6.pdf).

[77] **Dodder, R. et al.** "Reducing the Impact of Vehicles on Air and Environmental Quality in Cities," January 2004 (*http://www.iuappa.com/conference/SEMINAR/SUMMARY-REPORT.pdf*).

a total of 76 verificenters and 337 test lanes were in operation. Both technical and administrative improvements were made to improve the effectiveness of the testing, including a system that separated the testing process (and therefore the person performing the test) from the central computer that issued the pass or fail. The government also began performing remote video monitoring of the centers and on-site technical audits by government inspectors.[78,79] Tellingly, through technical and administrative adjustments and shifting toward test-only verificenters, the fail rate of test-and-repair centers almost quadrupled, and the fail rate of macrocenters doubled between 1995 and the first half of 1996.[80]

Figure 13. ***Verificentro*** **testing center in Mexico City**
[Photo courtesy of John A. Rogers, Grupo Trafalgar

Another step in the learning process was to allow vehicles registered in the Federal District of Mexico City (DF) to be tested at the less rigorous EM stations, causing many vehicles—an estimated 500,000 between the first half of 1997 and the second half of 1999—to be tested in EM instead of DF. As of January 2001, DF vehicles were again restricted to testing at DF stations, but the experience demonstrates that local jurisdictions with overlapping geographic distributions need to have equivalent protocols and equipment of comparable quality.[81]

In 2000, the authorities made another important improvement to the system by imposing a standard for NO_x in addition to HC and CO. Since the formation of NO_x is dependent upon combustion temperature, NO_x must be measured using a dynamometer, a sort of treadmill for the vehicle to measure emissions under simulated driving conditions. This latest change in procedure was important not only because it added a third critical pollutant, but because it significantly reduced the number of vehicles that were able to pass the CO and HC test when idling. Earlier, garages were able to pass some vehicles on the CO/HC test by "tuning late and lean," where the ignition timing is set late and the fuel-to-air mixture is lowered. Although the adjustments may compromise the vehicle to the point where it cannot be driven, and increase NOx emissions, they also reduce HC and CO emissions. However, late and lean tuning does not work when the test is performed "under load" with a warm engine.[82]

[78] Ibid.

[79] "Motor Vehicle Inspection and Maintenance: The Worldwide Experience", Michael P. Walsh, January 2005 (http://walshcarlines.com/pdf/SIAT2005%20IM.pdf).

[80] Ibid, pg. 10.

[81] Ibid.

[82] Ibid.

Results

Evolution of Emissions Inspection Program in Mexico City[83]	
Year	**Program Measure**
1982	Voluntary inspection program initiated, operated by Mexico City government.
1988	Mandatory annual emissions inspection introduced for 1982 and earlier models. Test-and-repair centers authorized.
1989	"Day without a car" program started.
1992	Mandatory test introduced for all vehicles.
1993	Test-only centers operated by the Mexico City governemtn closed, and multi-lane "macro-centers" opened. Dynamometer test introduced for all vehicles not privately owned.
1994	Emissions standards tightened.
1996	Test-and-repair centers closed. New "verificenters" authorized. "Double day without a car" program started. Emissions standards tightened further.
1997	"Clean" cars exempted from "day without a car" program. More verficenters authorized. Requirement that vehicles registered int eh Federal District be tested there lifted. Hybrid testing protocol (based on acceleration simulation mode) started in second half of year.
1999	New testing procedure fully adopted. Replacing catalytic converter mandatory for 1993 models. Emissions standards modified.
2000	Standards for NOx introduced. Replacing catalytic converter mandatory for 1994 and 1995 models.
2001	Requirement that vehicles registered in the Federal District be tested there reimposed.

~~Evolution of Emissions Inspection Program in Mexico City~~

Although serious air pollution challenges remain in the MCMA, the improvements in air quality from the time the vehicle inspections program began demonstrates that the program has improved vehicle maintenance: CO has declined by 50% from 1986 to 2003. Ozone levels have fallen by 36.5% since their peak in 1991. It should be noted, however, that even today Mexico City is in violation of the one-hour ozone standard about two days out of three.[84]

Lessons Learned

The Mexico City case provides a number of valuable lessons for other economies:

- Both the testers and the motorists must be prevented from engaging in fraud by using regularly audited testing protocols and by keeping testing separate from repairs.
- Use dynamometer testing and include NOx emissions standards to prevent vehicles from falsely passing the test by tuning late and lean.

The testing centers for overlapping jurisdictions should be comparably stringent, with equivalent protocols and equipment of comparable quality.

Remaining Challenges

Despite improvements in the program, eliminating test-and-repair centers has created a large bottleneck at verificenters, greatly increasing the "hassle factor." Measures to increase ease and

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[83] Kojima, Masami and Robert Bacon, "Privatizing Vehicle Inspection and Reducing Fraud in Mexico City," Emission Control *Viewpoint*, World Bank, September 2001 (http://www.worldbank.org/html/fpd/notes/).

[84] "Index of Leading Environmental Indicators", 11th edition, Steven F. Hayward, The Nature and Sources of Ecological Progress in the U.S. and the World, 2006 (http://www.aei.org/docLib/20060413_2006Index.pdf).

accessibility to inspection would increase compliance while balancing the necessity to ensure profitability and minimal fraud of verificenters. Additionally, insufficient monitoring and enforcement capacity on the roads to catch vehicles without the proper certificates results in a high incidence of illegal vehicles on the streets. Lastly, programs with comparable levels of stringency and enforcement need to be replicated and expanded to other areas of Mexico beyond Mexico City.

The problem of illegal vehicles in operation is compounded by the challenges in regulating "*chocolates,*" which are old, polluting, and unsafe vehicles exported from other countries, primarily the U.S. Between November 2005 and December 2008, more than 3 million used vehicles, ranging from 10-15 years old, were exported to Mexico from the U.S. Of that number, over 70% were vans, minivans, SUVs and pick-up trucks with fuel economy of less than 6 kilometers per liter (~14 miles per gallon).[85] Starting in 2009, this problem will be further exacerbated as borders are opened to vehicle imports under the North America Free Trade Agreement (NAFTA). The high volume of *chocolates* and other salvaged vehicles and spare parts presents an domestic regulatory problem, entrenches a culture of inspection evasion and illegality around car ownership and sale, undermines Mexico's domestic auto market, and presents challenging international trade and customs issues.

The Philippines Battles Corruption in Vehicle Inspections Program

The Philippines has a regulation requiring all motor vehicles to pass an emissions test given by one of 420 accredited Private Emission Testing Centers (PETC) before they can be registered.[86] The government has struggled, however, to ensure that the certificates produced by the PETCs have any relation to emissions performance. For example an investigation in 2004 found that out of 500 vehicles issued passing certificates, only 25 were actually tested.[87] In February 2008, the Land Transportation Office (LTO) announced that is was investigating all of the PETCs to uncover those that are providing certificates without conducting the tests. Alberto Saunsing, the head of LTO and Assistant Secretary for the Philippines Department of Transportation and Communications, promised to terminate the operations of all PETCs engaging in fraud.

Figure 14. Measuring equipment at an emissions testing center in Manila
(Photo courtesy of the Japan Bank for International Cooperation)

[85] Lacy, Rodolfo, Oral Presentation, "The Challenge of Used Car Imports and Retiring Old Vehicles in Mexico," APEC Workshop on Policies to Promote Energy Efficiency in Transportation, 24 Mar. 2009 (http://ase.org/uploaded_files/5342/apec_wppeet_rodolfo_lacy_2.pdf).

[86] "Land Transportation Office to probe 420 private emission centers", J. Icban-Legaspi, Journal Group of Publications, 8 February 2008 (http://www.journal.com.ph/index.php?issue=2008-02-08&sec=4&aid=48599).

[87] "USAEP Strategy and Program Design: Strategic Assessment Report", U.S. Agency for International Development, September 2004 (http://epiq2admin.web.aplus.net/pubs/usaep_strategic_asmt.pdf).

Retiring Old Vehicles

Jurisdictions can improve the efficiency of the overall fleet of vehicles operating within their borders through the accelerated retirement (scrappage) of older, inefficient vehicles. Usually retirements are voluntary, in exchange for compensation, but they can also be mandatory, with or without compensation. Careful design of the program is needed to prevent unintended consequences that dilute the intended environmental and efficiency benefits. For example, scrappage should be triggered by failure to pass an emissions inspection rather than only an arbitrary indicator such as age. Clearly, then, an accelerated retirement program cannot be effective in the absence of a properly enforced vehicle emissions inspection program. China uses a combination of age and emissions, setting a scrappage requirement for vehicles over a certain age but providing an exemption if the vehicle passes an emissions test (see description below).

Another key element of a scrappage program is the issue of replacement vehicles. Many vehicle owners will replace their retired vehicle, so the program must be designed with restrictions to ensure that the replacement is not as bad as or worse than the retired vehicle. Ireland, for example, required that the retired vehicle be replaced with a new one by tying compensation to the registration of a new car. Ideally, however, the vehicle owner will have sufficient alternatives such that replacing the vehicle can be avoided, such as convenient access to mass transit and perhaps a car-sharing program like the one described in Chapter 5 in Fukuoka, Japan. The Canadian province of British Columbia has a highly regarded vehicle retirement program in which over half of the participants in the Vancouver metropolitan area opted for a transit pass over compensation for a replacement vehicle.

The greatest impact of a retirement program will be realized by concentrating on polluting vehicles that are heavily driven and that will likely continue to be driven for a significant length of time unless the vehicle is removed from circulation. The program will not be cost-effective if it compensates owners for vehicles that are receiving little use. At a minimum, it should be determined that the vehicle is operational, for example by requiring that it be driven to the scrappage site. Care should also be taken that old vehicles are not imported into the program area in exchange for compensation. This can be avoided by requiring that the vehicle be registered in the area for a set period of time beforehand, such as two years.

Finally, it is critical to ensure that retired vehicles are actually destroyed. There have been problems with the program in China because vehicles slated for scrappage in target cities were instead sold in the countryside or to other cities.[88] Similarly, the goal of retiring old, inefficient vehicles cannot be met on a region-wide basis if such vehicles are simply exported from richer to poorer economies. A challenge for scrappage programs is that trade in old vehicles is often more lucrative than the rewards offered for retiring and destroying old, polluting, inefficient vehicles.

Canada's Voluntary Vehicle "Scrap-It Program"

The Canadian province of British Columbia has a widely regarded scrappage program that has run on a voluntary basis since 1996. A vehicle owner can be compensated for scrapping an older vehicle if it was built before 1988, is insured within the emissions inspection jurisdiction, was driven at least 5,000 km in the last year, and has failed an emissions test at any point. Compensation is in the form of either cash for a replacement vehicle (including a bicycle) or passes for the mass transit system.

[88] "Can the Environment Survive China's Craze for Automobiles?—Urban Transportation Challenges and Opportunities", Jimin Zhao, University of Michigan, 2004 (http://www.osat.umich.edu/research/global/164_Chinaenvironmentpaper.pdf).

The amount of cash depends on the replacement: C$900 for a bicycle, C$ 500 for a used car (built after 1988), and C$750 for a new car (unless it is powered by natural gas in which case the compensation is C$1,000). The transit pass is worth about C$1,400 and provides free mass transit for between eight and 14 months, depending on how many zones the pass covers.[89] In the greater Vancouver metropolitan area (the only major metropolitan area in the province), over half of all participants opted for the transit passes.[90]

Figure 15. 500th CNG Corsa Delivery in Lima *(Photo courtesy of Living Peru)*

China's Vehicle Elimination Standard

China has been steadily strengthening its Vehicle Elimination Standard—in 1997, 1998 and 2000—to require vehicles of a certain age to be scrapped if they cannot meet emissions standards after repairs. The specifics depend on the type of vehicle and whether or not it is used for generating revenue. Passenger vehicles with fewer than ten seats must be scrapped after 15 years unless they can pass emissions and vehicle requirements. If a passenger vehicle is used for commercial purposes, or if it has ten or more seats, this threshold drops to ten years (eight for taxis). However, if the vehicle is kept in good enough condition to pass emissions and safety tests, it can avoid the scrap pile for another ten years. For trucks of all types, the threshold is based on years of service or mileage, whichever is reached first: 400,000 km or ten years, with exemptions allowed for up to five years if the vehicle passes emissions and safety checks. The exception to this rule is mini-trucks, for which the threshold is 300,000 km or eight years, with no extension allowed regardless of emissions.[91] The program has experienced some difficulties due to lack of enforcement, which has allowed some vehicles slated for scrapping to instead be sold in other cities or rural areas.[92]

Hong Kong, China's Grant Incentives to Replace Aging Commercial Vehicles with Newer Models

In April 2007, Hong Kong, China began a new program providing financial incentives for replacing aging diesel commercial vehicles. Commercial vehicle owners can apply for one-time monetary grants to replace their pre-Euro[93] and Euro I[94] diesel commercial vehicles with new, clean and

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[89] "Fuel Efficiency Strategies For In-Use Vehicles", Appendix G of "Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada", Transport Canada, June 1999 (http://www.tc.gc.ca/programs/environment/climatechange/subgroups1/passenger_urban/study1/FinalAppendices/appendix_g.htm).

[90] Air Pollution from Ground Transportation: An assessment of the causes, strategies and tactics, and proposed actions for the international community", Roger Gorham, United Nations, 2002 (http://www.un.org/esa/gite/csd/gorham.pdf).

[91] "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO2 Emissions through 2050", Argonne National Laboratory, M. Wang, H. Huo, L. Johnson, & D. He, December 2006 (http://www.transportation.anl.gov/pdfs/TA/398.pdf).

[92] "Can the Environment Survive China's Craze for Automobiles?—Urban Transportation Challenges and Opportunities", Jimin Zhao, University of Michigan, 2004 (http://www.osat.umich.edu/research/global/164_Chinaenvironmentpaper.pdf).

[93] Pre-Euro vehicles are considered those initially registered before April 1, 1995.

efficient Euro IV-compliant vehicles. With a total program allocation amount of HK$3.2 billion, individual grant payout amounts range from HK$10,000 to HK$173,000 depending on the type and size of the outgoing vehicle to be replaced. Grants for light buses, however, are based on the replacement vehicle, with new LPG and electric light buses receiving larger grants than diesel ones. In the first two months after implementing this program, over 600 applications were submitted, with more than 400 of those already receiving approval (as of a mid-June 2007 report). This program is due to run into March 2010 (with some exceptions[95]) and applications are expected to continue coming in throughout the course of the program.[96]

Peru: New-Vehicle Finance Program Helps Replace Older Taxi Fleets in Lima

A new program in Lima, Peru helps to replace less efficient older diesel taxis with new compressed natural gas (CNG)-ready taxis while simultaneously improving safety and financial independence for taxi drivers. The program, "Mi Taxi," allows Lima taxi drivers to finance a brand-new CNG Chevrolet Corsa sedan with just a US$3,000 down payment. While some of the older diesel taxis in Lima are estimated to get around 8 kilometers per liter,[97] the new CNG Corsas can achieve the equivalent of around 15 km per liter.[98] That improvement in efficiency coupled with the lower relative cost of CNG compared to diesel fuel means that the drivers can experience significant savings in fuel costs. In a city where most taxi drivers must pay to rent their taxi from a third-party owner, the program has the added benefit of giving Lima taxi drivers a path towards ownership and independence, with expected payoff periods of less than 5 years per vehicle.

Finally, the program also hopes to replace many smaller and potentially less-safe vehicles with the relatively larger Corsas. Though the program initially planned to roll out 150-200 new Corsas in the first five months, "demand exceeded the [initial allotment of] 500, and there is a waiting list of 3,000 people" (Figure 15).[99] The program's success has helped to attract shipments of efficient new Nissans, Fiats and Volkswagens[100] to the Peruvian market to compete with the CNG Corsa.

Tire Pressure

Maintaining the recommended pressure in tires not only optimizes fuel economy by minimizing rolling resistance, but it maximizes the life of the tires and the performance of the vehicle. For a tire

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[94] Euro I vehicles are those registered between April 1, 1995 and March 31, 1997 for vehicles under 4 tons and non-franchised buses, and those registered between April 1, 1995 and September 30, 1998 for vehicles over 4 tons and light buses.

[95] Applications close September 30, 2008 to replace pre-Euro diesel buses (both light buses and non-franchised buses) as well as diesel vehicles under 4 tons. However, pre-Euro diesel vehicles over 4 tons as well as all Euro I diesel commercial vehicles can submit applications through March 10, 2010.

[96] "To Replace Pre-Euro and Euro I Diesel Commercial Vehicles by New Commercial Vehicles - Incentive Scheme," Hong Kong Environmental Protection Department, January 2008 (www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/old_diesel_com_veh_replace_prog.html).

[97] "Más de 3,000 taxistas presentaron solicitudes para incorporarse al Programa Mi Taxi," *Andina*, (www.andina.com.pe/Espanol/Noticia.aspx?id=iQGOSomUze0=).

[98] "CNG-Powered Opal Corsa," Green Car Congress, 5 March 2007 (www.greencarcongress.com/2007/03/cngpowered_opel.html).

[99] "The successful Program 'Mi Taxi' of Peru surpassed the expected requests," (www.ngvgroup.com/index.php?nav=noticias&id=645&PHPSESSID=c4f8f506d5ee606a1023a745f8f0e53b

[100] "Taxi Drivers in Peru begin using New Nissans, Fiats & Volkswagens," *Living Peru*, 10 January 2008 (http://www.livinginperu.com/news/5459).

that should be inflated to 29 pounds per square inch (psi), its rolling resistance will be 10% greater if it is inflated to only 24 psi.[101] This 5 psi drop below optimal pressure results in a 2% drop in fuel economy.[102] The impacts of tire pressure on fuel efficiency are profound enough that as of 1 September 2007, the U.S. government requires all new vehicles of 4,536 kg (10,000 pounds) or less to be equipped with a tire pressure monitoring system for all four tires that alerts the driver when pressure falls 25% below the recommended level.

[101] Tires and Passenger Vehicle Fuel Economy," Transportation Research Board, National Research Council, Washington, D.C., 2006 (http://onlinepubs.trb.org/onlinepubs/sr/sr286.pdf).

[102] "Gas Mileage Tips," U.S. Department of Energy, (http://www.fueleconomy.gov/feg/drive.shtml).

4. Reducing Road Congestion

Traffic congestion increases fuel consumption through delays that keep vehicles on the road longer per kilometer traveled, and through the fuel inefficiency of stop and go driving. The strategy of improving transportation efficiency by reducing motor vehicle congestion encompasses a wide range of approaches that reduce the volume of vehicles on those roads prone to congestion, and that improve the flow of traffic to reduce or eliminate stop and go traffic. Strategies for reducing congestion often focus on encouraging workers to commute to work by means other than by solo driving, or at least to do less solo driving, and they can be divided into two broad categories. One targets the roads themselves with regulations or traffic management techniques such as high occupancy vehicle (HOV) lanes, tolls to discourage the use of roads during peak traffic times, and lane restrictions that optimize flow on surface roads in central business areas. The other category of intervention is to provide commuters with options that make it easier for them to reduce or eliminate their motor vehicle commuting, such as allowing employees to work from home full or part time (telework), providing employees with transit passes in lieu of a parking space, and car sharing programs that relieve urban dwellers from the need for vehicle ownership.

Congestion Pricing

Congestion pricing consists of some form of fee charged specifically to reduce congestion on a given road or in a given area, as opposed to raising revenue for purposes such as road maintenance. In terms of technology, electronic collections methods have been fully developed (see for example Figure 16). This allows tolling of vehicles to be done at full speed and also allows prices to vary automatically with time of day or volume of traffic. The most basic form of congestion pricing is simply a fee charged to all vehicles passing a certain point. A subset of this approach is cordon pricing, where motorists pay a fee to drive into a particular area, usually a city center. Another subset of congestion pricing is the high occupancy toll (HOT) lane, which occurs in one of two forms. One allows *single* drivers to use lanes otherwise reserved for high occupancy vehicles if a toll is paid. The other allows vehicles with a threshold occupancy to travel free or at a discount in lanes where vehicles below this occupancy threshold must pay a fee.

Figure 16. On-board unit for electronic road pricing. *(Photo courtesy of the U.S. Department of Transportation)*

For any area or road subject to congestion pricing, the variables to consider in developing the program are:

1) whether to vary the fee with respect to time of day or volume of traffic;
2) the level of the fees; and
3) how the revenue is to be allocated.

The judicious allocation of revenue can go a long way in addressing the first challenge to congestion pricing: opposition by the pubic. The most appropriate uses of the funds collected will depend on the local situation. In areas with significant numbers of low-income residents, or with a population sensitive to taxation, the revenue might be used to offset regressive taxes such as sales taxes, and/or to fund tax credits for the poor. Where traffic congestion is of paramount concern, the funds might be allocated to making the mass transit system more convenient.

Public opposition can also be addressed through a public awareness campaign explaining that congestion pricing has been proven to save motorists driving time and fuel costs. This has been demonstrated by a study of the system of four toll roads in southern California (case study below).[103] Setting the congestion price requires finding an appropriate balance between being too low to be effective and being so high that traffic is inordinately curtailed and public resentment is generated. Likewise, the penalty for non-compliance must be high enough to be taken seriously. The following examples from APEC economies discuss various approaches and experiences with congestion pricing.

CASE STUDY
UNITED STATES: Electronic Road Pricing for Stretch of Highway in California

Purpose
To improve traffic flow on a severely congested highway in Southern California.

Summary of Actions
Two tolled express lanes were added in each direction of a ten-mile stretch of highway, State Route (SR) 91, southeast of Los Angeles.

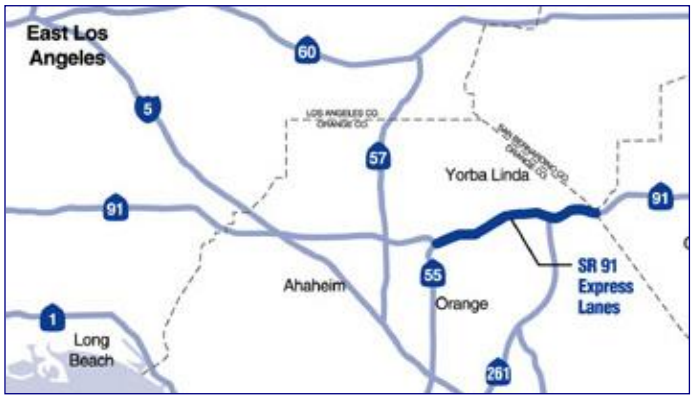


Figure 17. Map of SR 91 express lanes (thick blue line)
(Source: U.S. Department of Transportation Federal Highway Administration)

Background
California State Route (SR) 91 is a twelve-lane expressway used by many long-distance commuters to drive between their homes in Riverside County[104] and their jobs in Orange County. SR 91 is the only route available for this purpose, and before the express lanes were added it was one of the most congested routes in southern California, a region that is famous in the U.S. for its congestion. Before the express lanes were opened on 27 December 1995, the average commute on SR 91 was over an hour each way.[105]

Implementation
Capacity of SR 91 was expanded by the addition of two new lanes about ten miles long in each direction. However, while the new lanes run adjacent to the general purpose lanes, they are tolled express lanes separated by a plastic barrier from the other lanes and accessible only at either end of the facility (see Figures 17 and 18). Anyone using the express lanes must set up an account and have their vehicle equipped with a transponder to deduct the fees from the account. Compliance is

[103] "Economic Benefits of Toll Roads Operated by the Transportation Corridor Agencies", Tapan Munroe, et al., June 2006 (http://www.thetollroads.com/home/images/publications/6_15_06_LeCG_Toll_Road_Study.pdf).

[104] Riverside County is not marked on the map in Figure X but it is the county on the far right of the figure, bordering on the eastern end of SR 91.

[105] Intelligent Transportation Systems Mainstreaming Project, University of California Transportation Center, http://www.uctc.net/mainstream/papers/compendium/Compendium%204.pdf.

enforced with cameras. The facility was developed with private funding and was operated for some years by a private firm, but is now owned and operated by the Orange County Transportation Authority.

When the express lanes opened, a flat toll was charged during the peak period from 3:00 to 7:00 pm. and a sharp peak in volume occurred around 5 pm. The rate structure was then differentiated to vary according to time of day and day of week on a pre-set schedule that is periodically revised. The structure used today is so fine-tuned that the rates vary considerably during each day (including throughout the peak periods), across the different days of the week, and whether heading eastbound or westbound (see the toll cards in Figure 19). For example the rate at 5 p.m. in the heavier eastbound direction gets progressively higher from Monday through Thursday, but the 5 p.m. Friday rate is lower than Thursday because on Friday commuters begin their afternoon driving earlier, such that the peak rate on Friday occurs at 3 p.m. rather than 4 to 5 p.m. However, an in-depth analysis of the program found that the differentiated structure had little effect on making the distribution of traffic volume more even during the evening rush, although it did flatten the peak somewhat during the lighter morning rush.[106]

Figure 18. Express and general purpose lanes of SR 91
(Photo courtesy of the University of California Transportation Center)

The program has experimented with how to treat high occupancy vehicles (HOVs) carrying 3 or more passengers (HOV3+); dual occupant vehicles have always paid the same toll as single occupancy vehicles (SOVs). For the first two years of operation, HOV3+ could use the express lanes for free, causing a one-time surge of 40% in HOV3+ using this corridor. Beginning in 1998, however, HOV3+ were required to pay half the rate, causing about one-third of the HOV3+ traffic to shift from the express lanes to the general purpose lanes. The occurrence of HOVs in the overall corridor (general purpose and express lanes) has remained steady throughout the period of observation of the California Department of Transportation (CalTrans) study (1994 through 1999). Most recently, the lanes went back to being free for HOV3+ except for the heaviest period and direction: eastbound on Friday afternoon between 4 pm and 6 pm.

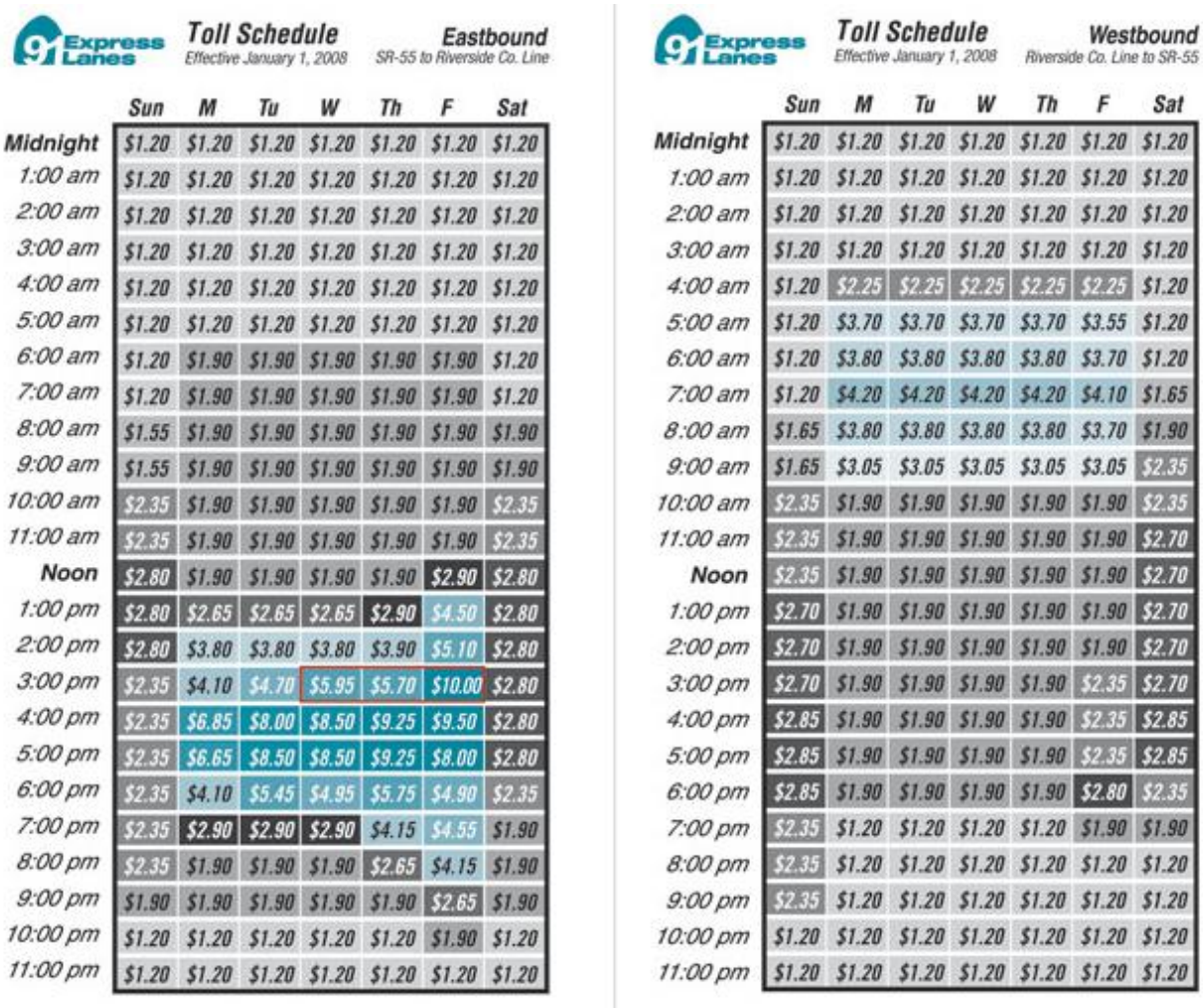
Results

In the first six months of operation, the typical delay experienced by the evening commuter was reduced from about 30 to 45 minutes to only 5 to 10 minutes. Although some of this benefit was due to the additional capacity, the express lanes are not a direct expansion of SR 91 because they do not connect with the general traffic lanes. Quantitatively assessing the impact of the express lanes is complicated by the rapid and continued growth in demand for the overall corridor, including a new road opened in September 1998 that caused a significant increase in volume on SR 91. The CalTrans

[106] "*Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes*", Edward Sullivan, California Department of Transportation, December 2000 (http://ceenve3.civeng.calpoly.edu/sullivan/SR91/).

study found that the express lanes absorbed more than 85% of the growth in traffic volume in September 1998, with delays during 1999 about 30 minutes during the evening rush, presumably less than they would be without the express lanes. Also, the express lanes eased congestion in the parallel arterials as some traffic shifted from the city streets to the expressway, a shift that was continuing in 2000 when the study was published.

The CalTrans study also found that in 1999, 42% of all commuters on SR 91 used the express lanes at least some of the time, but that only 12% of drivers use the facility for all of their commuting (defined as more than 20 times per month). During the evening rush, the portion of travelers on the SR91 corridor using the express lanes is about 35%. The study found HOV commuters overall are more likely than solo drivers to use the express lanes, with dual occupant vehicles just as likely as HOV3+ to use them even though they do not get a discount (although they can split the toll). Not surprisingly, the frequency with which commuters choose the express lanes increases with income level. A survey found that over 90% of people using the SR 91 corridor were satisfied.[107]



91 Express Lanes — Toll Schedule — Effective January 1, 2008 — Eastbound — SR-55 to Riverside Co. Line

	Sun	M	Tu	W	Th	F	Sat
Midnight	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
1:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
2:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
3:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
4:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
5:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
6:00 am	$1.20	$1.90	$1.90	$1.90	$1.90	$1.90	$1.20
7:00 am	$1.20	$1.90	$1.90	$1.90	$1.90	$1.90	$1.20
8:00 am	$1.55	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
9:00 am	$1.55	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
10:00 am	$2.35	$1.90	$1.90	$1.90	$1.90	$1.90	$2.35
11:00 am	$2.35	$1.90	$1.90	$1.90	$1.90	$1.90	$2.35
Noon	$2.80	$1.90	$1.90	$1.90	$1.90	$2.90	$2.80
1:00 pm	$2.80	$2.65	$2.65	$2.65	$2.90	$4.50	$2.80
2:00 pm	$2.80	$3.80	$3.80	$3.80	$3.90	$5.10	$2.80
3:00 pm	$2.35	$4.10	$4.70	$5.95	$5.70	$10.00	$2.80
4:00 pm	$2.35	$6.85	$8.00	$8.50	$9.25	$9.50	$2.80
5:00 pm	$2.35	$6.65	$8.50	$8.50	$9.25	$8.00	$2.80
6:00 pm	$2.35	$4.10	$5.45	$4.95	$5.75	$4.90	$2.35
7:00 pm	$2.35	$2.90	$2.90	$2.90	$4.15	$4.55	$1.90
8:00 pm	$2.35	$1.90	$1.90	$1.90	$2.65	$4.15	$1.90
9:00 pm	$1.90	$1.90	$1.90	$1.90	$1.90	$2.65	$1.90
10:00 pm	$1.20	$1.20	$1.20	$1.20	$1.20	$1.90	$1.20
11:00 pm	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20

91 Express Lanes — Toll Schedule — Effective January 1, 2008 — Westbound — Riverside Co. Line to SR-55

	Sun	M	Tu	W	Th	F	Sat
Midnight	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
1:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
2:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
3:00 am	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
4:00 am	$1.20	$2.25	$2.25	$2.25	$2.25	$2.25	$1.20
5:00 am	$1.20	$3.70	$3.70	$3.70	$3.70	$3.55	$1.20
6:00 am	$1.20	$3.80	$3.80	$3.80	$3.80	$3.70	$1.20
7:00 am	$1.20	$4.20	$4.20	$4.20	$4.20	$4.10	$1.65
8:00 am	$1.65	$3.80	$3.80	$3.80	$3.80	$3.70	$1.90
9:00 am	$1.65	$3.05	$3.05	$3.05	$3.05	$3.05	$2.35
10:00 am	$2.35	$1.90	$1.90	$1.90	$1.90	$1.90	$2.35
11:00 am	$2.35	$1.90	$1.90	$1.90	$1.90	$1.90	$2.70
Noon	$2.35	$1.90	$1.90	$1.90	$1.90	$1.90	$2.70
1:00 pm	$2.70	$1.90	$1.90	$1.90	$1.90	$1.90	$2.70
2:00 pm	$2.70	$1.90	$1.90	$1.90	$1.90	$1.90	$2.70
3:00 pm	$2.70	$1.90	$1.90	$1.90	$1.90	$2.35	$2.70
4:00 pm	$2.85	$1.90	$1.90	$1.90	$1.90	$2.35	$2.85
5:00 pm	$2.85	$1.90	$1.90	$1.90	$1.90	$2.35	$2.85
6:00 pm	$2.85	$1.90	$1.90	$1.90	$1.90	$2.80	$2.35
7:00 pm	$2.35	$1.20	$1.20	$1.20	$1.20	$1.90	$1.90
8:00 pm	$2.35	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
9:00 pm	$2.35	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
10:00 pm	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20
11:00 pm	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20	$1.20

Figure 19. January 2008 toll card for SR 91. (Source: http://www.91expresslanes.com/)

[107] "Express Lanes: Managing Congestion Success Stories", Maryland Department of Transportation, June 2004 (http://www.mdot.state.md.us/Planning/Express%20Toll%20Lanes/Success%20Stories%20I270.pdf).

Lessons Learned

The experience with SR 91 demonstrates a case where the transportation planners saw the need to expand an existing corridor, but realized that if the expansion consisted of more general purpose lanes, the continued growth in the area would quickly replicate the level of severe congestion that existed at the time of planning. The decision to make the expanded portion of the road a physically separate but adjacent tolled expressway has eased the overall condition of severe congestion on the corridor as a whole. Motorists have been shown to be satisfied with the system, in which they can choose to pay a toll on those occasions when warranted by their travel needs, congestion levels and—to a certain extent—their ability to pay. Although equity issues remain a concern in the case of this facility and with tolled facilities in general, the presence of the express option has resulted in improved flow on the entire SR 91 corridor, including in the general purpose lanes.

CASE STUDY
KOREA: Congestion Pricing for Namsan Tunnel in Seoul

Purpose
To reduce congestion in Seoul by reducing the number of low occupancy private vehicles entering the central business district through two key tunnels into the area.

Summary of Actions
Congestion prices are charged for all low occupancy private vehicles (one or two occupants) entering either of two tunnels—Namsan #1 or Namsan #3—that provide access to Seoul's central business district.

Background
The city of Seoul has been experiencing serious traffic congestion for many years, especially in and around the central business district, and over a decade ago the Seoul Municipal Government began a multi-faceted series of measures to address the problem. With the central business district located just north of the Han-gang River running through the city, two of the worst areas of congestion were the Namsan #1 and Namsan #3 Tunnels that cross the river adjacent to one another into the center of Seoul from the south side of the river. Before tolls were charged on these tunnels, more than 100 vehicles crawled through them every minute at speeds averaging 13.5 mi/hr (less than 22 km/hr).[108] Notably, more private vehicles used these tunnels than any other corridor entering the central business district, comprising 90% of all traffic through the two tunnels.[109]

Implementation
Starting in 1996, private vehicles with fewer than three passengers were charged 2,000 won (US$2.11) to enter either the Namsan #1 and Namsan #3 Tunnels at either end between 7:00 a.m. and 9:00 p.m. on weekdays and 7:00 a.m. and 3:00 p.m. on Saturday. All other vehicles are exempt, including high occupancy private vehicles (3+), taxis, buses, vans, trucks, diplomatic vehicles and government vehicles. The penalty for violations is 10,000 won, or five times the congestion fee. Revenue from the tolls is dedicated exclusively to improving transportation efficiency.

Results
The results of a study monitoring traffic in the tunnels from the time the congestion pricing began through 2000 are shown in Figure 20. As soon as tolling began, the volume of cars passing through the tunnels dropped by 25%, and then climbed steadily each year thereafter. By 2000, the volume through the tunnels was slightly higher than before tolling began in 1996. Most of the increased use was by vehicles that are not tolled. In spite of the steadily increasing volume, however, the original improvement in traffic flow was maintained: the average speed was fairly constant during the four years from when tolling began through 1999, at 46% faster (31.5 km/hr or 20 mi/hr). By November 2000, the speed had risen to 37.6 km/hr, even though the volume of traffic was higher than before the pricing scheme began. A survey of drivers through the tunnels found that 93% chose these

[108] "Introduction of traffic congestion pricing in Seoul, Korea", Asia-Pacific Environmental Innovation Strategies (APEIS) Good Practices Inventory, April 2003 (http://www.iges.or.jp/APEIS/RISPO/p_report_1st/ap_31-40.pdf).

[109] "Study on Urban Transport Development", World Bank, August 2000 (http://siteresources.worldbank.org/INTURBANTRANSPORT/Resources/ut_development_padeco.pdf).

routes because traffic flow through them was faster than other roads leading into the area. This demonstrates that roads with congestion pricing have improved flow relative to corridors in the area that do not.

Lessons Learned

Congestion pricing was successful in discouraging the use of low occupancy private vehicles to commute into the central business area via the two main tunnels used by these vehicles. A lasting improvement in traffic flow (average vehicle speed) resulted, even though the volume of traffic steadily increased as low occupancy private vehicles were replaced by vehicles such as buses, vans, and high occupancy private vehicles. The fact that average traffic speed through the tunnels increased significantly (by 74%) over the course of four years means that a sizeable portion of commuters abandoned their private vehicles for other modes of transportation. Therefore the success of this program should be attributed not only to congestion pricing, but to the other transportation improvements implemented during the same timeframe by the Seoul Municipal Government, funded in part from the revenues generated by the congestion pricing. This case study is another example of the efficacy of implementing a suite of transportation approaches in parallel, where one or more of the approaches are able to generate revenue needed for improvements.

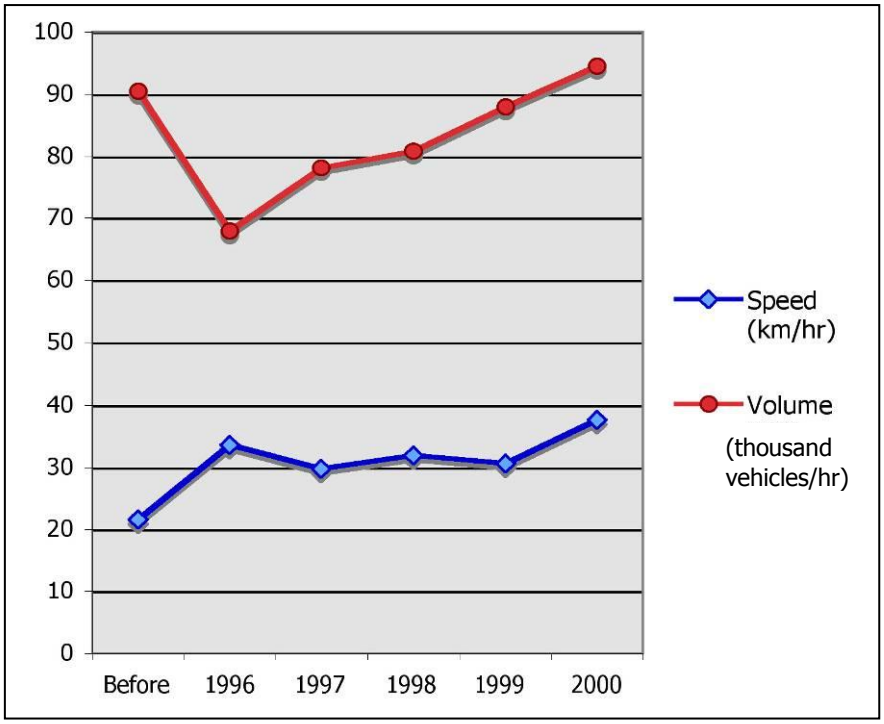


Figure 20. Speed and volume through Namsan #1 and #3 tunnels.
(in November 1996 just before and after congestion pricing, and every November afterwards through 2000). *(Data from the APEIS Good Practices Inventory)*

CASE STUDY
SINGAPORE: Cordon Electronic Road Pricing

Purpose
To reduce congestion in and around the central business district (CBD) during peak hours by reducing the number of vehicles entering the area.

Summary of Actions
Time-variable electronic road pricing that deducts an amount from a vehicle's smart card each time it enters the area.

Background
Singapore is the first city in the world to use a cordon pricing scheme, launching the program in 1975 for its 18.4 square km (7.2 square mile) CBD. The system has been operational ever since, becoming electronic in 1998. Electronic road pricing (ERP) not only allows vehicles to pass under a gantry without stopping (see Figure 21), but it enables the price for entry to be varied automatically according to time of day, day of week, and traffic conditions. The change to ERP also means that vehicles are charged every time they enter the CBD, not just once per day as was the case under the paper-based system.

Figure 21. Congestion pricing gantry to enter Singapore's central business district.
(Photo: Beng Wah Ang, National University of Singapore)

Implementation
Vehicles are equipped with transponders, operating on a 2.54 gigahertz (GHz) dedicated short-range radio system, that deduct the appropriate fee from a pre-paid smart card every time the vehicle enters the tolled area through one of 29 gantries. Digital photographs of license plates are used to enforce violations by vehicles not equipped with an on-board unit and smart card. The city has experimented with a number of variations on pricing, and settled on a scheme that varies the price with time, ramping up the fee to a peak time then ramping down. This approach eliminated the problem of rush periods just before and after the peak period, which occurred under the earlier scheme having only two rates: peak and non-peak. In addition to varying the rates according to time of day, the city tracks traffic speeds and adjusts the rates every quarter hour as needed to optimize flow. Their target speeds are 45 – 65 km/hr on the expressway and 20 – 30 km/hr on surface roads within the central business district.[110]

[110] "Congestion Pricing in Cities of the Developing World: Exploring Prospects in Mexico City", Anjali Mahendra, Massachusetts Institute of Technology, September 2004 (http://dspace.mit.edu/bitstream/1721.1/27862/1/60250189.pdf).

Results

A study in 1992 found that the volume of traffic entering the area was reduced by about half compared to the level before cordon pricing was implemented. As a result, speeds were up by 20% and there were 25% fewer accidents. The program successfully shifted a large number of commuters coming into the CBD from roads to mass transit, as revealed by the doubling in the percentage of commuters using mass transit from 33% in 1974 to 67% in 1992. The 1998 switch to a electronic system further reduced the volume by another 10-15%.

Lessons Learned

A cordon pricing program to reduce vehicle traffic into an area can only be successful if travelers, especially commuters, have other options. Singapore ensured this by using the revenues from the cordon system to expand their Mass Rapid Transit and light rail systems. The success of this strategy is evidenced by the fact that the halving in the number of vehicles during the period from 1974 to 1992 was matched by a doubling in ridership on public transit by commuters. Another lesson from the Singapore experience is the value of using a ramped pricing scheme around the peak time rather than flat peak and non-peak rates. This helps to prevent surges of traffic demand just before and after the peak.

Maximizing Efficiency of Highway Lanes

Measures apart from congestion pricing that maximize traffic flow on highways take three main forms: lanes restricted to high-occupancy vehicles (HOVs), automatic information systems that provide motorists with real-time traffic information to empower them to make the best travel choices, and highway incident management programs that minimize disruptions to traffic flow by rapidly clearing disabled vehicles.

Much of the experience with HOV lanes is in the United States, and much of that is in the state of California, with southern California alone having one-fifth of the nation's HOV lane-miles. A recent, detailed study of the California experience provides some useful insight into how to make effective HOV lanes.[111] Probably the most valuable lesson is that *single* HOV lanes—which dominate California's HOV system—offer little in the way of time savings because slower vehicles impede overall flow. With all HOVs restricted to the same lane, the speed of the lane is governed by the slowest drivers because faster drivers cannot use the adjacent, slower, general purpose lane to pass. A second HOV lane allows faster vehicles to pass slower ones and prevents the restricted speeds characteristic of single HOV lanes. It was found, however, that even where there is only one HOV lane—providing little benefit in time savings to HOV drivers much of the time—HOV lanes still have less variable (more predictable) travel times than the general purpose lanes. The study also found that experiments in California and Virginia allowing single occupancy *hybrid* vehicles into HOV lanes negatively impacted flow in those lanes. However, this is presumably because the lanes were already stressed by the constriction caused by the lack of a second HOV lane. Another role for HOV lanes is on entrance ramps, whether the general purpose lane is slowed by either metering lights or simply congestion. HOVs can experience a significant benefit in the time needed to get onto a highway or bridge where there is a separate HOV lane on the ramp.

An intuitively obvious strategy for improving flow on highways is to clear away accidents and disabled vehicles as quickly as possible. A well designed highway incident management program will use a variety of tools to get tow trucks to the scene as quickly as possible, such as roving patrols, surveillance cameras and a program for drivers to call in from their cell phones. In Houston, Texas, the SAFEclear program is committed to having tow trucks on the scene of an incident within six minutes.[112]

Another strategy that is becoming more common is the use of automated transportation information systems that are integrated with the transportation infrastructure system, be they highways, mass transit systems, or parking garages. On highways, such systems use electronic dynamic message signs to convey relevant, real-time information on traffic conditions, such as the time it will take to reach destinations and to provide information on accidents or hazardous road conditions so that drivers can know far enough in advance to take an alternate route. The information can also be posted on the Internet or made available by telephone so travelers can know before leaving whether congested conditions warrant an alternate route, more driving time than normal, postponing or canceling a trip, or taking mass transit instead of driving. Road conditions are monitored with devices such as cameras and vehicle detectors in the road, and transmitted wired or wirelessly to control equipment. The following example of this approach is from Chinese Taipei.

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[111] *Effectiveness of California's High Occupancy Vehicle (HOV) System,* Final Report for PATH TO 6301, Pravin Varaiya, University of California, Berkeley CA, California PATH Research Report UCB-ITS-PRR-2007-5, May 2007 (http://www.path.berkeley.edu/path/publications/pdf/prr/2007/prr-2007-05.pdf).

[112] "The 2007 Urban Mobility Report", David Schrank and Tim Lomax, Texas Transportation Institute, September 2007 (http://tti.tamu.edu/documents/mobility_report_2007_wappx.pdf).

Chinese Taipei: Traffic Monitoring System for Taipei Expressways

In 2004 the Taipei Department of Transportation installed a traffic monitoring system for the network of Taipei City expressways and bridges, providing motorists with real time information on road conditions.[113] The equipment in the system consists of closed-circuit cameras and in-road vehicle detectors to monitor traffic on Civic Boulevard and the Zhoumei and Huandong Expressways, and electronic signs to display information at various strategic locations. The signs are kept up to date in real time using the data from the cameras and detectors, and the images of the road and information on traffic conditions can also be viewed online at http://tms.bote.taipei.gov.tw/web/index.htm.

Maximizing Traffic Flow on Surface Roads

To optimize traffic flow on surface roads—that is, roads other than highways and expressways—the main strategies are to:

- designate separate lanes for motorcycles (in cities with large volumes of motorcycle traffic);
- synchronize traffic signals;
- program traffic signals to give preference to the dominant flows as conditions change during the day and week;
- convert two-way left-turn lanes to unidirectional, raised-median left-turn lanes;
- restrict turns from major arterials; and
- minimize the number of driveways (curb cuts) that disrupt traffic flow.

The following pages illustrate these approaches, for example of the experience in Taipei City with exclusive motorcycle lanes, a simple and effective way of streamlining congested areas where motorcycle make up a large share of the vehicles. Another traffic management technique is to synchronize traffic signals along a stretch of road so they change in sequence to allow groups of vehicles to encounter only green lights if they drive at a certain speed. The timing can be tricky, especially on two-way streets and under congested conditions, and the impact is often not great, but it helps and is one of the lower cost options available.[114] The last three approaches listed above fall into the category of "corridor access management" that aims to keep the main flow of traffic flowing along the corridor by minimizing the disruptions to flow caused by vehicles entering or exiting the road.

[113] "Taipei Department of Transportation Annual Report 2004" (http://www.dot.taipei.gov.tw/newch/web/annual/93/交通局93年刊.pdf).

[114] "The 2007 Urban Mobility Report", David Schrank and Tim Lomax ,Texas Transportation Institute, September 2007 (http://tti.tamu.edu/documents/mobility_report_2007_wappx.pdf).

Chinese Taipei: The Role of Pedestrians in Improving Traffic Flow

Traffic flow in congested areas of Taipei City was improved through three measures relating to pedestrian crossings: installing pedestrian countdown displays, shortening the crossing time, and changing pedestrian crossings from angled lines to two parallel lines.[115] The timer countdown displays tell pedestrians how much time they have to cross so they can avoid being in the intersection when the light changes—an unsafe situation as well as one that impedes traffic. The countdowns are also useful because in intersections with heavy volumes of traffic, the crossing time for pedestrians was reduced from 90 seconds to 60 in order to improve traffic flow. Finally, in some of the busier intersections, the markings used to delineate pedestrian crossings were changed from angled lines to two parallel lines, as shown in Figure 22. This measure was taken to prevent motorcycles and scooters from sliding on the slippery paint in the crossing when the pavement is wet, which is a common occurrence where angled lines are used. While a safety issue, the remedy also reduces congestion by preventing accidents.

Figure 22. Parallel line pedestrian crossings in Taipei City.
(Photo: Taipei Yearbook 2004)

CASE STUDY
CHINESE TAIPEI: Exclusive Motorcycle Lanes

Purpose

To improve traffic flow and motorcycle safety on the main arterials in the Taipei metropolitan area during periods of heavy traffic.

Summary of Actions

Lanes exclusively for motorcycles were delineated on the main arterials into and out of the Taipei metropolitan area.

Background

On the main commuting arterials into Taipei during the morning rush, over 80% of the traffic consists of motorcycles. (This is not the case on the expressways since in Chinese Taipei motorcycles are forbidden there.) As many Asian cities have seen, the mix of passenger cars with large numbers of motorcycles exacerbates congestion due to the fact that motorcyclists try to take advantage of

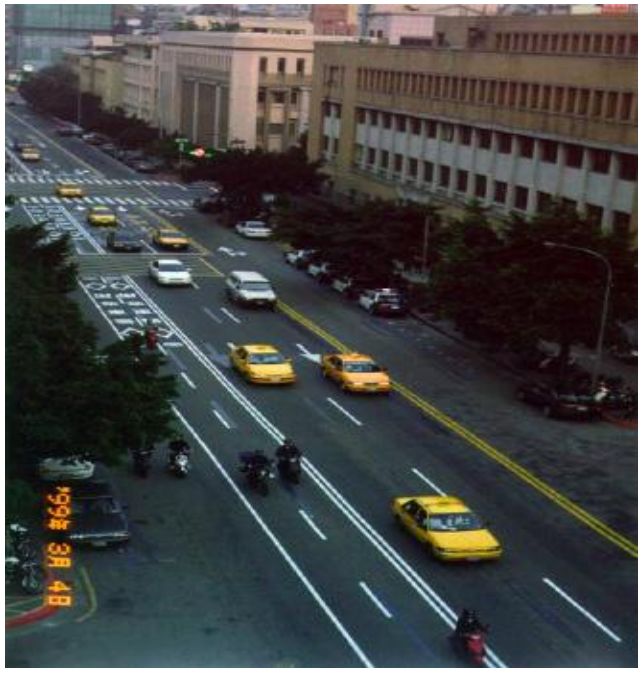

Figure 23. Exclusive motorcycle lanes in Taipei. *(Source: T-P. Hsu et al., 2003)*

[115] "Taipei Yearbook 2004" (http://english.taipei.gov.tw/yearbook/index.jsp?categid=5030).

the smaller size and greater nimbleness of their vehicles to jockey with cars and one another for position on the roads. The mix is also dangerous for motorcyclists.

Implementation

Lanes exclusively for motorcycles were created on the bridges and main arterials in metropolitan Taipei in February 1999 to segregate motorcycle traffic from other vehicles. The lanes are adjacent to those for other traffic, and where possible two motorcycle lanes are provided (see Figure 23).

Results

T-P. Hsu et al.[116] conducted a study of the Taipei example, along with a similar experience in Kuala Lumpur in Malaysia, and found that segregating motorcycles into dedicated lanes not only improves traffic flow, but it increases the capacity of the corridor to accommodate more vehicles. Not surprisingly, the lanes also reduced the number of motorcycle accidents.

Lessons Learned

In cities with traffic congestion during peak commuting periods, where a large percentage of the commuters are on motorcycles, exclusive lanes for motorcycles improve traffic flow and motorcycle safety.

In his research and analysis of factors influencing whether or not people will own and drive cars, John Holtzclaw found that residential density was the most effective variable in predicting auto ownership and driving, and that the second most effective variable was nearby accessibility to mass transit.[117] Conventional wisdom suggests that people who own a vehicle – a motorcycle, car, truck – will drive more frequently than those who don't own vehicles. The following chapters discuss improvements to mass transit and urban planning designs that enable and encourage less solo driving. The next two sections of this chapter discuss a couple of the other approaches that governments, communities, and businesses are using to provide people with better access to alternatives to owning and driving single-occupancy vehicles.

Car Sharing

In car sharing programs, people can conveniently access cars for occasional personal use so they can avoid having to own a vehicle. The approach is already firmly established in Europe, Japan, Singapore and North America, and a 2006 survey[118] found a high level of interest in Beijing. The approach shares a set of conveniently located vehicles among members who generally pay a fee to become a member and another fee on a per use basis.

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[116] "A comparison study on motorcycle traffic development in some Asian countries – case of Taiwan [Chinese Taipei], Malaysia and Viet Nam", T.-P. Hsu, et al., Eastern Asia Society for Transportation Studies, October 2003 (www.easts.info/activities/icra/2001/ICRA-ComparisonStudyMotorcycleDevelopment.pdf).

[117] Holtzclaw, John W. "Smart Growth – As Seen From the Air, Convenient Neighborhood, Skip the Car," paper presented at the Air & Waste Management Association's 93rd Annual Meeting & Exhibition, 23 June 2000, Salt Lake City, Utah.

[118] "Assessing Early Market Potential for Carsharing in China: a case study of Beijing," S.A. Shaheen and E. Martin, 2006 (http://www.carsharing.net/library/UCD-ITS-RR-06-21.pdf).

A car sharing network improves traffic efficiency by minimizing the number of vehicles used to meet a given level of travel demand. Further, people who use a car sharing program in lieu of owning their own vehicle are necessarily taking some form of transportation to their place of employment other than driving their vehicle. Also, in some cases car sharing programs feature highly fuel efficient vehicles. Car sharing is also a highly efficient from a general resource perspective, given that private cars are parked a majority of the time.

As would be expected, using vehicles through a car sharing network is considerably less expensive than owning a vehicle. A calculation made in 2003 for Japan, assuming light driving, estimated that it would cost about 47,443 yen (US$444) per month over five years to buy a new 1500 cc car, maintain it, and sell it after five years. Monthly costs for car sharing would be about 19,000 yen (US$178) for the use of an electric car, or 21,000 yen (US$196) for a hybrid (not counting gasoline costs).[119] Car sharing programs in Australia, Singapore and Japan are described below.

Australia: A Relative Newcomer to Car Sharing

In the last few years, car sharing has taken off in Australia, with three companies operating in separate areas of the economy. All of them are continuing to grow, and all have similar fee structures based on a biannual or annual membership fee and a one-time application fee, with multiple membership categories where the more expensive plans have lower hourly user fees. Operations and maintenance costs such as fuel and insurance are incorporated into the fees. The first and largest is GoGet CarShare (http://www.goget.com.au), operating in the provinces of New South Wales and Victoria. Its fleet includes larger station wagons and hatchbacks as well as compact cars, and it is spread over about 90 "pods" (locations). GoGet offers three membership categories depending on the frequency of driving and the number of people on the membership. The other two car sharing companies are still in the nascent stages of growth. GWhiz CarShare (www.gwhiz.com.au/) has five car locations in Brisbane, Queensland, while NexusCarshare has just four car locations so far in Perth, Western Australia (http://www.nexuscarshare.com.au). GWhiz also offers a three-month trial program for those reluctant to make an annual commitment.

Singapore's Well Developed Car Sharing Industry

Singapore has a flourishing car sharing industry serving over one million licensed drivers.[120] Car sharing began there in 1997 with the non-profit Car Co-Op program (www.carcoop.com.sg) launched by an insurance cooperative, NTUC Income Insurance Cooperative Ltd, which also has financial interests in high-rise apartment buildings. Since then three for-profit ventures were started—CitySpeed, Honda Diracc and WhizzCar—but CitySpeed ceased its car sharing operations after July 2007 to focus on the car rental market. Car Co-Op and WhizzCar (www.whizzcar.com/) focus on the residential market and therefore see the most use on weekends and evenings. Honda Diracc (www.hondadiracc.com.sg; short for Direct Access) serves residential customers as well, but caters mostly to the business market to provide cars for business trips during the work week. The Diracc program was initially launched with a government grant in February 2002 as a three-year

[119] "Car sharing through collaboration between an NGO, a city, and a private company, Fukuoka, Japan," Asia-Pacific Environmental Innovation Strategies Research on Innovative and Strategic Policy Options Good Practices Inventory, January 2004 (www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0071.pdf).

[120] "Carsharing and Station Cars in Asia: An Overview of Japan and Singapore," M. Barth, S. Shaheen, T. Fukuda, and A. Fukuda, April 2006 (http://database.path.berkeley.edu/imr/papers/UCD-ITS-RR-05-12.pdf).

pilot, starting out with only 15 cars. Among all of the programs, as of March 2006, about 439 vehicles were being shared by 12,200 drivers.

CASE STUDY
JAPAN: Car Sharing in Fukuoka

Purpose
To encourage the use of mass transit rather than commuting by private vehicle through the use of a car sharing scheme that provides residents with access to passenger cars without having to own one.

Summary of Actions
A member-based car sharing network where a set of fuel efficient vehicles are parked at a system of convenient stations for short-term use by members.

Background
Fukuoka is the capital city of Fukuoka Prefecture in southern Japan. The greater Fukuoka metropolitan area, with a population of 2.5 million, is prone to traffic congestion, especially in and around the Tenjin central business district (see Figure 24).

Figure 24. Congestion in Tenjin central business district, Fukuoka. *(Photo by Wendell Cox, www.demographia.com)*

The idea for the Fukuoka car sharing scheme came from a local non-profit organization, Citizen's Recycling Movement of Western Japan. The group generated enough interest in the idea that the Kyushu Electric Power Company and Fukuoka City provided 80 million yen (about US$750,000) for a three-year pilot project that ran from October 2002 through September 2005. Kyushu Electric Power covered the cost of developing the system, building the stations, and leasing 20 vehicles, while the City lent ten electric vehicles.[121] The non-profit organization managed the scheme during the pilot phase, after which it was taken over by Mazda Car Rental Corporation, which already had its own car-sharing program.[122] The program has been ongoing ever since.

Implementation
The program has a number of stations situated near subway stations, retail centers and office buildings. (After one year, there were 25 vehicles, five parking stations, and 400 members.) The fleet consists of a mix of electric, gasoline-electric hybrids, and ultra-low emissions gasoline vehicles, which are maintained by program staff. The program began with only electric vehicles, but it was

[121] "Car sharing through collaboration between an NGO, a city, and a private company, Fukuoka, Japan", Asia-Pacific Environmental Innovation Strategies Research on Innovative and Strategic Policy Options Good Practices Inventory, January 2004 (www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0071.pdf).

[122] "2005 report of Kyushu Electric Power" (http://www1.kyuden.co.jp/library/pdf/en/action-report/action-report06/11.pdf).

found that some longer-range hybrids and gasoline engines had to be added to meet the needs of members. The fleet also contains vehicles of various sizes to accommodate different needs in terms of the number of passengers. Fueling is handled by the users: a driver of an electric vehicle plugs the car into one of the chargers provided at each station when the car is returned, and drivers of gasoline vehicles use a card kept in the vehicle to pay to fill up the tank before returning it, if it is less than one-third full.

Figure 25. Electric cars in Fukuoka car sharing program.
(shown plugged in at left; single occupant vehicle on the right).
(Photos courtesy of Think the Earth Project)

Use of the stations is entirely automated, with each member using an integrated circuit card (smart card) to check vehicles in and out. Reservations can be made via the internet, phone, or a computer terminal at a station. Check-out time is between 7 a.m. and 10 p.m., and overnight service is available. There is one fee to become a member and another for each vehicle use. For those vehicles that use fuel there is another fee to cover fuel, based on distance driven. Memberships are offered in various categories, including individual, family, corporate and non-profit. The cost to become a member is quite low; for example, the individual rate is 1,000 yen (US$9.35) per month, or 10,000 yen if paid for a year.

Results and Lessons Learned

The popularity of the program is evident in that it was taken over by a for-profit firm. Experience from the Fukouka program provides two lessons for other such schemes. One is that membership increased when membership applications and checking vehicles in and out became automated, and the other is that the fleet should consist of a mix of different vehicle sizes and types to meet varying needs with regard to range and the number of passengers.

Employee Incentives to Reduce Vehicle Traffic

Employers can make a significant difference in the battle against congestion through any or all of a suite of incentives that encourage employees to get to work by means other than solo driving. Probably the greatest leverage an employer has is parking. Employers can best use this leverage by offering parking only to vehicles above a certain occupancy level, or at least by giving the best parking to high-occupancy vehicles (HOV), or providing parking free of charge to HOVs if there is normally a fee. If an employer has been providing free parking and wants to change that, employees can be offered transit passes in exchange for their parking spaces.

Car Pooling

Employers can make car pooling easier by offering a service, preferably web-based, through which employees can find car pooling partners who live nearby and have similar schedules. Some employees are reluctant to give up their solo driving because they need the flexibility to work late or occasionally end their workday at another site. For this the employer can guarantee that employees will be reimbursed for taxi rides home under these conditions.

Van Pooling

A step beyond encouraging car pools is to provide the infrastructure for van pooling. For this an employer provides a fleet of vans for people to commute together, rather than having people use their personal vehicles. Someone from each group drives the van, but the employer supplies everything else: the vans and all associated support such as fuel, maintenance and insurance. The following case study from Washington State in the U.S. illustrates a comprehensive employee incentive program and the results from it.

Telework

Another way to reduce congestion is to have employees work from home full or part time. Teleworking, also called telecommuting, is increasingly common in North America but is slow to catch on in the other APEC economies. While there are many advantages to teleworking, reducing traffic congestion and air pollution are the two most frequently cited. The National Environmental Policy Institute estimated that if 10% of the workforce in the U.S. worked from home one day a week, 1.2 million fewer gallons of fuel would be used and almost 13,000 tons of air pollution would be avoided.[123] Employers benefit from a reduced need for expensive office space and reduced absenteeism, especially in areas where inclement weather keeps employees at home unexpectedly.

The barriers to teleworking are numerous but are generally tied to ingrained managerial disincentives and cultural biases that can be overcome by directly addressing them. At the human level, aside from the general inertia that comes with change, both managers and their staff can be uncomfortable with the unfamiliar physical separation introduced into the manager and subordinate relationship. Managers might feel like they are losing control, and workers might feel like they are losing valuable "face time" important for success in the workplace, or that losing a permanent work space lowers their perceived ranking in the organization. Organizational barriers that can be readily addressed are issues such as tying the value of a manager to the amount of office space in their section, or having the monetary savings in facility costs go to headquarters rather than the budget of the facility making the savings.

Mass Transit

Incentive programs to increase the use of mass transit for commuting can also be implemented at the level of central government, with and sometimes even without employer participation. In the United States, federal legislation allows employers to offer their employees transit benefits up to US$115 per month and parking benefits (for parking at mass transit facilities) up to US$220 per month – either tax-free or pre-tax. As this is a voluntary program, it is up to employers to decide if they will offer this benefit.

Another approach is to offer a tax break directly to commuters who use mass transit on a regular basis. Canada recently introduced the Transitpass Tax Credit of 15.5 percent to tax-paying commuters who purchase weekly or longer duration mass transit passes. It is a non-refundable tax credit, meaning that the amount claimed – i.e. the passenger's expenditure on transit passes – is multiplied by the lowest personal income tax rate for the given year (15.5 percent in 2007) and then is deducted from the amount of tax owed for the year.[124]

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[123] "Regional Analysis of What If Transportation Scenarios", Delaware Valley Regional Planning Commission, July 2003 (http://www.dvrpc.org/LongRangePlan/2030/WhatIfFinal.pdf).
[124] More information available at http://www.transitpass.ca.

CASE STUDY

UNITED STATES: Washington State Commute Trip Reduction Program

Purpose

To reduce congestion and air pollution in Washington State by reducing the number of single occupancy vehicles used for commuting.

Summary of Actions

In 1991, the Washington State legislature passed the Commute Trip Reduction (CTR) Law requiring major employers in the nine most populous counties—including city and county governments—to develop and implement a commute trip reduction program, and submit an annual progress report for approval.[125]

Background

The State of Washington has a number of urban areas with serious congestion, most notably King County, much of whose population of almost 2 million is concentrated in the city of Seattle and surrounding residential and economic centers (see Figure 26). In recent years the Seattle metropolitan area has routinely ranked among the five worst areas in the nation for congestion.

Implementation

Under the CRT Law, each affected employer must develop its own plan to steadily reduce commuting trips by 35% over the course of 12 years. An employer must comply with the Law if it has 100 or more employees at a single site who begin their workday between 6 and 9 a.m. and work at least two days a week. The program began in 1993. This case study focuses on the King County program, which offers its employees a comprehensive suite of incentives to reduce single-commuter vehicles, while also encouraging area employers to offer the same or similar package.[126] The main points of the program are highlighted below:

- **Preferential Parking** - Guarantees premium parking spaces for carpools and vanpools.

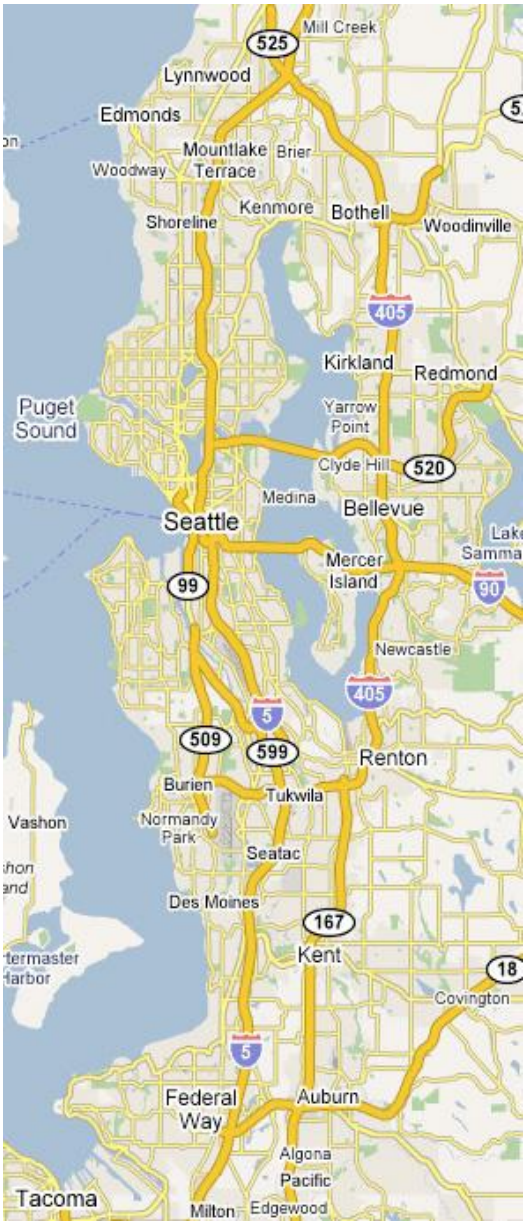

Figure 26. Tangle of traffic corridors in the highly congested Puget Sound area around Seattle. *(Source: Google Maps)*

[125] In the U.S., a county is a level of government in between state and municipal. More information on the Law is available at: http://www.wsdot.wa.gov/TDM/CTR/overview.htm. In 2006, the state passed the Commute Trip Reduction Efficiency Act to further strengthen the CTR Program (see http://www.wsdot.wa.gov/TDM/CTR/efficiency.htm).

[126] http://www.metrokc.gov/kcdot/alts/employer/options/rideshare.htm

- **Parking Cash-out (FlexPark) –** Employees who drive alone to work and get free parking from their employer can choose to exchange their parking space for benefits than help them take alternative modes of transportation. The most common choices are transit passes, cash or paid parking, but the benefits are highly flexible and can also include Flexcar membership[127], the Home Free Guarantee, and occasional parking privileges.
- **Commuter Bonus –** Transit vouchers for use on the mass transit and Washington State Ferry systems for employees who commute by bus, vanpool, or ferry.
- **VanPool –** King County provides vans (and fuel, maintenance, insurance, and rider support services) to transport groups of between five and fifteen to work. It is the largest publicly owned and operated vanpool program in the United States.
- **VanShare –** A system of vans that fills in the gaps left by other modes of transit (buses, ferries and the train). The program identifies areas of demand and provides shuttle service where it is needed most between different transit options.
- **Ridematch** - online service for users to identify people suitable for carpooling or vanpooling.
- **Home Free Guarantee –** assures a ride home via taxi for those who do not drive alone to work and for whatever reason cannot take their usual form of transit back home (usually due to working late).

Results

In 2005 a detailed study was conducted on the effectiveness of the statewide CTR program[128], the main results of which are summarized below:

- The morning commute on Washington State roads was reduced by more than 20,000 vehicles.
- In 2005, there were 126 million fewer vehicle miles traveled statewide, saving 6 million gallons of fuel and avoiding emissions of 3,730 criteria pollutants and 74,000 tons of CO_2 equivalents.
- Each weekday morning, participating employees in the Puget Sound region made 14,200 fewer trips than they did when the program began, reducing delays by an estimated 11.6%.
- The percentage of employees at CTR worksites who drove alone to work was 66% in 2005. This compares to 75% of solo commuters statewide (in 2004) and 71% of employees at CTR worksites in 1993. For those employers who began the program in 1993, there was a 14% drop in the portion of solo driving commuters by 2005.
- Those CTR employees who *always* drove alone to work during 2005 were fewer in number by 23% from when the program began in 1993. For downtown Seattle, the reduction was 35%.
- The share of commuters who took the train or bicycled to CTR worksites grew by 44% and 21%, respectively, from 2003 to 2005.
- The share of CTR employees who telework increased 47% from 2003 to 2005.

Lessons Learned

Employees respond to employer incentives to adopt alternatives to solo commuting. The study found that many of the reduced trips would have passed through choke points responsible for much of the area's congestion, points where even small reductions in volume significantly reduce delays.

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[127] Flexcar (www.flexcar.com) is a private company (soon to merge with Zipcar, www.zipcar.com) that provides fuel-efficient vehicles for members to use on a short-term basis (generally hours), enabling those who do not drive to work to avoid having to own a car.

[128] "2005 Report to the Washington State Legislature", CTR Task Force, February 2006 (http://www.wsdot.wa.gov/NR/rdonlyres/172087A9-85D1-416B-86C4-33281C7BDE68/0/CTR_Report_05.pdf).

5. Boosting Efficiency and Use of Mass Transit

In many APEC economies, the growth in urban populations and incomes has driven a trend toward increased motorization. Policymakers are striving to address this trend through investment in mass transit infrastructure and increasing passenger utilization so that the energy intensity and economic viability of mass transit improves. Increasing the operational efficiency, speed, reliability and quality of mass transit systems makes them an attractive alternative to cars and motorcycles. Cleaner, more energy-efficient mass transit networks can also help reduce congestion, pollution and reliance on imported fossil fuels.

The advantages of mass transit need to be competitive with the advantages of driving if people who have access to personal vehicles are going to opt for mass transit. The rising cost of fuel at the pump as well as many of the approaches described in other chapters (such as "green levies" on vehicles with poor fuel economy, increased parking fees in cities, congestion pricing and HOV lanes) can help to influence a shift from single-occupancy motor vehicles to mass transit. Although purchasing, maintaining, and insuring a personal vehicle exceeds the cost of using mass transit, for people who can afford vehicle ownership and have already invested in a personal vehicle, the relative appeal of mass transit is not only about money but about time and convenience. If the bus or the train can offer reliable service that is convenient and relatively time- and cost-efficient, drivers will be more likely to use it.

There are a number of ways to increase the speed of trips by mass transit, beginning with the access to mass transit stations (described in the following chapter), to the time it takes to obtain a transit pass, wait and board the vehicle, transfer between modes or routes, and walk or ride to the final destination. Because mass transit vehicles often share road space with cars and sometimes trucks, the way to avoid congestion and reduce travel times is to allocate road space to mass transit. This allocation can be done by giving priority signals to mass transit vehicles (e.g. as described below in Canada and New Zealand), providing real-time updates to mass transit drivers and passengers using intelligent transportation systems (one example described below for Chinese Taipei), and establishing exclusive mass transit lanes (as with many bus rapid transit systems).

Several economies and cities have set targets for increasing the share of mass transit in overall travel demand in large cities. For most APEC economies, the most popular ways to meet such targets and related policy goals are with bus rapid transit and light rail, with the objective of minimizing transit delays. Viet Nam, for example, has a 30% target that it plans to meet by promoting bus rapid transit and discouraging use of private transportation through tax schemes, parking fees, and compulsory insurance policies.[129] In China, about 20% of travel demand is already met with mass transit systems, and in cities where such infrastructure was recently improved and expanded, the share of mass transit in overall urban travel is even greater. At the end of 2007, more commuters in Beijing were using mass transit (34.5%) than compact cars (32%).[130]

[129] "Energy Efficiency Programmes in Developing and Transitional APEC Economies", Asia Pacific Energy Research Centre, 2003 (www.ieej.or.jp/aperc/pdf/project2002/efficiency.pdf).

[130] See "The Development of Kunming's Bus Rapid Transit (BRT) System", International Mayors Forum, pp. 44-47, 10 November 2004; "Beijing Public Transit Trips Surpass Compact Cars for First Time", Yang Mu (ed.) in Worker's Daily, 22 December 2007 at http://society.people.com.cn/GB/41158/6686122.html.

Bus Rapid Transit (BRT)

The research conducted for this survey indicates that bus rapid transit (BRT) has become an increasingly popular and efficient mass transit option in most APEC economies. BRT is a bus system with higher quality features than a simple bus service, such as its own right-of-way and specially designed buses—called "trunk" or "bi-articulated" buses—that are long and divided into two or three sections. Such buses can carry up to 140 or so passengers per ride and they travel in exclusive bus lanes, often with signal priorities at traffic lights. Because BRT generally utilizes or builds upon existing road infrastructure, it is less expensive than light rail and is thus a more approachable mass transit option for many APEC economies.

In addition, according to a study comparing the relative advantages of BRT and light rail, [131] BRT provides flexibility in choice that rail may not always offer. The study suggests that BRT – and bus-oriented design and development (a variation of TOD described in the following chapter) – may be particularly attractive and relatively cost-effective in communities that do not want high densities. Buses can also follow suburban travel patterns more flexibly than rail because they use roads. In some cases where demand for mass transit is expected to grow but not yet sufficient to justify the cost of light rail, BRT is an effective way to build ridership and shift driving commuters to mass transit, paving the way for possible light rail projects as illustrated in the case study below about a BRT system in Greater Vancouver, Canada.

More than half of the APEC economies have established or are introducing BRT, including Australia, Canada, Chile, China, Indonesia, Japan, Korea, Mexico, New Zealand, Peru, the Philippines, Chinese Taipei, Thailand, the United States, and Viet Nam. It is worth noting that two of the more widely-known BRT success stories – from Curitiba, Brazil and Bogota, Colombia – originated outside of APEC and have inspired the uptake of BRT as an efficient and affordable mode of urban transportation around the world, including the Orange Line in Los Angeles and Metrobus in Mexico City.[132] The system in Curitiba, which was introduced in the 1980s, is used by 85% of Curitiba's population (75% of weekday commuters according to the World Bank). Fuel consumption in Curitiba is 30% lower than in eight other Brazilian cities of comparable size. As Curitiba's BRT system is powered by diesel, there is still room for environmental improvement although according to the *Scientific American*, "the reduction in the number of cars used compensates, if not surpasses, the difference in carbon emissions."[133] A few BRT success stories in APEC economies are described below.

Australia's O-Bahn Busway System in Adelaide

The O-Bahn Busway in Adelaide opened in 1986, and at 12 km long and speeds of up to 100 km/h, it claims to be the "longest and fastest guided bus service in the world."[134] Modeled after a system in Essen, Germany, it is one of several BRT systems in Australia. At the time it was built, it cost A$98 million including buses, and its operation costs are half as much as rail systems in Australia with comparable capacity.

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[131] Currie, Graham, "Bus Transit Oriented Development – Strengths and Challenges Relative to Rail," in Journal of Public Transportation, volume 9, nr. 4, p. 12, online at http://www.nctr.usf.edu/jpt/pdf/JPT%209-4%20Currie.pdf.

[132] For more information see "Efficient transportation for successful urban planning in Curitiba", *Scientific American*, 28 April 2003. See also Currie (previous footnote).

[133] Ibid.

[134] Adelaide Metro website at http://www.adelaidemetro.com.au/guides/obahn.html.

The Adelaide O-Bahn has strived to become a carbon-neutral bus system. Its buses originally ran on diesel but have been replaced over time with new flexible-fuel buses. However use of the locally available alternative fuels such as biodiesel and natural gas has been limited because of a perceived lack of power when on an incline.[135] As with a growing number of mass transit services, the Adelaide O-Bahn website has a fuel calculator where people can enter basic data about their commuting habits and preferences in order to determine how much money they would save taking the O-Bahn versus a personal vehicle.

Indonesia's TransJakarta Bus Rapid Transit

The TransJakarta BRT opened in 2004. One of the primary goals behind the system was to reduce traffic congestion in the city. The system currently features lines in seven corridors and operates a total fleet of 253 Euro II-compliant diesel and CNG buses. All told, the system is expected reduce CO2 emissions for Jakarta by around 120,000 tons annually.[136] Service expansion, reliability, comfort, and safety are credited for helping to increase ridership from 16 million in 2004 to 39 million in 2006.

Figure 27. TransJakarta BRT *(Source: "Making TransJakarta a World Class BRT System", U.S. Agency for International Development, June 2005, www.itdp.org)*

[135] http://en.wikipedia.org/wiki/O-Bahn_Busway.

[136] "Jakarta, Indonesia: a 12.9 km bus rapid transport system built in just 9 months at a cost of $2million/km", Clinton Foundation Climate Initiative, 2008 (http://www.c40cities.org/bestpractices/transport/jakarta_bus.jsp).

Mexico's New Metrobús Line in the Capital City

In June 2005 Mexico City opened the first line of its new Metrobús bus rapid transit line along Insurgentes Avenue, one of the city's longest and most congested arteries. The 20-km line features pre-paid smart-card ticketing, designated bus lanes, and a fleet of 98 high-capacity new articulated diesel Volvo buses servicing 38 special raised-platform stations. The new line replaces the prior bus system which consisted of over 350 privately owned and operated buses and mini-buses jostling with traffic and competing for passengers along Insurgentes Avenue.[137] Under the old system, passengers needed between 1.5 and 2 hours to make the 20-km journey. The new BRT line has reduced that time by one-third to half, with an average time of just one hour. Carrying an average of 250,000 passengers per weekday, or 1.5% of public transportation trips in the city, that 33% travel time reduction represents an annual savings of 12 million person hours for Mexico City.[138] Additionally, by replacing the more than 350 buses and mini-buses used previously with 98 high-capacity buses in dedicated bus lanes, the system has also helped to reduce traffic congestion for other vehicles on Insurgentes Avenue. Overall the system is credited for eliminating at least 30,000 tons of annual greenhouse gas emissions.

Figure 28. New Metrobús in Mexico City.
(Photo: Wikipedia)

Chinese Taipei's Intelligent Transportation System for Taipei Metropolitan Rapid Transit

In 2004, the Taipei Department of Transportation (DOT) installed an intelligent transport system in the city's bus system, the Metropolitan Rapid Transit System (MRTS). The system consisted of two components to make the Taipei City bus system more convenient for passengers: on board the buses and at bus stops and MRTS stations. On board, 3,750 buses were equipped (as of December 2004) with a system to announce stops via both audio and liquid crystal display (LCD). At 80 bus stops and stations, electronic signs give passengers real-time updates, minute by minute, on the estimated time of arrival of the buses (Figure 29). The system is made possible by a Geographic Information Systems (GIS) monitoring system consisting of positioning devices installed on 500 buses, a control center, a phone query system for passengers, and a web-based system that allows passengers as well as DOT staff to monitor the system via the internet. The system also

Figure 29. Electronic sign for bus arrival in the Taipei City MRTS.
(Photo: Taipei Yearbook 2004)

[137] "Mexico City's Metrobus Celebrates its First Birthday", B. Baranda, Institute for Transportation & Development Policy, June 2006 (http://www.itdp.org/index.php/news_events/news_detail/mexico_citys_metrobus_celebrates_its_first_birthday/)

[138] "Metrobus General Description," Metrobus – Ciudad de México, June, 2007 http://www.metrobus.df.gob.mx/DESCRIPCION.pdf

improves the operating efficiency of the bus system by allowing dispatching to be computerized rather than manual, and by producing statistical reports needed for management.

CASE STUDY
CANADA: Vancouver Metropolitan 98-B Bus Rapid Transit and Canada Line

Purpose
To relieve traffic congestion associated with current and projected employment population growth around Greater Vancouver.

Summary of Actions
1) Preliminary design 98-B Line (1997-8)
2) Detailed design 98-B Line (1999-2000)
3) Construction 98-B Line (2000-1)
4) Training and service begins 98-B Line (2000-1)

Figures 30 and 31: A 98 bus (above) and the route map (left). *(Photos: Wikipedia)*

5) Public consultations, surveys Canada Line (since 2001)
6) Preliminary design Canada Line (2003 - 2005)
7) Detailed design Canada Line (2006)
8) Construction (since 2007)

Background
Greater Vancouver has experienced significant traffic congestion and related problems due to its growing population, expected to increase by 450,000 in the next decade, exceeding 3 million by 2021. The vehicle stock is growing by some 20,000 cars each year.[139] In 1995 BC Transit, the Canadian crown corporation responsible for public transportation stated its desire to improve mass transit service along a congested 16-mile corridor connecting Vancouver, Richmond and the Vancouver International Airport either through BRT or an automated light rapid transit service. First, a BRT service was constructed (98-B Line), which was very successful in moving commuters from their cars to mass transit. Then, as the demand for mass transit increased, there was more support for the Canada Line light rail project, although it was controversial due to the comparatively high cost.[140]

Implementation
Funding for the 98-B Line came from the Canadian government, the Greater Vancouver Transportation Authority (TransLink), and the municipality of Richmond. TransLink has served as

[139] See http://www.canadaline.ca/allFacts.asp.

[140] See http://en.wikipedia.org/wiki/98_B-Line.

the primary owner and operator. The overall project cost C$51.8 million: C$27.8 million for infrastructure, C$18.0 million for a 28-bus fleet, and C$6 million toward a C$30 million maintenance facility that shared costs with other bus projects. Comparatively, the Canada Line light rail project's capital cost is estimated at about C$1.9 billion, funded by public and private sources. The Canada Line's service is scheduled to begin in time for the 2010 Olympics.

The main features of the 98 B-Line are exclusive median bus lanes for most of the length of one of the major roads, queue jump lanes near bridges, exclusive curbside bus lanes in Vancouver, traffic signal priority when vehicles are behind schedule, and traveler information systems such as "next bus" announcements. The BRT stations are architecturally designed, and landscaping enhancements were made along the route. In February 2006, when construction of the Canada Line had sufficiently progressed, some of the bus lanes on the BRT line were closed to make way for the light rail project, shifting the buses to general traffic lanes.

Results

Benefits to passengers of the 98-B Line included a 20% reduction in travel time compared to previous services, and better overall service quality. According to customer surveys, about 23% of 98 B-Line riders were drivers or passengers of cars who changed their mode of transportation to the BRT. The modal shift resulted in 8 million fewer vehicle km traveled per year by private automobiles.

Due to the higher capacity and more time-efficient performance of the 98-B Line, TransLink needed 25% fewer vehicles and had 25% lower operating costs. The possibility of increased delays for cross-street traffic was assessed by looking at the transit priority statistics (i.e. data about providing priority to transit vehicles). The reductions in cross-street capacity were just 1% in Vancouver and 6% in Richmond, which has multi-phase signaling systems. An extensive evaluation of the project says these impacts are offset by capacity increases for traffic on the bus route, and that the overall cost-benefit analysis (for users and the owner/operator) shows that benefits are 30% higher than the costs.[141]

Lessons Learned

The evaluation[142] of the 98-B Line suggests several guidelines for BRT in other places:

- In the peak direction, the optimal transit ridership should be 500-1,500 passengers per hour.
- Frequency should be 6 to 20 vehicles per hour.
- Station spacing should be at least 400 m (high density locations) up to 1,500 m (low density locations).
- Travel time reduction targets should be 20-25% of the time traveled by other local buses, with an average speed of 25 km per hour, which can be facilitated by transit priority measures.
- Transit priority systems should minimize impact on cross-street traffic.
- The unique quality and branding of the service should be emphasized, e.g. through design of shelters, vehicle features, and service improvements like traveler information.

[141] IBI Group, "98-B Line Bus Rapid Transit Evaluation Study," conducted in association with Translink and funded by ITS Canada's Deployment and Integration Program, September 2003.

[142] Ibid.

CASE STUDY
CHINA: Expanding Bus Rapid Transit

Purpose
To expand public transportation infrastructure while improving service for customers and addressing traffic congestion and air quality issues.

Summary of Actions
State Council Decree No. 46, issued September 2005, encourages Chinese cities to develop BRT systems as a cost-effective way of expanding public transportation.[143,144] Many Chinese cities have developed or are in the process of developing BRT lines.

Background
With rapid economic growth over the past decade and with one of the world's largest populations, China is facing many challenges with growing urban populations and growing energy consumption. Urban populations are growing as people flock from the rural areas, and car ownership is increasing as a growing middle class emerges. Combined, these factors can put a lot of pressure on urban transportation infrastructure. Prior to the 2005 State Council Decree No. 46, many cities were investigating or constructing subway and metro systems to help deal with city congestion and air quality issues, but after the decree which encouraged cities to pursue more cost-effective BRT solutions.

Figure 32. BRT Station in Changzhou.
(Photo: www.chinabrt.org)

Implementation
While little transit planning takes place at the national level in China, Central Government policies such as the State Council Decree No. 46 can influence decisions at the municipal level where most urban and transit planning takes place. Promoted as a more cost-effective option than underground rail lines, BRT is attracting interest by cities across China. Prior to the 2005 decree, Beijing and Kunming had already opened BRT lines. Though Beijing is often associated with China's first BRT line in 2004, Kunming actually opened the first BRT line in 1999. Hangzhou opened a BRT line in 2007 and in January 2008 three more cities opened BRT lines: Changzhou (Figure 32), Chongqing, and Dalian. As many as 15 other Chinese cities are considering or developing BRT systems.[145]

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[143] "Bus Rapid Transit Developments in China", U.S. Dept. of Transportation Federal Transit Administration, July 2006 (http://www.fta.dot.gov/documents/China_BRT_Final_Report.pdf).

[144] "Country Synthesis Report on Urban Air Quality Management: People's Republic of China," Asian Development Bank Clean Air Initiative for Asian Cities, December 2006 (http://www.cleanairnet.org/caiasia/1412/csr/prc.pdf).

[145] "China Bus Rapid Transit", 8 February 2008 (http://www.chinabrt.org/defaulten.aspx).

Results

BRT is already bringing tangible benefits to the Chinese cities that have adopted it. In Kunming, for example, average bus speeds improved by a large proportion in the first 5 years, going from 10 km/h before BRT up to 15 km/h with the new BRT line. By expanding the more efficient BRT system to include more lines, public transportation ridership increased from 500,000 passengers per day in 1999 up to over a million per day in 2004, which represents an improvement from 8% to 14% of total vehicle trips in the city.

In Beijing, the new BRT has helped the city increase the share of mass transit trips from 24% in 2006 to over 34% at the end of 2007, surpassing trips made by compact cars, which stand at 32%[146].

In Hangzhou, the BRT's average speed of 25.3 km/h is about 20% faster than ordinary mass transit lines in that city. This translates to an average 40-minute daily commute savings, or 10 days per year.[147] In a passenger satisfaction survey, over 90% of respondents indicated that the BRT line had either significantly or somewhat reduced their commuting time.

[146] "Beijing Public Transit Trips Surpass Compact Cars for First Time", (北京公交出行比例首超小汽车 – *Beijing Gongjiao Chuxing Bili Shou Chao Xiaoqiche*), *Renmin Wang* (originally from *Gongren Ribao*, Worker's Daily), 12/22/2007, Editor: Yang Mu (杨牧). http://society.people.com.cn/GB/41158/6686122.html.

[147] "BRT #1 Line: 16Mil Passenger-Trips in First Year of Operation",
(快速公交一号线一年运营乘客1606万人次 – *Kuaisu Gongjiao Yi Hao Xian Yi Nian Yunying Chengke 1606 Wan Renci*), *Hangzhou Gongjiao Bao*,
April 30, 2007, Author: Yu Yi (余意). http://www.brtchina.org/ReportC/Hangzhou/ (PDFs 1-6).

CASE STUDY
THAILAND: Van Transit System in Bangkok Metropolitan Region

Purpose
To reduce congestion in the Bangkok metropolitan area by providing van service for the public along key routes that are not adequately served by bus routes.

Summary of Actions
Bangkok's public transportation system was expanded by the addition of a network of passenger vans run by the private sector.

Background
Traffic congestion in the Bangkok metropolitan area is notoriously bad, especially for commuters needing to cover the relatively long distances between the region's growing suburbs and central Bangkok. While there is a high quality, air-conditioned public bus service operated by the Bangkok Mass Transport Authority (BMTA), many highly traveled corridors are not adequately served by buses, leaving people to use low occupancy private vehicles, be they taxis or private cars.

Implementation
Although vans had been operating informally in the area for years, the official van transit system was launched in 1995 by BMTA. The public sector role in the system is limited, however: BMTA provides licenses to authorize the van operations (in exchange for an annual fee), sets the van routes, and enforces violations.[148] The van operators are private firms. The fare is about twice the bus fare, with vans providing express service between fixed starting and stopping points (although the driver may at times take an alternate route between these points in an effort to reduce traffic delays). Most vans have seats for 11 passengers, not including the driver.

It should be noted that an informal van system continues to operate, with a presence almost as large as the formal system: as of 2004, more than 40% of the vans, routes, and operators in the Bangkok area were informal. Operators do not have strong incentives to register, and they continue to appear as demand continues to grow, quickly replacing those informal operators who enter the formal system. Informal vans are not allowed to use the official van routes, although they do try at times, creating conflicts with registered operators.

Results
The system is immensely popular with both van operators and riders. As of 2004, there were 220 operators (formal and informal), 8300 vans, and more than 800,000 riders on average every day. On routes where no other mass transit is offered, the service provides an alternative to commuting by private motorcycle, car or taxi. Where the vans operate on the same routes as BMTA buses, the vans provide an alternative in between buses and private vehicles: somewhat more expensive than buses but faster and with a guaranteed seat. An analysis of efforts made in Bangkok to reduce air pollution from transport cited this van transit system as one of the milestones that "greatly contributed" to

[148] "Van Transit System in Bangkok Metropolitan Region", Asia-Pacific Environmental Innovation Strategies (APEIS) Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory, June 2004 (www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0095.pdf).

improving air quality in the area by reducing the number of vehicles on the roads.[149]

Lessons Learned

An analysis of the system published in 2005 describes difficulties that can arise on those routes shared by vans and buses.[150] For example, BMTA regulations for the vans require them to use specified terminals for picking up and dropping off passengers, but it is not uncommon for van drivers to try and increase their income by stopping to pick up additional passengers at bus stops. The restriction to two stops—beginning and end—not only minimizes travel time for van passengers, it avoids the congestion and danger that result when vans and buses compete for passengers along the route, is for any additional van stops to be located separately from the bus stops.

Light Rail and Subways

While rail is more expensive than BRT because it requires greater capital outlays for investment in infrastructure, light rail can carry a higher volume of passenger trips and can be an attractive alternative to private vehicles in densely congested urban areas. Some of the APEC economies building or expanding light rail include Canada, Chile, China, Japan, Korea, the Philippines, Thailand, and the United States. In some cases light rail builds upon the increased use of mass transit established by BRT. For example, the 98 B-Line in Greater Vancouver (case study above) has exceeded the capacity of riders that can be efficiently handled by bus, so it is being replaced by the Canada Line light rail project.

Light rail is also an integral component of transit oriented development (see the following chapter on Urban Design and Planning to Reduce Vehicular Transport). Light rail systems that are well maintained, efficiently operated, and affordable to passengers are an effective way to keep cars off the road, reducing vehicle fuel use, pollution and congestion. A recent study of urban transportation energy use in APEC economies finds that in Asia's most populous, rapidly growing cities, access to and investment in light rail is critical to reducing passenger vehicle dependence and improving energy intensity in Asian transport sectors.[151] The same study reports that rail, especially in Asian cities, uses considerably less energy per passenger kilometer than passenger vehicles. In Tokyo, for example, rail uses twenty times less energy than passenger vehicles do.[152]

Relative to other mass transit services, rail has also been found to attract more "choice" riders – i.e. people who have personal vehicles but choose mass transit for commuting; although some studies of

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[149] "Air Pollution Control in the Transportation Sector: Third Phase Research Report of the Urban Environmental Management Project", Institute for Global Environmental Strategies, March 2007 (http://enviroscope.iges.or.jp/modules/envirolib/upload/836/attach/836_air_pollution_control_transportation.pdf).

[150] "Market Structure of Passenger Vans in Bangkok", S.K. Leopairojna & S. Hanaoka, Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 4192 - 4207, 2005 (http://www.easts.info/online/journal_06/4192.pdf).

[151] "Urban Transport Energy Use in the APEC Region: Trends and Options," Asia Pacific Energy Research Centre, 2007, p. 2 (www.ieej.or.jp/aperc/2007pdf/2007_Reports/APERC_2007_Urban_Transport.pdf).

[152] Ibid, p. 9.

BRT markets suggest that BRT has more similarities with rail than with traditional bus markets.[153] The presence of rail networks in Tokyo and Hong Kong, China that connect the city center with suburbs has also helped keep the ratio of passenger vehicle stocks per 1,000 population relatively low considering the higher incomes of residents in these cities.[154]

Japan's Expanded and More Convenient Mass Transit Systems

As part of an integrated strategy to reduce the economy's greenhouse gas reductions, Japan has been expanding its urban rail systems and taking measures to make mass transit a more attractive option for travelers, especially commuters.[155] To make systems around the economy more convenient, 25 rail systems and 30 bus carriers now use integrated circuit cards for ticketing. Also, bus location systems, which allow passengers to monitor the location of buses in real time, are becoming increasingly common. As of March 2005, such systems existed in 4,683 bus routes throughout the economy. The most extensive system is in Osaka City, where the bus location system serves over 80% of the riders (about 300,000 daily).[156]

Figure 33. Train on the Tsukuba Express line. *(Photo courtesy of Japan Ministry of Land, Infrastructure & Transport)*

Figure 34. Street car portion of the tram-train Toyama commuter system. *(Photo: Tsuda, Light Rail Now!)*

Japan's train systems have seen two recent expansions. The Tsukuba Express is a rapid urban train line that opened in August 2005 (Figure 33). It spans 144 km (90 mi) through a number of urban areas, including Tokyo. The new line helps relieve congestion on the eleven existing lines to which it connects, most notably the crowded Joban Line. Seven of the 20 stations are in Tokyo, helping improve transport efficiency there. The line is also part of a smart growth strategy for the

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[153] Currie, Graham, "Bus Transit Oriented Development – Strengths and Challenges Relative to Rail," in *Journal of Public Transportation*, vol. 9, nr. 4, p. 5, online at http://www.nctr.usf.edu/jpt/pdf/JPT%209-4%20Currie.pdf.

[154] "Urban Transport Energy Use in the APEC Region: Trends and Options," Asia Pacific Energy Research Centre, 2007, p. 11 (www.ieej.or.jp/aperc/2007pdf/2007_Reports/APERC_2007_Urban_Transport.pdf).

[155] "Current Status of Measures Against Global Warming In Transport Sector", The Ministry of Land, Infrastructure and Transport, September 2007 (http://www.jama-english.jp/europe/news/2007/no_3/MrMiyazawa.pdf).

[156] "Bus Location System and Comprehensive Bus Operation Management System in Osaka City", H. Sato et al., Osaka City Foundation for Urban Technology, 2002 (http://www.osakacity.or.jp/en/seibi/info002/28/28-001.htm).

development of new urban areas along the line.[157] Another recent addition is the Toyama commuter light rail line, which opened in Toyama City in April 2006 (Figure 34). With 13 stations over 7.6 km, the system blends trams (streetcars) and light rail, replacing an older line that was in poor condition and experiencing declining ridership. Use of the system has exceeded expectations and as a result is expected to reduce the ownership of private vehicles and the prevalence of driving in the city.[158]

Chinese Taipei: Parking Charge for Motorcycles

In the congested Xinyi Business District of Taipei City, a policy was put in place on 15 December 2004 that constrained motorcycle parking to designated areas and charged a fee for parking in them. There are more than a million motorcycles registered in Taipei City, and prior to this measure large numbers of them commuted in and out of the Xinyi Business District everyday, many of them parking on the sidewalk. The aim of the measure was to reduce congestion by providing an incentive for motorcyclists to switch to mass transit—which is readily available to the business district—and to restore sidewalks for pedestrians. The measure affected 44 sections of road and 5,122 parking spaces. The Taipei City Department of Transportation advertised the new policy in late 2004 in all forms of the media (radio, television and print), put flyers on motorcycles on Nan-yang Street, and held a game on the internet. Public satisfaction for the measure was 80% according to a survey authorized by the Taipei Municipal Parking Management Office and conducted by the Taipei Society for Traffic Safety.[159] A later study of the program found that the on-street motorcycle parking charges were effective in increasing the use of mass transit among those who had been riding their motorcycles into the Xinyi Business District.[160]

[157] "Tsukuba Express", Metropolitan Intercity Railway Company, 2005 (www.mir.co.jp/english_guide.pdf).

[158] "Toyama: Tram-Train" Streetcar Line is 'Model' for Japan's Light Rail Revival", Light Rail Now!, May 2006 (www.lightrailnow.org/news/n_toy_2006-05a.htm)

[159] "2004 Annual Report", Taipei City Government Department of Transportation, 2004 (http://www.dot.taipei.gov.tw/newch/web/annual/93/交通局93年刊.pdf).

[160] "Stated Travel Response to On-street Motorcycle Parking Charge: A Case of Taipei CBD", C-H. Wen, et al., 85th Annual Meeting of the Transportation Research Board, 2006 (http://pubsindex.trb.org/document/view/default.asp?lbid=775740).

6. Urban Design and Planning to Reduce Vehicular Transport

The global trend toward greater urbanization and suburbanization has an enormous impact on energy demand growth. An extensive report by the Asia Pacific Energy Research Centre (APERC) analyzes the urban growth trends within APEC's economies with regard to transportation-related energy consumption and shows that demand for motorized transport increases dramatically as cities expand and sprawl. The report tracks two general growth paths:

Figure 35. Designated, paid parking for motorcycles in the Taipei central business district. *(Photo: Taipei Yearbook 2004)*

1. cities with lower density in North America and Oceania that have relatively higher gasoline consumption per capita as suburbs develop, usually fostered by increased availability of road infrastructure; and
2. cities in Asia and Latin America that are on an upward though relatively lower trajectory with similar trends toward greater per capita gasoline consumption as suburbanization increases, typically fostered by development of rail infrastructure.[161]

As a result of the rapid urbanization and suburbanization that took place during the second half of the 20th century, many cities in APEC economies have experienced significant problems with traffic congestion and pollution that have prompted rethinking and redesigning of urban and suburban development. The term and concept of "smart growth" emerged in the United States during the 1990s as a way to advocate – through a nationwide coalition – for a better way to grow. Other APEC economies use such terms as "sustainable urban design," "new urbanism" and "livable communities" to describe approaches to addressing problems with sprawling development patterns. With urban and suburban populations projected to double in Asia between 2000 and 2030,[162] sustainable "smart growth" planning is of paramount importance.

"Smart Growth" and Transit-Oriented Design and Development

For economies and their cities on the first above-mentioned trajectory, particularly in the United States, where per capita gasoline consumption in cities is twice as high as in Australia, and ten times as high as in most modern Asian cities,[163] the focus of smart growth concepts is to shift transportation from single-occupancy vehicles to higher-occupancy vehicles, mass transit and non-

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[161] Asia Pacific Energy Research Centre (APERC), *Urban Transport Energy Use in the APEC Region, Trends and Options*, Institute of Energy Economics, Japan: 2007, p. 9-10.

[162] *State of World Population 2007*, United Nations Population Fund, at http://www.unfpa.org/swp/2007/english/introduction.html.

[163] Holtzclaw, John W. "Smart Growth – As Seen From the Air, Convenient Neighborhood, Skip the Car," paper presented at the Air & Waste Management Association's 93rd Annual Meeting & Exhibition, 23 June 2000, Salt Lake City, Utah, quoting Newman and Kenworthy's *Cities and Automobile Dependence: An International Sourcebook*, 1989.

motorized options. Federal, state and local governments can introduce policies, planning reforms, redevelopment projects, and incentive programs that contribute to a reduction of vehicle miles traveled. The states of California, Maryland, Massachusetts, New Jersey, Oregon, Washington and Wisconsin, among others, have enacted legislation that encourages developers to apply smart growth principles and transit-oriented design (TOD) instead of following conventional patterns of suburbanization that perpetuate sprawl and reliance on private vehicles.

Instead of continuing the trend of urban sprawl that increases dependence on cars or other personal motorized vehicles for most transportation needs, smart growth aims to counter the negative impacts of sprawl by providing more options for where and how people live, and how they get around. Smart, transit-oriented design (TOD) harmonizes transportation efficiency goals with the zoning, permitting and regulations issued to developers. For example in areas well served with mass transit, carefully crafted zoning laws can create high-density, mixed-use zones that combine business and housing, making it easy for people to travel to work, shopping and recreational areas without having to get into a car. Pedestrian and bicycle paths can be strategically located to facilitate non-motorized transport within higher-density, mixed-use zones. The powerful leverage available in parking may be exploited by restricting parking spaces and increasing parking costs in areas where the use of mass transit, biking and walking can be encouraged over driving.

There is no one-size-fits-all design and each economy and city or community will have its own criteria and resources for addressing or averting the impacts of sprawl. For policymakers, it is important to raise public awareness about known problems related to urbanization and suburbanization and provide foresight in policymaking and incentives to address and avoid those problems. Policy mandates, voluntary approaches, or a combination of the two can be used to engage citizens and communities in the support of smart growth.

New Zealand: Auckland Urban Living Program

Some of the most tangible examples of smart growth planning are evident at the local level. For example, in an effort to reduce sprawl, several of New Zealand's cities have adopted plans that limit development within a certain radius of the city center. Suburbanization has been on the rise and the use of mass transit as a proportion of total trips has declined, so development plans that focus more on re-development of urban space aim to counteract this trend, and there are some signs that it may be reversing. The city of Auckland adopted the Auckland Urban Living program, featuring the "Livable Communities 2050 Strategy," and it unanimously passed a groundbreaking planning law in 2003 that established the "residential 8" zone to help the city cope with the projected population growth by at least 140,000 residents in the next 18 years. Areas that may qualify for residential 8 zoning must be served by an established town center and demonstrate sufficient infrastructure and storm water systems to accommodate projected population growth. The elements used to evaluate applications for zone 8 include such features as: density, energy efficiency, building envelope, driveways and parking, landscaping, among others. The city has also acted to make mass transit a more appealing and thus more viable alternative to private vehicles by greening its fleet and introducing bus rapid transit with priority signals to reduce trip times and improve reliability.[164]

On an economy-wide level, New Zealand also recently adopted a series of travel demand management programs. Funding for these programs – including a walking and cycling strategy,

[164] Eley, Carlton, "Smart Growth Down Under, Taking Steps Towards Sustainable Settlements in New Zealand," December 2003, p. 52.

neighborhood accessibility plans, an active living program, and "Bikewise Week" – has increased by nearly 75 percent since July 2007, indicating the government's commitment to them.[165]

The upside and the downside of zoning policies that allow greater density, mixed use and access to mass transit is that the cost of housing increases. The relationship between property values and access to community centers and mass transit is well known, and the affordability of housing in TOD neighborhoods is an important consideration for policy makers and urban planners. It is desirable that the property located near mass transit is in high demand so that ridership will go up and labor markets in mixed-use areas will grow, enabling more people to get to and from work without relying on personal vehicles. If property values are so high that only the higher income groups can afford homes in such neighborhoods, then access to mass transit could still be low for many households who will have to rely on personal vehicles. Therefore smart growth planners and policy makers often choose to include affordability of housing in their development projects.

New Zealand and United States: Location Efficient Mortgages

There are some approaches to bridging the distance between workplaces and housing that deserve exploration and have been recommended in some APEC economies, such as in the United States and New Zealand.[166] Location Efficient Mortgages (LEM) enable homebuyers to purchase property in areas more efficiently located to work and community, which may be more expensive to buy but less expensive in terms of transport expenditures. The LEMs apply savings in transportation costs to pay the relatively higher mortgage. In the United States, LEMs are offered by lenders in the cities of Seattle, Chicago, San Francisco and Los Angeles.

Chinese Taipei: Network of Bicycle Lanes in Taipei

Dedicated bicycle routes in the City and County of Taipei total more than 500 km, including in the central business district of Xinyi.[167] The first section of the downtown bike lane network was completed in 2004, with the riverside lane along the Keelung River, running past downtown Taipei, now exceeding 100 km (see Figure 36). The government announced plans to promote the use of bicycles over motor vehicles by extending the network of bike lanes to 2,600 km by 2011. To help residents use the bike paths for commuting, the city government provides hundreds of thousands of bicycle parking spaces near the city's Metropolitan Rapid Transit (MRT) stations, and produces a map showing how the bike lanes wrapping around the city connect to the MRT system.[168]

Figure 36. Riverside bicycle lane in Taipei.
(Photo: Taipei City Government)

[165] Communication with Terry Collins, Energy Efficiency and Conservation Authority, more at http://www.ltsa.govt.nz/sustainable-transport/index.html.

[166] Holtzclaw, John W. "Smart Growth As Seen From the Air, Convenient Neighborhood, Skip the Car," presented paper at the Air & Waste Management Association's 93rd Annual Meeting & Exhibition, 23 June 2000, Salt Lake City, Utah, pp. 9-11. See also Eley, Carlton, "Smart Growth Down Under, Taking Steps Towards Sustainable Settlements in New Zealand," December 2003, p. 53.

[167] "Proposals look set to bring cheer to cyclists in Taipei", *Taipei Times*, 13 June 2006 (http://www.taipeitimes.com/News/taiwan/archives/2006/06/13/2003313271).

United States: Massachusetts Smart Growth Legislation Challenges and Opportunities

One approach to addressing housing affordability as part of smart growth is to give municipalities incentives to adopt TOD zoning. In 2004-2005, the U.S. state of Massachusetts passed financial incentives known as Chapters 40R and 40S that aimed to offset the fiscal burden that drafting and redrafting of existing zoning codes places on municipalities. Chapter 40R makes cities or towns that adopt smart growth zoning eligible for (1) a one-time payment of US$10,000 - US$60,000 proportional to the number of housing units planned for the zone, and (2) an additional US$3,000 per unit actually approved. Chapter 40S aims to reimburse cities for education costs of new students living in the smart growth zones. But municipalities have yet to take advantage of these incentives. There is uncertainty about the actual amount of funds available to pay for the incentives, and the amounts stated in the legislation are deemed too small in exchange for what appears to be giving local land use control to the state, and for increasing density, which is not popular with some groups.[169]

However another incentive has been more popular: the TOD Bond Program stimulated over 25 projects in its first two years. Municipal bonds may be used for TOD housing, parking, cycling and pedestrian friendly projects within a quarter mile of transit stations.[170]

United States: New Jersey's Transit Village Initiative

Coordination of planning and funding for economic development, mass transit and TOD is essential but can be challenging to achieve. The state of New Jersey, which has embraced smart growth in its policies and programs, has grappled with this challenge, raising some issues that are relevant for many APEC economies – namely, that there may be a disconnect between locations of job growth and locations with access to mass transit.

Figure 37: Transit Village Initiative Logo

New Jersey set statewide clean air goals that are pursued through its 1999 Transit Village Initiative that prioritizes public funding for redevelopment of communities located near mass transit. Unfortunately, some of the 19 communities participating in the Initiative are located too far away from the state's projected job growth locations for Transit Village residents to use mass transit for commutes to work. In her reference to this mismatch, President of PlanSmart New Jersey Dianne Brake said that there is a critical need for better coordination on targeting state funding for

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[168] "2005 Taipei Healthy City Profile and Project", Taipei City Government, 2005 (http://healthycity.taipei.gov.tw/admin/upload/cityprofile/2005004.pdf).

[169] Dunham, Molly, "Massachusetts Smart Growth Legislation: How It Works, How It Compares, and Prospects for Success," 2006, at http://dev.reai.harvard.edu/research/pdfs/masmartgrowthfinal.pdf; and Darcy Rollins, "An Overview of Chapters 40R and 40S: Massachusetts' Newest Housing Policies, Policy Brief 06-1, New England Public Policy Center at the Federal Reserve Bank of Boston, February 2006, at http://www.bos.frb.org/economic/neppc/briefs/2006/briefs061.pdf.

[170] Smart Growth/Smart Energy Toolkit on website for Commonwealth of Massachusetts at http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-tod.html.

residential and enterprise zones so that funding for redevelopment goes to sites where there can be access to mass transit between home and work.[171]

United States: Live Near Your Work Incentives

Also in the United States, the state of Maryland is piloting a Live Near Your Work program that provides US$3000 or more to homebuyers who move to designated neighborhoods near their workplaces. Participating employers set the criteria for eligibility and provide matching resources. The employee must live in the designated neighborhood for at least three years to qualify for the program. A Live Near Your Work program is also offered in Arlington, Virginia.

United States: Integrated Transportation Planning in Portland, Oregon

The city of Portland, Oregon is widely hailed as a model for smart integrated urban planning, especially with regard to transportation. The city integrates light rail, streetcars, buses, bicycle lanes and smart pedestrian access planning (Figure 39) to greatly reduce the portion of residents commuting by car. Transportation options in Portland include two light rail lines, a streetcar system, and 750 miles of bicycle paths. Central to the Portland approach was to rezone the areas around light rail stations to make them mixed use zones that combine business and housing, making it easy for people to walk or bike both to work and to commercial amenities such as shopping and restaurants.[172] Parking is also key: in contrast to many cities that impose parking minimums on developers, Portland has low parking *maximums*. The ratio of maximum parking spaces per area of building space varies depending on the availability of transit options and the type of use (retail, residential, office or restaurant). Parking maximums are at their lowest in the center business district. Although there are some areas in Portland with parking minimums, there are no minimum parking requirements where mass transit is accessible within 500 feet.[173] The City of Portland provides no parking to its employees other than car pool parking, giving employees a choice between that or transit passes, and it encourages businesses in the city to do likewise. In the decade from 1996 to 2006, cycling traffic in the city

Figure 39. Portland planning document. Purple dots denote the pedestrian axis linking residents to retail and commerce in the town center, and mass transit. *(Source: Platetizen)*

[171] Brake, Dianne, "Transit Villages: A Great Way to Reduce Greenhouse Gases?" 30 October 2007, PlanSmart NJ Blog, A Forum for Regional Planning Issues, http://planningpartners.blogspot.com/2007/10/transit-villages-great-way-to-reduce.html.

[172] "Making TODs Work: Lessons from Portland's Orenco Station", M. Mehaff, *Platetizen*, 16 June 2003 (http://www.planetizen.com/node/92).

[173] "Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices", Metropolitan Transportation Commission, January 2007 (http://mtc.ca.gov/planning/smart_growth/parking_seminar/BestPractices.pdf)

increased by over 250%, the use of mass transit increased 65%, and the projected 40% increase in congestion never materialized.[174]

Figure 38. Portland bike lane alongside a bus route. *(Photo: BBC News)*

[174] "Where the car is not king", S. Warsi, *BBC News*, 15 August 2006 (http://news.bbc.co.uk/2/hi/programmes/newsnight/4777801.stm)

7. Promoting Fuel-Efficient Freight Transport

There are numerous opportunities to save fuel economy and improve energy efficiency in the freight and logistics industry, and a combination of government policies and voluntary programs can help tap into that potential. The movement of goods within economies and across borders accounts for a substantial portion of fuel use and polluting emissions. The commercial highway sector in Canada is responsible for nearly 10 percent of the economy's greenhouse gas (GHG) emissions.

Energy Efficient Technologies for Heavy Vehicles

In the tractor-trailer type of vehicles predominant in the long haul trucking industry, more than 40% of the energy used per liter of diesel fuel is consumed by drag on the vehicle, rolling resistance in the tires, and idling (see Table 2).[175] Almost one-fifth of the energy used to haul tracker-trailers over long distances is lost to aerodynamic drag, but efficiency gains of at least 25% are possible if a truck is fitted with the six devices illustrated in Figures 40 and 41.

Table 2. Energy used in the average long-haul trucking operation due to drag, friction and idling

Overcoming aerodynamic forces	19%
Idling	12%
Rolling resistance of tires	11%

Source: *M.J. Ogburn and L.A. Ramroth, Rocky Mountain Institute, 2006*

Idling can be addressed in two types of technologies. One is through a device that automatically shuts down the engine after it has been idling for a set amount of time, such as five minutes. The other is through one or more auxiliary power units (APUs) that provide heating, cooling and electricity for drivers who spend their rest periods in their trucks, instead of using the idling engine as the source of power. APUs are either themselves small diesel engines (sometimes with the capability of plugging into an electrical socket), or they are battery operated with the batteries recharged by the primary engine during driving.

Figure 40. Side skirts and rear drag device added to a truck. (*Photo: Rocky Mountain Institute)*

In the U.S. state of California, regulations went into effect January 1, 2008 requiring all trucks with gross vehicle weight over 4,536 kg (10,000 pounds), which have 2008 model engines or later, to be equipped with a device that automatically shuts off the engine after five minutes of idling. Alternatively, the engine must meet a stringent standard for NO_x emissions. For earlier models, the driver must manually shut down the engine after five minutes of idling. To ensure that the intent of the regulations are not circumvented by auxiliary power units (APUs) used during rest periods in place of an idling engine, the regulations also require fossil fuel-powered APUs to meet strict standards.

[175] Truck Efficiency and GHG Reduction Opportunities in the Canadian Truck Fleet, Michael J. Ogburn and Laurie A. Ramroth, Rocky Mountain Institute, 2006 (http://www.rmi.org/images/PDFs/Transportation/T07-10_CanadianTruckEff.pdf).

To obtain more efficient tires, trucks can be outfitted with either low rolling resistance versions of the usual dual tires, for an improved fuel efficiency of up to 4%, or with "super-singles" for savings of 4% to 6%. The super-singles, or "wide-base" tires have the added benefit of halving the number of wheel rims, reducing the weight of a four-axle truck by about 363 kg (800 pounds).[176]

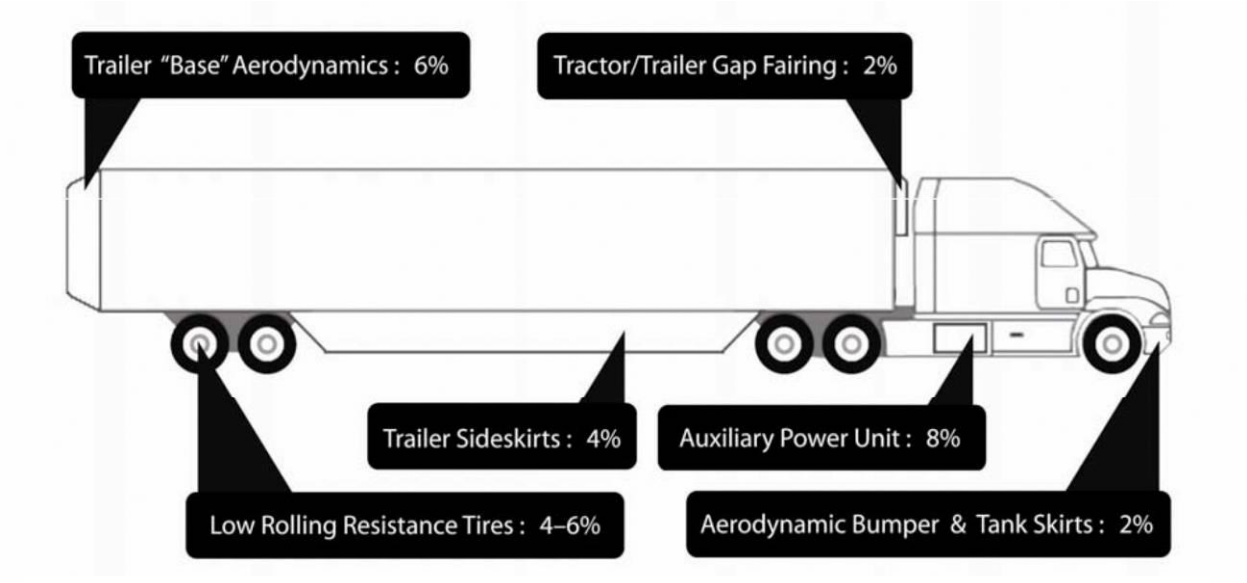

Figure 41. Retrofits that can be made to tractor-trailers and the approximate gains in fuel efficiency that result.

(Figure courtesy of M.J. Ogburn and L.A. Ramroth, Rocky Mountain Institute, 2006)

An emerging technology for trucking is hydraulic regenerative braking, which stores energy from braking in the form of a high-pressure fluid rather than a battery. Energy from braking pumps hydraulic fluid from a low-pressure chamber into a high pressure accumulator, which compresses nitrogen gas. Upon acceleration, some pressure from the accumulator is released to provide propulsion. The system is most suited to short distance trucking involving frequent braking. For example, one manufacturer cites an improvement in fuel economy of at least 17% for a refuse truck making stops every 100 feet.[177]

United States: 21st Century Truck Partnership

The 21st Century Truck Partnership focuses on R&D for heavier vehicle technologies. With over fifteen industrial partners, four federal partners and technical expertise from the national laboratories, this partnership supports information-sharing and coordination of research activities while still protecting proprietary information as appropriate. The partners have set technology-specific goals in five areas (many of which are described above as relevant to energy efficiency): engine systems, heavy-duty hybrids, parasitic losses (aerodynamic drag resistance, rolling resistance, drive train and auxiliary load losses), idle reduction, and safety.

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[176] "Truck Efficiency and GHG Reduction Opportunities in the Canadian Truck Fleet", Michael J. Ogburn and Laurie A. Ramroth, Rocky Mountain Institute, 2006 (http://www.rmi.org/images/PDFs/Transportation/T07-10_CanadianTruckEff.pdf).

[177] "Hybrid Hydraulic System Development for Commercial Vehicles", Eaton Hybrid Power, November 2007, (http://www.aqmd.gov/tao/conferencesworkshops/HydraulicHybridForum/BohlmannSlides.pdf).

United States: Wal-Mart Making Significant Efficiency Improvements in Truck Fleet

Wal-Mart is a large multinational retailer based in the United States with about 4,000 stores in the domestic market, and 2,700 in 13 foreign markets, including three APEC economies. In December 2005, the company announced a goal to improve energy efficiency by 25% over the course of three years (2006 to 2008), and by 100% over ten years (by 2015). After the first year and a half since the announcement, Wal-Mart had already improved the fuel efficiency of its fleet of large semitractor-trailer trucks (generally 18-wheelers) by 15%, and it anticipates reaching its 2008 goal of 25% improvement on schedule or sooner.[178] The fleet now achieves an average of about 7 mpg (3 km/L) compared to a 2005 base of about 6 mpg (2.5 km/L). Wal-Mart made these gains thanks to a fuel-additive mix, fuel-efficient tires, and alternate power units that reduce idling by allowing the truck engine to be turned off while still powering systems needed for the driver when parked, such as heating, cooling and electricity. The impetus for the efficiency goals—considered the most ambitious in the industry—was the need to offset rising fuel costs in order to keep retail prices low. The investments are producing the desired results, yielding annual savings to the company of between US$35 million and US$50 million so far.

Wal-Mart intends to extend fuel savings to about 30% by updating its entire fleet with new, more energy-efficient vehicles by 2010 that are 8% more efficient due to lighter materials and improved aerodynamics. An undisclosed new tire innovation and improved driving practices are expected to further increase efficiency. To attain the goal of doubling energy efficiency by 2015, about half of the improvements will come from hybrid diesel-electric engines that are currently being developed by American truck manufacturers with US$2 million per year in support from Wal-Mart, which has agreed to buy the prototypes that result. Wal-Mart has also partnered with a trailer manufacturer to reduce drag by experimenting with side skirts and modifications to the back, striving for another 5% to 6% increase in fuel efficiency.

United States: Coca-Cola Adopts Hybrid Delivery Trucks

Coca-Cola Enterprises purchased five new hybrid-electric delivery trucks for its 90-truck/24,500 m² South Bronx distribution center in New York City.[179] The hybrid versions of the side-load trucks (Figure 42) use one-third less fuel than conventional technology. Hybrids are especially well suited for city delivery trucks because at speeds of less than 30 mi/hr (48 km/hr)—which are common during the stop and go deliveries in congested New York City—the truck draws only on the 340-volt battery. By the end of 2008, Coke plans to add another 120 side-loading delivery trucks to it U.S. fleet, although they are 25% more expensive. The speed at which the additions can be made is restricted by the rate at which the

Figure 42. Hybrid-electric Coca-Cola delivery truck.

[178] "Wal-Mart on track to cut truck fuel use by 25%", Associated Press, 17 July 2007 (http://www.msnbc.msn.com/id/19810648/).

[179] "Coca-Cola Enterprises, Inc. and NYC Mayor Michael R. Bloomberg Announce Expansion of Hybrid Trucks Fleet in New York", Coca-Cola press release, 28 November 2007 (http://ir.cokecce.com/releasedetail.cfm?ReleaseID=278958).

manufacturers can produce them. The truck is manufactured by International Truck and Engine Corp., while the hybrid system is supplied by Eaton Corp.

Government Policies and Programs for the Commercial Freight Industry

A few APEC economies have passed legislation that influences energy consumption behavior in various economic sectors, including in the freight industry. Japan's revised energy conservation law, for example, has prompted commercial logistics companies like Nippon Express (featured in a case study below) to undertake measures that will improve fuel economy and reduce pollution. Thanks to progress made internationally toward targets and policies to mitigate effects of global climate change, many APEC economies are developing legislation or policy strategies to curb GHG emissions. Major energy-consuming industries, including freight, need to manage the regulatory risks of increased energy costs when carbon will be priced.

Canada: ecoFREIGHT Technology Demonstration Fund

The ecoFREIGHT Freight Technology Demonstration Fund operated by Transport Canada provides the freight transportation industry with cost-shared funding for real world testing of freight transportation technologies that have the potential to reduce the emissions of air pollutants and greenhouse gases. Projects can be funded to cover 50 percent of total eligible costs and up to C$500,000 over a two-year period.

New Zealand: Shifting Freight to Coastal Shipping

New Zealand is working on a draft strategy called Sea Change that aims to shift domestic freight from road transport to coastal shipping. About 15 percent of domestic freight is currently carried by coastal ships, and Sea Change proposes to double this share of sea shipping in the freight industry by 2040. A few studies are in progress that will establish baseline data showing how modal shifts in the freight industry can improve New Zealand's performance in terms of fuel economy and reduced GHG emissions.

The government of New Zealand is also partnering with industry to identify and recommend a package of fuel efficiency measures that will optimize the fuel use of the economy's heavy and light vehicle fleets.

CASE STUDY
JAPAN: Energy Conservation Law Improves Freight Efficiency

Purpose
To take steps towards reaching Kyoto Protocol targets by reducing CO_2 emissions in the freight sector through fuel efficiency standards for new freight vehicles and through requirements that freight and shipping companies lay out plans to reduce energy consumption and submit annual energy consumption reports.

Summary of Actions
The 1998 Amendment of the 1979 Energy Conservation Law established a "Top Runner" program setting efficiency standards for freight vehicles; the 2005 Amendment requires cargo and passenger-companies to "draw up energy conservation plans and [annually] report energy consumption".[180]

Background
With few domestic fossil fuel sources, Japan is one of the world's biggest net importers of crude oil,[181] making Japan more vulnerable to international energy price fluctuations than other economies with larger domestic energy supplies. In response to the 1970s oil crises, Japan enacted the Energy Conservation Law in 1979, establishing energy conservation guidelines for factories, buildings, and machinery. In following decades as the threat of climate change and global warming came into focus, Japan recognized the need to reduce CO_2 emissions. After ratifying the Kyoto Protocol in 1997 Japan has used amendments to the original 1979 Energy Conservation Law as a mechanism to help reduce the economy's CO_2 emissions in an effort to comply with the Kyoto Protocol.

Implementation
There are primarily two amendments to the Energy Conservation Law which influence energy efficiency in the freight transportation sector. First, in 1998 the "Top Runner" program was added to the Energy Conservation Law. This program set energy efficiency testing protocols and energy efficiency targets for many manufactured products, including heavy freight vehicles. Different categories and classes of vehicle have different average fuel efficiency standards and different compliance deadlines. Heavy freight vehicle manufacturers are facing a 2015 compliance deadline, which should allow roughly two product cycles to implement necessary new technologies. While the law does not stipulate what kinds of efficiency-improving technologies manufacturers use, the standards are set based on likely possible efficiency gains from available technology like direct fuel injection or idle-stop systems, for example. The "Top Runner" program also allows the Minster of Economy, Trade, and Industry to take measures against manufacturers whose products are found to be non-compliant with the efficiency standards. Actions are taken on a case-by-case basis and can vary from a warning, to a public announcement, to an order to comply, and even to a monetary fine if an order is violated.[182]

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[180] "Chronological Changes of the Energy Conservation Law", Energy Conservation Center Japan, 2008 (www.eccj.or.jp/chronicle/index.html).

[181] "Japan: General Background", U.S. Energy Information Administration, December 2006 (www.eia.doe.gov/emeu/cabs/Japan/Background.html).

[182] "Final Report of Joint Meeting Concerning Revisions of Evaluation Standards for Manufacturers with regard to improvement of automobile energy consumption efficiency", Energy Conservation Center Japan, February 2007 (www.eccj.or.jp/top_runner/pdf/vehicles_gasdiesel_feb2007.pdf).

The other amendment to the Energy Conservation Law that affects the economy's freight sector is the 2005 amendment requiring companies which utilize freight transport in their business models to create medium-term and long-term plans for reducing their energy consumption and to submit annual reports on their energy usage to the Minister of Economy, Trade, and Industry. This amendment applies both to companies that carry freight (carriers) as well as companies that employ their services (consigners), and includes both cargo and passenger transport. As in the "Top Runner" program, companies that fail to implement sufficient energy-reducing schemes may be ordered to implement government recommendations.[183]

Results

While Japan is already highly efficient in converting energy resources to gross domestic product (GDP) wealth, these two measures are helping to increase energy efficiency in the economy while also spurring technical innovation and development. Fuel efficiency in heavy diesel freight vehicles is expected to improve by more than 12% over 2002 averages when the "Top Runner" program standards become compulsory for those vehicles in 2015.[184] Additionally, many companies are already beginning to create plans and take action to comply with the 2005 amendment that requires companies to plan and report energy usage reductions.

One example is Nippon Express, a large shipping and logistics company in Japan. Their 2007 corporate social responsibility report describes several energy efficiency measures the company is implementing,[185] including purchase of efficient vehicles, modal shift towards more efficient methods, shipping route improvements, employee training programs, and joint distribution.

In 2006, new eco-friendly and energy-efficient vehicles that reduce emissions and meet long-term regulations represented the company's largest area of investment at 3.8 billion yen (~US$35 million). Focusing primarily on larger vehicles, investments were directed towards CO_2-reducing technologies like CNG, LPG, and hybrid electric.

Nippon Express and some of its clients like S&B Foods have also been switching from a transport system based on trucking to one that makes use of other modes like trains and ships. As part of this effort, Nippon Express has been developing and improving systems that make it easier to transfer cargo between different transport modes.

The company is also implementing measures to encourage efficient vehicle operation. There is an employee training program that emphasizes efficient driving techniques, as well as proper vehicle maintenance and inspection. Digital vehicle efficiency monitoring devices have been installed in company vehicles to help drivers operate vehicles more efficiently.

[183] "Act Concerning the Rational Use of Energy, 2005," Energy Conservation Center Japan, 10 August 2005 (www.eccj.or.jp/law/revised/10aug2005.pdf).

[184] "Developing the World's Best Energy-Efficient Appliances (Japan's "Top Runner" Standard)", Energy Conservation Center Japan, Revised Edition, October 2006, Chapter 7.2 (www.eccj.or.jp/top_runner/index_contents_e.html).

[185] "Nippon Express CSR Report 2007" (www.nittsu.co.jp/about/pdf/2007env_report.pdf).

CASE STUDY
UNITED STATES: SmartWay Transport Partnership

Purpose
To improve fuel efficiency in ground freight transportation, targeting an annual savings of 150 million barrels of oil by 2012.

Summary of Actions
In a voluntary program run by the U.S. Environmental Protection Agency (EPA), partners commit to improving the energy efficiency and environmental performance of their operations and to monitoring those improvements.[186] Those demonstrating a certain level of performance are allowed to display the logo (Figure 43). The program estimates that fuel economy can be improved by about 25% through better aerodynamics of truck tractors, more efficient routing, self-inflating tire systems, and driver training. SmartWay works with states and banks to link its partners with viable financing options for the energy-efficiency investments that partners commit to making.

Figure 43. SmartWay Transport logo for display by partners meeting the program's criteria.

Background
Freight vehicles account for more than one-fifth of the energy consumed by the U.S. transportation sector, or about 6 quadrillion Btu annually, and considerable opportunities exist for cost-effective efficiency improvements. EPA estimates that the measures promoted by SmartWay save at least 4,256 gallons (16,111 L) per year. Assuming a typical long-haul combination truck uses 16,667 gal (63,091 L) of diesel per year[187], this translates to a fuel savings of more than 25%.

Implementation
Partners in the program consist mostly of truck carriers, but also shippers, shipper-carriers, trucking logistics firms, and rail carriers. Affiliates are organizations that help to promote the Partnership as part of their interest in improving energy efficiency and reducing pollution. They are a large group consisting mostly of trucking and related associations, plus some environmental groups and manufacturers of trucking systems and components.

Participating corporations commit to implementing energy efficiency measures, and those achieving a certain level of performance may use the SmartWay logo. The specific requirements for enrollment differ depending on whether a Partner is a carrier or a shipper. Carriers must determine their baseline performance using the SmartWay Transport FLEET (Fleet Logistics Energy and Environmental Tracking) Performance Model for carriers and commit to improve that performance within three years. The SmartWay website has a "Technology Package Savings Calculator" for companies to use in calculating their estimated savings with various combinations of technologies. Based on these results, each carrier and logistics company is given a score of "outstanding", "very

[186] "SmartWay Transport Partnership Overview", U.S. Environmental Protection Agency, February 2004 (www.epa.gov/otaq/smartway/documents/partnership_overview.pdf).

[187] "SmartWay Innovative Financing Program for the Trucking Industry", U.S. Environmental Protection Agency, February 2006 (http://www.epa.gov/smartway/documents/420f06016.pdf).

good" or "good" for their the fuel efficiency and environmental performance, which are posted at http://www.epa.gov/otaq/smartway/partners/scores.htm. Only those carriers rating as very good or outstanding may use the SmartWay logo. The baseline for SmartWay shippers is the percent of goods shipped by SmartWay Partner carriers. Shippers must commit to ship at least half of their goods using SmartWay carriers. Each year U.S. EPA acknowledges those freight companies that excel in energy efficiency.
The energy efficiency strategies promoted by the program are:

- *idle reduction* – can reduce up to 2,000 gallons per long-haul truck per year, a savings of 12%;
- *improved aerodynamics of truck tractors* – can reduce fuel consumption by at least 600 gallons annually emissions compared to typical tractors, a savings of 3.6%;
- *improved freight logistics* such as load matching, more efficient routing and scheduling of vehicles can save around 200 gallons per year, a savings of 1.2%;
- *self-inflating tire systems* – can save nearly US$300 per year in tire replacement costs and reduce fuel consumption by at least 90 gallons annually (0.5%); and
- *driver training* – can save more than US$1,000 in fuel costs by improving fuel economy by at least 5%.

SmartWay provides a choice of upgrade kits that bundle energy efficiency upgrades with emissions controls devices: either a diesel oxidation catalyst (DOC) or particulate matter filter (PM). The program helps find financing for the participants through a set of approved lenders offering loans from US$5,000 - US$25,000 on affordable terms with no collateral. This is especially important for small trucking companies and owner-operators. In addition to the loans there are federal and state grants available for qualifying partners. Table 3 shows that the efficiency improvements save the borrower more money per month than the cost of the loan. The SmartWay website has a "Technology Package Savings Calculator" to help companies figure out their estimated savings with various combinations of technologies.

Table 3. Typical costs and savings from the SmartWay truck efficiency upgrade kits.

	Cost	**Monthly Fuel Savings***	**Monthly Loan Payment** (@ 9% for 48 months)	**Net Monthly Savings**
Individual Technologies				
Idle Reduction Device – Bunk Heater	$1,500	$215	$37	$178
Idle Reduction Device – Auxiliary Power Unit	$8,500	$330	$212	$118
Aluminum Wheels for Single Wide Tires	$5,600	$153	$139	$14
Trailer Aerodynamics	$2,400	$191	$60	$131
Possible SmartWay Upgrade Kit Options				
Heater, Tires, Aero, DOC	$10,070	$520	$266	$254
APU, Tires, Aero, DOC	$17,700	$636	$440	$196
Heater, Tires, Aero, PM Filter	$16,000	$520	$386	$134

Source: "SmartWay…" (http://www.epa.gov/smartway/documents/420f06016.pdf)

** Based on a long-haul truck that on an annual basis uses 16,667 gallons of diesel and idles 1,200 hours for bunk heaters and 2,400 hours for APUs. Fuel cost was estimated at US$2.75/gallon. By May*

2008, the average price of fuel per gallon had risen to over US$3.60.[188]

Results

The original SmartWay Partners joining with EPA to found the program in February 2004 numbered just 13, including big names such as Coca-Cola, Federal Express and the United Parcel Service. Now the Partners and Affiliates number in the hundreds, many of which are rated as outstanding or very good in their efficiency (listed at www.epa.gov/otaq/smartway/partners/scores.htm).

[188] United States Energy Information Agency, U.S. Retail Gasoline Prices, http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_home_page.html.

8. Cross-Cutting Approach: Taxes on Fuels

A fuel tax as used in this paper is defined as a tax on fossil fuel combustion, in addition to those taxes on fuel used as a general source of tax revenue, for example to pay for roads. The cause and effect relationship between transport fuel taxes and reduced fuel use (through consumer selection of more efficient vehicles and reduced driving) cannot be pinpointed with quantitative precision. However, many years of empirical evidence allow comparisons to be made among developed countries with different fuel tax rates, using indicators like fuel usage per distance traveled and carbon intensity. For example, the average passenger car in the United States uses over 40% more fuel per kilometer than the average car in Europe[189], a fact that is related to the difference in fuel taxes which cause the price of gasoline in Europe to be 2.5 times that in the United States, and the price of diesel to be double.[190] Another indication that fuel taxes lead to reduced fossil fuel combustion can be seen in Figure 44, which plots average fuel prices in eleven developed countries against the carbon intensity of their economies (in grams of carbon per GDP).

Table 4. Retail Prices for Fuel in APEC Economies*

	Gasoline (premium)	**Diesel**
Australia	93	94
Brunei	34	21
Canada	84	78
Chile	109	86
China	69	61
Hong Kong, China	169	106
Indonesia	57	44
Japan	109	90
Korea	165	133
Malaysia	53	40
Mexico	74	52
New Zealand	98	70
Papua New Guin.	94	64
Peru	122	86
The Philippines	76	67
Russian Fed.	77	66
Singapore	92	63
Chinese Taipei	83	71
Thailand	70	65
United States	63	69
Viet Nam	67	53

**Mid-November 2006, in U.S. cents/liter, except 2004 prices for Papau New Guinea.*

Fuel taxes applied in the APEC economies span the entire range from Brunei—with prices subsidized below the cost of production—to Korea, with rates higher than those used in Luxembourg, which the German federally owned international cooperation enterprise (GTZ) classifies as "very high taxation" (see Table 4). Most European countries fall in the "very high" range for fuel taxation. In the United States, on the other hand, fuel prices do not include costs other than industry profit, value added tax (VAT), and about 10 cents for federal and state road funds; so according to the GTZ system, it can be considered an approximate benchmark for a rate that is neither taxed to decrease the use of fuel, nor subsidized.

Figure 44 shows the relationship between fuel prices and carbon emissions per unit of GDP for several APEC and European economies. Over the years, weighted average retail fuel prices in the transport sector (including taxes) have generally been higher in Japan and Europe than in Australia, Canada and the United States. Not surprisingly, the carbon intensity of GDP is also low in Japan and Europe. Yet even holding fuel prices constant -- for example comparing years in which

[189] "Experience with the Use of Economic Instruments in Europe", Jacqueline McGlade, 19 March 2007.

[190] "International Fuel Prices 2007", 5th Edition, GTZ, April 2007.

Australia, Canada, Japan and the United States all have fuel prices around US$0.5 per liter -- there is a variation by more than a factor of four in carbon intensity of GDP. This would seem to be partly because the carbon intensity shown includes all major energy consuming sectors (residential and commercial buildings, industry, and electric power as well as transportation) and partly because Australia, Canada and the United States are geographically dispersed while the population of Japan is highly concentrated.

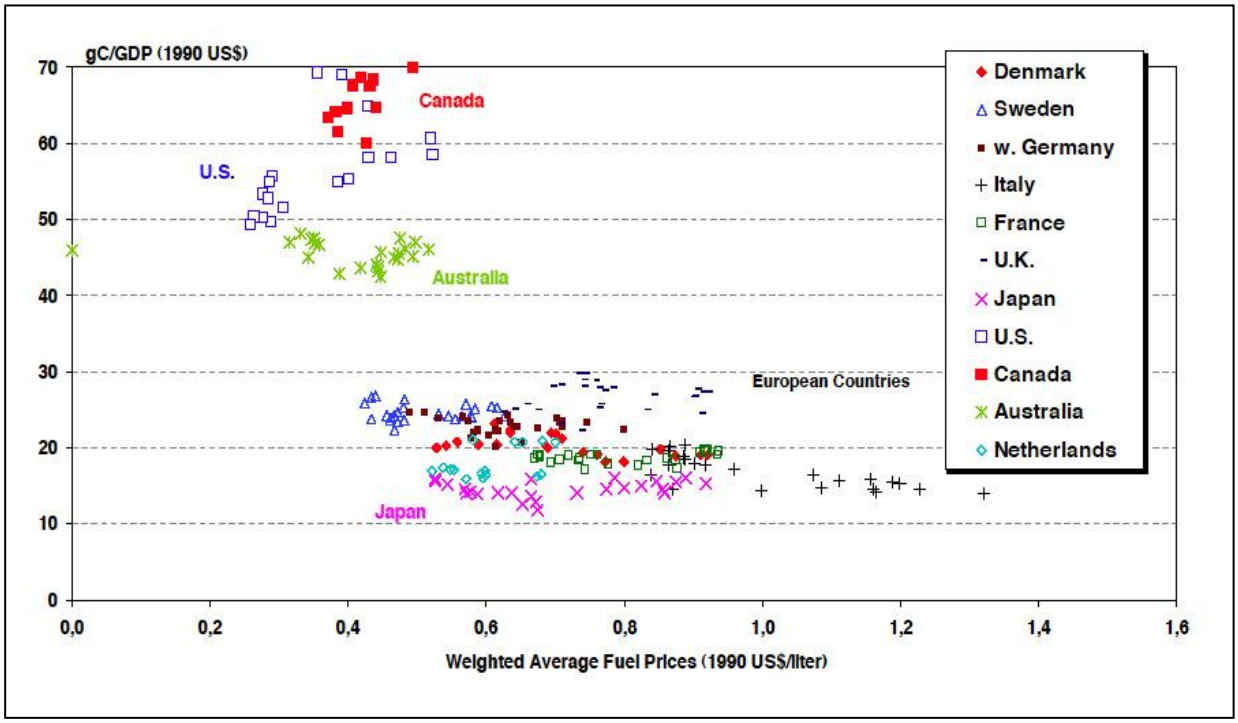

Figure 44. The Relationship between Fuel Price and Carbon Intensity of Selected Economies.
(Source: "Addressing Energy Efficiency in the Transport Sector", Axel Friedrich, GTZ, 2007)

Retail fuel prices used in the APEC economies are provided in Figures 45 and 46 for gasoline (premium grade) and diesel, respectively. For sake of comparison, the average price across five Western European countries (Belgium, France, Germany, Italy and the Netherlands) is also included.

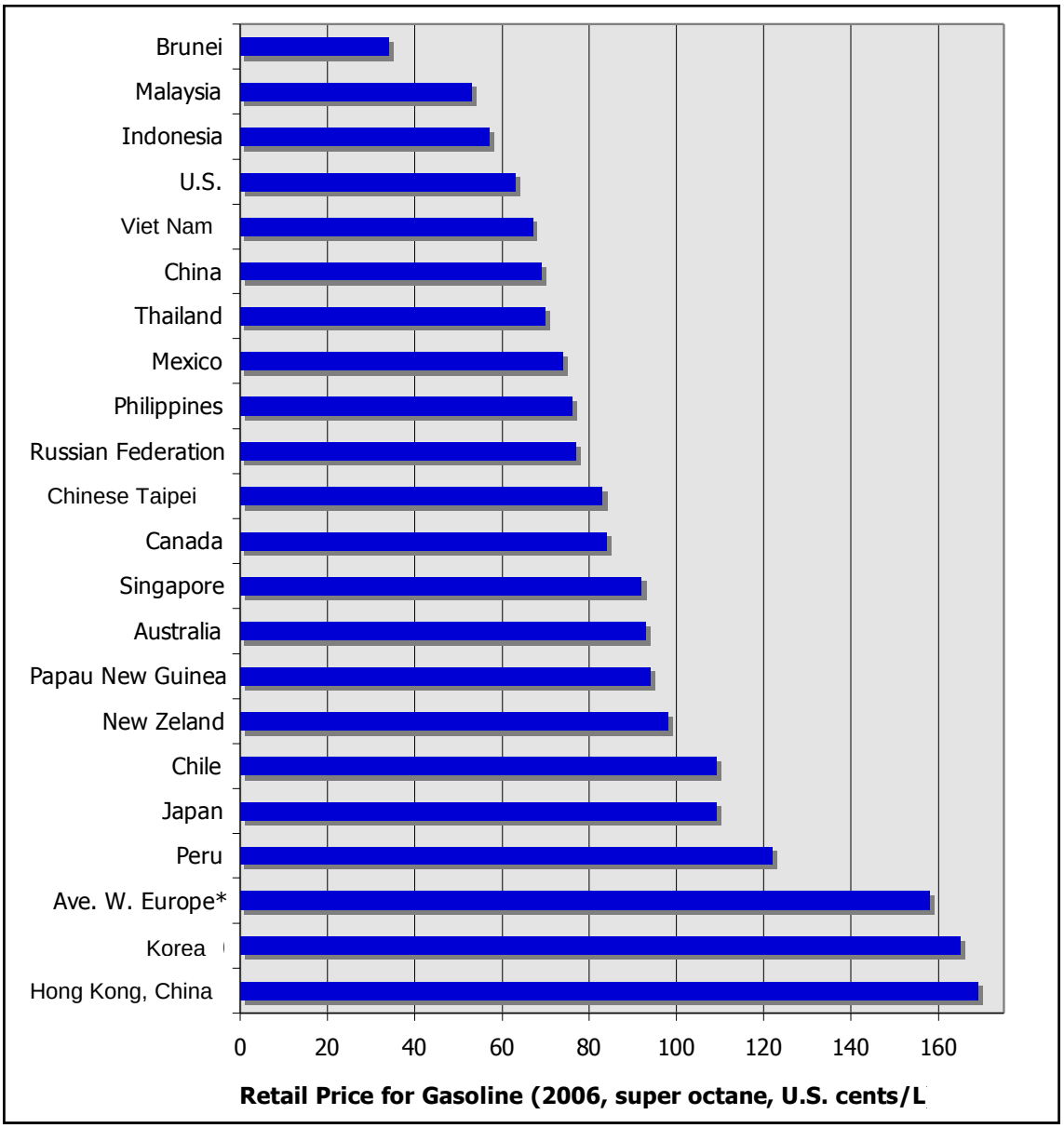

Figure 45. Comparison of Gasoline Prices in APEC Economies in mid-November 2006.
(*with the average of 5 Western European countries shown for comparison:
Belgium, France, Germany, Italy and the Netherlands)

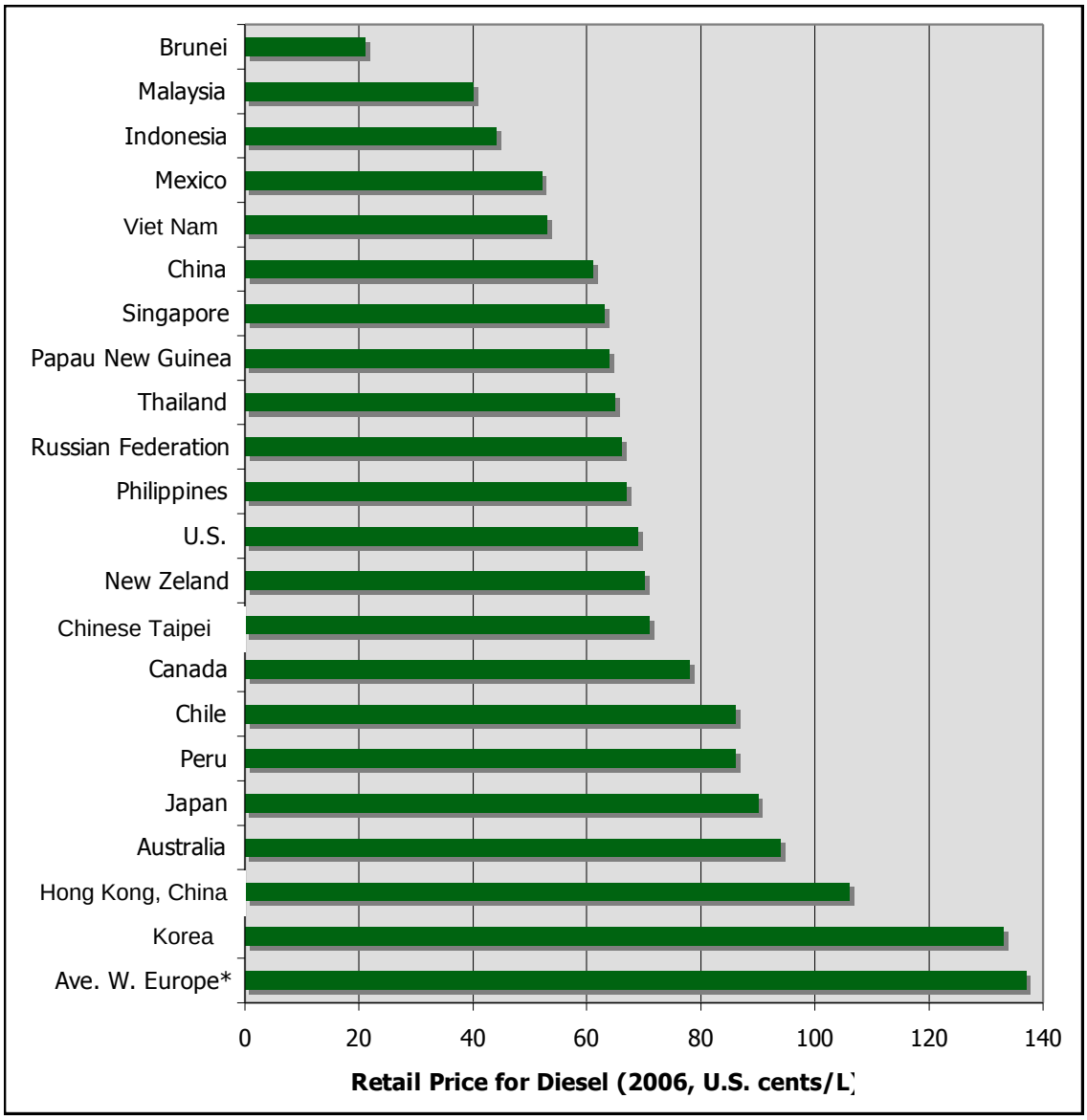

Figure 46. Comparison of Diesel Prices in APEC Economies in mid-November 2006.
(*with the average of 5 Western European countries shown for comparison:
Belgium, France, Germany, Italy and the Netherlands)