Success Stories: The Transport Sector

GHG emissions from transportation are a result of fuel consumption, which is affected by three factors, the efficiency of the vehicle, the carbon content of the fuel and the amount of travel activity. Achieving improvements in transport sustainability requires that measures be taken in all three of these areas. Nevertheless, differing circumstances among nations, regions or cities have resulted in a range of best practice examples, some of which concentrate more on one type of factor and less on another. Some strategies are best deployed at the national level, while others are most effective, and indeed, most possible to implement, locally.

Vehicle Efficiency: China's National Fuel Economy Standards for Passenger Vehicles

Among non-OECD countries, only China has developed fuel economy standards (FES) for its light-duty passenger vehicles (cars, vans, SUVs, and mini-buses). While China's motivation for adopting a FES was not related to climate change but by a desire to address a number of other factors – improve energy security, modernize the vehicle fleet technologically, improve the competitiveness of domestic manufacturers, etc. – these standards have nevertheless served to significantly improve the GHG emissions of new vehicles sold in China. However, China's FES applies only to vehicles manufactured within the country; imported vehicles are exempt.

There are a number of ways in which a FES can be designed and implemented. In China, the structure of the FES was dictated by the state of the auto manufacturing in 2002 when the FES were developed. At that time, China's automotive industry was not very large and was very fragmented, consisting primarily of small companies, many of which made only specific types of vehicles. This meant that a corporate average fuel economy (CAFE) standard, such as that in the US, was infeasible. Instead, China chose to design a system in which the vehicle fleet is divided into 16 weight classes, with a minimum FES applying to every vehicle within a given class. By designing the FES in this way, every manufacturer was forced to improve the fuel economy of its vehicles. In addition, in an attempt to encourage the production and sale of smaller vehicles, the FES was designed to be more difficult to meet for the heavier weight classes, and a system of excise taxes was adopted in which the tax became progressively more burdensome as the vehicle engine size increased (e.g., a 3% tax for the smallest engines and a 20% tax for the largest).

China originally set its FES to be instituted in two phases, with Phase I beginning in 2005/6 and Phase II in 2008/9. However, since both phases were announced in September of 2004, many manufacturers immediately began to produce vehicles that could reach the Phase II standards. The result was an improvement in fuel efficiency of 11-12% in the new passenger vehicle fleet in China between 2002 and 2006 – producing one of the most fuel-efficient new vehicle fleets in the world, largely because most of the new car sales were small vehicles – but a much smaller improvement (1-2%) between 2006 and 2008, when the Phase II FES took effect. The enhancement in fuel economy over this period was diminished by one additional factor – a shift in vehicle sales to higher weight vehicles. This was largely driven by the increasing incomes of car buyers, an increase in imported vehicles (particularly SUVs), and a lack of differential taxation among the two smallest engine sizes. Prior to April 1, 2006, the excise tax rate for vehicles with engines less than 1.0 liter in size was lower than the rate for cars with engine sizes between 1.0 and 1.5 liters. After that time, the tax rate for these two classes was the same, and that drove buyers to move from the smallest engines, which previously dominated the market, up to the next largest engine class.

As China's vehicle manufacturing industry and consumer purchasing decisions evolve, China is trying to adapt to keep improving the average fuel efficiency of its passenger vehicles. In September of 2008, it revised its differential excise tax system, lowering the tax rate to 1% for the cars with the smallest engines and raising it for heavier engine classes (with the maximum increasing from 20% to 40%). In addition, China is currently designing a third phase of FES, and they will be moving away from a system binned by vehicle weight to a CAFE-type system because this will allow them to better control the average fuel economy of the entire fleet of new vehicles. It has been estimated that this new FES will improve the new fleet average (and decrease the associated CO_2 emissions) by about 12% between 2008 and 2015.

Fuels: Brazil's Bioethanol Program

Brazil is known globally for its production and use of ethanol in the transportation sector. While the country has been producing ethanol from sugar cane for decades, its efforts have been much more sustained since the introduction of its (now defunct) National Alcohol Program (PNA) in 1975. This program was adopted in response to the 1973 global oil crisis as a way to reduce Brazil's dependence on imported oil. The PNA made blending of ethanol with gasoline mandatory, and while the percentage of blending has fluctuated over time, current law calls for the minimum blending level to fall between 20% and 25%, depending on the sugarcane harvest, sugar prices, and other factors. The PNA ended in 1990, and the sector was deregulated in the 1990s.

The PNA was successful because the Brazilian government initially provided three incentives for ethanol production and use – it guaranteed that Petrobras, the national oil company, would buy a specific quota of ethanol, it provided concessionary loans to agro-industrial ethanol producers, and it fixed the price of ethanol at 59% of the price of gasoline at the pump (which was also set by the government). At first, car buyers had only two options: typical gasoline vehicles and ethanol-only cars. Ethanol supply shortages sometimes required Brazil to import ethanol to meet demand and caused drivers to wait in long lines or encounter other difficulties finding fuel.

The situation has changed dramatically since 2003 when flex-fuel vehicles, which can operate on any blend of gasoline and ethanol, were introduced into the market. These types of cars now dominate new vehicle purchases in Brazil, growing from 22% of new car sales in 2004 to 94% in August of 2009. Flex-fuel motorcycles and buses are now becoming a part of the vehicle fleet in Brazil as well. The interesting piece of the flex-fuel story is that the Brazilian government has not provided any types of incentives or quotas for the development of this market; it apparently arose naturally in the automobile industry as a response to the ethanol blending requirement and market demand. However, the new ethanol buses, introduced in Sao Paulo, have been funded in part by the EU's BEST – BioEthanol for Sustainable Transport – program.

A big part of Brazil's success with its ethanol program is due to its considerable investments in both public-sector and private-sector research and development in ethanol production. This has led to continuous improvements in its ethanol yields. For example, between 1975 and 2003, the state of Sao Paulo improved its sugar cane yields per hectare by 33%, the sugar content per ton of sugar cane by 8%, its ethanol production per ton of sugar cane by 14%, and its fermentation productivity by 130%. This resulted in a growth in its ethanol yield from 4200 liters of ethanol per hectare (l/ha) in 1980 to 6350 l/ha in 2003.

Such improvements in ethanol yields have led this fuel to be economically competitive with gasoline in Brazil without a need for subsidies (although the tax on a gallon of gasoline is higher than it is for ethanol – about 54% for gasoline vs. 12-30% for ethanol, depending upon the State). It turns out that ethanol is a viable alternative to gasoline as long as it is 25-30% cheaper per gallon (due to the lower energy content per gallon of ethanol), which works out to an oil price of around $30 per barrel, much less than today's price for oil. This is why, in February of 2008, ethanol sales made up more than 50% of the fuel needed to power Brazil's light-duty fleet.

Of course, much of Brazil's success with ethanol is due to its good climate for growing sugar cane. A life-cycle assessment shows that the energy balance for sugar-cane ethanol in Brazil is 8.3-10.2 units of energy output per unit of fossil energy input. This results in an 86-90% reduction in GHG emissions (compared to gasoline) if no significant land-use changes are associated with the ethanol production.[1] It is estimated that Brazil has reduced the emissions from its vehicles by more than 600 Mt CO_2 since it began the PNA in 1975.

In addition, ethanol from sugar cane has significant benefits beyond reduced GHG emissions. Including ethanol in the fuel mix allowed Brazil to eliminate lead in its gasoline. It also improved air quality by reducing emissions of CO, sulfur, particulate matter and photo-reactive organic compounds. Another significant co-benefit is the electricity than can be produced from bagasse, a remnant of sugar cane, which has made the ethanol plants self-sufficient in terms of their energy

[1] These impacts are generally small if new sugar cane production occurs on abandoned pasture lands. However, if undisturbed lands (such as the Brazilian cerrado) are converted to sugar cane plantations or the use of abandoned pasture land displaces soy bean or cattle farms to the Amazon region (and increases deforestation there), the impacts of land-use changes can be high enough to completely offset the reduction in GHG emissions due to the use of the ethanol produced from the sugar cane grown there.

needs. In fact, these plants often produce an electricity surplus, which since 2005 can be sold back into the grid – the sugar industry currently provides about 3% of Brazil's power supply, substituting for an equivalent amount of production through fossil fuels.

Travel Activity:
Bogota's Development of Mass Transit and Non-motorized Travel Modes

The City of Bogota, in Colombia is often held out as a model for effectively moving a developing country city's transportation system toward sustainability. The comprehensive effort to transform the way residents regarded travel around the city involved the integrated use of a number of strategies. The political focus was on reducing congestion, improving quality of life and increasing productivity. There were three main pillars of the transformation: education and public awareness of transit and non-motorized travel options, planning and constructing Bus Rapid Transit and bike infrastructure, and restrictions on automobile use. A proposed rail rapid transit line is expected to be completed in 2015.

Education involved *ciclovias*, a network of 100+ km of the main avenues and streets are closed to cars on Sundays and holidays, between 6 AM and 2 PM. There is also an annual Car Free Day throughout the city, although busses and taxis still run. Success of CicloVia led to creation of network of 329 km of bike paths that allow nearly 182,000 people to circulate every day.

TransMilenio, the iconic Bus Rapid Transit system, was opened in 2000. The system is overseen by a public body, which awards contracts to private bus companies on a competitive basis. Private contractors are paid based upon the total number of kilometers that their vehicles operate. 2006 upgrades included new feeder networks and a new integrated fare card system allowing free transfers. The system received CDM credits, mainly for the replacement of about 9000 dirty busses with 1200 new busses run in a more efficient manner. Over the next two decades the project is expected to generate nearly 13 MMT in emissions credits for a value of at least $130 million. Ridership in 2009 was 1,400,000 daily. At buildout total planned busways are 388 km.

A vehicle restriction program, *Pica y Placa*, bans driving two days out of week depending on license plate last digit, to reduce traffic congestion. The system restricts both private and public use vehicles based on the last digit of the license plate numbers. Four numbers are restricted every day for private use vehicles, and two for public transportation vehicles.

Other Sustainable Transport Best Practices:

A wide range of best practices have been implemented worldwide. The examples above show some existing efforts for each leg of the GHG "stool", but many other measures are possible. Below, best practices are organized into five categories based on the different types of policy instruments available to governments. Although the balance of types of measure may vary, successful policies will combine strategies to achieve the best results.

Infrastructure and Land Use: Planning and implementing the infrastructure, whether for transportation itself or for the other components of the built environment, sets the parameters for the supply and demand for transport. Minimizing the length of necessary travel and encouraging the use of more efficient modes should be the goal. Comprehensive integration of best practices can maximize accessibility between origins and destination. Additional examples:

- Transit oriented compact, walkable, mixed use neighborhoods (Curitiba, Brazil)
- High quality rail or bus based mass transit (Manila, Philippines)
- Extensive bicycle and pedestrian infrastructure and programs (Changwon, Korea- bike sharing)

Regulation: Rules and regulations that restrict the unlimited use of certain modes, often in limited areas, can be implemented at any level of government. Additional example:

- Restriction of all vehicle access to certain urban areas (Buenos Aires, Argentina)

Public Awareness: Because individual behavior is variable with regard to transportation, GHG reductions can be achieved by raising public awareness of choices that reduce or increase emissions. This can include methods of changing opinions about public and non-motorized transport, as well as education about vehicle trip reduction and vehicle operation. Example:

- Driver education for “eco-driving” (Jakarta bus drivers)

Technology: Improving vehicle and fuel technologies can make motorized vehicles, both private and public, emit fewer GHGs for each kilometer of travel. Technological improvements to non-motorized vehicle can also be addressed. It is important to consider the life cycle emissions of technological solutions. The fuel mix for electricity generation is also critical to consider. Depending on power plant location, electric vehicles should benefit local air quality, but could increase GHGs, for example if coal use is high. Additional examples:

- Electric vehicles (Lujiang, China – substitute electric bikes and mini busses for motorcycles)
- Improved non-motorized vehicles (Delhi, India- rickshaws)
- Information technology applications (Klang Valley, Malaysia - traffic information system)

Pricing: Economic instruments can be used to encourage more efficient use of transport through charges that internalize some or all of the costs. Raising the price of modes that emit higher GHG per person can be done in a number of ways. Additional examples:

- Road pricing (tolls, congestion pricing, time of day pricing, etc) (Singapore)
- Fuel taxes (Costa Rica)

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