

The development of various components — particularly increased performance in environmental recognition sensors — are important in terms of achieving these types of systems. Furthermore, the effective application of information gathered through these sensors can be considered a crucial factor in the popularization and expansion of these systems. In the future, Hitachi will continue to combine infrastructures and on-board components in an effort to develop services and systems that will improve driving comfort as well as safety.

Dr. Issa Ismail Ebadah, Center for Strategic International Studies, University of Baghdad.

## **TRANSPORT AND ITS INFRASTRUCTURE**

Transport activity, a key component of economic development and human welfare, is increasing around the world as economies grow. For most policymakers, the most pressing problems associated with this increasing transport activity are traffic fatalities and injuries, congestion, air pollution and petroleum dependence. These problems are especially acute in the most rapidly growing economies of the developing world. Mitigating greenhouse gas (GHG) emissions can take its place among these other transport priorities by emphasizing synergies and co-benefits (*high agreement, much evidence*).

Transport predominantly relies on a single fossil resource, petroleum that supplies 95% of the total energy used by world transport. In 2004, transport was responsible for 23% of world energy-related GHG emissions with about three quarters coming from road vehicles. Over the past decade, transport's GHG emissions have increased at a faster rate than any other energy using sector (*high agreement, much evidence*).

Transport activity will continue to increase in the future as economic growth fuels transport demand and the availability of transport drives development, by facilitating specialization and trade. The majority of the world's population still does not have access to personal vehicles and many do not have access to any form of motorized transport. However, this situation is rapidly changing.

Freight transport has been growing even more rapidly than passenger transport and is expected to continue to do so in the future. Urban freight movements are predominantly by truck, while international freight is dominated by ocean shipping. The modal distribution of intercity freight varies greatly across regions. For example, in the United States, all modes participate substantially, while in Europe, trucking has a higher market share (in tkm1), compared to rail (*high agreement, much evidence*).

Transport activity is expected to grow robustly over the next several decades. Unless there is a major shift away from current patterns of energy use, world transport energy use is projected to increase at the rate of about 2% per year, with the highest rates of growth in the emerging economies, and total transport energy use and carbon emissions is projected to be about 80% higher than current levels by 2030 (*medium agreement, medium evidence*).

There is an ongoing debate about whether the world is nearing a peak in conventional oil production that will require a significant and rapid transition to alternative energy resources. There is no shortage of alternative energy sources, including oil sands, shale oil, coal-to-liquids, biofuels, electricity and hydrogen. Among these alternatives, unconventional fossil carbon resources would produce less expensive fuels most compatible with the existing transport infrastructure, but lead to increased carbon emissions (*medium agreement, medium evidence*).

In 2004, the transport sector produced 6.3 GtCO<sub>2</sub> emissions (23% of world energy-related CO<sub>2</sub> emissions) and its growth rate is highest among the end-user sectors. Road transport currently accounts for 74% of total transport CO<sub>2</sub> emissions. The share of non-OECD countries is 36% now and will increase rapidly to 46% by 2030 if current trends continue (*high agreement, much evidence*). The transport sector also contributes small amounts of CH<sub>4</sub> and N<sub>2</sub>O emissions from fuel combustion and F-gases (fluorinated gases) from vehicle air conditioning. CH<sub>4</sub> emissions are between 0.1–0.3% of total transport GHG emissions, N<sub>2</sub>O between 2.0 and 2.8% (based on US, Japan and EU data only). Worldwide emissions of F-gases (CFC-12+HFC-134a+HCFC-22) in 2003 were 0.3–0.6 GtCO<sub>2</sub>-eq, about 5–10% of total transport CO<sub>2</sub> emissions (*medium agreement, limited evidence*).

When assessing mitigation options it is important to consider their lifecycle GHG impacts. This is especially true for choices among alternative fuels but also applies to a lesser degree to the manufacturing processes and materials composition of advanced technologies. Electricity and hydrogen can offer the opportunity to ‘de-carbonise’ the transport energy system although the actual full cycle carbon reduction depends upon the way electricity and hydrogen are produced. Assessment of mitigation potential in the transport sector through the year 2030 is uncertain because the potential depends on:

- World oil supply and its impact on fuel prices and the economic viability of alternative transport fuels;
- R&D outcomes in several areas, especially biomass fuel production technology and its sustainability in massive scale, as well as battery longevity, cost and specific energy.

Another problem for a credible assessment is the limited number and scope of available studies of mitigation potential and cost.

Improving energy efficiency offers an excellent opportunity for transport GHG mitigation through 2030. Carbon emissions from ‘new’ light-duty road vehicles could be reduced by up to 50% by 2030 compared to currently produced models, assuming continued technological advances and strong policies to ensure that technologies are applied to increasing fuel economy rather than spent on increased horsepower and vehicle mass. Material substitution and advanced design could reduce the weight of light-duty vehicles by 20–30%. Since the TAR (Third Assessment Report), energy efficiency of road vehicles has improved by the market success of cleaner direct injection turbocharged (TDI) diesels and the continued market penetration of numerous incremental efficiency technologies.

Hybrid vehicles have also played a role, though their market penetration is currently small. Reductions in drag coefficients of 20–50% seem achievable for heavy intercity trucks, with consequent reductions in fuel use of 10–20%. Hybrid technology is applicable to trucks and buses that operate in urban environments, and the diesel engine’s efficiency may be improved by 10% or more. Prospects for mitigation are strongly dependent on the advancement of transport technologies.

There are also important opportunities to increase the operating efficiencies of transport vehicles. Road vehicle efficiency might be improved by 5–20% through strategies such as eco-driving styles, increased load factors, improved maintenance, in-vehicle technological aids, more efficient replacement tyres, reduced idling and better traffic management and route choice (medium agreement, medium evidence).

The total mitigation potential in 2030 of the energy efficiency options applied to light duty vehicles would be around 0.7–0.8 GtCO<sub>2</sub>-eq in 2030 at costs <100 US\$/tCO<sub>2</sub>. Data is not sufficient to provide a similar estimate for heavy-duty vehicles. The use of current and advanced biofuels would give an additional reduction potential of another 600–1500 MtCO<sub>2</sub>-eq in 2030 at costs <25 US\$/tCO<sub>2</sub> (low agreement, limited evidence).

Although rail transport is one of the most energy efficient modes today, substantial opportunities for further efficiency improvements remain. Reduced aerodynamic drag, lower train weight, regenerative braking and higher efficiency propulsion systems can make significant reductions in rail energy use. Shipping, also one of the least energy intensive modes, still has some potential for increased energy efficiency. Studies assessing both technical and operational approaches have concluded that energy efficiency opportunities of a few percent to up to 40% are possible (medium agreement, medium evidence).

Passenger jet aircraft produced today are 70% more fuel efficient than the equivalent aircraft produced 40 years ago and continued improvement is expected. A 20% improvement over 1997 aircraft efficiency is likely by 2015 and possibly 40 to 50% improvement is anticipated by 2050. Still greater efficiency gains will depend on the potential of novel designs such as the blended wing body, or propulsion systems such as the unducted turbofan. For 2030 the estimated mitigation potential is 150 MtCO<sub>2</sub> at carbon prices less than 50 US\$/tCO<sub>2</sub> and 280 MtCO<sub>2</sub> at carbon prices

less than 100 US\$/tCO<sub>2</sub> (medium agreement, medium evidence). However, without policy intervention, projected annual improvements in aircraft fuel efficiency of the order of 1–2%, will be surpassed by annual traffic growth of around 5% each year, leading to an annual increase of CO<sub>2</sub> emissions of 3–4% per year (high agreement, much evidence).

Biofuels have the potential to replace a substantial part but not all petroleum use by transport. A recent IEA analysis estimates that biofuels' share of transport fuel could increase to about 10% in 2030. The economic potential in 2030 from biofuel application is estimated at 600–1500 MtCO<sub>2</sub>-eq/yr at a cost of <25 US\$/tCO<sub>2</sub>-eq. The introduction of flexfuel vehicles able to use any mixture of gasoline<sup>2</sup> and ethanol rejuvenated the market for ethanol as a motor fuel in Brazil by protecting motorists from wide swings in the price of either fuel. The global potential for biofuels will depend on the success of technologies to utilise cellulose biomass (medium agreement, medium evidence).

Providing public transports systems and their related infrastructure and promoting non-motorised transport can contribute to GHG mitigation. However, local conditions determine how much transport can be shifted to less energy intensive modes. Occupancy rates and primary energy sources of the transport mode further determine the mitigation impact. The energy requirements for urban transport are strongly influenced by the density and spatial structure of the built environment, as well as by location, extent and nature of transport infrastructure. If the share of buses in passenger transport in typical Latin American cities would increase by 5–10%, then CO<sub>2</sub> emissions could go down by 4–9% at costs of the order of 60–70 US\$/tCO<sub>2</sub> (low agreement, limited evidence).

The few worldwide assessments of transport's GHG mitigation potential completed since the TAR indicate that significant reductions in the expected 80% increase in transport GHG emission by 2030 will require both major advances in technology and implementation via strong, comprehensive policies (medium agreement, limited evidence).

The mitigation potential by 2030 for the transport sector is estimated to be about 1600–2550 MtCO<sub>2</sub> for a carbon price less than 100 US\$/tCO<sub>2</sub>. This is only a partial assessment, based on biofuel use throughout the transport sector and efficiency improvements in light-duty vehicles and aircraft and does not cover the potential for heavy-duty vehicles, rail transport, shipping, and modal split change and public transport promotion and is therefore an underestimation. Much of this potential appears to be located in OECD North America and Europe. This potential is measured as the further reduction in CO<sub>2</sub> emissions from a Reference scenario, which already assumes a substantial use of biofuels and significant improvements in fuel efficiency based on a continuation of current trends. This estimate of mitigation costs and potentials is highly uncertain. There remains a critical need for

comprehensive and consistent assessments of the worldwide potential to mitigate transport's GHG emissions (low agreement, limited evidence).

While transport demand certainly responds to price signals, the demand for vehicles, vehicle travel and fuel use are significantly price inelastic. As a result, large increases in prices or taxes are required to make major changes in GHG emissions. Many countries do heavily tax motor fuels and have lower rates of fuel consumption and vehicle use than countries with low fuel taxes (high agreement, much evidence).

Fuel economy regulations have been effective in slowing the growth of GHG emissions, but so far growth of transport activity has overwhelmed their impact. They have been adopted by most developed economies as well as key developing economies, though in widely varying form, from uniform, mandatory corporate average standards, to graduated standards by vehicle weight class or size, to voluntary industry-wide standards. The overall effectiveness of standards can be significantly enhanced if combined with fiscal incentives and consumer information (medium agreement, medium evidence).

A wide array of transport demand management (TDM) strategies have been employed in different circumstances around the world, primarily to manage traffic congestion and reduce air pollution. TDMs can be effective in reducing private vehicle travel if rigorously implemented and supported (high agreement, low evidence).

In order to reduce emissions from air and marine transport resulting from the combustion of bunker fuels, new policy frameworks need to be developed. However ICAO endorsed the concept of an open, international emission trading system for the air transport sector, implemented through a voluntary scheme, or incorporation of international aviation into existing emission trading systems. Environmentally differentiated port dues are being used in a few places. Other policies to affect shipping emissions would be the inclusion of international shipping in international emissions trading schemes, fuel taxes and regulatory instruments (high agreement, much evidence).

Since currently available mitigation options will probably not be enough to prevent growth in transport's emissions, technology research and development is essential in order to create the potential for future, significant reductions in transport GHG emissions. This holds, amongst others, for hydrogen fuel cell, advanced biofuel conversion and improved batteries for electric and hybrid vehicles (high agreement, medium evidence).

The best choice of policy options will vary across regions. Not only levels of economic development, but the nature of economic activity, geography, population density and culture all influence the effectiveness and desirability of policies affecting modal choices, infrastructure investments and transport demand management measures (high agreement, much evidence).