Annex 7.c Emissions from the transport sector

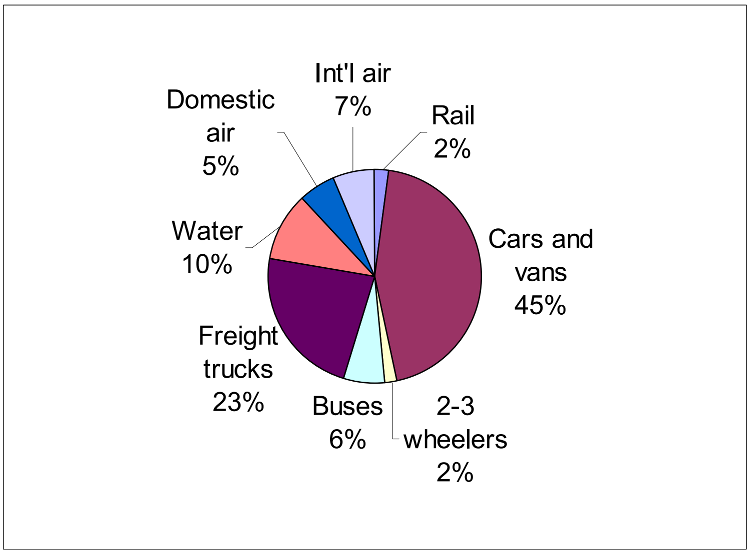
This annex outlines sources of emissions from transport today (by mode and country), historical and projected business as usual trends, the drivers behind emissions growth, and the prospects for cutting emissions from this sector.

Now

Transport accounts for 14%[1] of global greenhouse gas (GHG) emissions, behind the power and land use sectors and the same as the agriculture sector. The majority of these emissions are from road transport (76%) and aviation (12%)[2] (see figure 1 below).

By far the largest source of transport emissions is OECD North America, producing 37% of the total[3]. This partly reflects the fact that OECD North America has the highest car ownership level in the world (around 0.6 vehicles per person, compared to 0.4 in OECD Europe and 0.01 in China), yet lags behind most nations in terms of fuel efficiency[4].

Figure 1 Transport CO_2 emissions by mode in 2000[5]



In addition to direct CO_2 emissions from road vehicles, aircraft, trains and ships, transport also contributes to climate change in two other ways:-

- Non-CO_2 effects of aviation. The gases emitted from aircraft and their effects at high altitudes mean that the warming effect of aviation is greater than its CO_2 emissions alone would suggest (as discussed in chapter 15, box 15.6). There is no internationally agreed methodology for presenting the warming effect of emissions from aviation as CO_2e so it is excluded from emission estimates.
- Upstream CO_2 emissions. The refineries that produce transport fuel release CO_2 emissions. Also, electricity consumed by electric trains and road vehicles is indirectly associated with CO_2 emissions from the power sector.

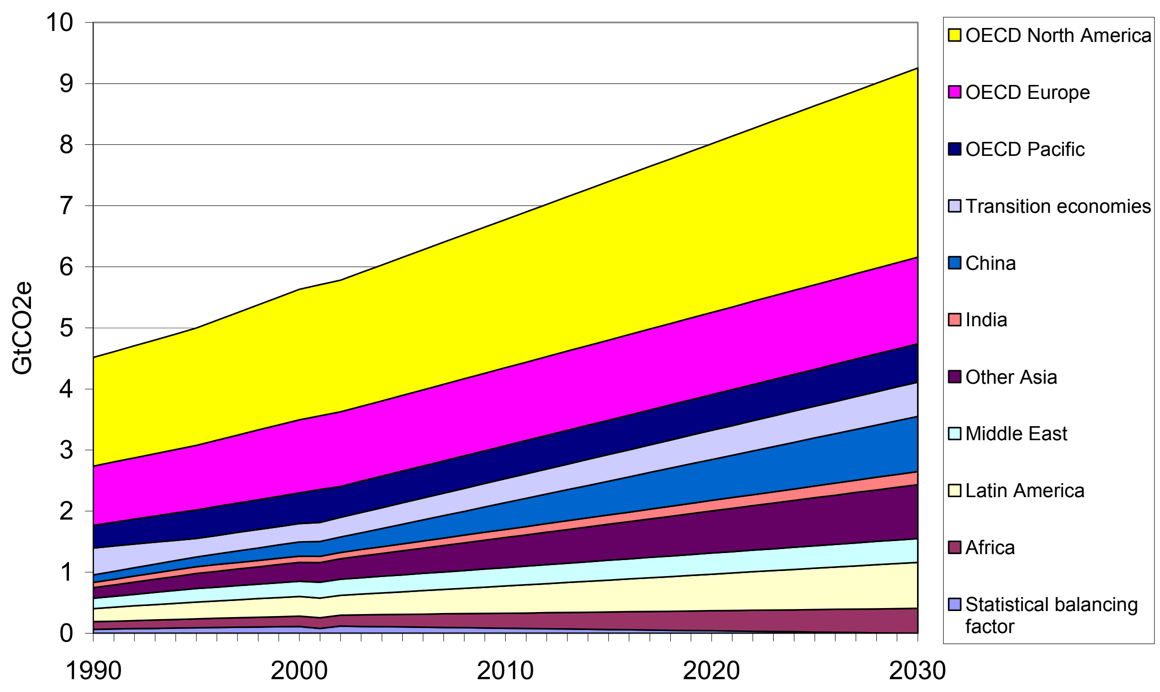
[1] Figures for 2000, WRI (2006).
[2] Figures for 2000, WBCSD (2004).
[3] WRI (2006).
[4] Car ownership figures for 2000, WBCSD (2004). Fuel efficiency in the US is about two-thirds the level in the EU (An and Sauer (2004)).
[5] Figures for 2000, WBCSD (2004).

Historical and projected business as usual trends[6]

Transport was the fastest growing sector in OECD countries and the second fastest growing sector in non-OECD countries between 1990 and 2002 (emissions increasing by 25% and 36% respectively[7]).

Under business as usual (BAU) conditions, transport emissions are expected to reach 9 $GtCO_2e$ in 2030[8]. Transport emissions are expected to grow fastest in non-OECD countries, such that their share of global emissions grows from one third to one half by 2030.

Figure 2 Transport emissions by country, 1990-2030[9]



In 2050, transport emissions are expected to reach 12 $GtCO_2$[10] (double current levels), however the sector's contribution to climate change is likely to be significantly greater than this because of the use of synfuels. Synfuel is oil produced from coal and gas; it is twice as polluting as conventional oil because of emissions released in the production process[11]. By 2050, the rising cost of conventional oil could mean that one quarter of transport energy demand would be met by synfuel[12].

Between 2005 and 2050, emissions are expected to grow fastest from aviation (tripling over the period, compared to a doubling of road transport emissions). Transport's share of total emissions is expected to remain the same as today, at 14%.

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[6] Note the projected BAU trends already include any incremental improvements in fuel efficiency and switch to biofuel expected to occur in the absence of policy intervention.
[7] WRI (2006).
[8] Stern Review calculation based on figures from IEA (2006b).
[9] Data source: WRI (2006) and IEA (2004). This includes emissions by source, and excludes emissions generated by the production of transport fuel. Figure 3 indicates that total emissions by source will reach 9.3 $GtCO_2$ in 2030, however latest data from IEA (2006b) suggests that transport emissions are expected to reach 8.7 $GtCO_2e$ in 2030 under BAU conditions. The country level breakdown consistent with the new emissions estimate was not available at time of going to print.
[10] IEA (2006a).
[11] Well-to-wheels emissions from fuels such as gasoline are around 27.5 pounds of CO_2 per gallon of fuel. This compares with 49.5 pounds per gallon from coal-to-liquids, assuming the CO_2 from the refining process is released into the atmosphere. See Natural Resources Defence Council (2006)
[12] IEA (2006a). Figure 2 includes direct emissions from transport only, so excludes emissions released during the synfuel production process.

By 2050, CO_2 emissions from aviation are expected to account for 2.5% of global GHG emissions. However taking into account the non-CO_2 effects of aviation would mean that it would account for around 5% of the total warming effect (radiative forcing) in 2050[13].

Drivers of emissions growth

The demand for transport is a derived demand: it is not demanded for its own sake, but rather for the things it enables people to do (such as get to work, take leisure trips, and move goods from one place to another).

The key driver behind growth in transport emissions is income As people get richer, they tend to want to transport more goods and make longer trips. Associated transport emissions increase both because more travel is being undertaken, and because as people get richer they want to travel using more carbon-intensive modes (switching from bus to train, from train to car, from small car to large car, etc).

Transport emissions are also influenced by the cost: an increase in prices tends to choke off relatively less demand in the transport sector than it does in the buildings and industry sectors[14]. Other important factors affecting emissions include availability of less carbon intensive modes of transport (the balance between public and private transport for example), social choices (such as willingness to walk or use bicycles), the carbon content of fuel and a large number of technical developments affecting fuel efficiency (for example, factors related to vehicle weight and design).

Prospects for cutting emissions

Transport is one of the more expensive sectors to cut emissions from because the low carbon technologies tend to be expensive and the welfare costs of reducing demand for travel are high. Transport is also expected to be one of the fastest growing sectors in the future. For these two reasons, studies tend to find that transport will be among the last sectors to bring its emissions down below current levels[15].

Cost effective emission savings from transport are initially likely to come from improvements in the fuel efficiency of oil-based transport vehicles, behavioural change, and use of biofuels. There are limits to the role that biofuel could play in transport as land availability and technological constraints could drive up the cost; this is discussed in chapter 9, box 9.5. IEA analysis suggests that efficiency improvements and biofuels could together contribute to 7 $GtCO_2$ savings by 2050 at a cost of $25/$tCO_2$[16]. Efficiency improvements account for about three quarters of this carbon saving; this could be obtained using measures such as more use of hybrid cars[17].

If innovation policy is used to bring down the cost of low carbon transport technologies (such as hydrogen or electric powered vehicles), then these will become viable options in the longer term. However the electricity or hydrogen would have to be generated in a low carbon way for these technologies to be truly low carbon. It is very uncertain how quickly the costs of these technologies might come down. A study by the IEA found that hydrogen could fuel up to 30% of road transport vehicles by 2050, but with significant downside potential[18]. Analysis by Dennis Anderson presented in

[13] IPCC (1999). This assumes that the warming effect (radiative forcing) of aviation is 2 to 4 times grater than the effect of the CO_2 emissions alone. This could be an overestimate because recent research by Sausen et al (2005) suggests the warming ratio is closer to 2. It could be an underestimate because both estimates exclude the highly uncertain possible warming effects of cirrus clouds. The non-CO_2 effects of aviation are discussed in chapter 15, box 15.6.

[14] The International Energy Agency's World Economic Model indicates that price elasticity of demand for transport is lower than for industry and buildings sectors. See: http://www.worldenergyoutlook.org/model.asp

[15] Studies producing this result include Dennis Anderson's resource cost analysis, discussed in chapter 9, and the IEA (2006a).

[16] IEA (2006a). Note that at the time of going to print there was not a baseline to compare the 7 $GtCO_2$ saving in 2050 against. This is because the BAU transport emissions estimate of 12 $GtCO_2$ described above reflects direct CO_2 emissions only, whereas the 7 $GtCO_2$ estimate includes some indirect transport emissions too.

[17] Hybrid cars have both a conventional oil-based engine and an electric motor.

[18] IEA (2005).

chapter 9 finds that by 2050 at a cost of $25/t$CO_2$, hydrogen could account fuel 10-20% of road transport vehicles globally.

Whilst transport is likely to be largely oil-based in 2050, it is important for it to decarbonise in the longer term if stabilisation at 550ppm CO_2e is to be achieved. For example, in the period beyond 2100, total GHG emissions will have to be just 20% of current levels (around 5 GtCO_2e, which is roughly the same as today's emissions from agriculture). It is impossible to imagine how this can be achieved without a decarbonised transport sector.

Road transport is likely to be decarbonised before aviation. Biofuels and hybrid electric/ICE technologies are already feasible for roll out in road transport vehicles. Lignocellulosic biofuels may be ready for use in aviation in the longer term. Road transport would probably be the first transport mode to adopt hydrogen technology, although as the technology developed it could potentially be ready for use in other modes. Rail could be decarbonised by electrifying the service and generating the electricity in a renewable way.

References

An, F and Sauer, A (2004) "Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around the World", prepared for the Pew Centre on Global Climate Change

Commission of the European Communities (2005), *Reducing the Climate Change Impact of Aviation*, COM(2005) 459 final, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Brussels.

IEA (2004) *World Energy Outlook 2004*, IEA/OECD, Paris.

IEA (2005) *Prospects for Hydrogen and Fuel Cells*, IEA/OECD, Paris

IEA (2006a) *Energy Technology Perspectives: Scenarios and Strategies to 2050*, IEA/OECD, Paris.

IEA (2006b) *World Energy Outlook 2006*, IEA/OECD, Paris.

IPCC (1999) *Aviation and the Global Atmosphere* - Summary for Policy Makers. www.ipcc.ch/pub/av(e).pdf

Natural Resources Defence Council (2006), Testimony of David G Hawkins to the Committee on Energy and Natural Resources, 24 April 2006

Sausen, R., I. Isaksen, V. Grewe et al (2005): 'Aviation radiative forcing in 2000: an update on IPCC (1999)', Meteorologische Zeitschrift, 14 (4): 555-561

WBCSD (2004) *Mobility 2030: Meeting the Challenges to Sustainability*, World Business Council for Sustainable Development.

World Resources Institute (2005) *Navigating the Numbers – Greenhouse Gas Data and International Climate Policy*, World Resources Institute, USA.

World Resources Institute (2006): Climate Analysis Indicators Tool (CAIT) on-line database version 3.0., Washington , DC: World Resources Institute, available at http://cait.wri.org