# MOVEET

## MObility, Vehicle fleet, Energy use and Emissions forecast Tool

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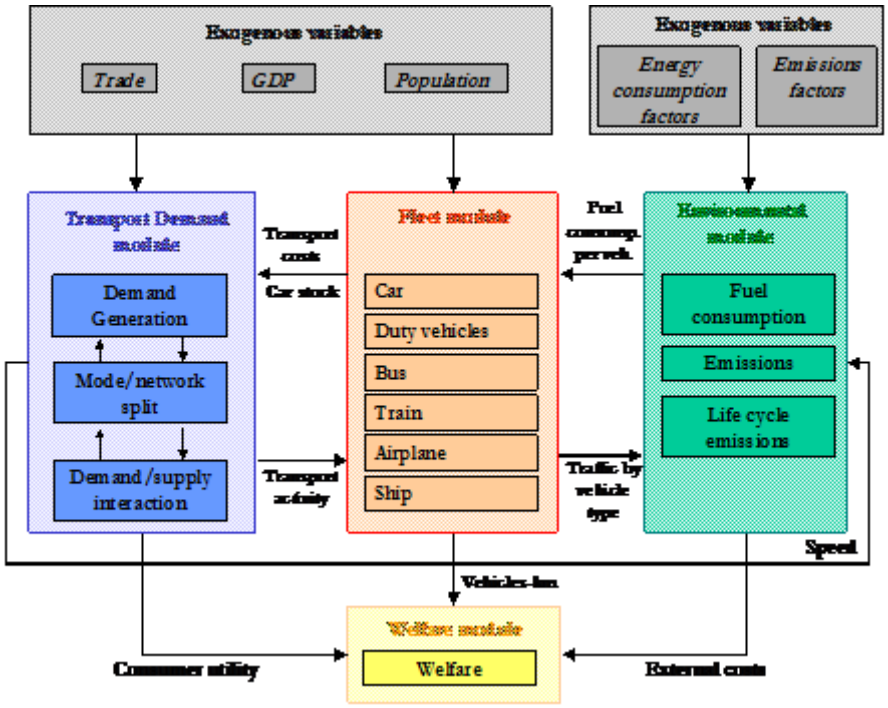
## The model

MOVEET is a system dynamic based analytical tool to address the policy problems related to transport and climate change. The model has been developed at Transport & Mobility Leuven since 2012. The tool is capable of estimating transport demand and emissions, as well as forecasting the impacts of policy and technological measures in transport-related sectors, covering all transport modes from the different regions in the world up to 2050.

The model consists of 57 regions of the world, many of them representing single countries, i.e. all the European countries and other world major economies. In the model, we consider all transportation modes (road, air, rail, maritime, and inland navigation) that interact through four interrelated modules: Transport Demand, Fleet, Environmental, and Welfare.

*Figure 1: Modular structure of MOVEET*




The *Transport Demand module* forecasts the future transport volumes demand under a set of exogenous economic and demographic inputs, in line with the most recent estimations from the European Commission, the United Nations, and the International Monetary Fund.

In the first step, the demand module segments transport demand in a sequence of splits, i.e. by origin and destination, then by purpose, distance band, network level, and finally by period. In the second step, the demand module splits demand by mode. On one hand, generalized costs of transport influence both demand generation and segmentation steps. On the other hand, total transport demand and the composition of the different vehicle fleets influence also these generalized costs of transport.

The *Fleet module* converts aggregate estimation of transport demand into a more detailed vehicle classification and cohort which directly relates to vehicle technology, fuel use and emission. In other words, this module gives projection of world vehicle stocks of all transport modes up to the year 2050

The *Environmental module* calculates fuel use and emissions by using disaggregated transport volume and emission factors coefficients available in the model database.

Finally, the *Welfare module* calculates the total social welfare as the sum of three elements: (i) external effects, (ii) distortion effects due to taxes and subsidies and (iii) consumer surplus taking into account the nested-logit-tree structure used in the demand and fleet modules.

The four modules are linked together, i.e. they exchange information in order to provide a consistent picture of the different aspects modelled. Within the Transport Demand module, motorised transport demand is endogenously generated and segmented according to several dimensions (e.g. national/international, long or short distances, etc.). In addition, the choice of mode and road type for each specific context is carried out taking into account demand-supply interaction. Transport demand by mode is then the input for calculating vehicle-kilometres by type and technology according to the fleet structure estimated in the Fleet module. In the Environmental module, fuel consumption and emissions are calculated on the basis of vehicle-kilometres (from the fleet module) as well as average speed of each transport mode (from the demand module). Finally, the Welfare module takes its input from both the transport module and the environmental module in terms of consumer utility and, respectively, external costs.

The model is capable of prediction transport volumes, vehicle fleets and effects on energy use and emissions for the following types of policies:

- Changes in vehicle technologies, such as new emission standards, new technologies, supplementary technical measures.
- Changes in fuel qualities, such as fuel standard related to carbon content.
- Changes in fiscal instruments, such as vehicle taxation, incentive for low emission cars.
- Changes in traffic management such as logistics, changes in speed-flow curves.

## Baseline scenario background

We developed the baseline scenario using several main exogenous demographic and economic assumptions that are in line with the Transport White Paper 2011 of the European Commission:

- *Demographic:* World population grows steadily from 6.3 billion people in the year 2005 to 8.9 billion in 2050 with the strongest increase taking place in developing regions, especially in Africa (149%), Middle East (98%) and South West Asia (66%).

- *Economic:* expressed in constant rate of euros of 2005, the total world GDP would rise from 31.5 T€ in 2000 to 128 T€ in 2050. In 2000, 82% of word GDP was produced in developed regions, but by 2050 those regions would generate mere 56% of GDP. Asia share in global GDP would increase from 8% in 2000 to 25 in 2050.

Other assumptions, related to energy prices and greenhouse gas taxes are given as below:

- *Energy prices:* oil price would rise according to World Energy Outlook (2008) from 100 $/bbl in 2010 to 120 $/bbl in 2030 to 300 $/bbl in 2050 (in nominal prices).
- *Greenhouse gases:* carbon tax in the 33 European countries is assumed to increase linearly from 1 €/ton $CO_2$ in 2013 to 38 €/ton $CO_2$ in 2050. This tax is assumed to be zero in the rest of the world.

## Preliminary results of the baseline scenario

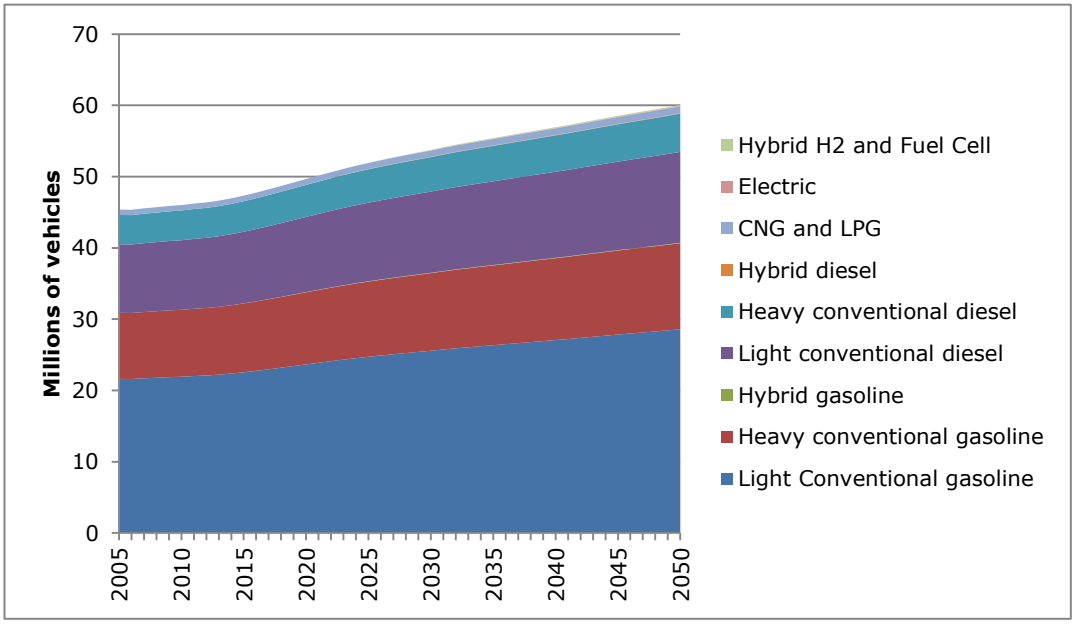
Based on the above assumptions the world passenger transport demand will increase by 120% between 2005 and 2050 from 34.2 trillion passenger-kilometers (pkm) to 73 trillion pkm. The share of cars is around 45% of this demand during the whole period, while bus share will slightly decrease from 30% in 2005 to 25% in 2050. Aviation share increases from 11% in 2005 to 17% in 2050 while rail modes capture the rest of the share, i.e. from 6% in 2005 up to 8% in 2050.

Freight transport demand is also expected to grow remarkably, increasing globally from 26.3 trillion ton-kilometers (tkm) in 2005 to 50.8 billion tkm in 2050. More than 75% of the world freight demand is maritime shipping. The shares of road and rail freight are comparable during the whole projection period, i.e. around 10%-11% of the total each. The share of the inland shipping volumes would remain slightly higher than 2% during the whole period. Air freight is expected to grow as well, although the volumes are negligibly in comparison with other modes.

In order to satisfy the increasing transport demand the global fleets will also to grow.

The world fleet of passenger cars will double, changing from 735 million vehicles in 2005 to 1400 million vehicles in 2050. Most of them (around 85%) are gasoline powered. Only diesel (10%-11%) and natural gas (3%) engines are expected to be present in sizeable proportions. New vehicle technologies (electric and hydrogen based) begin to appear only from 2030 onwards and they are expected to account for less than 0.5% of the global fleet by 2050.

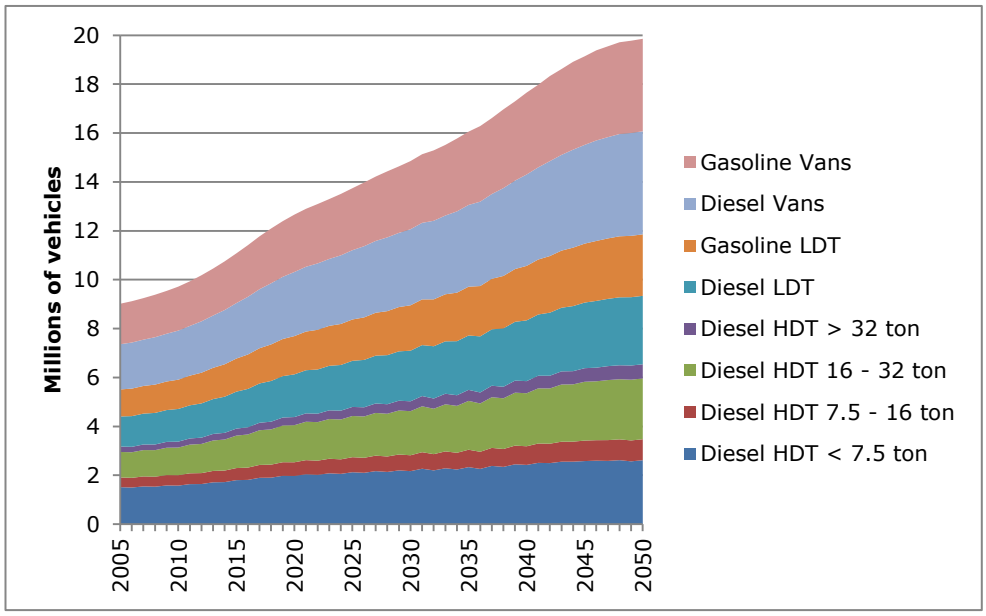
*Figure 2: Passenger car fleet stock in Germany*




In the case of road freight vehicles, the model foresees a growth in the global fleet from 107 million in 2005 to 160 million vehicles in 2050. More than 40% of that fleet are vans, the share of heavy duty trucks will remain around one third, while the rest of the fleet, i.e. around one quarter are light

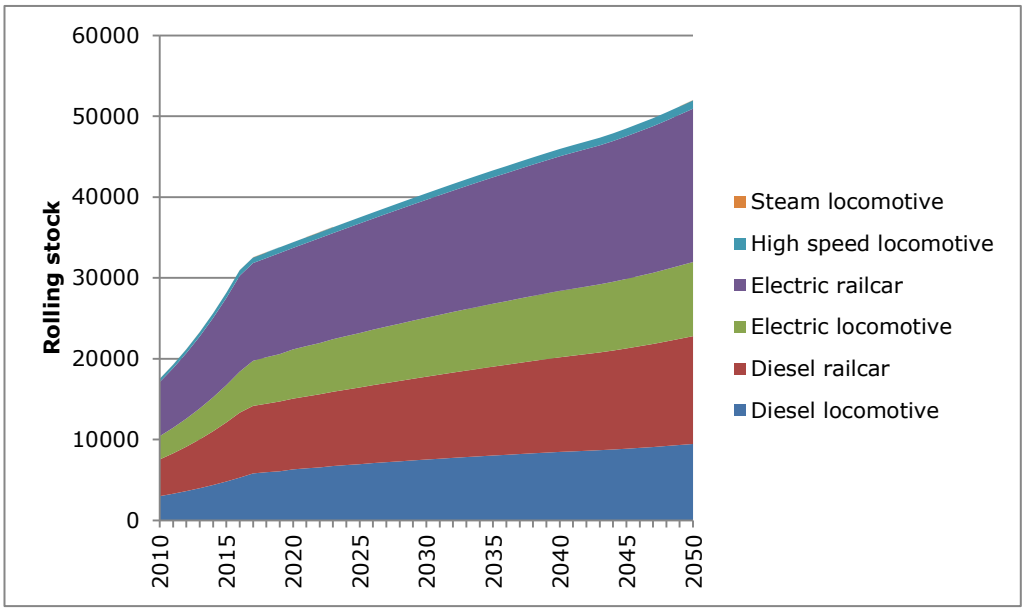
duty trucks. Diesel powered engines would dominate this sector, accounting for around 64% during the whole projection period.

*Figure 3: Truck, van and LDT fleet stock in China*




Regarding rail transport, the growth in transport volumes will double the amount of rail vehicles, changing from 297 thousand vehicles in 2005 to 622 thousand in 2050. Locomotives, which currently account for around 74% of the global fleet, will increase their share to nearly 80% by 2050, while the amount of railcars is expected to diminish remarkably (from 26% to 20% of the world total). Around 58% of the global rail fleet will be diesel powered, being most of the remaining fleet electric-powered. Obsolete steam powered locomotives disappear completely around 2020.

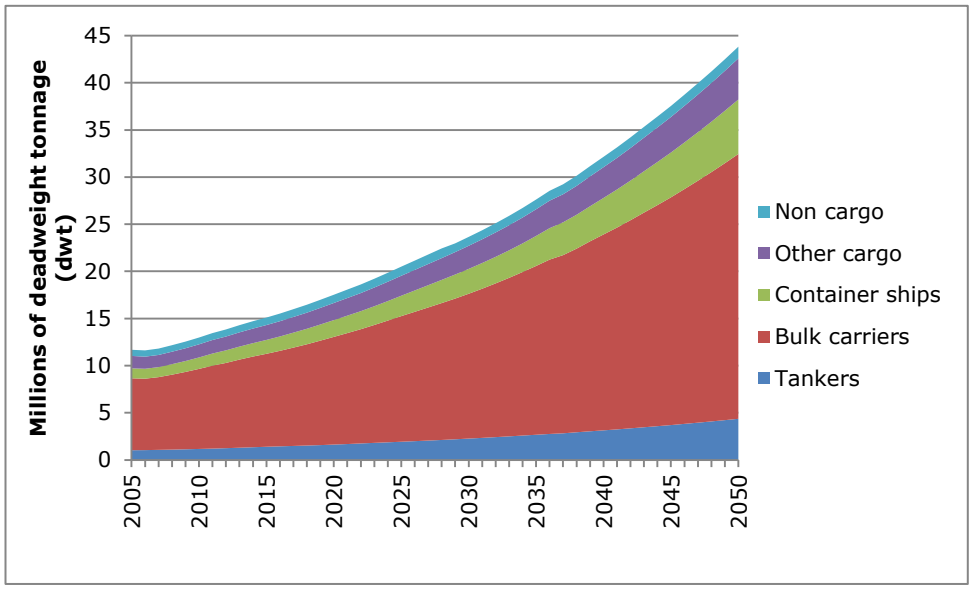
*Figure 4: Rail rolling stock in Japan*




Maritime transport volumes are expected to grow fast, from 901 million deadweight tonnage (dwt) in 2005 to 2027 million dwt in 2050. Oil tanker tonnage, remaining one third of the world fleet, increases from 287 million dwt in 2005 to 1002 million dwt in 2050. The share of bulk carriers in

total tonnage increases from around 47% in 2005 to nearly 50% in 2050. Gas carrier tonnages increase from 2.2% in 2005 to 3% in 2050. The fleet of container ships expands from 9% to 12% of the world total, displacing other obsolete cargo vessels. The proportion of non-cargo vessels (a mixture of fishing boats, barges, and other service vessels) diminishes from 6% to around 2.7% of the global total.

*Figure 5: Maritime tonnage in South Korea*




The rapid growth of air transport demand induces a growth in the amount of aircrafts in service from 13410 in 2005 to around 21335 aircrafts in 2050. Most of these (91% in 2005, 86% in 2050) are for passenger transport. As regards aircraft size, there are no significant changes to be expected. Narrow body aircraft make up most of the fleet (51% in 2005 vs. 58% in 2050). The share of wide-body and regional jets is expected to be around 28% of the total, while jumbo jets account for approximately 7.5% of the global fleet. In terms of propulsion technology, most aircrafts (88% in 2005 and 93% in 2050) are expected to be jet engined.

*Figure 6: Aircraft fleet in the United States*

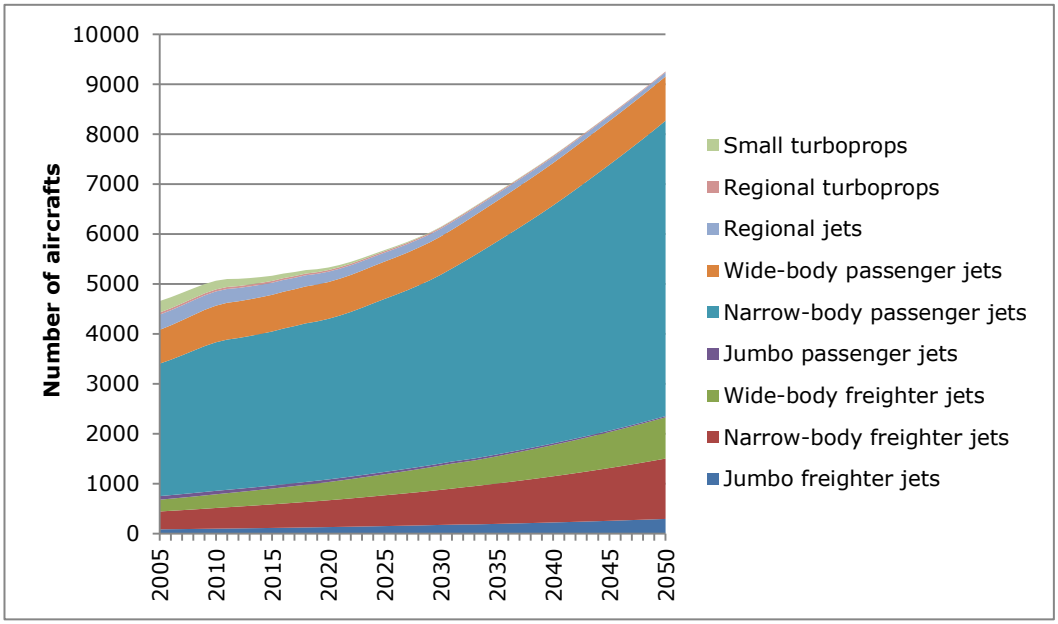
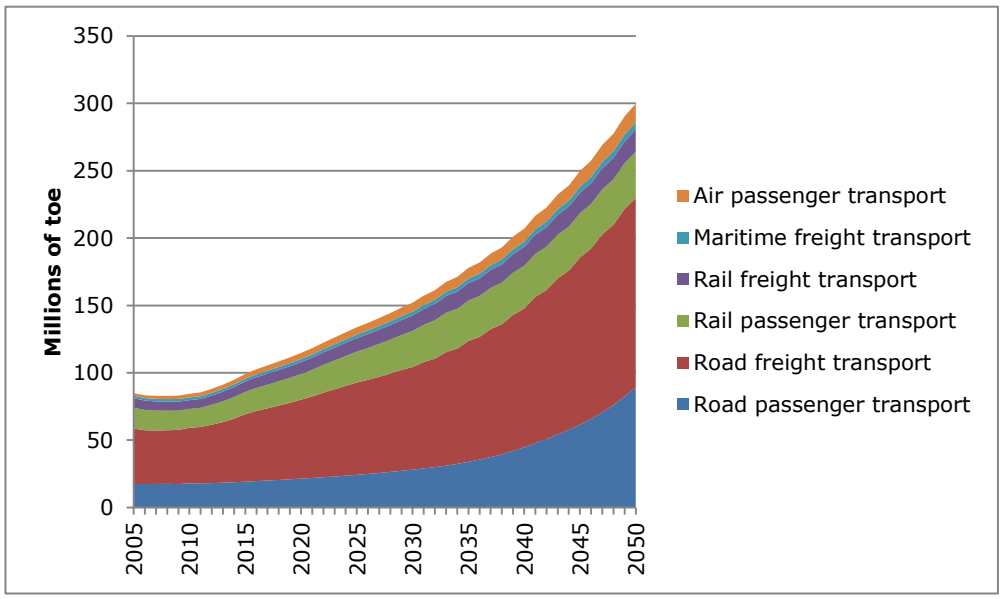


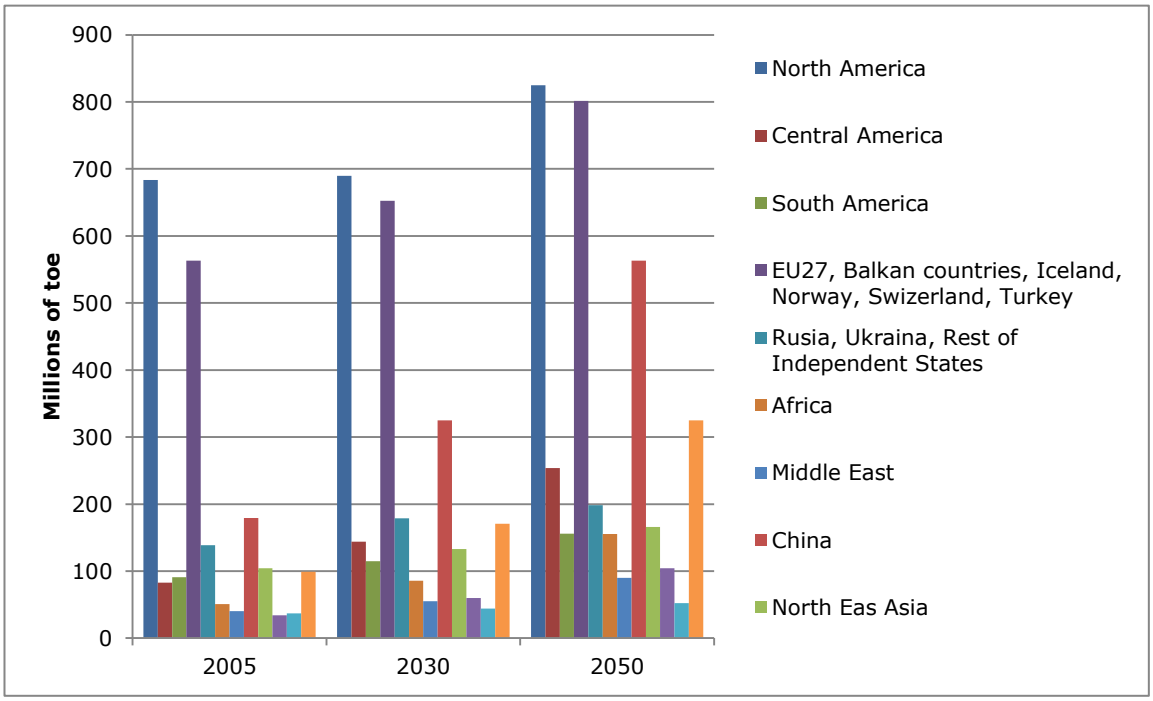
*Figure 7: Transport energy use in India*




The total energy use will grow from 2100 million toe in 2005 to around 3700 million ton of oil equivalent (toe) by the year 2050, which is a yearly increase of 1.7%. As a comparison, the baseline scenario of IEA/OECD (2009) that has a similar world economic background, predicts a growth of transport energy use from around 2200 million toe (2005) to 3855 million toe (2050).

The energy use from road passenger modes will increase by only 0.8% per year while energy use from sea freight and air passenger transport show the strongest growth with yearly 5.1% and 3.0% respectively. It is expected that the share of road modes will decrease but remains higher than 50% during the whole period.

*Figure 8: Transport energy use in the world*




Contribution of North America and Europe regions to the energy use of transport remains the highest but will decrease significantly from nearly 60% in 2005 to 44% in 2050. China's share will almost double during the observed period, from 8% in 2005 to 15% in 2050 meaning a yearly

growth rate of 4.8%. The South West Asia region with India as its motor will come up as the region with the strongest yearly growth rate (5%). Central America, Africa and South East Asia have almost the same yearly growth rates of 4.5%.

## Planned further development of the tool

We will further update the tool database up to 2010, align the main exogenous assumptions with assumptions used in the reference scenario of the World Transport Outlook produced by the International Transport Forum (ITF) followed by calibration and validation, compare with results of other stock projections (e.g. Outlooks from Boeing and Airbus for aircraft, Panama Canal Authority for maritime transport, etc.) and finally test the tool with some alternative scenarios that includes policy measures.