Road Technology and Fuels to 2050

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Topics

- The IEA analysis framework
- Key facts and trends
- Efficiency options
- Alternative fuels
- Scenario analysis
- Conclusions
- Request for advice on alternative scenarios for supply security, CO₂ reduction and economic growth (IEA ministerial and G8)
- Mobility Modelling (MoMo) together with BP, Honda, Hydro, Nissan, Shell & Toyota: building on WBCSD SMP project
- MoMo feeds ETP and WEO
- WEO2030: policies implemented and under consideration today, 2030 focus
- ETP2050: aiming for CO₂ emissions stabilization at today’s level by 2050
Key Facts and Trends
Oil Demand by Sector
Total 84 mb/d in 2005
2/3 Transport related
Global Fuel Use by Mode, 2005

LDVs constitute the largest share, but the total of other modes dominates.
New LDV sales
Sales have almost doubled in 25 years; the OECD region is still dominant
LDV weight trends 1980-2005
Weight explains most fuel efficiency differences

LDV Weight Trends

- USA
- EU-15
- Japan

Average LDV weight [kg/vehicle]

USA: 28% increase
EU-15: 35% increase
Japan: 28% increase
LDV Stock Efficiency Trends 1980-2005
19% improvement since 1980
US Fuel Efficiency Trends
Weight gains have balanced important technology improvements
Europe Fuel Efficiency Trends
50% Dieselization explains largely the difference with the US
Efficiency Options
Engines

- Improved ICEs
  - Relies heavily on electronics
  - Gasoline engines applying modified diesel technologies
  - Operate closer to optimum conditions
  - This will narrow the gap with diesel engines

- Hybrids
  - Different levels of hybridization
  - Proven technology
  - Relies also heavily on electronics
Non-Engine Options

- Roughly 30-35% of the energy delivered as work by the engine in a vehicle is wasted in the tires, about 35-40% is needed to overcome the inertial forces (mass related), another 25-30% is dissipated in the air (drag).
- Accessories need 5-10% of the work done by the engine (air conditioners, lighting...).
- This is not entirely considered in test cycles.
- Improvements in tires and accessories can reduce fuel consumption by 5-7%.
## Key Options and Their Cost

<table>
<thead>
<tr>
<th>Improvement</th>
<th>[%]</th>
<th>Cost [USD/car]</th>
<th>Cost [USD/%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct injection (lean burn)</td>
<td>10-15</td>
<td>400</td>
<td>30-40</td>
</tr>
<tr>
<td>Cylinder deactivation</td>
<td>6-8</td>
<td>340</td>
<td>40-55</td>
</tr>
<tr>
<td>Variable valve lift and timing</td>
<td>5-7</td>
<td>350</td>
<td>50-70</td>
</tr>
<tr>
<td>Turbocharger &amp; intercooler</td>
<td>5-6</td>
<td>470</td>
<td>80-90</td>
</tr>
<tr>
<td>(downsizing)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybridization</td>
<td>20-30</td>
<td>1500-4000</td>
<td>80-130</td>
</tr>
<tr>
<td>CVT (for automatic transm.)</td>
<td>5-7</td>
<td>50</td>
<td>8-10</td>
</tr>
<tr>
<td>Lightweighting</td>
<td>10</td>
<td>500-1000</td>
<td>50-100</td>
</tr>
<tr>
<td>Improved aerodynamics</td>
<td>2-4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tires</td>
<td>2-4</td>
<td>100-200</td>
<td>25-100</td>
</tr>
<tr>
<td>A/C</td>
<td>2-3</td>
<td>100</td>
<td>35-50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20-40</td>
<td><strong>1500-5000</strong></td>
<td><strong>30-100</strong></td>
</tr>
</tbody>
</table>
Alternative Fuels
Many Competing Alternative Fuels + Non-Convention Oil

Diversity

High
- Oil sands
- Oil shale
- FT-coal
- DME/MeOH coal

Non-conventional oil + CCS
- FT-coal + CCS
- DME/MeOH coal + CCS

Low
- FT-natural gas
- CNG vehicles
- DME/MeOH natural gas

FT-natural gas + CCS
- DME/MeOH natural gas + CCS

Low or no reduction
- More efficient ICEs
- FCV + H2 from coal + CCS, nuclear or renewables
- Bioethanol (cane/cellulosic)
- FT-Biodiesel
- Plug-in hybrids

Emissions increase
- Hydrogen from natural gas + CCS

Emissions reduction
The Cost of Alternative Fuels

- Oil sands <30 $/bbl today
- FT-synfuels from coal for 30-50 $/bbl crude today
- FT-synfuels from gas may be even cheaper, but depends on stranded gas price & availability
- Biofuels: cane ethanol 30-40 $/bbl today (Brazil); lignocellulosic ethanol 50-60 $/bbl crude by 2030
- Hydrogen supply cost equivalent to 200 $/bbl today; 50-60 $/bbl crude by 2030 (but expensive vehicle needed)
Plug-In Hybrids

- A hybrid with a larger battery
- Electricity from the grid results in efficiency gains and zero tailpipe emissions
- Rapid improvements in Li-ion polymer batteries (claims):
  - Rapid loading
  - Explosion safety (no Cobalt alloys)
  - Use of cheaper electrode materials
  - Longer life span for deep cycling
  - Can all these features be combined into one battery?
- Cost-effectiveness depends on oil & CO₂ price, battery mileage and future battery cost
- May facilitate a transition to H₂/FCV?
- So far not considered in the analysis
Fuel Cell Vehicles

- Efficiency gain factor 2-3 compared to advanced ICE
- Cost is a challenge (today $2000/kW; <100 $/kW drive system needed)
- Technology is not ready; long-term option
- Policy support needed
- H₂ infrastructure + transition workshop, Detroit, April 2-4
Scenario Analysis
IEA Scenarios

- World Energy Outlook Reference Scenario - *Implemented policies, 2030*
- World Energy Outlook Alternative Policy Scenario - *Policies under consideration, 2030*
- Energy Technology Perspectives ACT Map Scenario - *New policies for global CO\(_2\) emissions stabilization, 2050 (incl. USD 25/t CO\(_2\) incentive)*
- Energy Technology Perspectives Tech Plus – *ACT Map policies and breakthroughs for second generation biofuels and H\(_2\) FCVs result in CO\(_2\) emissions 16% below 2003 levels in 2050*
● Total transport fuel demand in Baseline scenario grows 140% (2050)
● LDV vehicle travel grows 140%
● Average Baseline LDV stock efficiency gain 18% (annual gain half that of the past 25 years)
● 20 mb/d Baseline efficiency gains for all modes
● Average LDV stock efficiency gain Act Map +40%, TechPlus +50%
Transport CO$_2$ Emissions

- 2050 Baseline Emission Level
- Hydrogen (incl. efficiency)
- Biofuels
- Fuel Efficiency
- CO$_2$ Emissions
Total Emission Reductions
ACT Map, 2050
Transport is Only Part of the Solution

MAP Scenario – 2050
32 Gt CO₂ Reduction

- Power Gen 34%
- End-use efficiency 45%

Industry 10%
- Energy & feedstock efficiency 6%
- Materials & products efficiency 1%
- Process innovation 1%
- Cogeneration & steam 2%

Buildings 18%
- Space heating 3%
- Air conditioning 3%
- Lighting, misc. 3.5%
- Water heat. cooking 1%
- Appliances 7.5%

Transport 17%
- Fuel economy in transport 17%
- Biofuels in transport 6%

Other renewables 6%
- Biomass 2%
- Fossil fuel gen eff 1%

Fuel mix in building 5% and industry 2%
- CCS 12%
- CCS in fuel transformation 3%
- CCS in industry 5%

Biofuels in transport 6%
- CCS in fuel transformation 3%
- CCS in industry 5%
- Fuel mix in building 5% and industry 2%

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Oil Supply and Demand (incl. non-conventional oil)
Conclusions

- Most oil demand is transport related
- Oil remains a key transportation fuel *in any scenario*
- Efficiency *and* alternative fuels are needed
- Efficiency and biofuels can mitigate the oil demand growth and reduce CO$_2$ emissions
- Plug-in hybrids and/or Hydrogen FCVs may play an important role, but this is uncertain
- CO$_2$ incentives pose no major driver, other instruments needed
- Policies are needed to avoid that technology gains are mainly used to increase the performance
LDV Efficiency Projections

- 18%
- 40%
- 50%