Energy for road transport: a road map to 2050

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Context and motivation

The final target: to reduce transport CO$_2$ emissions by a factor 4 in 2050

- Large discrepancies among experts on long term technology options regarding vehicles and motorization (Biofuels, electricity, H$_2$...)

- the goal of the study: a research road map for road transport power gathering experts from automobile industry, oil industry and research with the support of methodological consultant (EPRI)
Key elements and road map process

- The road map addressed a specific use of energy (not a single technology) and assessed various technological responses options to climate change challenge.
- The road map process involved experts from automobile industry (Renault and PSA), oil industry (TOTAL) and research (IFP), Environment Business Association (EPE), ADEME with the support of methodological consultant (EPRI).
- Several meetings dedicated to “drivers” identification and shared “visions” (no economic scenario).
**Economic scenarios identify a large set of options (example WETO-H₂)**

- A dedicated module representing the behaviour of the road passenger transport demand has been developed.
- With three categories of users:
  - Urban (< 10,000 km/yr)
  - Normal (~ 20,000 km/yr)
  - Intensive (> 40,000 km/yr)

11 generic car technologies are represented:
- Light Gasoline
- Large Gasoline
- Light Diesel
- Large Diesel
- Electric vehicle Biomass Gasification
- Fuel cell H₂-fuelled
- Hybrid-gasoline fuelled
- Hybrid-diesel fuelled
- Hybrid-Fuel cell H₂ fuelled
- Internal Combustion Engine H₂ fuelled
- Internal Combustion Engine Natural Gas-fuelled
In scenarios more than 10 options are sharing the market: is it realistic?

- WETO: in 2050 cars are driven by oil, natural gas, electricity, hybrid, hydrogen + fuel cell, hydrogen ICE…
  No lock-in effect.

Reference

H2 cases
Main drivers and key options

• Two main drivers:
  – the value of CO$_2$
  – energy security

• Two ways to solve the problem:
  – to reduce the energy demand
  – to offer CO$_2$ free energies

Biofuels (2nd generation) was not considered as a key option but as a partial contribution to all other options
The key technologies

- technologies which could change the way to solve the problem

- 4 key “technologies”:

  To reduce the energy requirement
  energy efficiency of the vehicle
  new segmentation of the market

  to offer alternative energy
  electricity storage
  hydrogen and fuel cell

Biofuels and hybrids are useful but not key technologies
### The main ways

<table>
<thead>
<tr>
<th>Reduction of Energy demand</th>
<th>Energy substitution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step by step</strong></td>
<td></td>
</tr>
<tr>
<td>business as usual:</td>
<td>biofuels (1\textsuperscript{st} and 2\textsuperscript{nd} generations)</td>
</tr>
<tr>
<td>vehicle characteristics</td>
<td>hybrids</td>
</tr>
<tr>
<td>engine efficiency</td>
<td></td>
</tr>
<tr>
<td><strong>Breakthroughs</strong></td>
<td></td>
</tr>
<tr>
<td>strong mass reduction</td>
<td>high energy capacity</td>
</tr>
<tr>
<td>new market of minicars</td>
<td>batteries</td>
</tr>
<tr>
<td></td>
<td>fuel cells</td>
</tr>
</tbody>
</table>
Scenario 1: energy efficiency

- Improvement of vehicle efficiency by 64%
- Mass reduction by 40%

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofuels</td>
<td>40%</td>
</tr>
<tr>
<td>Oil + synthetic fuels</td>
<td>60%</td>
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</tbody>
</table>

Conventional flex fuel ICE
Mild hybrid vehicles
Scenario 2: Specific Urban Car

- New market of min and micro cars for urban use (30%)
- Improvement of vehicle efficiency by 33%
- Mass reduction by 20%

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Electricity</td>
<td>50%</td>
</tr>
<tr>
<td>Biofuels</td>
<td>20%</td>
</tr>
<tr>
<td>Oil + synthetic fuels</td>
<td>30%</td>
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</tbody>
</table>

Battery range ~ 200 km

New business models for urban mobility
Scenario 3: hydrogen and fuel cell

- hydrogen and fuel cells become competitive
- improvement of vehicle efficiency by 8%

Fuel cell vehicles: 60%-70%
Biofuels: 20%
Oil+synthetic fuels: 10%-20%

Hydrogen produced without CO₂ emissions
ICE flex fuel vehicles
Scenario 4: electrical vehicle

- Vehicle range > 500km with batteries

<table>
<thead>
<tr>
<th>Electricity</th>
<th>80%</th>
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<tbody>
<tr>
<td>Biofuels + synthetic</td>
<td>20%</td>
</tr>
</tbody>
</table>

Electric battery + hybrid plug-in vehicles
Electricity is produced without CO$_2$ emissions
What consequences on Research and Development?

1 – key technologies have not a “linear effect” on the solution

2 – today, it is too early to select the ”winning technology”

3 – automotive industrial model is not compatible with high diversity of products

there is a breaking-point (2015-2020)
**What consequences on Research and Development?**

From now to the breaking point:

*we need to work on all the challenging technologies*

<table>
<thead>
<tr>
<th>Power plant</th>
<th>best adaptation engine / synthetic fuels</th>
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<tbody>
<tr>
<td></td>
<td>hybridization</td>
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<tr>
<td></td>
<td>pure electric vehicles</td>
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<td></td>
<td>fuel cells</td>
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<table>
<thead>
<tr>
<th>Vehicle</th>
<th>mass reduction by redesigning the vehicle</th>
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<tbody>
<tr>
<td></td>
<td>active aerodynamics</td>
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</table>

| New concepts         | dedicated urban vehicles                  |
What about short and mid term developments?

- All the scenarios lead to electric vehicles by different ways:
  - strong lightening
  - mini cars
  - hydrogen and fuel cell
  - efficient batteries

- Other functions of the vehicle could take advantage of using electricity:
  - steering
  - braking
  - air conditioning

the vehicle of the future will be electric
What about short and mid term developments?

- **Power electricity** is a big challenge for car industry (R&D, manufacturing, sale, maintenance....)
What about short and mid term developments?

- **Power electricity** is a big challenge for car industry (R&D, manufacturing, sale, maintenance....)

- In order to get ready for the “break point”: we need to do research
  we need to start development and production of “electric vehicles”
What can be done?

- Mild hybrid is the first step
- Plug-in hybrid could be the second

The main problems to solve:
- performances
- batteries
- reliability
- cost
- system
- simplification (cost)
- reliability
What can be done?

- electric vehicles with batteries
  problems are mainly coming from batteries

The way to succeed:
  batteries are making progress
  but no breakthrough is expected for the time being

  to adapt the vehicle to batteries
  small and light
  limited performances (speed, crash)
  adapted business model

self-service urban car?
### What road map for “electric vehicles”? 

<table>
<thead>
<tr>
<th>Electric vehicles with batteries</th>
<th>2010/2012</th>
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<tbody>
<tr>
<td>Plug-in hybrids</td>
<td>2012</td>
</tr>
<tr>
<td>Fuel cell vehicles (on-board reformer)</td>
<td>2015/2020</td>
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<tr>
<td>Fuel cell vehicles (on-board hydrogen)</td>
<td>2020+</td>
</tr>
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</table>
Output: research priorities for ADEME in the field of road vehicles

- Increasing hybridization of vehicle from low hybridization (stop and start) to high hybridization (plug in).

- Optimization of conventional thermal motorization in association with hybridization (down sizing, efficiency, weight reduction…)

- Electricity storage on board

- Fuel cells and hydrogen, an option for longer term

*Small urban car: which conditions for a market, competing with other transport modes? New road map on urban mobility going*
Road map implementation and further steps

• Economic modelization of scenarios (using POLES) in order to assess real impact on CO₂ emissions at world level of each option (on going work)

• Which conditions for urban small car market facing mobility demand in 2050: new « road map » going on dedicated to « urban mobility in large cities at 2050 »

• Present road map useful for identification of « research demonstrators » to be implemented in the field of transport
Thank you for your attention

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