H2-Mobility
Preparing for a hydrogen infrastructure in Germany

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Nationale Innovationprogramme Hydrogen and Fuel Cell Technologies (NIP)

Market preparation for hydrogen- and fuel cell technologies

- **200 M€** funding focus R&D
  BMWi, NOW, PtJ-Jülich

- **500 M€** funding focus demonstration
  BMVBS, NOW, PtJ-Berlin

- **700 M€** industry investment

- **1.400 M€** overall budget

- **10-year-programme**
  (2007-2016)

The NIP is a strategic alliance combining politics, industry and academia
National Innovation Programme - NIP
Transportation Sector (overview)

<table>
<thead>
<tr>
<th># projects</th>
<th># partners</th>
<th>funding (mio. €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>approved (BMWi)</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>approved (BMVBS)</td>
<td>50</td>
<td>103</td>
</tr>
<tr>
<td>LoI BMVBS</td>
<td>8</td>
<td>10</td>
</tr>
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**Focus areas 2008 – 2011:**
- ramp-up of hydrogen vehicle fleets (passenger cars, busses)
- testing of hydrogen refuelling stations in key regions
- development of fuel cell systems and key components (BoP)
- fuel cells in aviation

**Additional areas 2011-2016:**
- building an initial hydrogen infrastructure network
- increasing the deployment of fuel cell busses
- developing key components (hydrogen storage/refueling technology)

**Lighthouse project:**
- Clean Energy Partnership (CEP)
  5 regions, 130 passenger cars, 11 busses, 15 refueling stations
Key role of FCEV in reaching Germany's target is to fully decarbonize private transport by 2050

Objectives set by German government

- Germany aims to reduce CO₂ emissions by 40/55/80 - 95% until 2020/2030/2050 compared to 1990
- The transport sector accounts for ~ 19% of total German CO₂ emissions in 2009
- Until 2020, Germany aims to reduce transport emissions by 33.6 million tons CO₂¹

¹ According to the Integrated Energy and Climate Program; 21% compared to 1990
² Range for 2050 based on fuel-economy improvement (constant tank size assumed); assumed 6% CO₂ reduction due to biofuels by 2020, 24% by 2050
Clean Energy Partnership – Hydrogen Refueling Stations (HRS)

Publicly Accessible Hydrogen Refueling Stations in Germany (GH2, 700 bar)

Key achievements
- Safety of stations proven
- Refueling standards agreed
- Storage and compressor technology tested
- H₂ supply chain tested
- Bugs of station technology eliminated

Several additional stations are currently planned
- Daimler and Linde have announced to build 20 HRS within the next years

Hamburg, Bramfelder Chaussee Shell
Hamburg, HafenCity Vattenfall/Shell
Hamburg, Cuxhaven Str. Total
Düsseldorf, Air Liquide
Stuttgart, EnBW
Stuttgart, Airport OMV
Karlsruhe, ENBW
Karlsruhe, KIT
Freiburg, FhG ISE

Berlin, Heidestraße Linde/Total
Berlin, Heerstraße Total
Berlin, BBI Total
Berlin, Holzmarktstraße Linde/Total/Statoil
Berlin, Sachsendamm Shell
Frankfurt (Höchst), AGIP
Munich, Detmoldstraße Total (only LH2)
Toyota confirms commercial hydrogen plans


18.01.2012

Having long been a leader in developing new sustainable transportation technologies for the automotive industry, Toyota has confirmed it plans to push ahead with commercial production of hydrogen fuel cell vehicles.

Speaking to the press, Didier Leroy, CEO of Toyota Motor Europe said: “In our quest for sustainable mobility Toyota is investing in a range of environmentally friendly technologies to address key issues such as energy supply and transport emissions. Alongside hybrids, plug-in hybrid electric and pure electric vehicles, we believe that fuel cell vehicles will play an important role in realizing a low carbon society.

“We plan to commercialize fuel cell vehicles in 2015 and to achieve this goal a hydrogen charging infrastructure will be required. That is why we welcome the establishment of the UK H2 Mobility Group to confirm the potential for hydrogen as a low carbon fuel in the UK.”

Toyota has been researching fuel cell technology and hydrogen storage for almost 20 years and in 2002 its first generation of fuel cell vehicles underwent field tests in Japan and the USA. Most recently it revealed its FCV-R Concept, a vision for a practical sedan-type fuel cell vehicle that is scheduled for launch in 2015.
B-Klasse F-CELL World Drive 2011 – in 125 Tagen um die Welt

- 125 Tage
- 14 Länder
- 3 Fahrzeuge
- Rund 35.000 km je Fahrzeug
GM’s Next Generation Fuel Cell Propulsion Systems

Equinox Fuel Cell

Next Generation (Gen 2)

1/2 Size
1/2 Weight
Study Continued:

left: storage capacity in relation to feed-in wind power in E.ON grid 2007

below: costs of weekly storage

source: VDE

- almost no locations for pumped hydro available in Germany
- storage capacity of $\text{H}_2$ 60 times bigger than capacity of CAES
- $\text{H}_2$ most important option in longer term
- potential synergies between $\text{H}_2$ as energy storage, fuel and industrial gas should be exploited
Key role of hydrogen as an energy carrier to facilitate the energy transition in Germany (I)
In-depth analysis investigating the potential development of a hydrogen infrastructure in Germany

<table>
<thead>
<tr>
<th>Year</th>
<th>H₂ Mobility setup</th>
<th>H₂ Mobility business case (joint study)</th>
<th>H₂ Mobility business and implementation plan (joint study)</th>
<th>Negotiations for founding joint entity</th>
<th>Market preparation and validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 - 2011</td>
<td></td>
<td></td>
<td>H₂ Mobility coalition objectives</td>
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<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td>H₂ Mobility coalition objectives</td>
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**Main achievements**

- Memorandum of understanding for H₂ Mobility signed Sep 10, 2009 in Berlin
- Consistent HRS and FCEV ramp-up scenarios for Germany agreed
- Design of joint entity structure outlined
- Business case calculated and implementation plan outlined
- Negotiate joint entity agreement
- Win (new) H₂ Mobility members as investors
- Start HRS rollout in Germany via the CEP
- Synchronize HRS rollout with FCEV ramp-up

**H₂ Mobility coalition objectives**

- DAIMLER
- TOYOTA
- NISSAN
- BMW GROUP
- INTELLIGENT ENERGY
- TOTAL
- VATTENFALL
- EnBW
- SIEMENS
- AIR LIQUIDE
- NOW
- Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

H₂ Mobility analysis participants in 2011
Potential HRS rollout in Germany

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of FCEVs (Thousands)</th>
<th>No. of HRS</th>
<th>Total population covered by HRS (Percent)</th>
</tr>
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<tbody>
<tr>
<td>2015</td>
<td>~ 5</td>
<td>~ 100</td>
<td>~ 20</td>
</tr>
<tr>
<td>2020</td>
<td>~ 150</td>
<td>~ 400</td>
<td>~ 60</td>
</tr>
<tr>
<td>2030</td>
<td>~ 1,800</td>
<td>~ 1,000</td>
<td>~ 100</td>
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Phased approach to a profitable commercial infrastructure ramp-up

**When and Who?**

<table>
<thead>
<tr>
<th>R&amp;D and demonstration</th>
<th>Market preparation and validation</th>
<th>Commercial ramp-up</th>
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<tbody>
<tr>
<td>Since 2006</td>
<td>For the next 5 - 10 years</td>
<td>Around 2020</td>
</tr>
<tr>
<td>CEP/NIP</td>
<td>H2 Mobility and CEP/NIP</td>
<td>H2 Mobility and free market</td>
</tr>
</tbody>
</table>

**Goals**

- HRS technology up and running
- Costs significantly reduced
- Proof of HRS, FCEV technology, and H₂ supply chain
- Customer acceptance of FCEVs
- Attractive business case for next phase
- Scaled nationwide HRS network to enable FCEV mass take-up
- Profitable, high-growth business
Thank you very much for your attention!

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