Fuel Cells and Hydrogen Joint Undertaking

Main achievements and development perspectives in the frame of Horizon 2020

Bert De Colvenaer, Executive Director
Sofia, 15 May 2014
**Sustainability**
- $\text{H}_2$ is a clean carrier of energy
- Transport and stationary applications, generate electricity and heat
- Storage of renewable energy sources
- Reduction of CO$_2$ emissions

**Energy Security**
- Increase independence from unstable outside regions

**Competitiveness**
- Research excellence leading to industry innovation and growth
The FCH JTI in the SET plan

EU targets:
- 20% increase in renewables
- 20% increase in efficiency
- 20% decrease in emissions

Fuel Cell and Hydrogen Joint Undertaking
- FCH JU: community body
- Budget: 940 M €
- FCH JU Programme Office

The European Industrial Bioenergy Initiative
The European CO2 Capture, Transport and Storage Initiative
The European Electricity Grid Initiative
The Sustainable Nuclear Initiative
The Solar Europe Initiative
The Wind Initiative
Energy Efficiency – The Smart Cities Initiative

FCH JU: Fuel Cell and Hydrogen Joint Undertaking

20% increase in renewables
20% increase in efficiency
20% decrease in emissions

EU targets:

Fuel Cell and Hydrogen Joint Undertaking
- FCH JU: community body
- Budget: 940 M €
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450 = RTD: 315 ENER: 120 MOVE: 15
3
Fuel Cells & Hydrogen Joint Undertaking

Industry Grouping
Over 60 members

European Union
represented by the European Commission

Research Grouping
Over 60 members

Both the Industry Grouping and the Research Grouping are non-profit organisations with open membership.

To accelerate the development of technology base towards market deployment of FCH technologies from 2015 onwards.
<table>
<thead>
<tr>
<th>Category</th>
<th>Projects</th>
<th>Demos</th>
<th>Research</th>
<th>CSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSPORTATION &amp; REFUELLING INFRASTRUCTURE</td>
<td>25</td>
<td>8</td>
<td>14</td>
<td>3</td>
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<tr>
<td>HYDROGEN PRODUCTION &amp; DISTRIBUTION</td>
<td>28</td>
<td>4</td>
<td>24</td>
<td></td>
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<tr>
<td>STATIONARY POWER GENERATION &amp; CHP</td>
<td>36</td>
<td>9</td>
<td>26</td>
<td>1</td>
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<tr>
<td>EARLY MARKETS</td>
<td>21</td>
<td>13</td>
<td>8</td>
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<td>CROSS - CUTTING</td>
<td>17</td>
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</tbody>
</table>

FCH JU portfolio: 127 (+21) projects

RCS, Safety, Education, PNR, …
Clean Hydrogen in European Cities

Objectives

• Operation of **26 fuel cell buses** in 5 cities in Europe (Aargau, Bolzano, London, Milano, Oslo) and the respective infrastructure for a period of 5 years
• Transfer of learning from cities with experience in operating buses and infrastructure (Hamburg, Berlin, Cologne, Whistler; ~ 30 fuel cell buses) to the 5 cities
• Assessment of the technology with focus on environment, economy and society
• Dissemination to the general public and to cities preparing for the technology in the next step
• 2 filling stations per city
• Demonstration phase 2010-2016
• **Cost 82 M€, 26 M€ funding**

Main Partners

25 partners from cities, consultants and industry:
The HyTEC project will expand the existing European network of hydrogen demonstration sites into two of the most promising early markets for hydrogen and fuel cells, Denmark (Copenhagen) and the UK (London).

30 new hydrogen vehicles (taxis, passenger cars and scooters)

16 partners from 5 countries

2 refuelling stations:
- London
- Copenhagen
Ene.field project

- Demonstration of up to 1000 residential fuel cell μCHP (1-5 kW) units from 9 manufacturers in 12 EU member states
- Establish supply chains, validate new routes to market, stimulate cost reduction for final commercial deployment

<table>
<thead>
<tr>
<th>FCH JU Target</th>
<th>State of the Art</th>
<th>Expected performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical efficiency (min) 35%</td>
<td>30 %</td>
<td>35 % – 50 %</td>
</tr>
<tr>
<td>Overall efficiency &gt; 85% (LHV)</td>
<td>70 % – 85 %</td>
<td>Up to 90 %</td>
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<tr>
<td>Lifetime: of 8 - 10 years</td>
<td>3 years</td>
<td>Up to 8 years</td>
</tr>
</tbody>
</table>
HyLIFT DEMO

European demonstration of fuel cell powered materials handling vehicles including infrastructure

Objectives

- demonstration of 30 fuel cell forklifts
- demonstration of hydrogen refuelling infrastructure
- performance of accelerated durability tests
- preparation of market deployment from 2013 on
Objectives:
• Electrical output between 50 W and 500 W_e
• Demonstrate electrical efficiency of 30%+
• 1,000 h lifetime with 100 start-stop cycles
• Size < 50 l/kW, weight < 35 kg/kW
• Demonstrating a cost < 5,000 €/kW

Challenges:
• Salty environment (air)
• Sea movements
FCH JU Main Achievements

- **Transport sector**:  
  - 49 buses, 37 passenger cars, 95 mini cars  
  - 13 new refuelling stations  
  - FC Bus H₂ consumption halved  
  - H₂ cost < 10€/kg

- **Stationary sector**:  
  - 1000 domestic Combined Heat & Power generators  
  - Cost - 50%, efficiency 90%, lifetime up to 8 years

- **Early markets sector**:  
  - 9 fork lifts, 1 tow truck  
  - 19 back up power units

- **For the European FCH community**:  
  - Strong, visible and coherent  
  - Consensus strategy (MAIP/AIP)  
  - Pre-competitive collaboration  
  - 430 participants in 127 projects  
  - SME participation 23%
+10% average increase of annual turnover (on a 2012 total of €0.5 billion)

+8% average increase of R&D expenditures (2012 total €1.8 billion)

+6% average increase of market deployment expenditures (2012 total €0.6 billion)

+6% growth in jobs per year (~4,000 FTE in 2012) while average EU job market has contracted

+16% annual increase in patents granted in the EU to European companies (average 1.5% for all European industries)

A portfolio of power-trains for Europe: a fact-based analysis

The role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles
Battery and fuel cell vehicles can achieve low emissions

CO₂ emissions

\( g\text{CO}_2 / \text{km} \)

ICE – gasoline\(^1\)

ICE – diesel\(^1\)

PHEV

BEV

FCEV

Low emissions and high range

Range

km
After 2025, costs of all power trains converge

TCO ranges\(^1\) of different power-train technologies

<table>
<thead>
<tr>
<th>Year</th>
<th>BEV</th>
<th>FCEV</th>
<th>PHEV</th>
<th>ICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
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<td>2015</td>
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<td>2025</td>
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<td>2030</td>
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\(^1\) TC0 ranges refer to total cost of ownership and include all relevant costs such as fuel, maintenance, and depreciation.
- Initiative gathering the German government and 6 major industrial companies
- 400 hydrogen stations by 2023
- Investment of €350 million
- Benchmark at international level
Defined as most attractive regions for FCEV deployment based on vehicle density and per capita income

Seeding of Tier 1 regions\(^1\) – major cities and connecting roads in 2015

Initial seeding in major population centres

Coverage extended to Tier 2 regions and all major roads <2025

Extend coverage to enable close-to-home refuelling to 50% of the population and long distance travel

Full population coverage by 2030

Extend close-to-home refuelling to the whole of the UK, including less populated regions

\(^1\) Defined as most attractive regions for FCEV deployment based on vehicle density and per capita income
Current state of initiatives

H2Mobility Germany:
Recent announcement made - 350M€ for 400HRS by 2023

H2 Mobilité: Government and industry partners building common strategy

UK H2Mobility: Government and 11 companies developed common strategy Business case in development

Danish Government has announced an Energy Plan 2020 that includes a range of initiatives for hydrogen infrastructure and FCEVs, amongst which are significant incentives

Government and 13 companies announced program for FCEV mass production and 100 HRS by 2015 connecting 4 metropolitan areas

Government announced program to finance and deploy 100,000 FCEV and 170 HRS by 2020

Demo initiatives in California and East Coast H₂ Highway; partially funded by DoE. New "Clean Fuels Outlet" regulation in California requiring deployment of HRS (to avoid penalties).

California Fuel Cell Partnership announced roadmap to rollout 68 stations by 2015 H2USA started
Clean Power for Transport Package

• Proposal for Directive on the deployment of alternative fuels infrastructure
  - Build a competitive and resource efficient transport system.
  - Establish long term fuel strategy.
  - Remove technical and regulatory barriers.
  - Facilitate a single market for alternative fuels vehicles and vessels.

• Associated costs:
  - Electricity = 8 M charging points = 8 B€
  - LNG Waterborne = 139 refuelling points * 15 M€ = 2,1 B€
  - LNG trucks = 144 refuelling points * 0.4 M€ = 58 M€
  - CNG road = 654 refuelling points * 0.25 M€ = 164 M€
  - Hydrogen = 77 refuelling stations * 1.6 M€ = 123 M€
Urban buses: alternative powertrains for Europe

A fact-based analysis of the role of diesel hybrid, hydrogen fuel cell, trolley and electric powertrains
The coalition of more than 40 industrial companies and organizations

<table>
<thead>
<tr>
<th>Bus OEMs</th>
<th>Technology Providers</th>
<th>Infrastructure</th>
<th>Transportation Companies</th>
<th>Other organizations</th>
</tr>
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<tbody>
<tr>
<td>EvoBus</td>
<td>Siemens</td>
<td>Shell</td>
<td>GVB</td>
<td>elementenergy</td>
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<td>Hess</td>
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<td>Linde</td>
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<td>MAN</td>
<td>NuCellSys</td>
<td>Hydrogenics</td>
<td>Hochbahn</td>
<td>HyER</td>
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<td>Air Liquide</td>
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<td>Bombardier</td>
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<td>PM</td>
<td>Ballard</td>
<td>Air Liquide</td>
<td>STIB</td>
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<td>UTC Power</td>
<td>Vossloh</td>
<td>Bombardier</td>
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<tr>
<td>ABB</td>
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</tbody>
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1 Bombardier, Hydrogenics and ABB participate in both the Technology Providers and the Infrastructure working groups

SOURCE: FCH JU; McKinsey
### In depth analysis of 8 different powertrains for standard and articulated bus

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diesel powertrain</td>
<td>Conventional diesel combustion engine</td>
</tr>
<tr>
<td>2. CNG powertrain</td>
<td>Conventional CNG combustion engine</td>
</tr>
<tr>
<td>3. Parallel hybrid powertrain</td>
<td>Serial hybrid configuration of electric and ICE drive</td>
</tr>
<tr>
<td>4. Serial hybrid powertrain</td>
<td>Serial hybrid configuration of dominating electric system  &lt;br&gt; Fully electric driving for smaller distances (&lt;10 km); larger range possible depending on capacity of battery</td>
</tr>
<tr>
<td>5. Hydrogen fuel cell powertrain</td>
<td>Serial hybrid configuration of fuel cell system and electric drive  &lt;br&gt; Hydrogen tank pressure typically 350 or 700 bar</td>
</tr>
<tr>
<td>6. Trolley powertrain</td>
<td>Purely electric drive  &lt;br&gt; Electric energy taken from the overhead wiring while driving</td>
</tr>
<tr>
<td>7. Opportunity e-bus</td>
<td>Purely electric drive  &lt;br&gt; Only charging of battery from the grid while stationary at intermediate stops (e.g. via an overhead catenary system)</td>
</tr>
<tr>
<td>8. Overnight e-bus</td>
<td>Purely electric drive  &lt;br&gt; Only charging of battery from the grid while stationary at the depot</td>
</tr>
</tbody>
</table>

**SOURCE:** Study analysis
E-bus opportunity and hydrogen fuel cell expected to be the cheapest zero local-emission standard bus by 2030

Labeling of powertrain according degrees of operational experience (kilometers driven):
- **Commercial solution (>> 100 million km):** Conventional, trolley
- Test fleets (> 1 million km): Diesel hybrids, fuel cell
- **Prototype phase (< 10 thousand km):** E-buses

1 Total cost of ownership for a 12m bus including purchase, running and financing costs based on 60,000km annual mileage and 12 years bus lifetime – not all powertrains available for articulated buses therefore articulated buses not shown
2 Total CO$_{2e}$ emissions per bus per km for different fuel types from well-to-wheel
3 Electricity cost for e-bus and water electrolysis part of hydrogen production based on renewable electricity price with a premium of EUR50/MWh over normal electricity

SOURCE: Clean team; working team analysis
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**TCO**$^{1,3}$

<table>
<thead>
<tr>
<th>EUR/km</th>
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<tbody>
<tr>
<td>5.5</td>
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<td>5.0</td>
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<tr>
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<td>1.0</td>
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<td>0.5</td>
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</table>

**GHG emissions**$^2$
gCO$_2$/km

- E-bus overnight
- Hydrogen fuel cell
- Trolley
- E-bus opportunity
- Serial hybrid
- Parallel hybrid
- CNG
- Diesel

**SOURCE:** Clean team; working team analysis

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SOURCE: Clean team; working team analysis
Objectives

Explore and accelerate the commercialization of fuel cell city buses in Europe by:

In a first phase,
- Aligning a coalition of private and public stakeholders to allow the development of a large scale FC Bus commercialization project
- Developing a functional specification of a commercial scale FC bus project and scoping city level FC bus business cases

In a potential second phase,
- Develop the basic and detailed engineering of the hydrogen infrastructure and developing national ramp up scenarios

In a potential third phase,
- Detail the business cases to be implemented
- Developing an EU vision for zero emission public FC bus transport and agree on a regulatory framework and funding in support of the commercialization of fuel cell buses
General objectives

- Contribute to the objectives of the Joint Technology Initiative on FCH
- Development of a strong, sustainable and competitive FCH sector

Adopted by the Commission on 10 July 2013 as part of the Innovation Investment Package (Horizon 2020)
Fuel Cell and Hydrogen 2 Joint Undertaking

Transport

- Road vehicles
- Non-road vehicles and machinery
- Refuelling infrastructure
- Maritime, rail and aviation applications

Energy

- Hydrogen production and distribution
- **Hydrogen storage** for renewable energy integration
- Fuel cells for power and combined heat & power generation

Cross-cutting Issues

(e.g. standards, consumer awareness, manufacturing methods, ...)

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Particular objectives:

- **reduce the production cost** of fuel cell systems to be used in transport applications, while increasing their lifetime to levels competitive with conventional technologies,
- **increase the electrical efficiency** and the durability of the different fuel cells used for power production, while reducing costs, to levels competitive with conventional technologies,
- **increase the energy efficiency** of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace,
- demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a competitive energy storage medium for electricity produced from renewable energy sources,
- reduce the use of the EU defined "Critical raw materials", for instance via low or platinum free resources and through recycling or reducing or avoiding the use of rare earth elements.
New aspects: - tentatively -

• from 2014 – 2020; projects activities until 2024
• budget: 665 M €; to be complemented by equal amount of Ind/Res investment
• of which 19 M € for operational and financial administration
• of the remaining: 5 – 10 % to Cross Cutting activities
• of the remaining: 50/50 split Energy/Transport and
  60/40 split Demonstration/Research
• Project funding: max 100 % Direct Cost & 25 % Indirect Cost for research,
  (= H2020) max 70 % Direct Cost & 25 % Indirect Cost for demonstration
• continue with annual Call for Proposals (target in January, except 2014 and 2015)
• for 2014: Call launch 09/07; closing 06/11; GA latest 06/07/15; Info Day: 10/07
• TTG = 8 months; will require perfect proposals
• TTP = 1 month; with clarification stop
Hydrogen as “smart link”
Conversion of electrical into chemical power

Applications and examples of use of hydrogen electrolysis
Thank you for your attention!

Further info:

- FCH JU: http://fch-ju.eu
- NEW-IG: http://www.fchindustry-hti.eu
- N.ERGHY: http://www.nerghy.eu