Five key challenges for commercialisation of PEM fuel cell technology

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Who we are

Ricardo delivers world class strategy, engineering & technology to the global automotive, transport, defence & energy industries

- Established in 1915 and independent
- Annual sales ~ £240m
- Global presence in 21 locations
- Significant internal investment in R&D
- Currently delivering over 600 projects with average value of £500k
- More than 2300 employees - over 2000 technical, scientific & engineering staff
- Acquired AEA Europe in 2012
Ricardo Hydrogen & Fuel Cell services

Ricardo creates value for our clients through enabling good decisions, providing tools for modelling system performance, and delivering complete technology solutions.
Introduction

Applications for PEM Fuel Cell Technology

Motive

- Passenger Car
- Bus
- Personal Mobility
- Material Handling
- Truck APU

Stationary

- mCHP
- Backup Power

Portable

- Military
- Recharging
- Portable Generator

Pictures: Hyundai; Icelandic New Energy; Shutterstock; Ceramic Fuel Cell Ltd.; U.S. DoE; ClearEdge; Reilon; UltraCell; SFC; Multiquip; Neah Power Systems / Fuel Cell Today
Introduction

Ricardo Technology Roadmap for Light-Duty Vehicles

Automotive fuel cell technology will need to overcome the technical and infrastructure challenges to break out of niche into mainstream.

Fuel Economy Targets (mpg)

- 27.3
- 35.5
- 54.5

Fleet Average CO₂ Targets (g/km)

- 130
- 95
- 60
- 30

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>Description</th>
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<tbody>
<tr>
<td>2010</td>
<td>IC Engine and Transmission Innovations (gasoline/diesel/gas/renewables/H₂)</td>
<td>Vehicle Weight and Drag Reduction</td>
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<tr>
<td>2020</td>
<td>Full Hybrid</td>
<td></td>
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<tr>
<td>2030</td>
<td>Micro/Mild Hybrid</td>
<td>Plug-In Hybrid</td>
</tr>
<tr>
<td>2040</td>
<td></td>
<td>Fuel Cell Vehicle</td>
</tr>
</tbody>
</table>

Source: Ricardo
Challenges facing the commercialisation of fuel cell systems

- The search for renewable hydrogen
- The roll-out of hydrogen infrastructure
- Exceeding customer expectations
- Cost vs. Price
- The competition

Source: R.A. Frost, "Stopping by Woods on a Snowy Evening"

"But I have promises to keep, 
And miles to go before I sleep."

R. A. Frost
Challenge 1 – The search for renewable hydrogen

If fuel cell vehicles are to help lower GHG emissions, then hydrogen must to produced from renewable energy sources

Well-to-Wheels comparison of automotive powertrain technologies and fuels

- Fuel Cell (H2 from Natural Gas)
- Fuel Cell (H2 from Electricity EU-mix)
- Fuel Cell (H2 from Renewable Electricity)
- Fuel Cell (H2 from biomass)
- Gasoline
- Gasoline Hybrid
- Ethanol
- Diesel
- Diesel Hybrid
- Biodiesel

Source: JRC EUCAR CONCAWE Well-to-Wheel Analysis, 2011 – WTW v3c July 2011 – Appendix 1
Challenge 2 - The roll-out of hydrogen infrastructure

- What options will you choose?
- Where will you put the refuelling stations?
- When will you build them?
- How will you fund the roll-out?
Challenge 3 – Exceeding customer expectations

Customer requirements will define what the fuel cell system has to be able to achieve.
Challenge 3 – Exceeding customer expectations

Many factors influence the vehicle specification set by the vehicle manufacturer.

Drivers influencing vehicle design:
- Legislation & Policy
- CO₂
- Design for Recycling
- Safety
- Connectivity
- Market Price
- Durable & Reliable
- Driveability
- Performance
- Brand Image
- Profit
- Common Platforms
- New Vehicle

Business Demands
Customer Expectations
Drivers influencing vehicle design
Many factors influence the vehicle specification set by the vehicle manufacturer.
Challenge 4 – Cost vs. Price

Some vehicle manufacturers are beginning to talk about retail price for first market entry of their fuel cell vehicles, but remember, cost does not equal price ...

Hyundai Hydrogen Fuel Cell ix35
2014 lease from $ 499 / month

Toyota FCV-R
2015 retail < £70,000

Price - Cost = Margin ≈ Profit
Challenge 4 – Cost vs. Price

... And it’s not just about the cost of the fuel cell system

Vehicle image courtesy of American Honda Motor Co., Inc.
Challenge 5 - The Competition
Automotive fuel cell technology will be one option among many

Ricardo Technology Roadmap for Light-Duty Vehicles

Fuel Economy Targets (mpg)
27.3  35.5  54.5

Fleet Average CO₂ Targets (g/km)
130  95  60  30

Demonstrators
Niche FCEV
Fuel Cell Vehicle

Early H₂ Infrastructure
Energy Storage Breakthrough

Niche EVs
Plugging In Hybrid

Charging Infrastructure
Energy Storage Breakthrough

Full Hybrid
Mass Market EV Technology

Micro/Mild Hybrid

IC Engine and Transmission innovations (gasoline/diesel/gas/renewables/H₂)
Vehicle Weight and Drag Reduction

2010  2020  2030  2040

Source: Ricardo
Challenge 5 - The Competition
And the competitor technology for Zero Emission Vehicles already exists

Tesla Model S  £50,000 - £70,000
- All electric ZEV
- Acceleration 0-60 mph in 5.4 seconds
- Top speed 125 mph
- Range 300 miles with 85 kWh Li-ion battery
- 8 year battery warranty

Source: Tesla
Challenge 5 - The Competition
And there might be strong competition for using the hydrogen in something else

Power-to-Gas

Syngas

E.g. GridGas project

Audi e-gas plant

Source: GridGas Project; Audi
Challenges facing the commercialisation of fuel cell systems

- The search for renewable hydrogen
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- Exceeding customer expectations
- Cost vs. Price
- The competition

What contribution will your research make towards meeting these challenges?

Source: R.A. Frost, "Stopping by Woods on a Snowy Evening"

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