"I've got my hydrogen fuel cell car and….it's great, but you have to find a hydrogen filling station."
Jay Leno, The Sunday Times 12/9/10
Contents
Introduction to ITM Power
The Case for Energy Storage
Sector Export
Hydrogen Fuel: The Vehicles
Hydrogen Fuel: The Refuelling Infrastructure
HOST Trials
Summary
Energy Storage | Clean Fuel
Essential Technology & Systems
- Harnessing Renewable Energy
- Producing Green Hydrogen
- Regeneration of Power
- A Zero Carbon Footprint Fuel
The Case for Energy Storage
Demand varies daily, weekly, seasonally:

- Winter peak is 60 GW
- Base load plant
- Mid merit plant
- Peaking plant

Data from National Grid
Plant utilisation over time:

- Inefficient utilisation of plant
- 40% fully utilised

UK Load Duration Curve

Data from National Grid
Shifting the peaks to fill the troughs:

- Turns mid merit in base load
- Reduces the need for peaking
- Increases system efficiency
- Day night arbitrage!

Data from National Grid
Shifting the peaks to fill the troughs:

- Turns mid merit in base load
- Reduces the need for peaking
- Increases system efficiency
- Day night arbitrage!

The Balancing Mechanism Reporting System (BMRS)
The BMRS website provides near real time and historic data about the Balancing Mechanism which is used by the National Grid (System Operator) as a means of balancing power flows on to and off the electricity Transmission System in the UK.
Adding Intermittent Power:

- Need take or break decisions
- Undermines Base load
- Increased need for spinning reserve
- Pushes you back down merit order

Data from National Grid
CO₂ targets to be met by power & heavy industry:

- 16% reduction in GG emissions by 2020
- 31% renewable generation by 2020
- This cannot be achieved without energy storage!
Wind Energy: The UK
A plentiful resource?
• Best Wind resources in Europe
• Entering Phase Three of construction in UK
• Onshore capacity factor 30%, offshore 40%
Wind Energy: The Case for Denmark

Study by CEPOS Sept 2009

- 20% of its generating capacity is wind
- Only 5% of demand is met by wind
- Negative electricity prices
- 50% is exported to Sweden and Norway
- The report calls for energy storage
Scotland's New Target
Is this technically achievable?

- Energy storage an essential element
- Demand side management
- Opportunity for hydrogen

Scotland's 2020 renewables target lifted from 50% to 80%

Scottish First Minister Alex Salmond jumped the country's 2020 renewables target from 50% to 80%, claiming the older target, implemented three years ago, is too modest to create an explosion of green jobs.
Storing Renewable Energy
Adding energy storage to the logistics:

- Five elements are dynamically balanced
- Energy storage is additive
Exporting power to high value applications

Supply/Demand mismatch can be alleviated by exporting power to another sector

- Fuel is a huge sector
- Needs decarbonising
Drivers for a Clean Fuel

Acceptance is now mainstream

- Decreases dependence on fossil fuels
- Decarbonizes transport
- Improves air quality
Clean Fuel
A Chicken and Egg Type Situation

- The vehicles need somewhere to refuel for large scale deployment
- The infrastructure is expensive and needs customers for the business case
- A legislative framework is required or we’ll be breaking the law
The Vehicles
Hydrogen Cars

Serious Traction envisaged around 2015
- Air quality may drive early adoption
- Commercial fleet early adoption

<table>
<thead>
<tr>
<th>Year</th>
<th>Daimler</th>
<th>GM</th>
<th>Honda</th>
<th>Hyundai</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>1000/yr</td>
</tr>
<tr>
<td>2011</td>
<td>1000/yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>10,000/yr</td>
<td>100,000/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td>250,000/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td>Commercialisation</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td>&gt;100,000/yr</td>
</tr>
</tbody>
</table>

- 100,000/yr per manufacturer
- Potential trickle to London
- Trials, conversion design cars and niche vehicles
- Ramp up Purpose design FC hybrid vehicles
Hydrogen Internal Combustion Engine (HICE) Vehicles

ITM Power HICE Ford Focus
A Pragmatic Stepping Stone
- Low cost
- Uses existing technology
- Breaks the ‘chicken and egg’ scenario
The HOST Programme
Hydrogen On-Site Trials

- Hydrogen On-Site Trials
- Targeted at commercial fleet operators
- HFuel unit and two Revolve HICE Transit vans
Revolve HICE Ford Transit vans
Hydrogen Internal Combustion Engine Transit Vans
The Revolve Ford Transit Van

Evolution of the Revolve Technologies Transit Van
A collaboration between ITM Power, Revolve and Cenex

- Building on the Stornoway trial
- Developed through the 2011 HOST trials

1st Generation
- Stornoway deployment
- The Post Office & Cenex
- Feedback to system providers
- NOx performance Euro III

2nd Generation (2010)
- Injectors improve fuel economy
- Improved inter-cooling increases power by \( \sim 10\text{hp} \)
- Calibration upgrade improves NOx performance to Euro IV

3rd Generation (HOST)
- H2 in cabin fuel gauge
- Algorithm for fast fill
- Leak detection strategy
- ECU allows in-motion fuel switch
- Targeting Euro V
Evolution of the Revolve Technologies Transit Van
A collaboration between ITM Power, Revolve and Cenex

- Building on the Stronoway trial
- Developed through the 2011 HOST trials

Prototype
- Demo or Trial only
- No emissions requirements
- Standard procedures
- MOT only requirement

National Small Series (NSSTA)
- Best Practice safe design
- ECE R-110 (EU CNG standard)
- Euro III emissions requirements
- Limited production (100s PA)

Euro Community (ECWVTA)
- Whole vehicle testing
- Crash, emissions, corrosion etc.
- Conformance of Production
- Euro V emissions requirements
- Legislation to be confirmed
The Refuelling Infrastructure
Hydrogen Cars – Infrastructure
Germany leads the way
- FC Vehicle LoI signed 2009
- H₂ infrastructure MoU signed 2009
- 1,000 refuelling stations by 2015

- 2015 commitment to FC vehicle roll out in Germany
- Letter of understanding signed 2009

- H₂-mobility project for infrastructure in Germany
- MoU signed 2009
Hydrogen Refuelling

HPRU – 2009
Stationary High Pressure Refueller
- Rapid cascade refuelling at 350 bar
- Flexible and modular
- One of only four refuellers in the UK
**HPRU – 2009**

Stationary High Pressure Refueller

- Rapid cascade refuelling at 350 bar
- Flexible and modular
- One of only four refuellers in the UK
HFuel® – 2010

Hydrogen Fuel infrastructure unit

- HFuel 15kg/day, rapid cascade refuelling at 350 bar
- Flexible, modular and transportable refuelling unit
- Targeted at the urban commercial fleet market
- Part funded by TSB
Hydrogen on Site Trial

Trials begin Q1 2011

- Scheduled in signing order
- Simple contract
- Seeking further partners
Hydrogen on Site Trial

Trials begin Q1 2011

- Scheduled in signing order
- Simple contract
- Seeking further partners
Lobby the House

Chain of Influence

Ministers need positive solutions to huge problems

Scotland
• Stewart Stevenson (Transport)
• Jim Mather (Energy & Climate)

Westminster
• Norman Baker (DoT)
• Chris Huhne (DECC)
Lobby the House

Chain of Influence
The King Review needs revisiting
- Pitched EV’s vs Hydrogen vehicles
- Many subtleties have now emerged
- Commercialisation has commenced
- Technologies have matured
- The EV is the platform of the Hydrogen vehicle
- Most global OEM’s share this vision

The King Review of low-carbon cars
Part I: the potential for CO₂ reduction
ITM Power plc
Green Hydrogen Transport Fuel, 28th September 2010
Dr Graham Cooley, CEO

- Renewable power needs energy storage
- 80% renewable target is ambitious
- Sector export a great solution
- Transport is a large enough sector
- Green hydrogen is a zero carbon footprint fuel