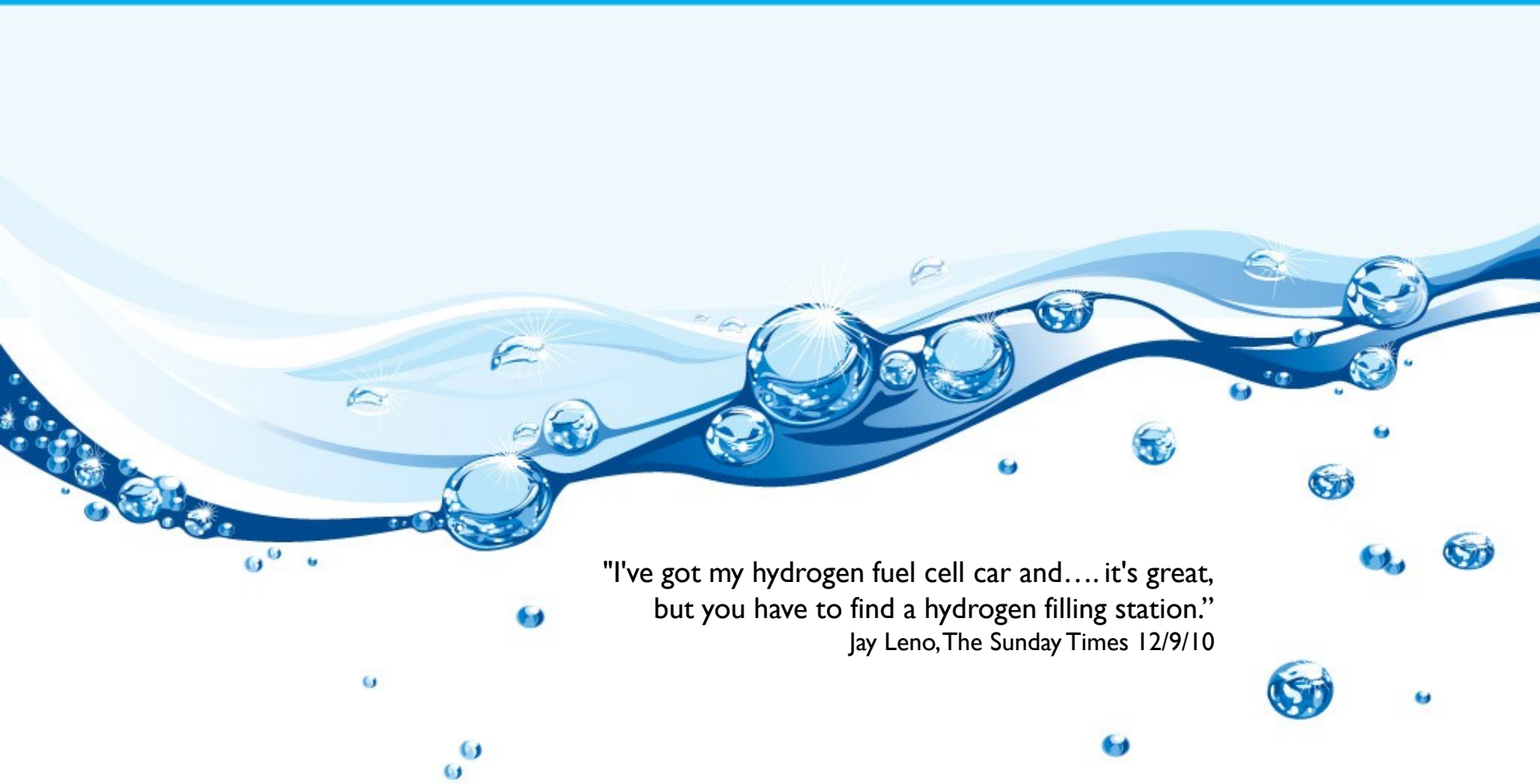
ITM Power plc

Green Hydrogen Transport Fuel, 28th September 2010

Dr Graham Cooley, CEO



"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

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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

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Energy Storage | Clean Fuel

Energy Storage | Clean Fuel

ITM Power has designed hydrogen systems technology for integration into the built environment and transport to provide energy security and zero-carbon energy solutions for early adopters.

Harnessing Renewable Energy

Here's the problem: renewable energy such as wind and solar are unpredictable and need storage technology to be fully utilised. How do you store electricity for long periods of time? The answer is Hydrogen produced by electrolysis enabling you to:

- Use your renewable power whenever you need it
- Keep the lights 'on' during a power cut
- Replace your electricity and natural gas supply

Green hydrogen is produced in an electrolyser by splitting water using renewable energy. It therefore has a zero carbon footprint. All other fuels produce carbon somewhere in the supply chain.

- You can produce your own fuel
- When you produce Green Hydrogen the only by-product is oxygen
- When you burn it; no carbon in means no carbon out
- Once you've paid for the equipment your ongoing fuel is free

About ITM Power

ITM has systems design and integration expertise covering the production, storage, compression and dispensing of high pressure gaseous hydrogen. To find out more visit our website: **www.itm-power.com**

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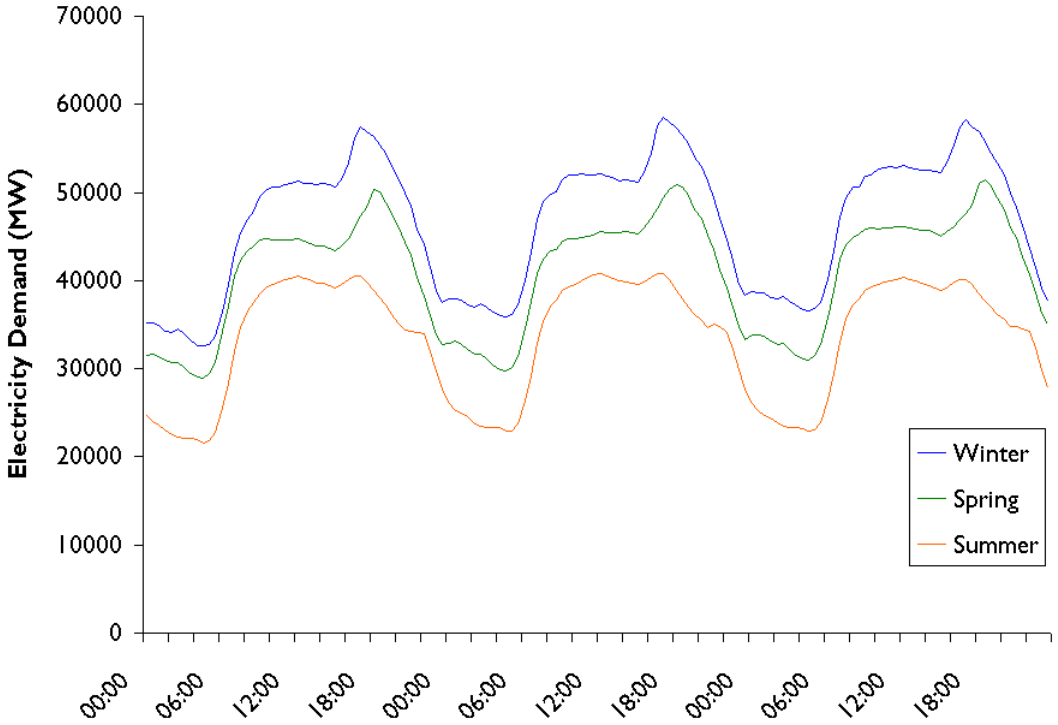
The Case for Energy Storage

UK Electricity Demand

Demand varies daily, weekly, seasonally:

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

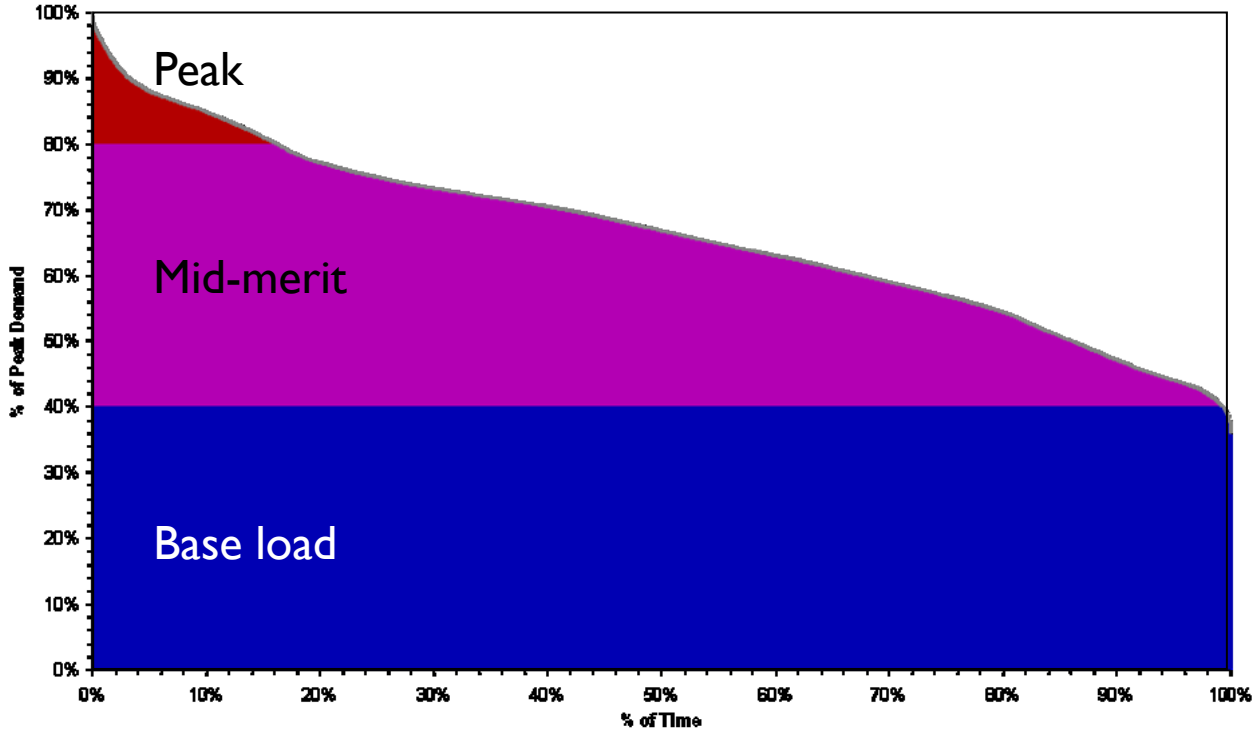


Data from National Grid

UK Load Duration Curve

Plant utilisation over time:

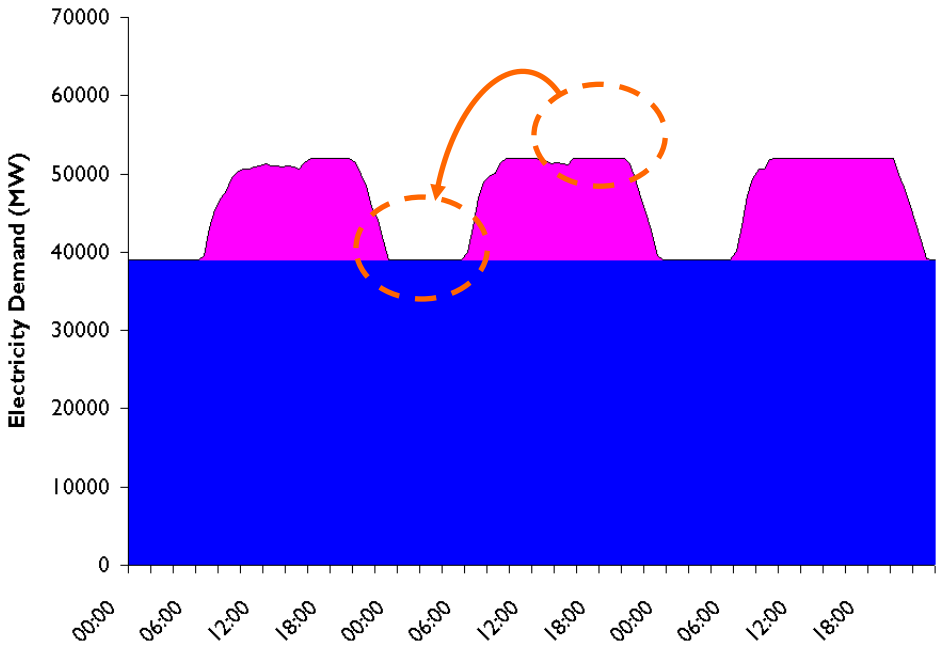
- Inefficient utilisation of plant
- 40% fully utilised



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

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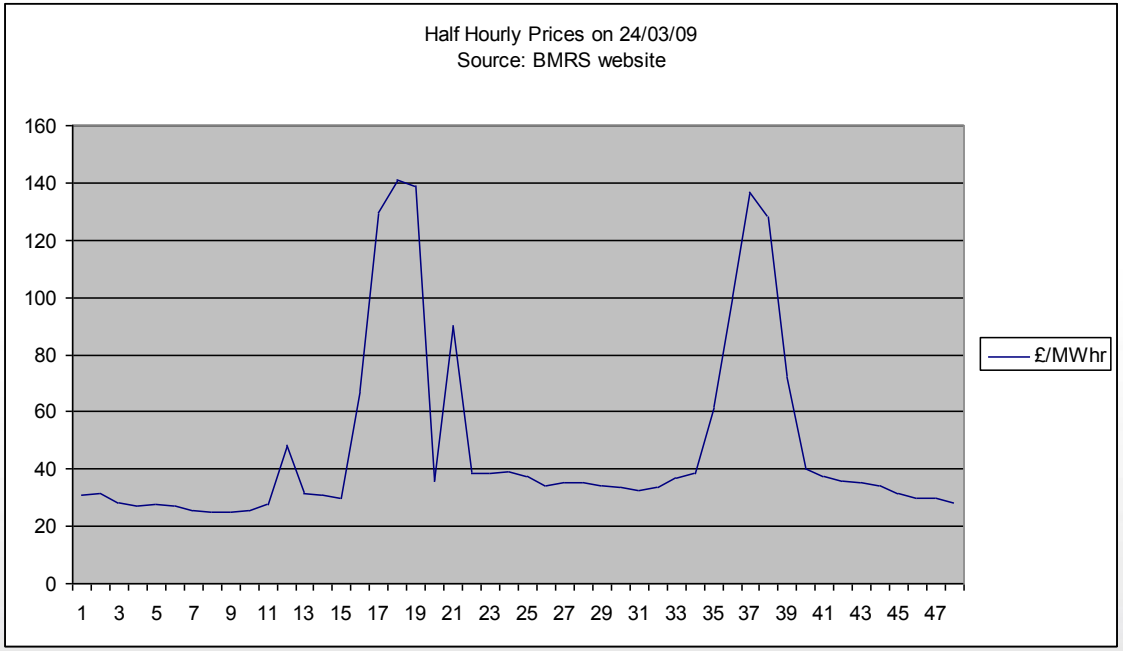
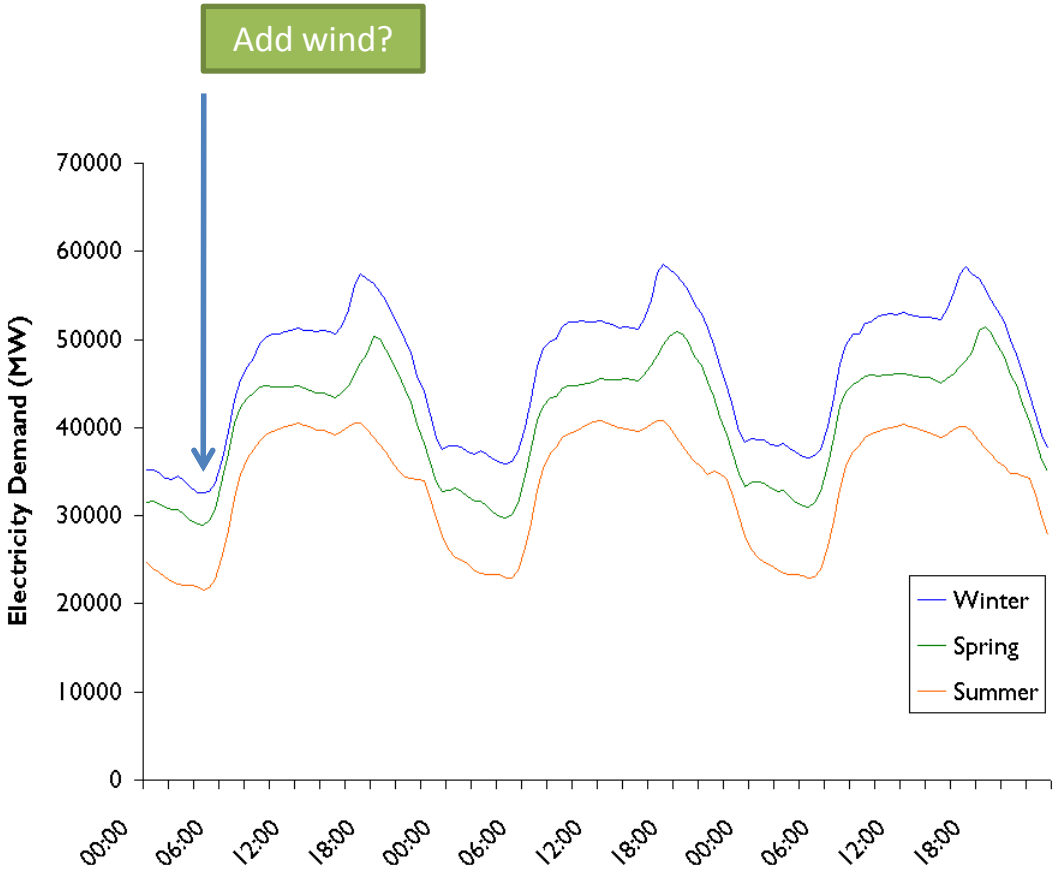


The Balancing Mechanism Reporting System (BMRS)
The BMRS website provides near real time and historic data about the Balancing Mechanism which is used by the National Grid (System Operator) as a means of balancing power flows on to and off the electricity Transmission System in the UK.

UK Electricity Demand

Adding Intermittent Power:

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

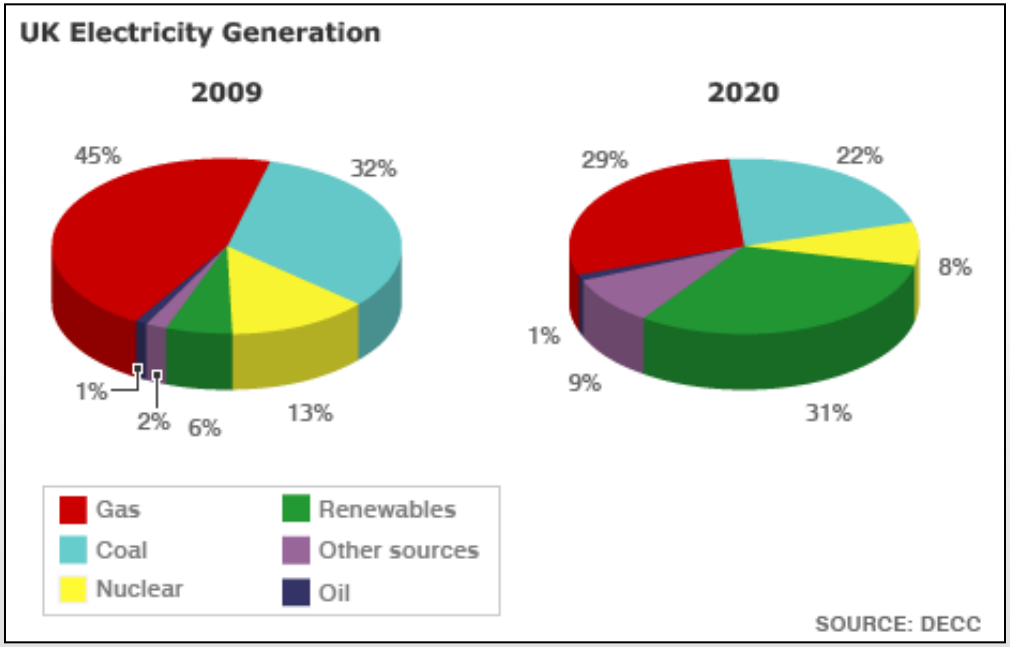


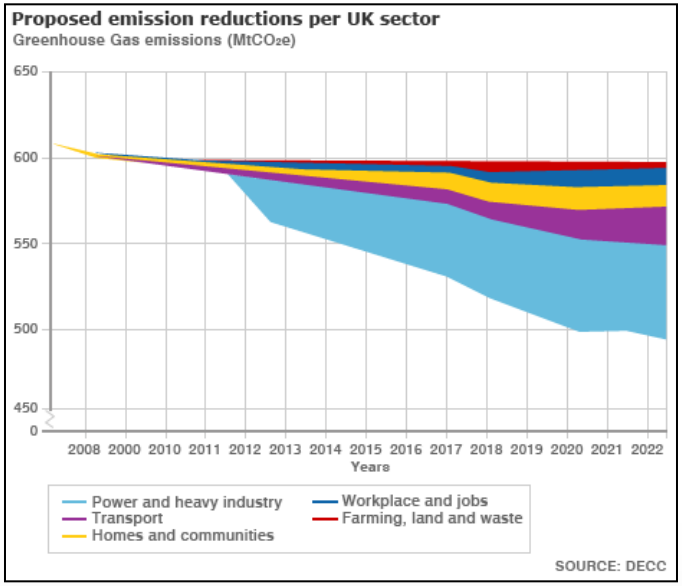
Data from National Grid

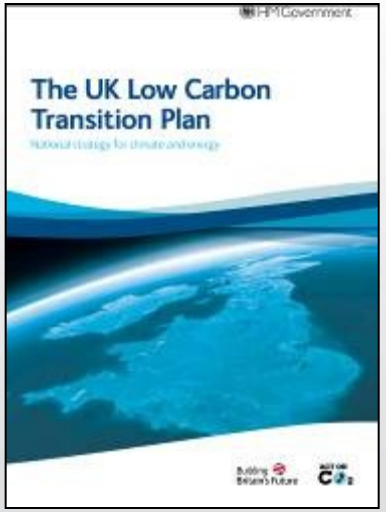
UK Generation

CO_2 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!







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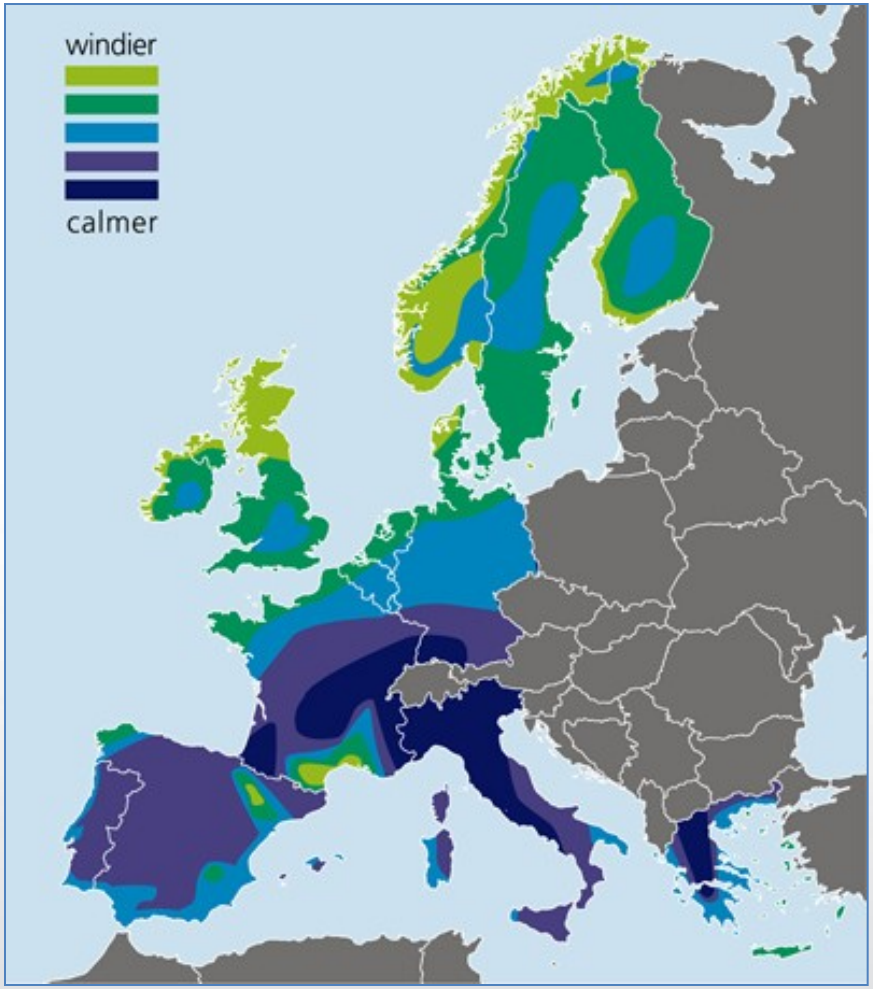
Wind Energy: The UK

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

RECHARGE the global source for renewable energy news

Subs

WIND SOLAR BIOMASS WAVE / TIDAL / HYDRO GEOTHERMAL POLITICS FINANCE

Politics

Photograph: Recharge

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.

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Storing Renewable Energy

Supply Chain Logistics

Adding energy storage to the logistics:

- Five elements are dynamically balanced
- Energy storage is additive

Bulk Energy Storage

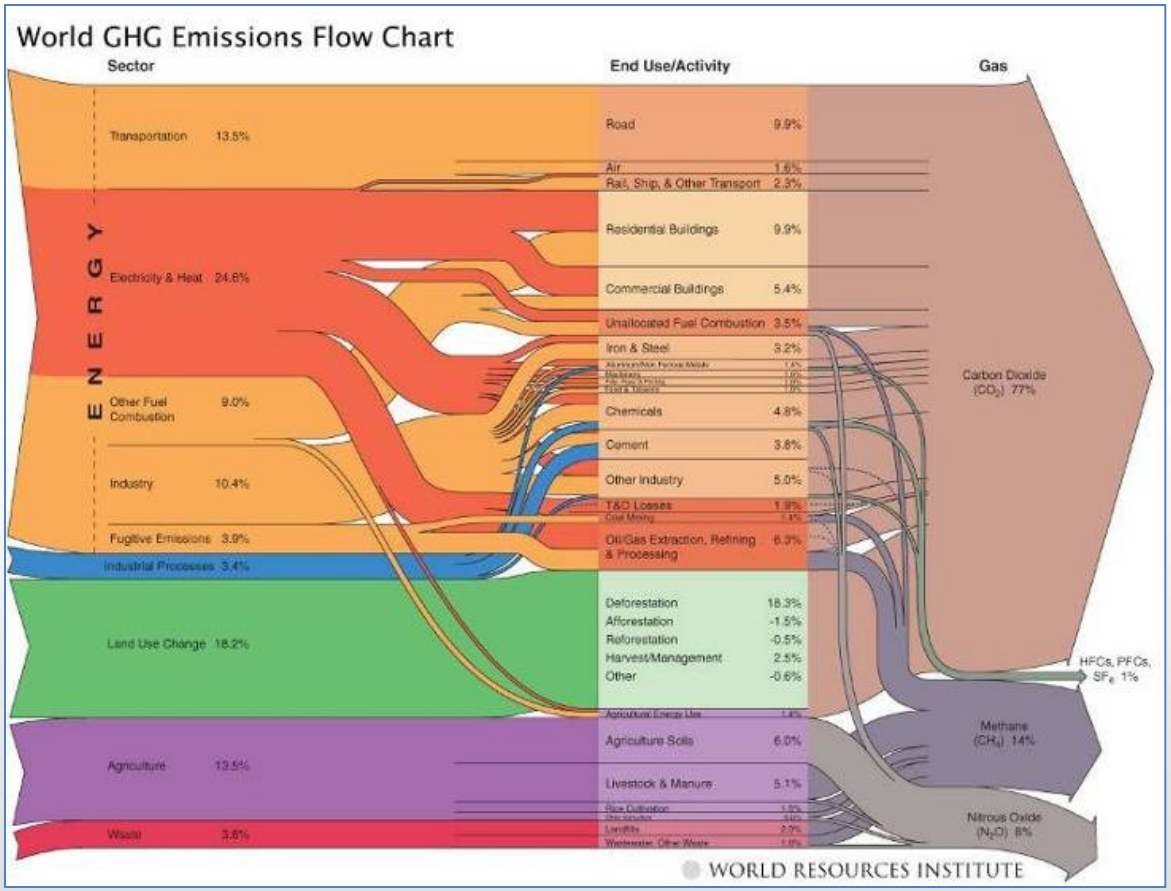
Fuel → Generation → Transmission → Distribution → Customer Services

Distributed Energy Storage

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



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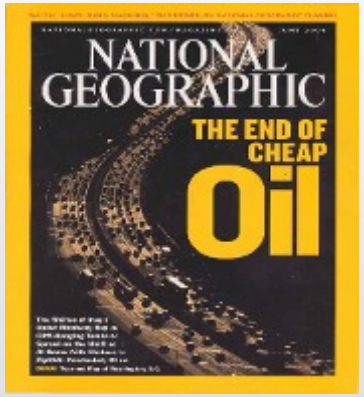
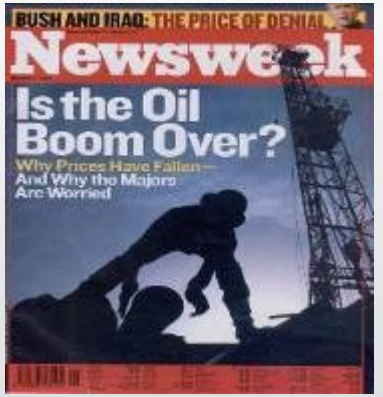
Drivers for a Clean Fuel

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

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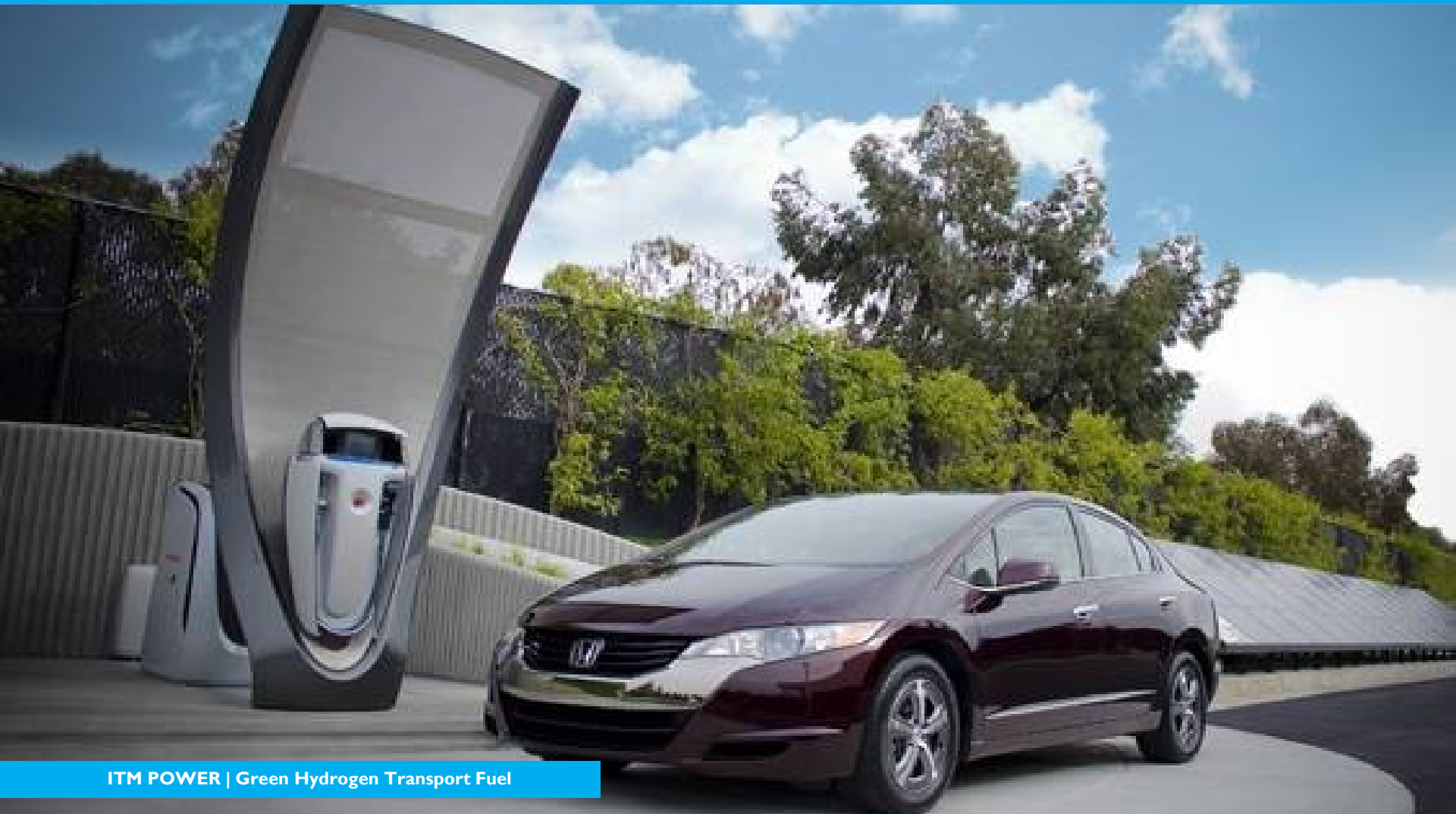
The Vehicles



Hydrogen Fuel Cell Vehicles

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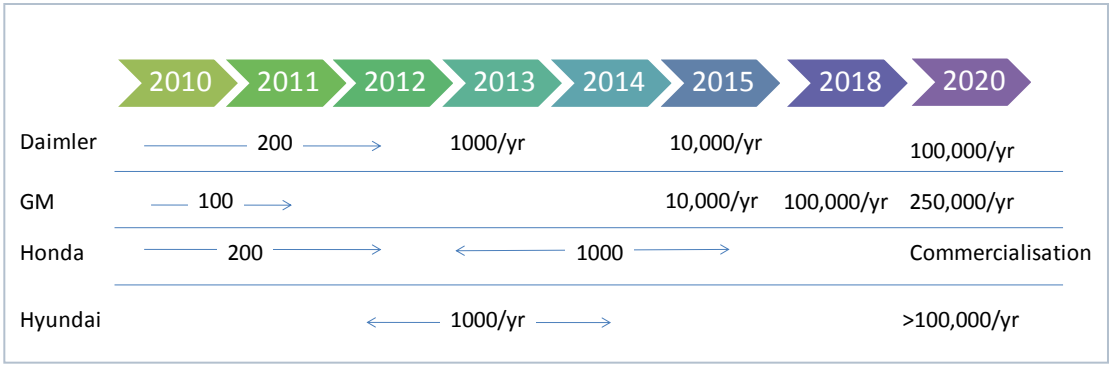
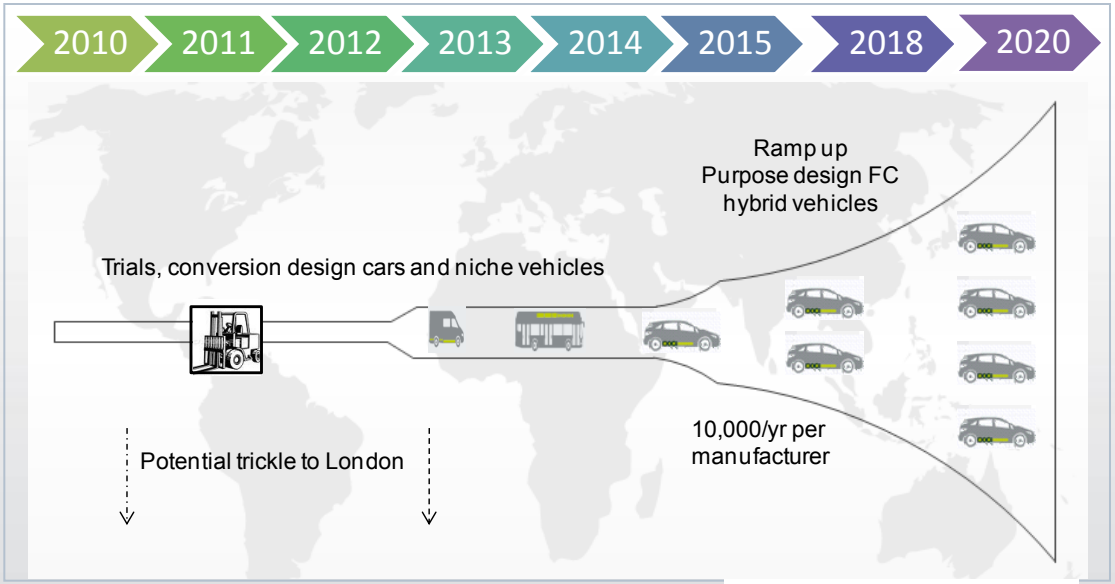
Hydrogen Cars

Serious Traction envisaged around 2015

- Air quality may drive early adoption
- Commercial fleet early adoption





elementenergy

Hydrogen Internal Combustion Engine (HICE) Vehicles

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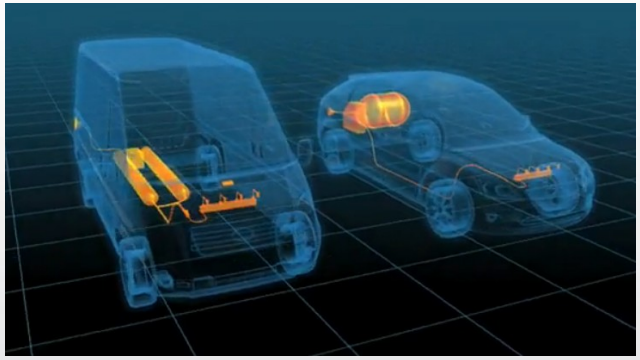
ITM Power HICE Ford Focus

A Pragmatic Stepping Stone

- Low cost
- Uses existing technology
- Breaks the 'chicken and egg' scenario



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Technology Strategy Board

The HOST Programme

Hydrogen On-Site Trials

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Revolve HICE Ford Transit vans

Hydrogen Internal Combustion Engine Transit Vans

Technology Strategy Board

revolve
The centre of excellence

LCV 2010

cenex

The Revolve Ford Transit Van

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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

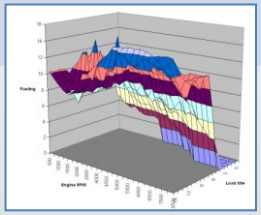
cenex

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 ~ 10hp
- 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

The Revolve Ford Transit Van

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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

cenex

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

DVLA

VOSA Vehicle & Operator Services Agency

VCA

Driver & Vehicle Agency

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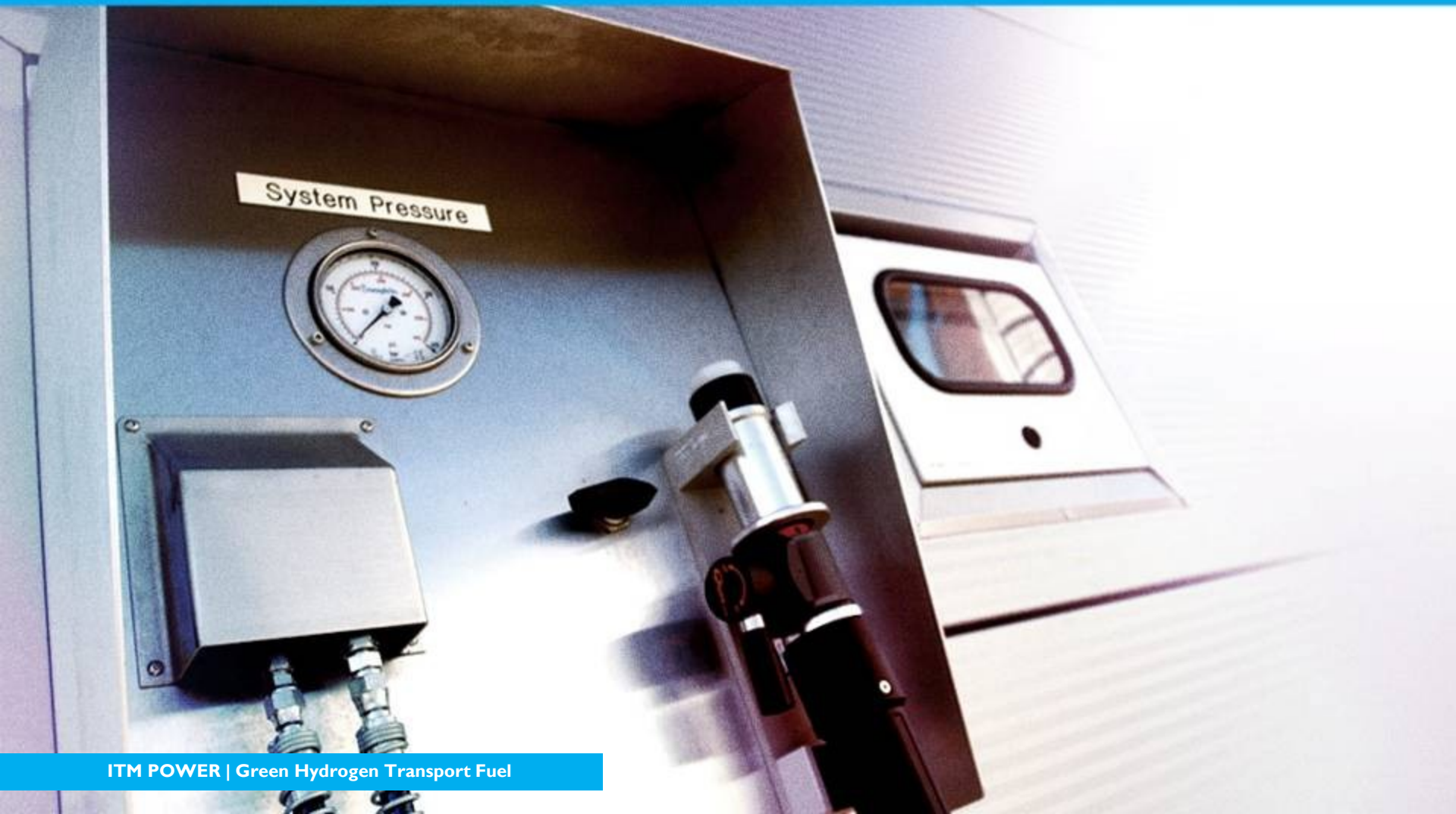
The Refuelling Infrastructure



Hydrogen Refuelling Infrastructure

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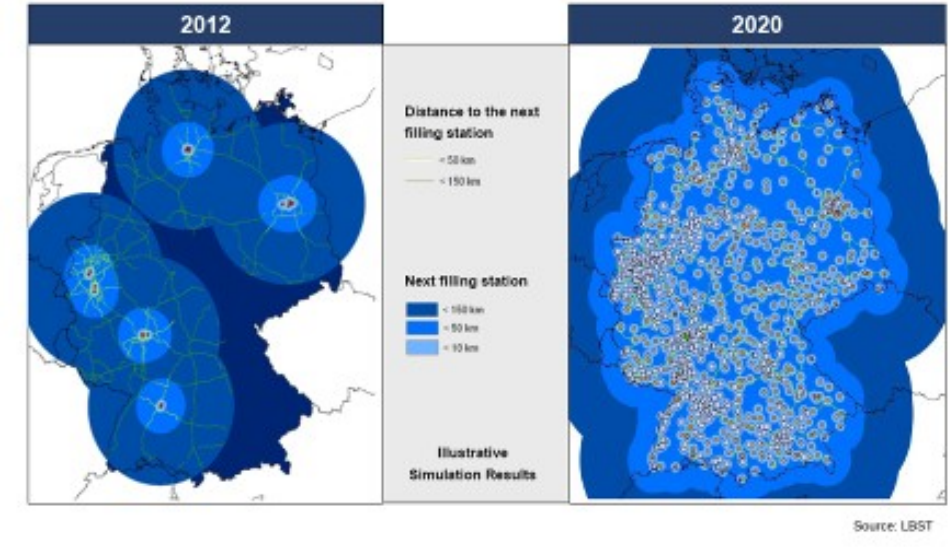
Hydrogen Cars – Infrastructure

Germany leads the way

- FC Vehicle LoI signed 2009
- H_2 infrastructure MoU signed 2009
- 1,000 refuelling stations by 2015



HONDA RENAULT NISSAN TOYOTA
DAIMLER Ford GM OPEL KIA

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

DAIMLER EnBW THE LINDE GROUP
OMV VATTENFALL TOTAL NOW Nationale Organisation Wasserstoff-

- H_2-mobility project for infrastructure in Germany
- MoU signed 2009

Hydrogen Refuelling

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HPRU – 2009

Stationary High Pressure Refueller

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

Hydrogen Refuelling

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HPRU – 2009

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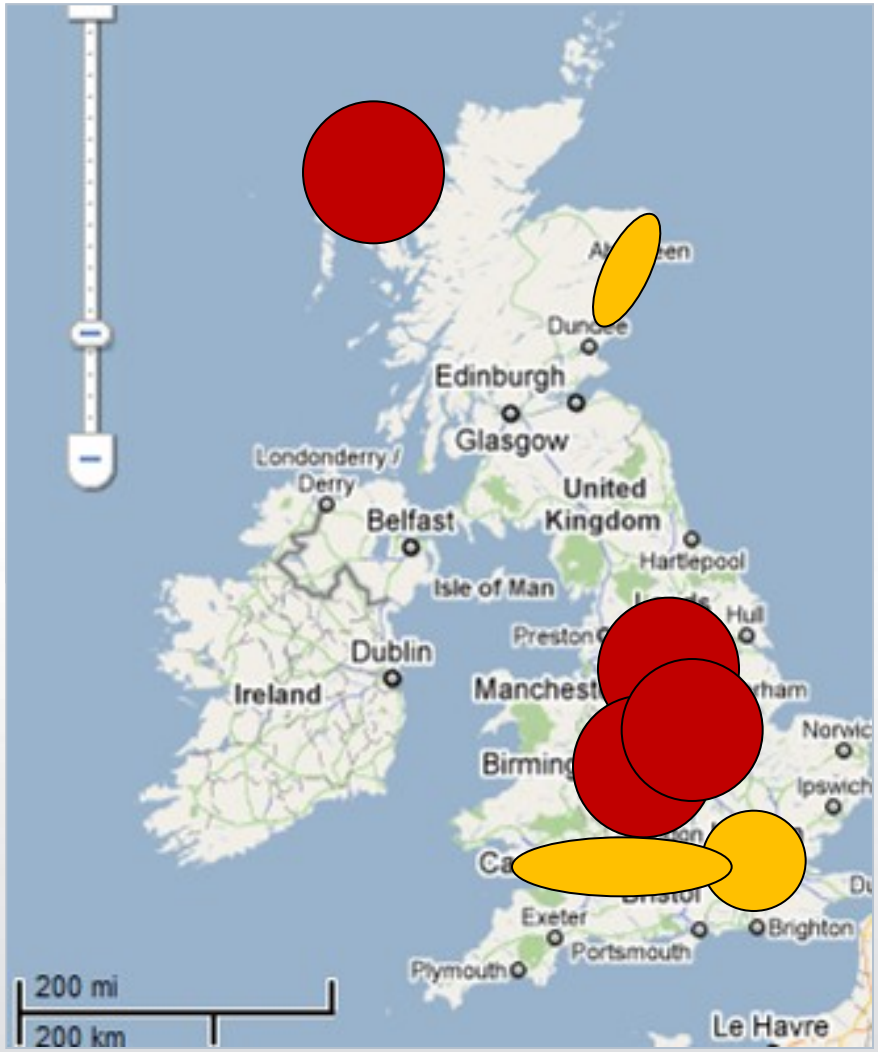

Hydrogen Refuelling | Infrastructure

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Technology Strategy Board

HFuel® – 2010

Hydrogen Fuel infrastructure unit

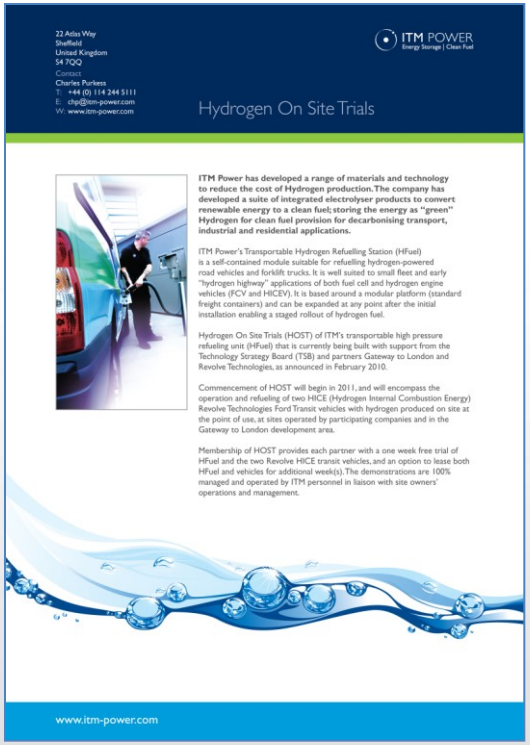
- HFuel 15kg/day, rapid cascade refuelling at 350 bar
- Flexible, modular and transportable refuelling unit
- Targeted at the urban commercial fleet market
- Part funded by TSB

HOST | Plan

Hydrogen on Site Trial

Trials begin Q1 2011

- Scheduled in signing order
- Simple contract
- Seeking further partners



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Hydrogen On Site Trials

ITM Power has developed a range of materials and technology to reduce the cost of Hydrogen production. The company has developed a suite of integrated electrolyser products to convert renewable energy to a clean fuel; storing the energy as "green" Hydrogen for clean fuel provision for decarbonising transport, industrial and residential applications.

ITM Power's Transportable Hydrogen Refuelling Station (HFuel) is a self-contained module suitable for refuelling hydrogen-powered road vehicles and forklift trucks. It is well suited to small fleet and early "hydrogen highway" applications of both fuel cell and hydrogen engine vehicles (FCV and HICEV). It is based around a modular platform (standard freight containers) and can be expanded at any point after the initial installation enabling a staged rollout of hydrogen fuel.

Hydrogen On Site Trials (HOST) of ITM's transportable high pressure refueling unit (HFuel) that is currently being built with support from the Technology Strategy Board (TSB) and partners Gateway to London and Revolve Technologies, as announced in February 2010.

Commencement of HOST will begin in 2011, and will encompass the operation and refueling of two HICE (Hydrogen Internal Combustion Energy) Revolve Technologies Ford Transit vehicles with hydrogen produced on site at the point of use, at sites operated by participating companies and in the Gateway to London development area.

Membership of HOST provides each partner with a one week free trial of HFuel and the two Revolve HICE transit vehicles, and an option to lease both HFuel and vehicles for additional week(s). The demonstrations are 100% managed and operated by ITM personnel in liaison with site owners' operations and management.

www.itm-power.com

Hydrogen Refuelling | HOST

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Hydrogen on Site Trial

Trials begin Q1 2011

- Scheduled in signing order
- Simple contract
- Seeking further partners

Gateway to London

Forestry Commission

SCOTTISH WATER

DHL

Sheffield City Council

SSE

BAA Stansted

Camden

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Chain of Influence

Ministers need positive solutions to huge problems

Scotland

- Stewart Stevenson (Transport)
- Jim Mather (Energy & Climate)

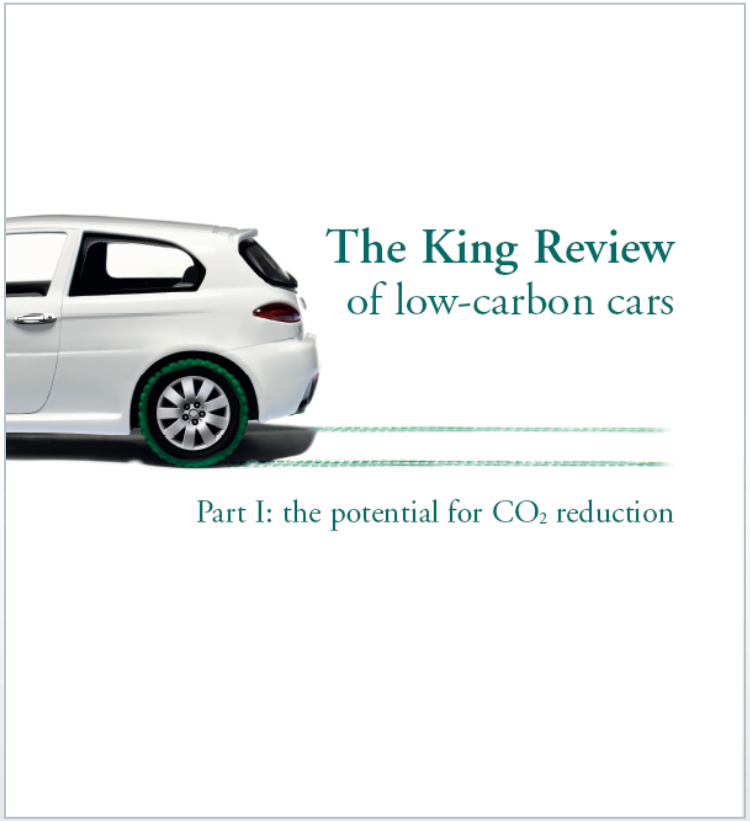
Westminster

- Norman Baker (DoT)
- Chris Huhne (DECC)

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



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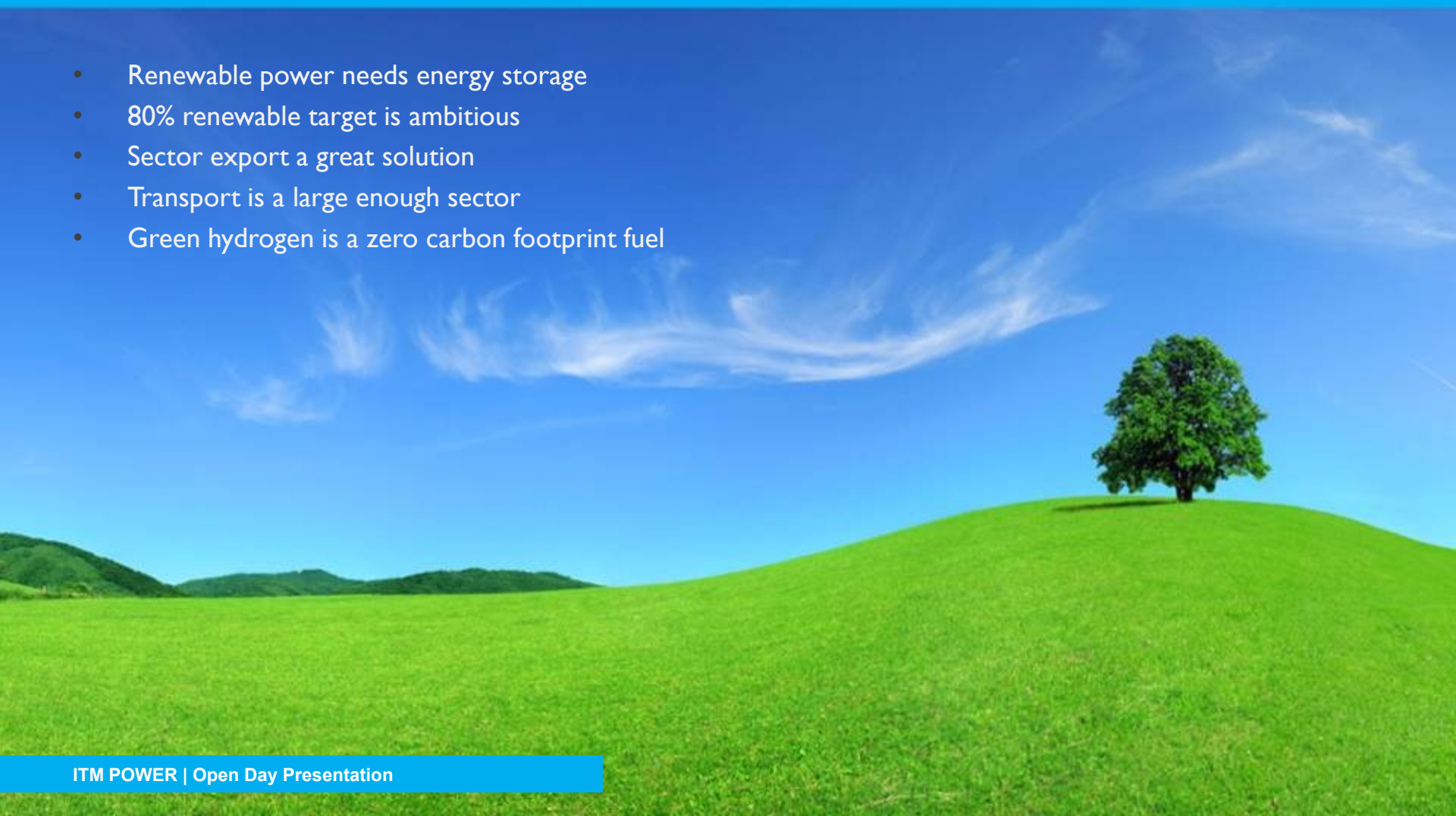
- Renewable power needs energy storage
- 80% renewable target is ambitious
- Sector export a great solution
- Transport is a large enough sector
- Green hydrogen is a zero carbon footprint fuel