POWER TO GAS - ENABLED LOCAL ENERGY SYSTEMS

BRISTOL, 20TH MAY 2015

ITM POWER
Energy Storage | Clean Fuel

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- Summary

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ITM POWER PLC

DESIGN AND MANUFACTURE ENERGY STORAGE & CLEAN FUEL SYSTEMS

ITM Power | History

- First AIM listed fuel cell & hydrogen company
- 2004 IPO | £10m | ITM.L
- 2006 Secondary | £30m
- 2012 -14 Expansion | £17m
- 2015 JCB £4.9m Strategic Investment
- Two facilities in Sheffield | 70 staff
- Manufacturing business model

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MARKET OFFERING

Rapid Response | High Pressure | High Efficiency | MW scale

- Rapid response: less than 2s; for primary grid balancing
- High pressure: up to 80bar; for direct injection
- High efficiency: 75% measured by third parties in the field
- MW scale: 1MW modules available today
- Compliant: EU, USA and Asia

REGULATIONS, CODES & STANDARDS

A leading role in shaping hydrogen deployment

- Secretary of BCGA Technical Steering Committee 9
- Secretary and UK Expert to ISO Technical Committee 197
- UK Expert to ISO working groups…
- …for electrolysers, dispensers & H2 quality
- Next Chair of BSI PVE/3/8

Code of Practice 41: H_2 Fuelling Stations
Design & Construction
Maintenance & Operation

ISO 19880-1: H_2 Fuelling Stations
ISO 22734: Electrolyser
ISO 14687: H_2Quality

BSI PVE/3/8: H_2 Systems Standardisation
Production & Storage
Transport, Measurement & Use

CLEAN FUEL | ENERGY STORAGE | RENEWABLE HEAT

Three massive emerging markets for PEM Electrolysers


Wind Power


Grid


Solar Power


Electrolyser


Clean Fuel


Energy Storage


Renewable Heat

RAPID RESPONSE INTEGRATION

HYDROGEN ENERGY SYSTEMS

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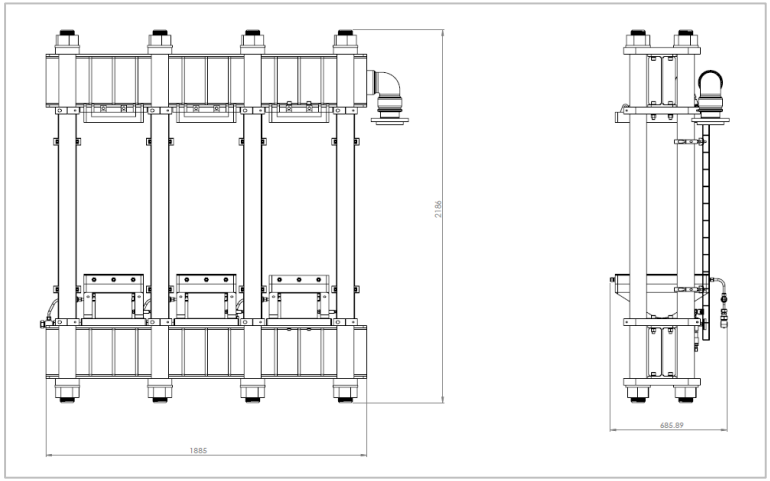
1MW P2G SKID | HANNOVER LAUNCH

New 1MW Skid | 3 x 350kW stacks

- Hannover launch April 2015
- Smallest 1MW on the market
- Based on the new 350kW stack
- Rapid response | Modular unit
- Developing projects now



1MW P2G SKID | HANNOVER LAUNCH

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ENERGY STORAGE

THE NEED
THE MARKET

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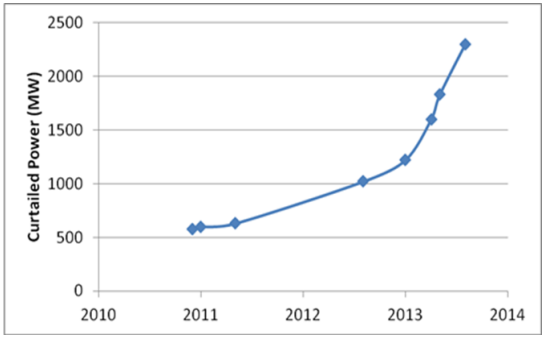
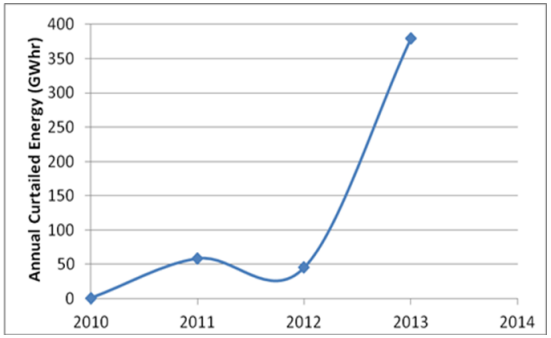
RES CURTAILMENT INCREASINGLY COMMON

Wind curtailment is a growing problem for TSOs

- Priority of dispatch: merit order effect (MOE)
- High curtailment payments available in the UK
- An increasing problem across Europe
- Problems start at 20% capacity; UK hit this threshold at the end of 2013
- Solved by energy storage e.g. Power-to-Gas (P2G)





The Telegraph

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Scottish wind farms paid £1 million to shut down one day

Wind farm companies operating in Scotland were paid more than £1 million to shut down their turbines for a single day last month, it has emerged.

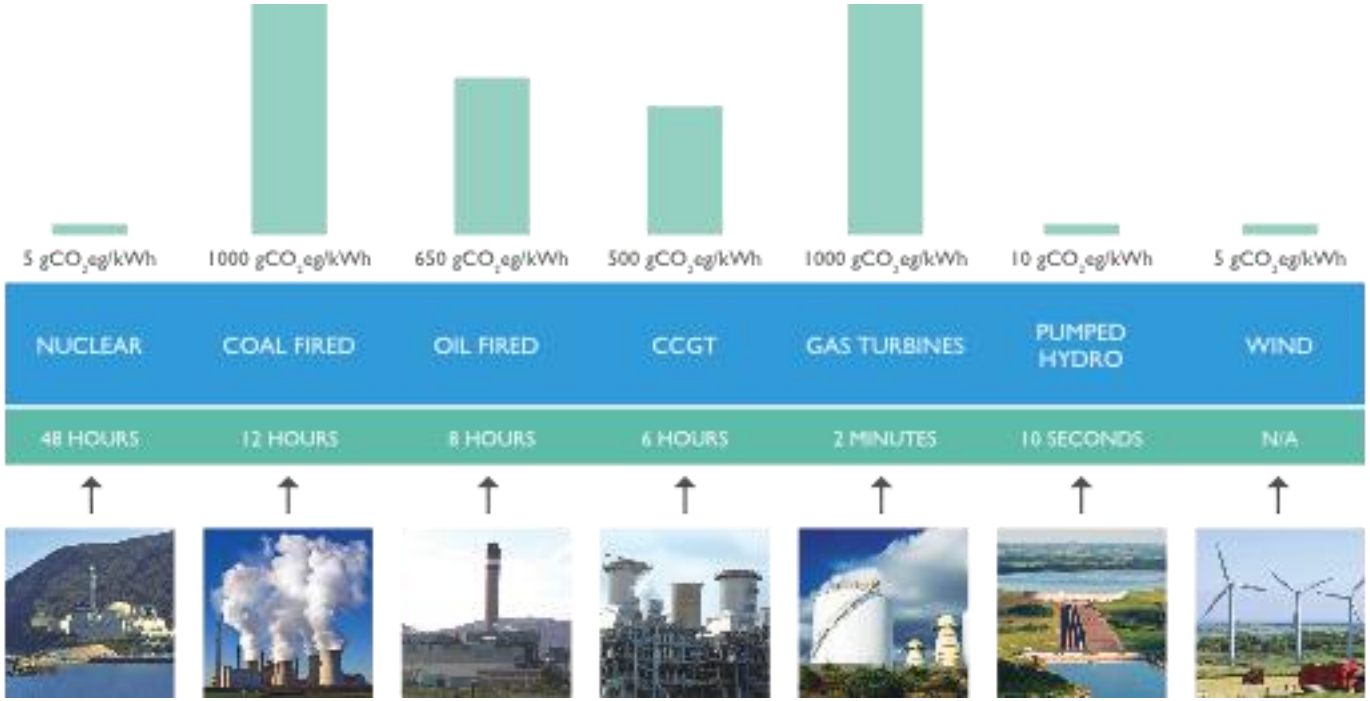
Wind farm companies receive constraint payments to switch off their turbines when supply exceeds demand Photo: PA

By Simon Johnson, Scottish Political Editor
12:38PM BST 05 May 2013

Print this article

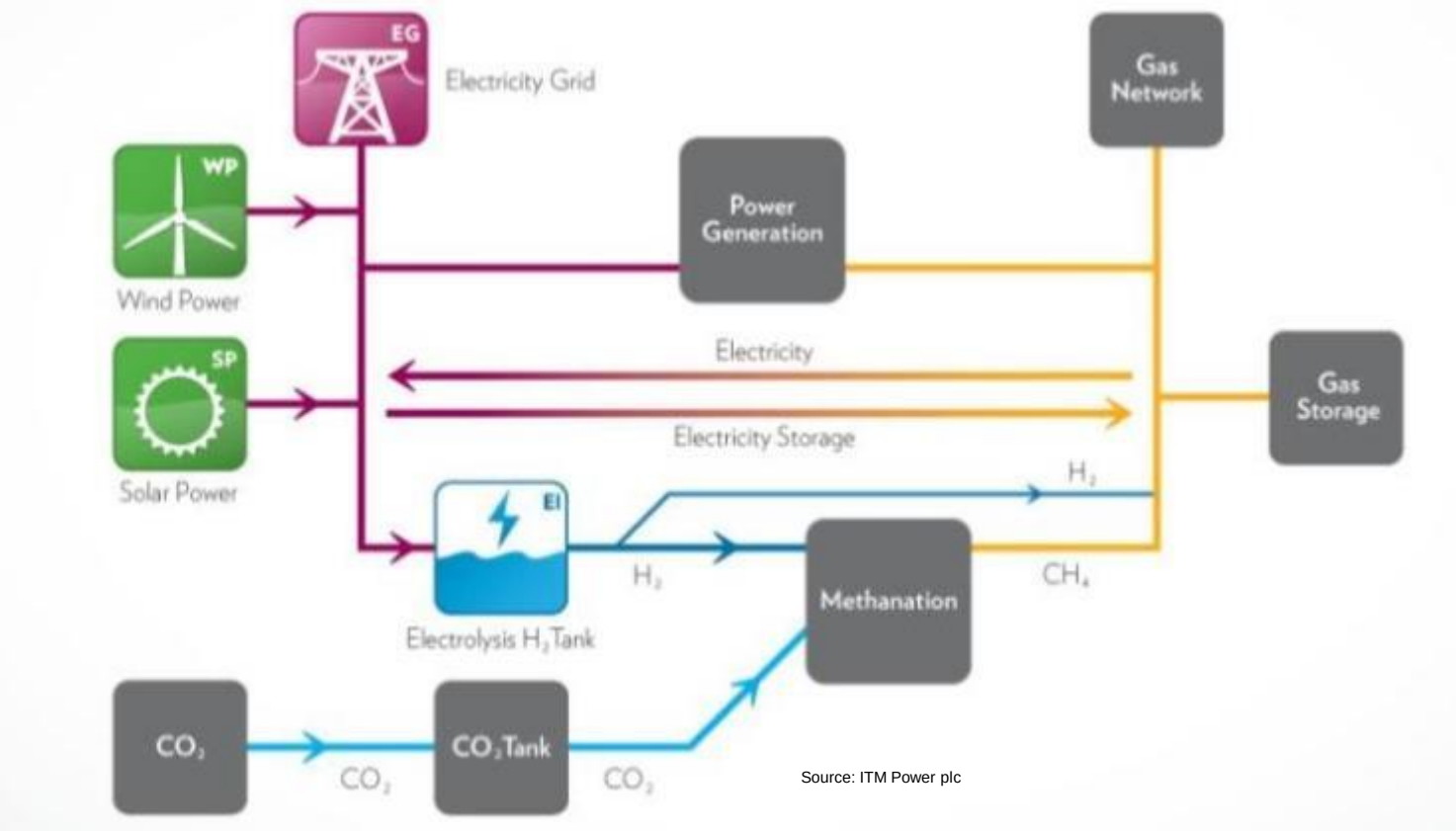
BALANCING SUPPLY AND DEMAND:

- A total of £725m paid for balancing services in 2010–11
- Estimates in 2020 are: circa £1.9bn – £5.9bn pa
- Tariffs already operational in the UK: FCDM response sub 2 seconds



WHY POWER-TO-GAS?

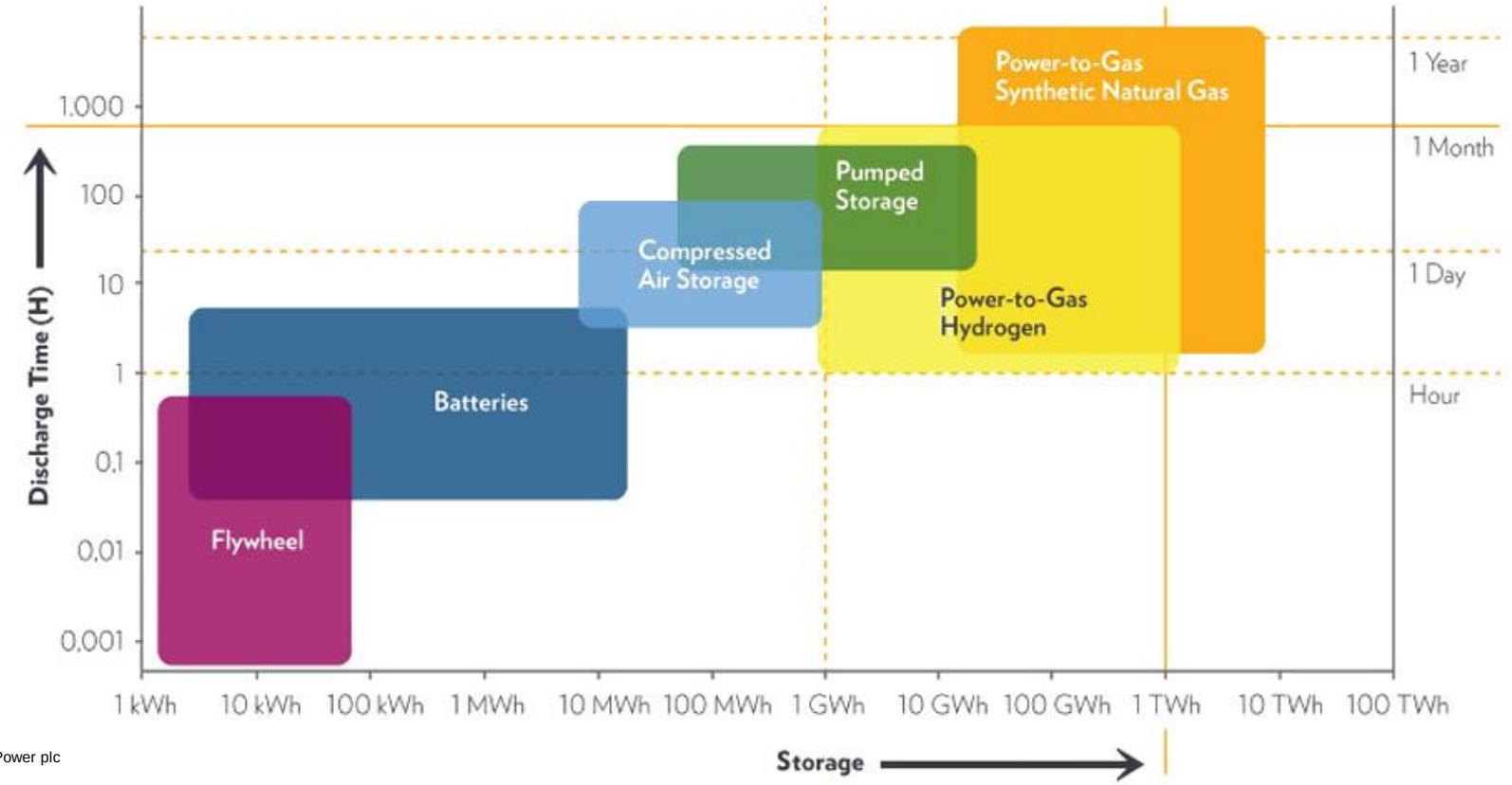
Electricity cannot be stored easily | Hydrogen can be stored easily in the gas grid



Source: ITM Power plc

ENERGY STORAGE TECHNOLOGIES

Power-to-gas is efficient | long term | low energy cost



Source: ITM Power plc

ENERGY STORAGE TECHNOLOGIES

ENERGY STORAGE | CLEAN FUEL

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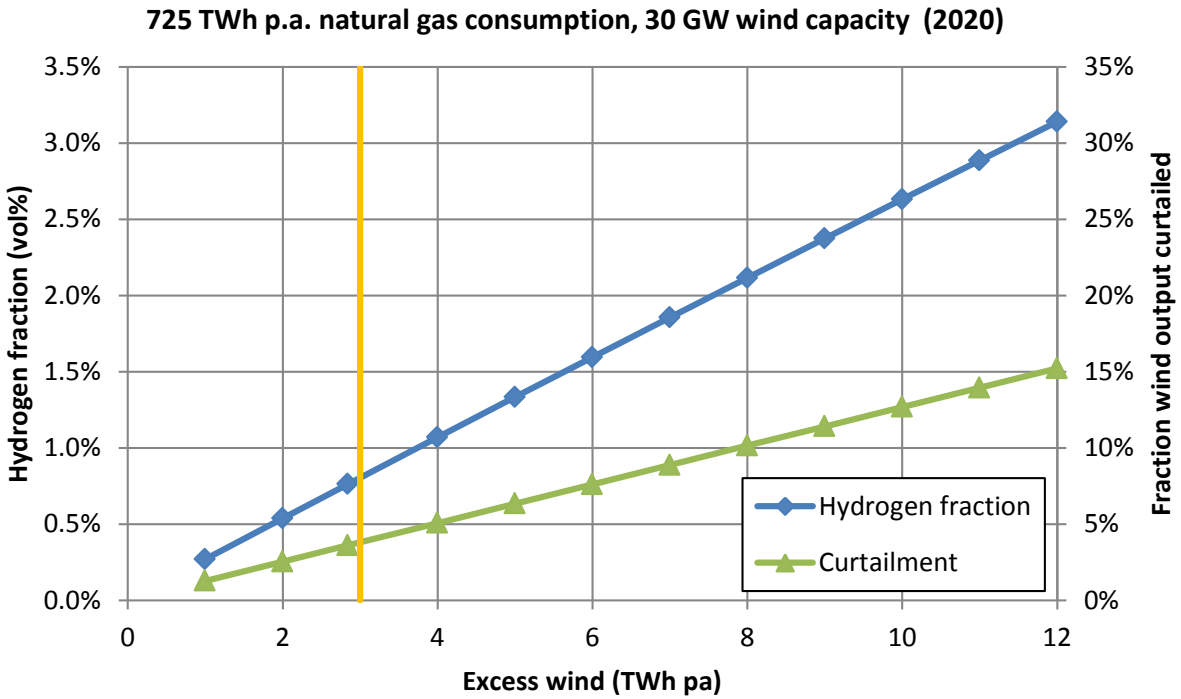
HYDROGEN FRACTION VS EXCESS WIND LEVELS

- Capturing 2.8 TWh pa of excess wind (ie 4% of 2020 output)
- Requiring 978MW of electrolysis at 30% utilisation
- Results in average national hydrogen content of 0.5%, reducing carbon footprint by 0.2%

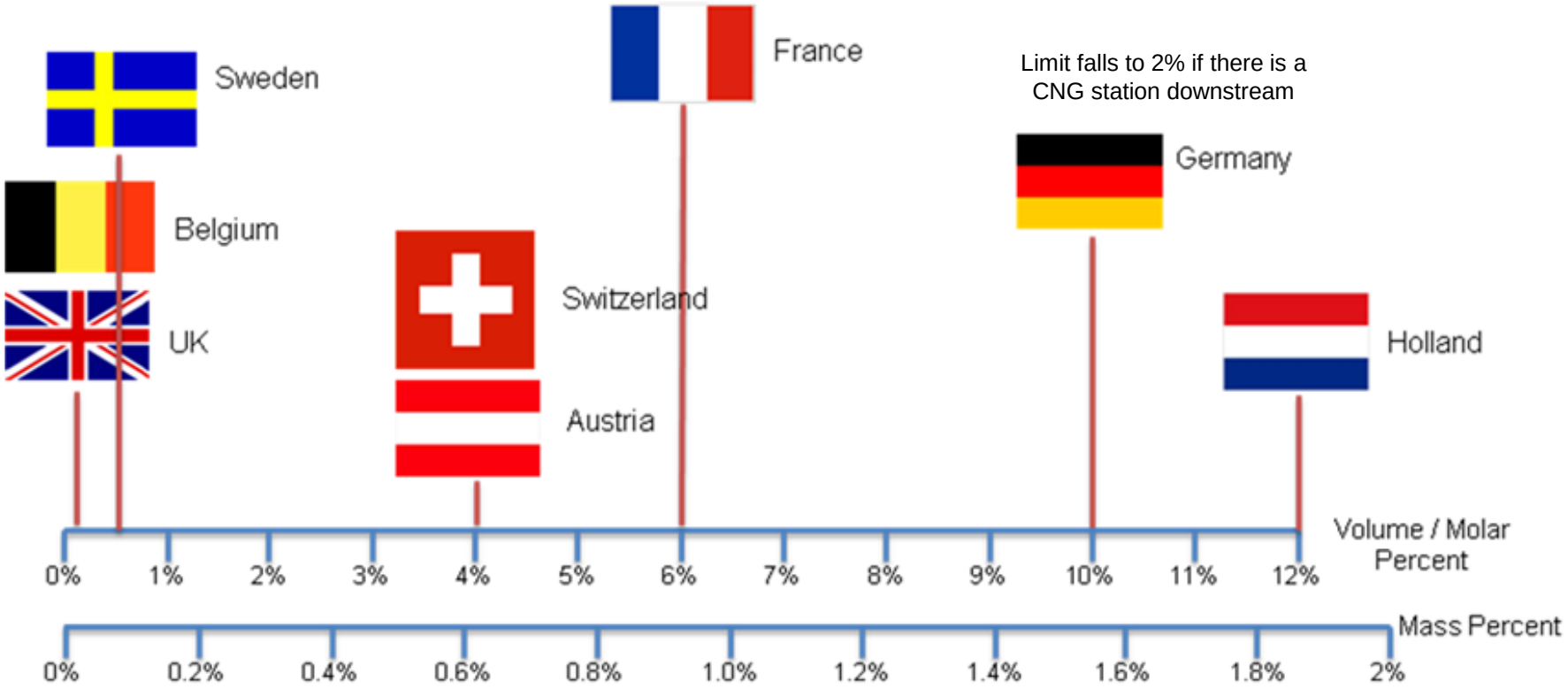


Source: ITM Power plc

EU Hydrogen Limits for Injection into the HP Gas Grid

Covered by a range of local laws and EU Directives

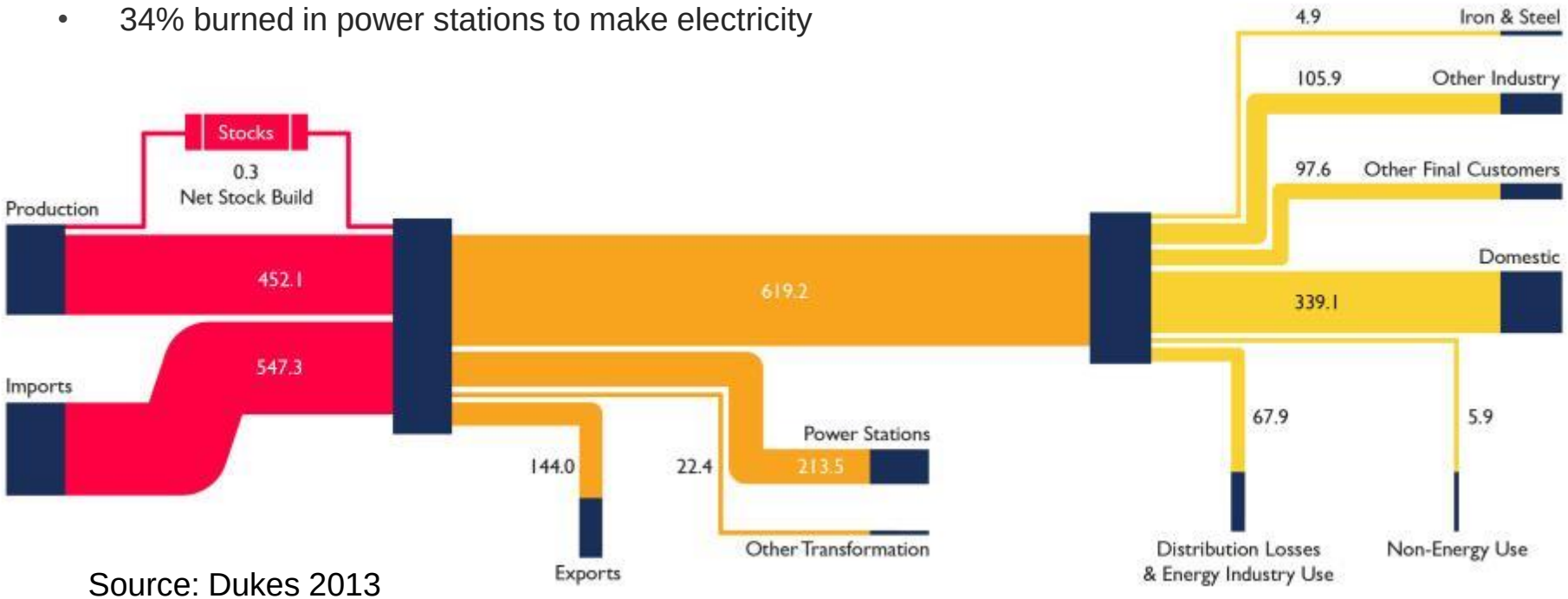
Note: interpretation of these rules is complex



GAS USAGE IN THE UK (DUKES 2013)

Where does the gas go?

- 906 TWh of natural gas consumed in the UK in 2011
- 52% was used to provide heat
- 34% burned in power stations to make electricity



Source: Dukes 2013

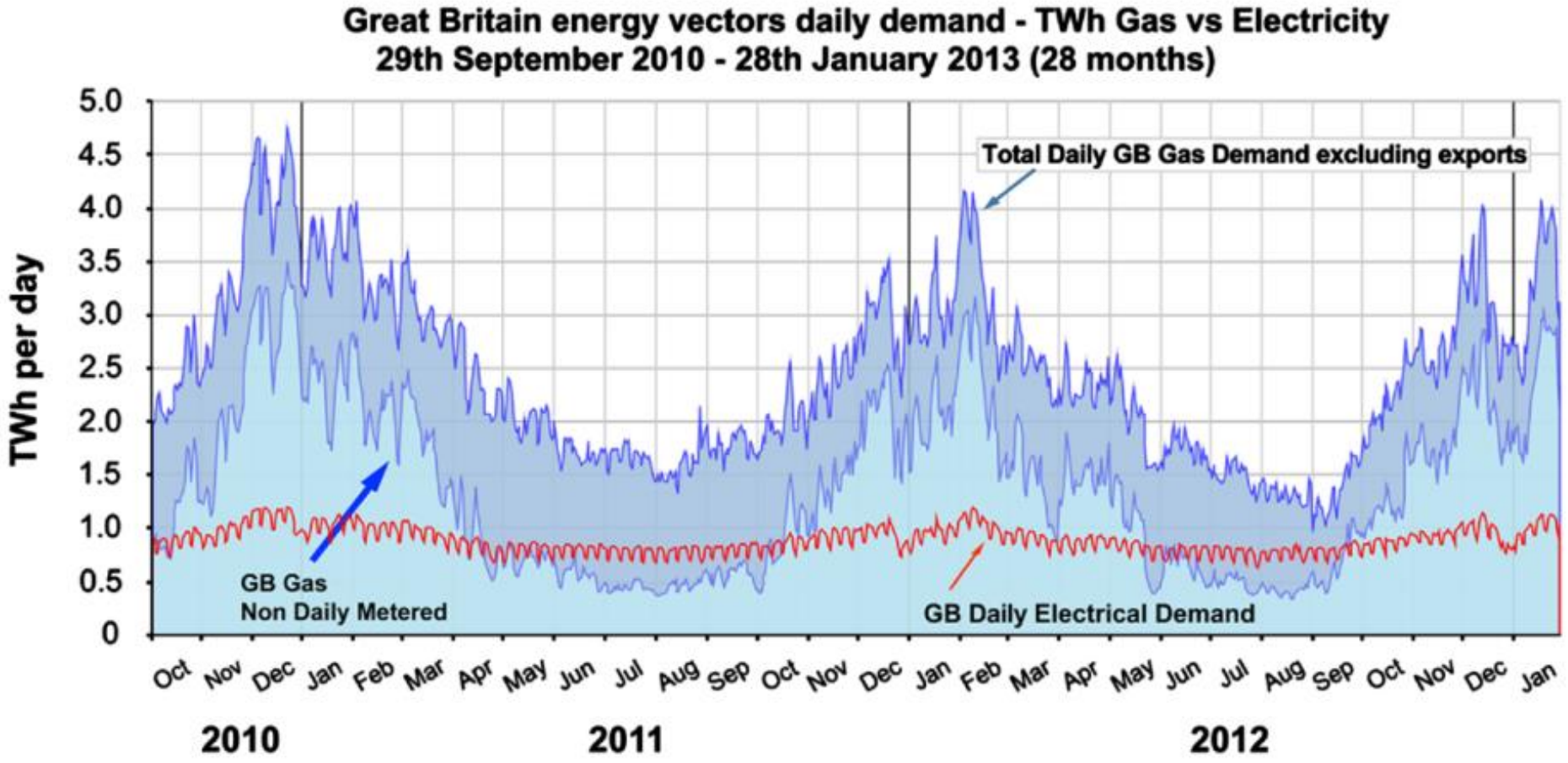


Fig. 1. Daily GB Gas and Electricity Demands (TWh). Data sourced from National Grid website (NGDIE, 2013; MHHED, 2013).

ELECTRIFY HEAT?

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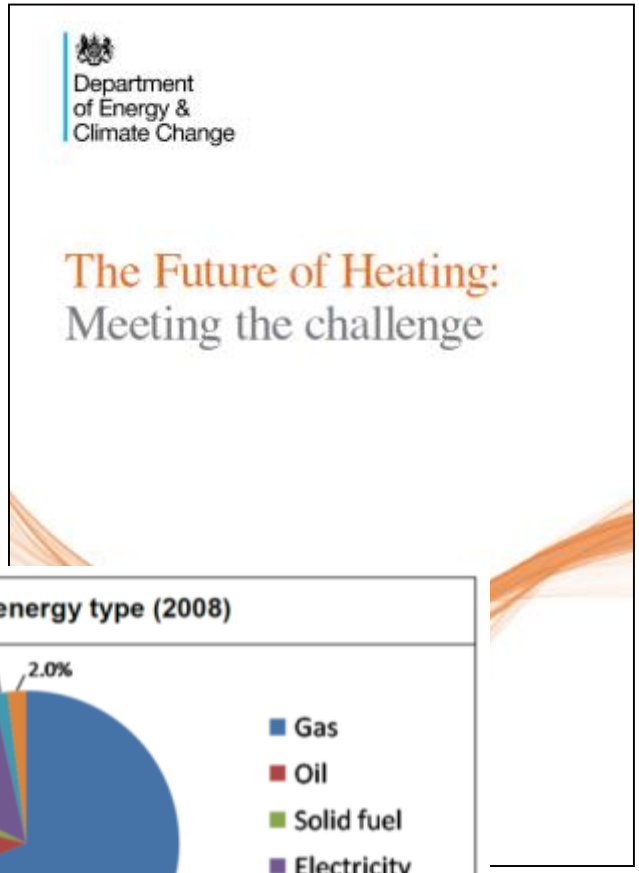
DECC: UK HEAT STRATEGY

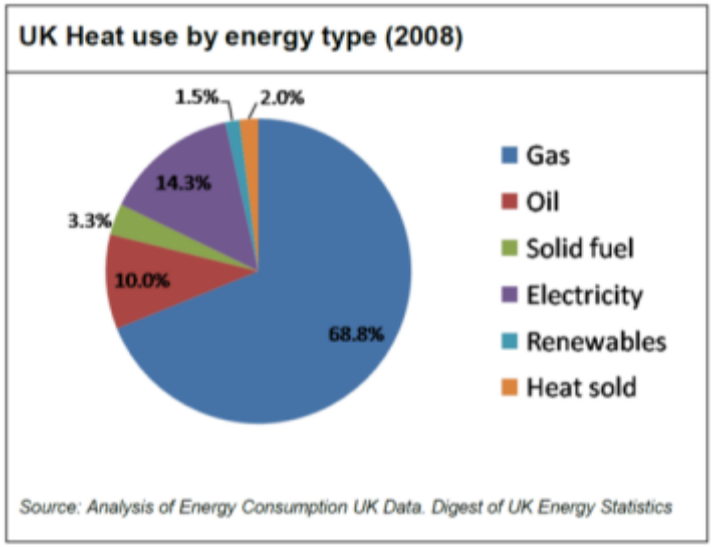
The Future of Heating: Meeting the challenge

- 70% of UK heat comes from natural gas
- Low penetration of renewable heat in the UK

RHI launched Nov. 2011

- 12% of heating from renewables by 2020
- 57 TWh hydrogen
- Circa 18,600 MW Electrolysis





DECC: UK HEAT STRATEGY

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P2G: ELEMENTS OF VALUE

- Value to the power grid
- Value to the gas grid
- Value to the economy

Value to the Power Grid

- Avoided wind curtailment
- Avoided infrastructure upgrades
- Reduced reserve power
- Reduce CO_2 from open cycle GTs
- Absorbing reactive power

Value to the Gas Grid

- Decarbonising gas
- Providing renewable heat
- Reducing GHG emissions from gas transportation

Value to the UK Economy

- Reducing fuel imports
- Improved energy security
- Creating jobs in manufacturing

P2G: ELEMENTS OF VALUE

P2G PLANT & VISITOR CENTRE

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ONE YEAR ON…….

The only rapid response PEM electrolyser plant to be injecting hydrogen into the gas distribution network

- Passed its first annual re-assessment by TUV Hessen
- Thüga report that the system:
  - Able to participate in the secondary power market
  - Capable of offering grid balancing services
- Tariffs increase the economic viability

TÜV HESSEN

thüga DIE ENERGIEGRUPPE

THE FEEDBACK

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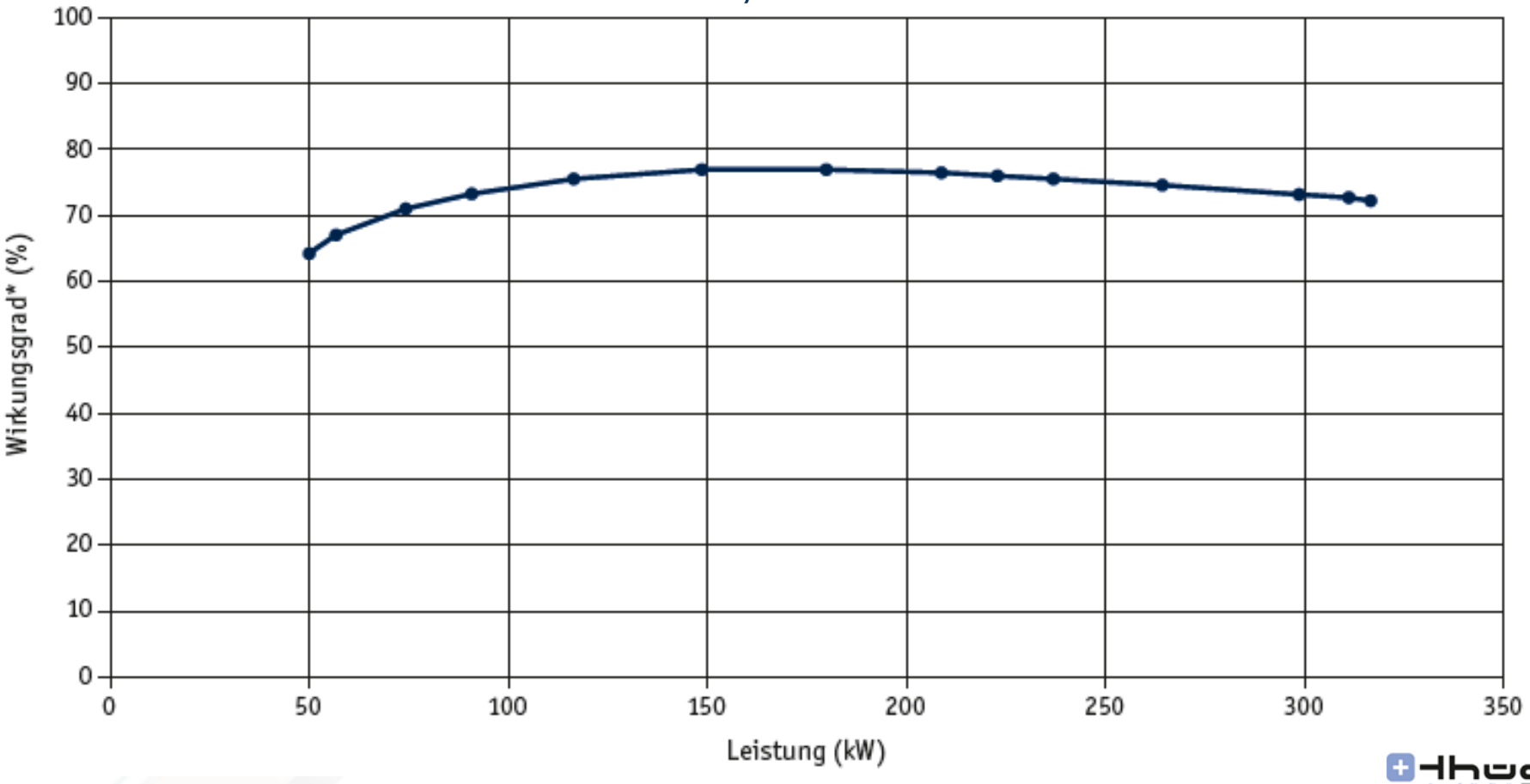
SYSTEM EFFICIENCY:
ELECTRICAL ENERGY IN, CHEMICAL ENERGY OUT



* Die angegebenen Werte zum Wirkungsgrad sind auf den Brennwert bezogen / Quelle: Thüga

THÜGA P-2-G TOTAL SYSTEM EFFICIENCY

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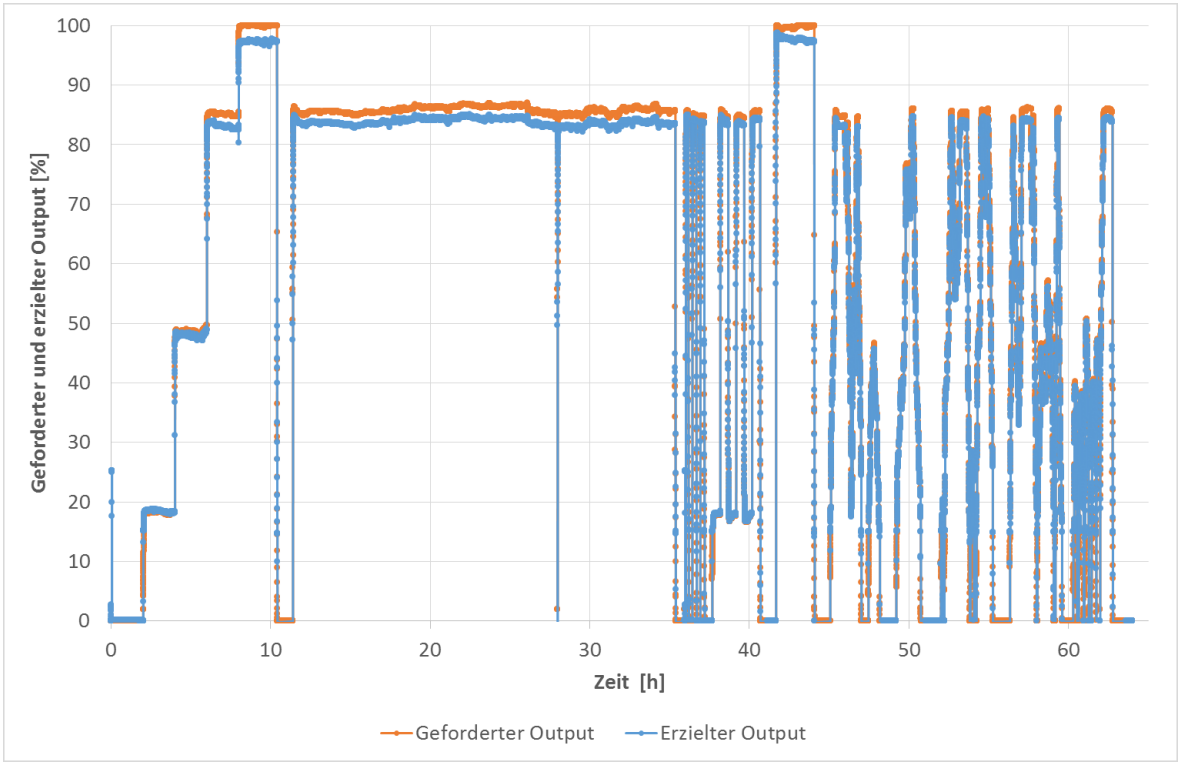
LOAD FOLLOWING

Rapid response Electrolysis

- Full system test program
- Set Point v's Actual (blue)
- Multiple start/stop tests
- Load modulation for full range
- Challenge system reliability
- Validate system to assimilate intermittent renewable power



RWE

ITM Power's HGas System was delivered to RWE within 10 weeks of receiving the order, which was won as part of a competitive tender. The system is a second generation ITM Power PEM electrolyser system using a higher current density, permitting higher hydrogen output per stack. The system efficiency is also increased by simplification of the balance of plant.

ON-SITE HYDROGEN PRODUCTION

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POWER-TO-GAS IN UK

National Grid | AMEC

- Grid Gas: NG | SSE | Shell
- NG/AMEC 1: Feasibility study | £120k funded by NG
- 200/300 x Multi-MW opportunities in the UK alone
- NG/AMEC 2: Contract to identify the first project sites

MARKET SIZE | NEW EU REPORT

Germany: 46 GW (£46bn) in 2030 | 115 – 170 GW in 2050

4.4 At realistic values of hydrogen, large installed electrolyzer capacity would be viable and able to utilize nearly all excess RES energy in the 2050 horizon

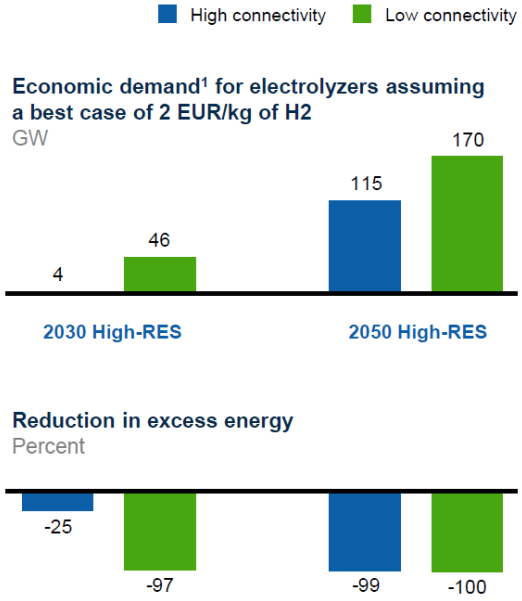
Germany archetype

Non-hydrogen P2P and heat storage will only be able to absorb a small part of the excess energy generated, resulting in the necessity of curtailment – from societal point of view, such electricity could be used at close to zero cost

The excess energy can be used to produce hydrogen via water electrolysis for re-electrification or use outside of the power sector

If the value of hydrogen at the point of production can reach a price in the range of 2-4 €/kg very large installed electrolyzer capacity would be economically viable and able to utilize nearly all of the excess electricity

Such use of the excess electricity would create value for the society and the surplus could be divided between the electricity and hydrogen producer



ABENGOA HIDROGENO · AIR LIQUIDE · AkzoNobel · ALSTOM · ECN · elementenergy · eurogas · GERG · HEDNO · HELLENIC PETROLEUM · HYDROGENICS · INABENSA · ITM POWER · THE LINDE GROUP · moixa · NEL HYDROGEN · NORTHERN POWERGRID · NOW · PROTON · PAE · REDT · res · Shell · SIEMENS · Statkraft · Statoil · sunfire · TATA CHEMICALS · VANADIS POWER · VATTENFALL · VOITH

REFUELLING STATIONS | P2G UNITS

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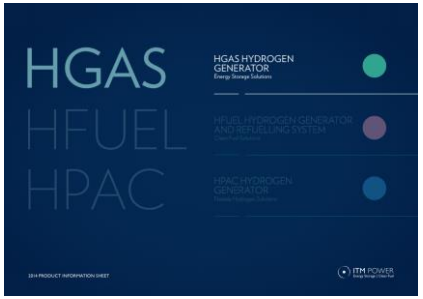
REFERENCE PLANT | GERMANY | UK | USA

A major barrier to entry overcome

- NRE has been invested
- Products have been standardised
- Compliance in UK | EU | USA
- Power-to-Gas and Refuelling Stations



REFERENCE PLANT

HYDROGEN ENERGY SYSTEMS

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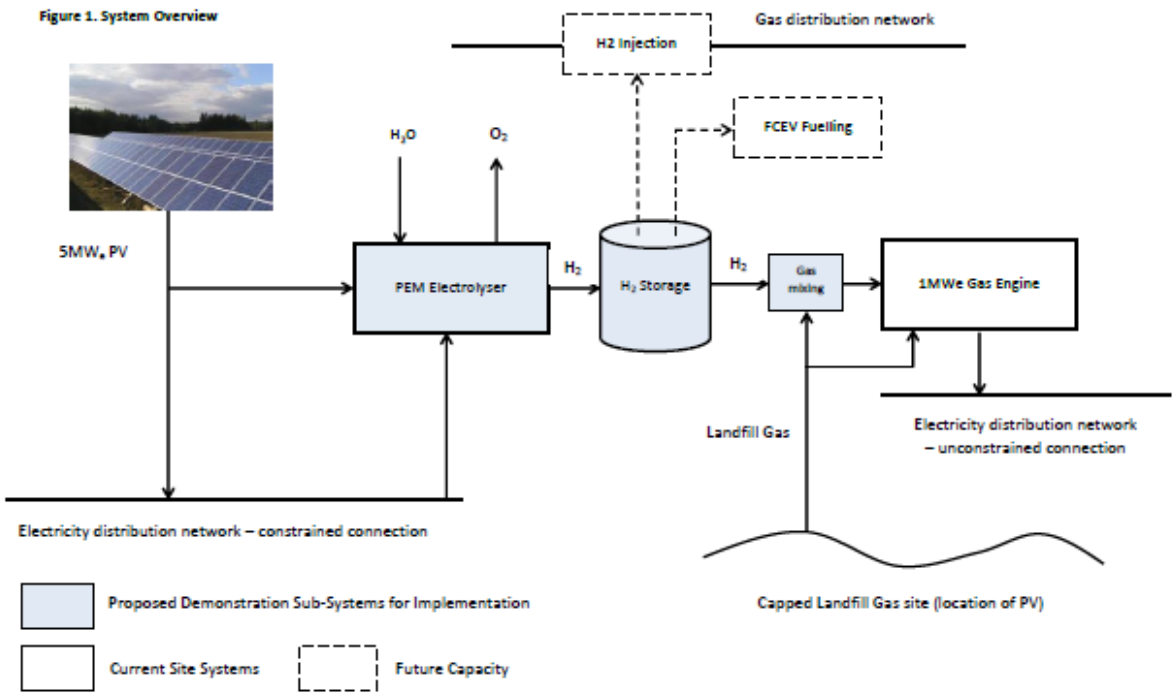
HELES PROJECT

Rapid Response PEM electrolysis, Solar PV , Landfill gas

- Demonstration
- Combining technologies
- Seasonal storage of PV
- Power In: Storage: Power Out
- Avoiding network constraints
- Future applications



CARDIFF
CAERDYDD

Innovate UK
Technology Strategy Board

ISLAND & REMOTE SYSTEMS

Sale of 0.5MW PEM electrolyser System to EMEC

- Integrated Hydrogen system for Tidal Energy Storage
- Eliminate island grid constraints for Tidal Testing Site
- Hydrogen for back-up power to EMEC's data & control systems
- Local community wind turbine – fully utilised for clean fuel
- Separate project for Eday Renewable Energy Ltd

Fall of Warness tidal test site, Eday

EMEC ORKNEY
The European Marine Energy Centre Ltd

ENERGY INDEPENDENCE

ENERGY STORAGE | CLEAN FUEL

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ITM POWER | REFUELLING STATIONS

Code	Status	Project	Location	Specification	Ownership
HRS 001	Operating	Nottingham	Univ of Notts	5kg/day 350 bar	Univ of Notts
HRS 002	Operating	HOST	Mobile refueller	15kg/day 350 bar	ITM Power
HRS 003	Operating	Ecoisland marine	Ventnor, Isle of Wight	15kg/day 350 Bar	ITM Power
HRS 004	Commissioned	Hydrogen Island	AMP S. Yorkshire	80kg/day 350Bar	ITM Power
HRS 005	In Build	HyFive	3 stations in London	80kg/day 700 bar	ITM Power
HRS 006	In Build	HyFive	3 stations in London	80kg/day 700 bar	ITM Power
HRS 007	In Build	HyFive	3 stations in London	80kg/day 700 bar	ITM Power
HRS 008	In Build	CHINO Hyundai	Chino, California	100 kg/day 700bar	Hyundai
HRS 009	In Build	Riverside	Riverside, California	33kg/day 700 bar	ITM Power
HRS 010	Contracts	UKH2M	London	80kg/day 700 bar	ITM Power
HRS 011	Contracts	UKH2M	London	80kg/day 700 bar	ITM Power

ENABLING A SUSTAINABLE LOCAL ENERGY FUTURE

Renewables, rapid response PEM electrolysis and Power to Gas

Offers the only way to achieve ultra low carbon transportation and energy without disruption to social and business routines……..

- Meets multiple policy goals incl. clean air, heat cross-sector sustainability and GHG targets
- Onsite production – no need for fuel delivery
- Key enabling technology for infrastructure development

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