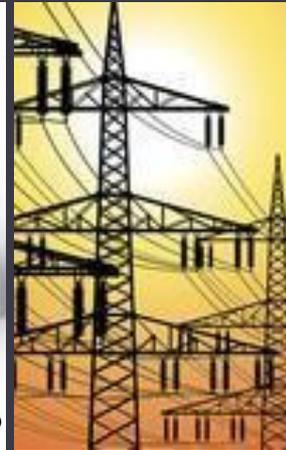
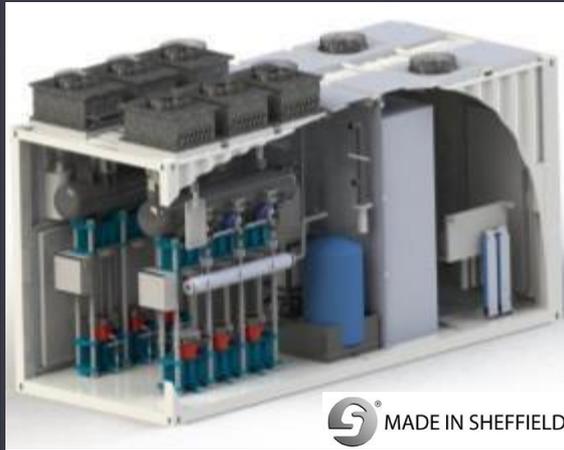


ITM POWER INC.

Electrolysis for Grid Energy Storage

DOE-Industry Canada Workshop

May 15, 2014



INTRODUCTION

HYDROGEN ENERGY SYSTEMS FOR ENERGY STORAGE AND CLEAN FUEL PRODUCTION



ITM POWER INC.

Positioned well.....

Energy Storage:

- Pioneers of HES / P2G initiative in CA
- Board member of CHBC – Title sponsor at Spring summit, 5th May in Long beach
- Committee member CHBC HES
- Member of FCHEA, CHFCA, OFCC,

Clean Fuel:

- Founder member of H₂USA and H₂FIRST
- Actively engaged in CEC solicitations
- Member of CaFCP
- Member of CTE and CALSTART
- 2 projects under CEC H₂ mobility



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ENERGY STORAGE | CLEAN FUEL



ENERGY STORAGE | CLEAN FUEL

Two significant emerging markets

Energy Storage:

- Follows the deployment of renewables
- Adds value to RE and balances the grid
- BCG estimates a cum. global market to 2030 of c.\$370bn
- H₂ Projects starting around the world

Clean Fuel:

- Fuel is the largest global market (91m barrels per day)
- Hydrogen from renewable power offers fuel security
- Fuel cell vehicle roll out is underway worldwide
- California a world leader



Energy Storage



Clean Fuel

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HYDROGEN ENERGY SYSTEMS

CLEAN FUEL | ENERGY STORAGE | RENEWABLE HEAT



Wind Power



Grid



Solar Power



Electrolyser



Clean Fuel



Energy Storage



Renewable Heat

HYDROGEN IS THE ONLY VIABLE HYBRID SOLUTION

ENERGY STORAGE

P2G (HES) THE NEED THE MARKET



CURTAILMENT = LOST ENERGY & MONEY

RE curtailment is a growing occurrence

Storage is required not just for hours but days/weeks/months

The traditional route of storing energy has limitations of capacity

GWhrs (weeks/months) of energy storage is only achievable with hydrogen

Europe leading the way so far.....

The Telegraph

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Politics Obits Education Earth Science Defence Health Scotland Royal Celebrities

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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.



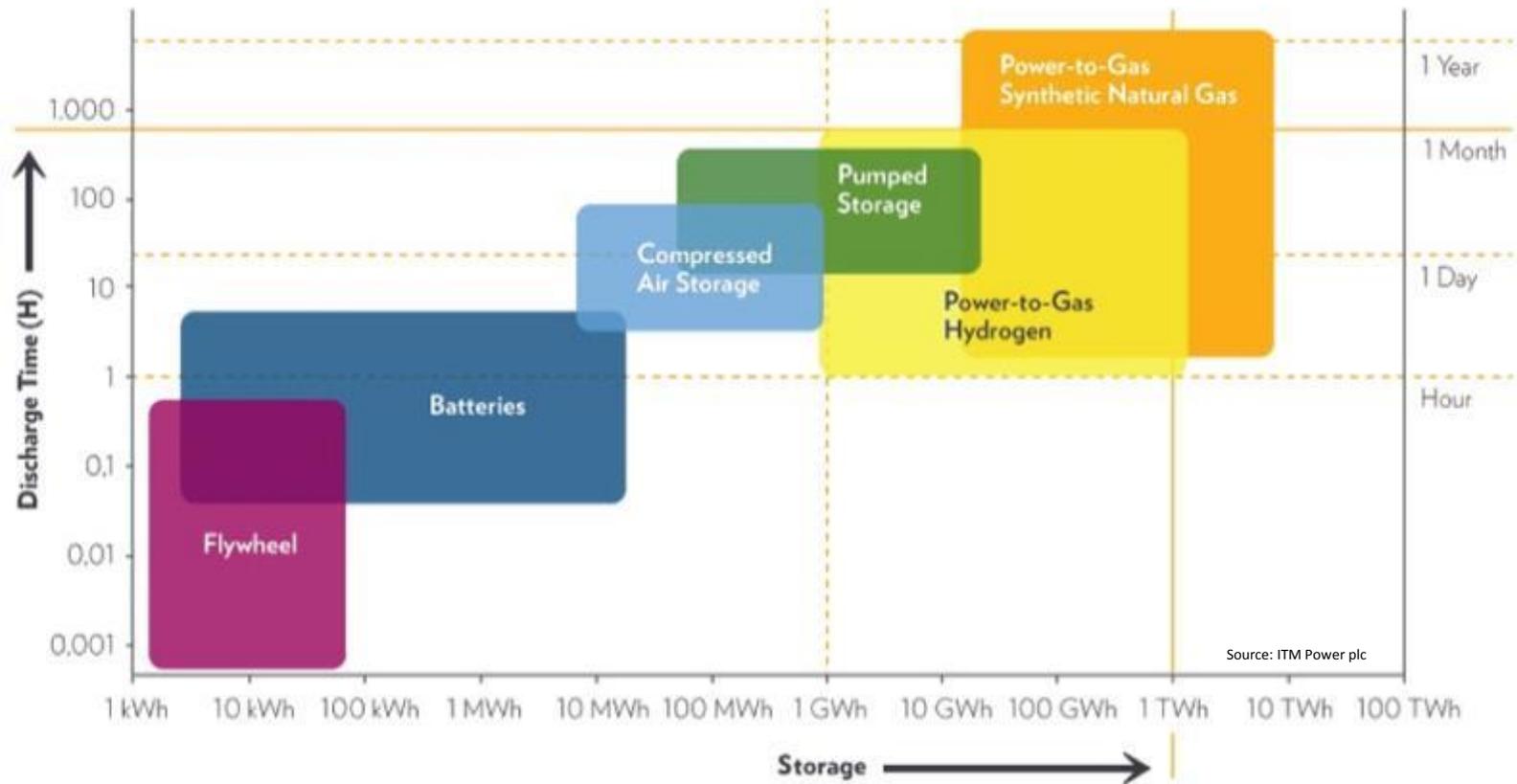
Wind farm companies receive constraint payments to switch off their turbines when supply exceeds demand Photo: PA

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

 Print this article

ENERGY STORAGE TECHNOLOGIES

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



ENERGY STORAGE TECHNOLOGIES

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OTHER OPTIONS?



Limitations with
scale and capacity



Geography limitations
and exploration expensive



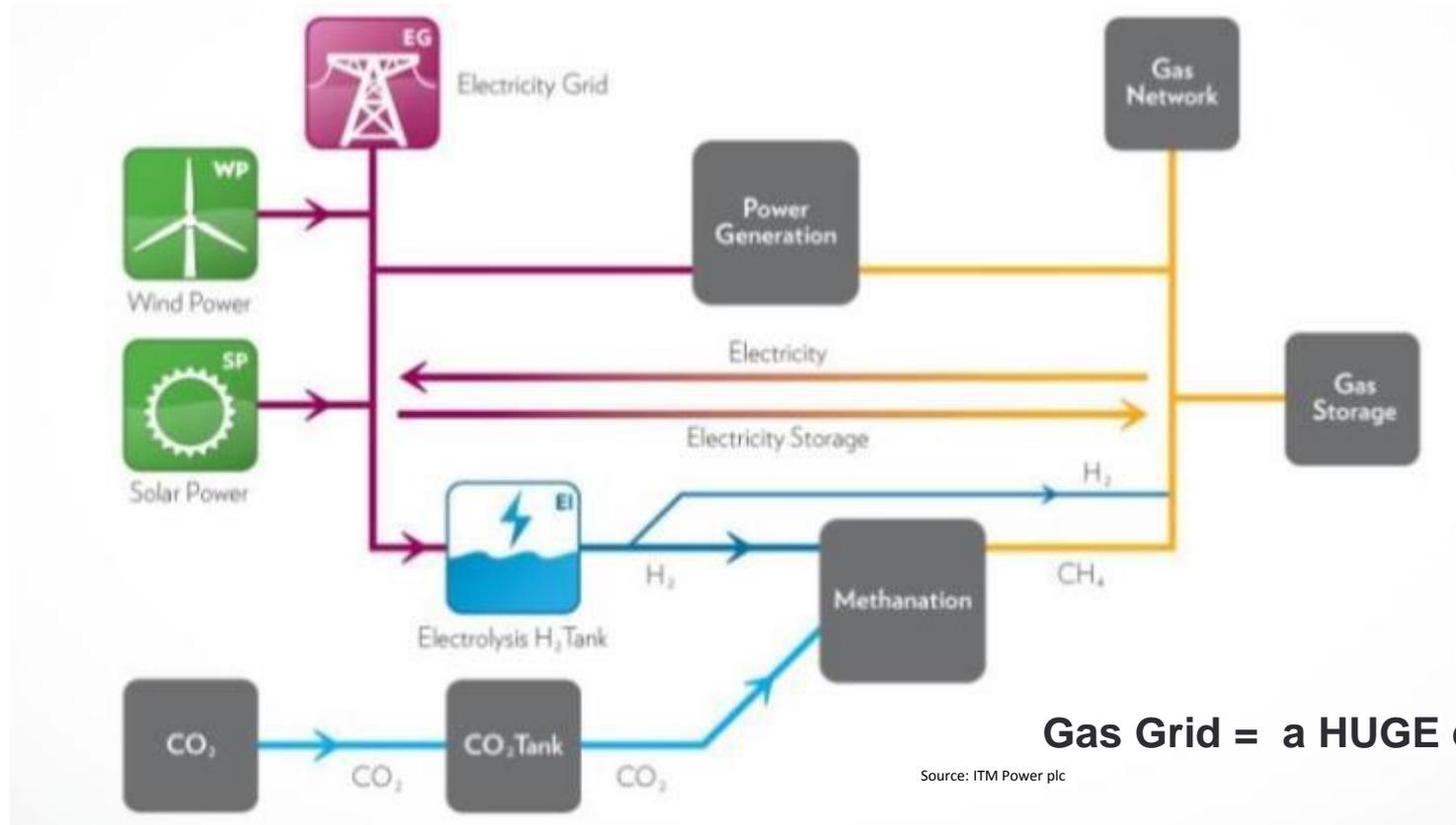
Geographic limitations

POWER-TO-GAS RATIONALE

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WHY POWER-TO-GAS?

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



Gas Grid = a HUGE existing asset!!

POWER-TO-GAS RATIONALE
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P2G (HES): 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 CO₂ 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 US Economy

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

P2G: ELEMENTS OF VALUE

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PROJECTS

HYDROGEN ENERGY
SYSTEMS FOR
ENERGY STORAGE
AND CLEAN FUEL
PRODUCTION



FIRST P2G SALE: THÜGA GROUP

Won competitive tender on price & performance

- One of the world's largest utility groupings
- 18,200 employees
- 5.7m customers (electricity, 3.6m, gas 2.1m)
- Sales of €21.3bn

- Plant located at Mainova AG in Frankfurt
- 1/3 MW – 150kg H2 per day
- Direct Injection
- Delivered ahead of schedule



Source: Thüga-Gruppe

360KW POWER-TO-GAS MODULE
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P2G PLANT & VISITOR CENTRE
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THUGA DETAILS

Three year project

Operational since December

NOT a technology demonstration– utility already convinced of capability of the technology

Designed to

- Educate regulators – who will be paying for demand management – that the system is a responsive load and can meet requirements
- Help develop the business model: payment structure that supports investment, allows calculation of ROI.



Energy Storage



Clean Fuel

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HYDROGEN ENERGY SYSTEMS

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Ideal marketplace

Cheap power – e.g. Curtailed wind

High demand for grid balancing e.g. % of renewables

Constraints on gas supply (e.g. parts of mid-Atlantic)

Demand for H2 vehicle fuel

Access to other hydrogen markets

Regulatory pressure on carbon

Great variations between winter and summer peak

Enlightened regulatory environment



Energy Storage



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Competitive Advantages (PEM)

Responsive load

Nearly instantaneous response (ITM stacks 0.2 sec stack = 10 cycles)

Compatibility with gas grid (miscible, no need for additional compression (ITM up to 80 bar))

Capacity and storage time effectively unlimited

Never “fills up”

Allows for long term (seasonal, annual) storage

Links electric grid to gas grid, heat demand, vehicle fuelling, water purification, industrial markets



Energy Storage



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R&D needs (synergy with PEM fuel cells)

Demonstrations at MW+ scale

Convince regulators and marketplace of viability

Mixing technology (and regulations)

Reliability (always available)

Durability (lasts a long time)

Cost reduction (synergies with PEM fuel cells)

Efficiency

Self pressurization to 700-800 bar



Energy Storage



Clean Fuel

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HYDROGEN ENERGY SYSTEMS

CHALLENGES AND TECHNOLOGY DEVELOPMENTS

FORECOURT

Challenges:

- Footprint requirements – Greenfield vs. Brownfield sites, storage capacity on site.
- Alkali verses PEM - ramp up / down response / footprint / gas purity / safety / pressure
- Power infrastructure – 1500kg/day = 3MW electrolyzer

Focus on Technology Developments. Continuous Improvements:

- Reduction in unit CAPEX costs – 50%
- Reduction in O&M costs – component selection
- Improvement in efficiency – 15-20%
- Packaging improvements.
- Overrun capacity 50% – make extra H2 when power prices low
- Focus on demand response linked to renewables
- Rain water/grey water harvest



MODULAR ELECTROLYSERS
HYDROGEN ENERGY SYSTEMS

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