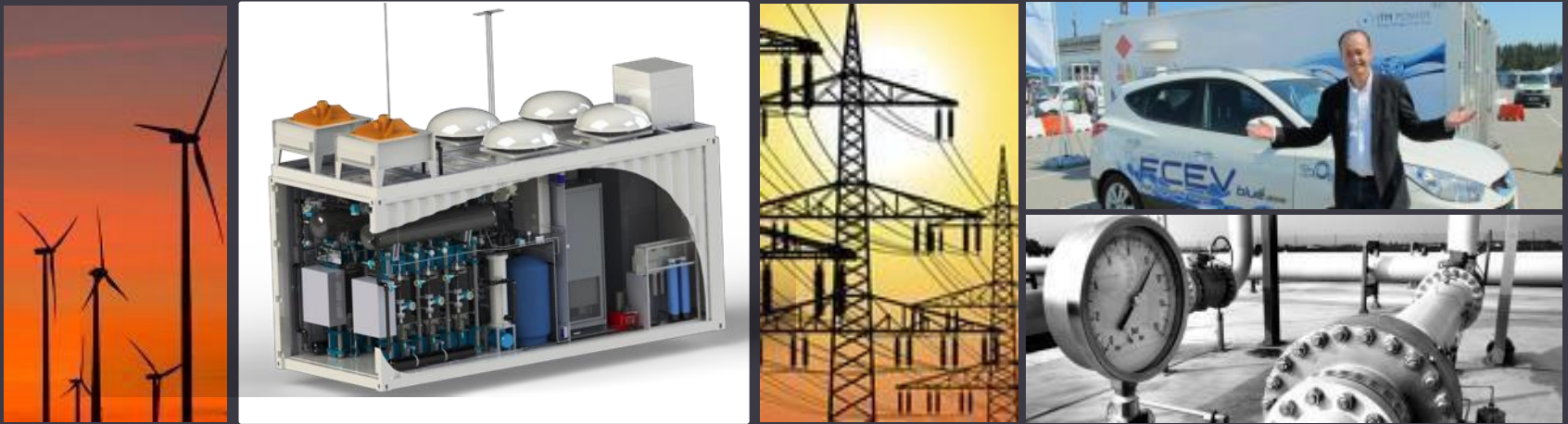


ITM POWER ENERGY STORAGE | CLEAN FUEL

Rethink Methane – June 2015, Sacramento



HYDROGEN = ENERGY + FUEL

ITM POWER ENERGY STORAGE | CLEAN FUEL

Contents:

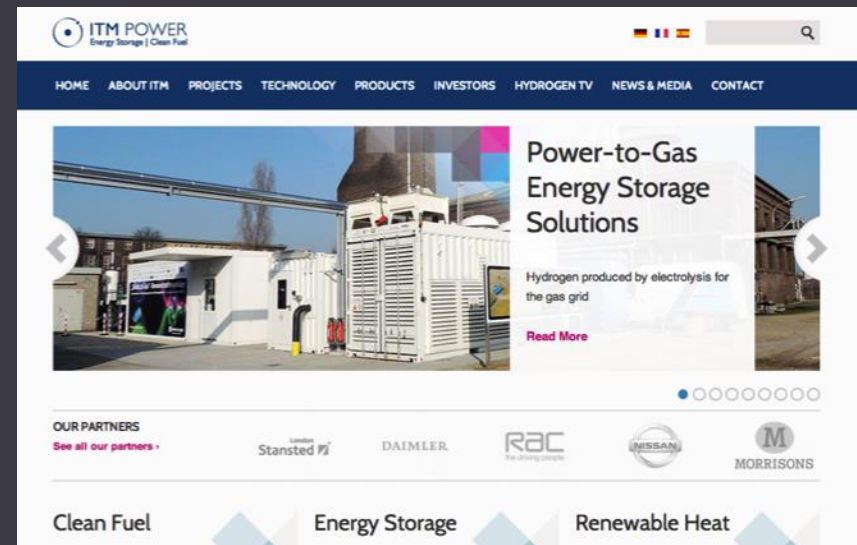
- Introduction to ITM Power Inc.
- Renewable natural gas
- Energy - Power to Gas (P2G)
- The link
- Summary

HYDROGEN = ENERGY + FUEL

ITM POWER ENERGY STORAGE | CLEAN FUEL

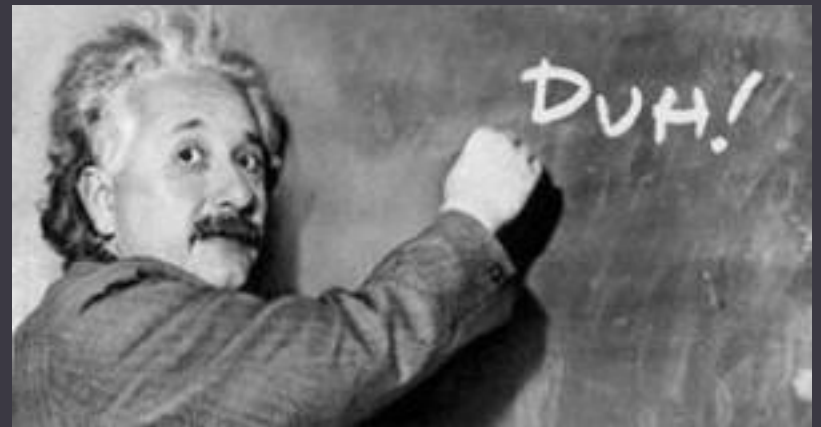
ITM Power | History

- First AIM listed fuel cell & hydrogen company
- 2004 IPO
- 2011 Established ITM Power GMBH
- 2012 Established ITM Power Inc.
- +/- 80 staff
- 2015 JCB Strategic Investment in ITM
- Positioned for growth



ITM POWER ENERGY STORAGE | CLEAN FUEL

What does RNG mean for my industry??



HYDROGEN = ENERGY + FUEL

CLEAN FUEL | ENERGY STORAGE | RENEWABLE HEAT



Wind Power



Grid



Solar Power



Electrolyser



Clean Fuel



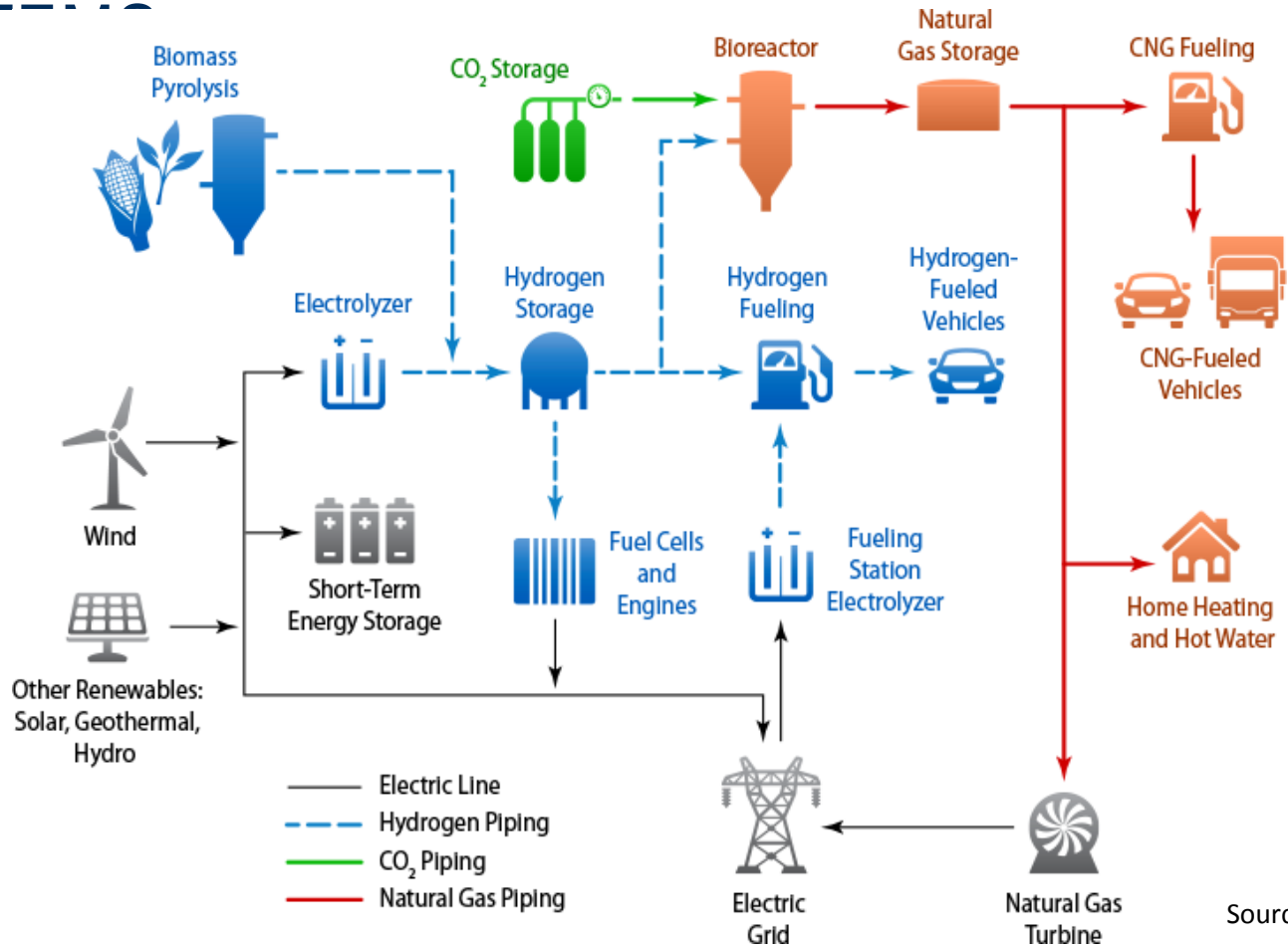
Energy Storage



Renewable Heat

HYDROGEN IS THE ONLY VIABLE HYBRID SOLUTION

POWER TO GAS: RATIONALE – HYBRID SYSTEM



Source - NREL

POWER TO GAS: RATIONALE HYDROGEN ENERGY SYSTEMS

HGas

HGas brings together rapid response and self-pressurising PEM electrolysis into a fully integrated package.

Power-to-Gas



HFUEL

HFuel is a self-contained module suitable for refuelling hydrogen-powered road vehicles and forklift trucks.

Refuelling Stations

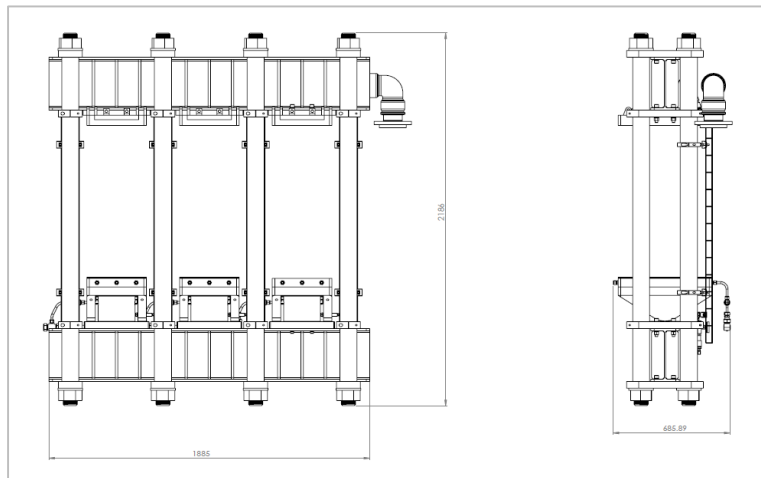


REFUELLING STATIONS | P2G UNITS
HYDROGEN ENERGY SYSTEMS

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

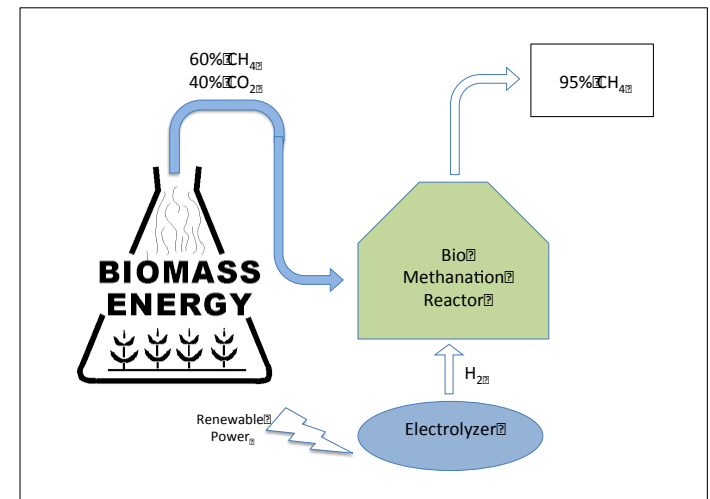
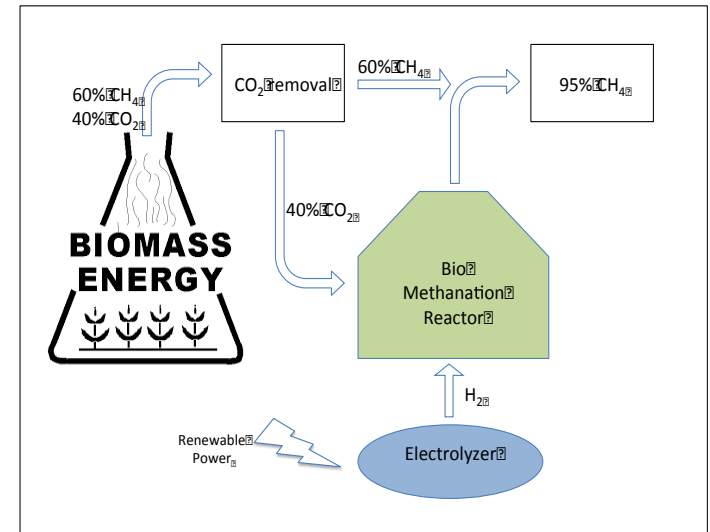


1MW P2G SKID | HANNOVER LAUNCH
HYDROGEN ENERGY SYSTEMS

RENEWABLE NATURAL GAS

Methanation for BioGas | CO₂ removal

- A modular and scalable technology for CO₂ removal
- BioGas typically 30-50% CO₂
- Upgrade Biogas to 95+% yeild
- Increases calorific value | Increases output
- High value application



REMOVING CO₂ FROM BIOGAS

ENERGY STORAGE | CLEAN FUEL

ENERGY STORAGE

POWER TO GAS
(P2G)/ HYDROGEN
ENERGY STORAGE
(HES)
THE NEED
THE MARKET



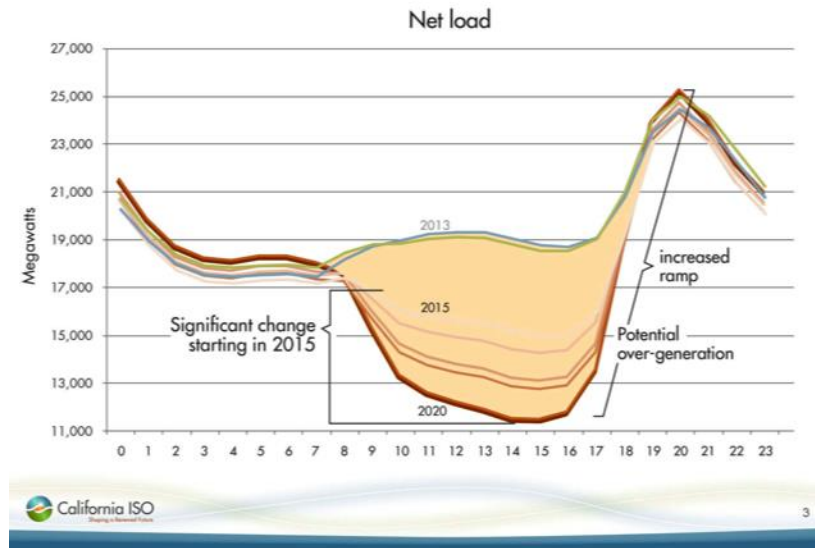
CURTAILMENT = WASTED ENERGY AND MONEY

- 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

50% renewable future NEEDS large storage

Europe leading the way so far.....

Growing need for flexibility starting 2015



ENERGY STORAGE

ENERGY STORAGE | CLEAN FUEL

EU STUDIES CONFIRM IT

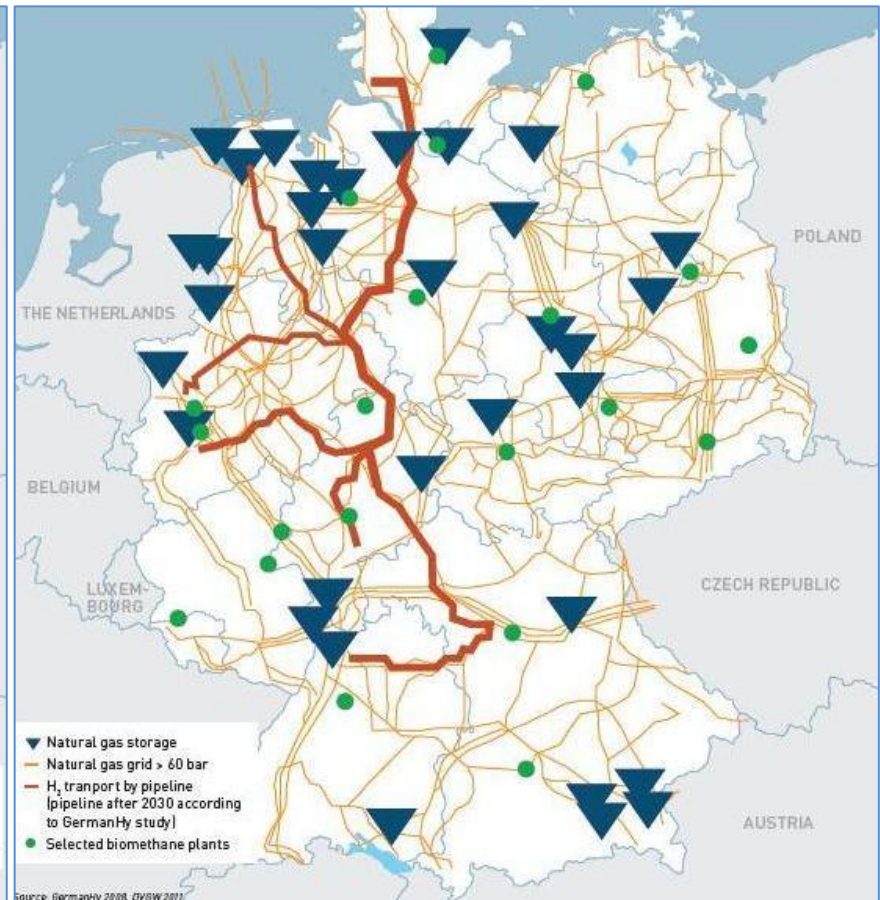
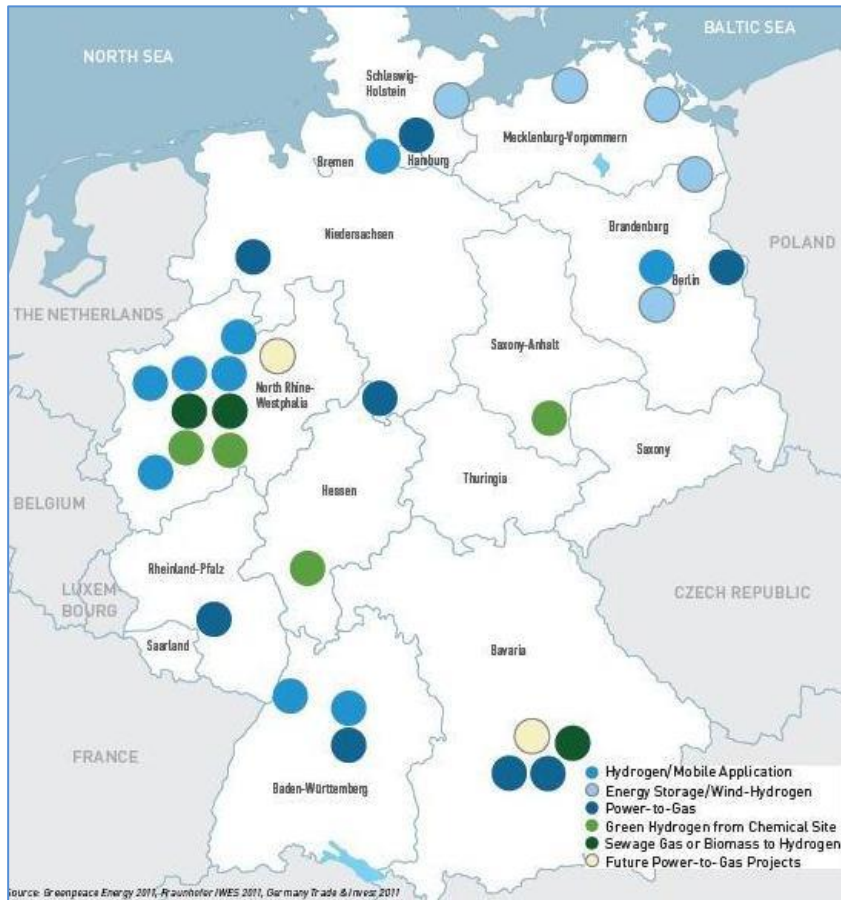
- P2G has massive potential
- One of, if not the only way do do massive storage of renewable electricity

Study	Result (P2G potential size)
Electricity storage in Germany - Energiewende	16GW 2023 130GW 2050
Energy storage in Europe - McKinsey	170GW by 2050
P2G in the Dutch energy system – ECN & DNVGL	20GW by 2050
UK P2G potential – Haines et al	23GW by 2050

P2G: ELEMENTS OF VALUE

ENERGY STORAGE | CLEAN FUEL

GERMAN POWER TO GAS SCHEMES



POWER TO GAS
ENERGY STORAGE | CLEAN FUEL

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

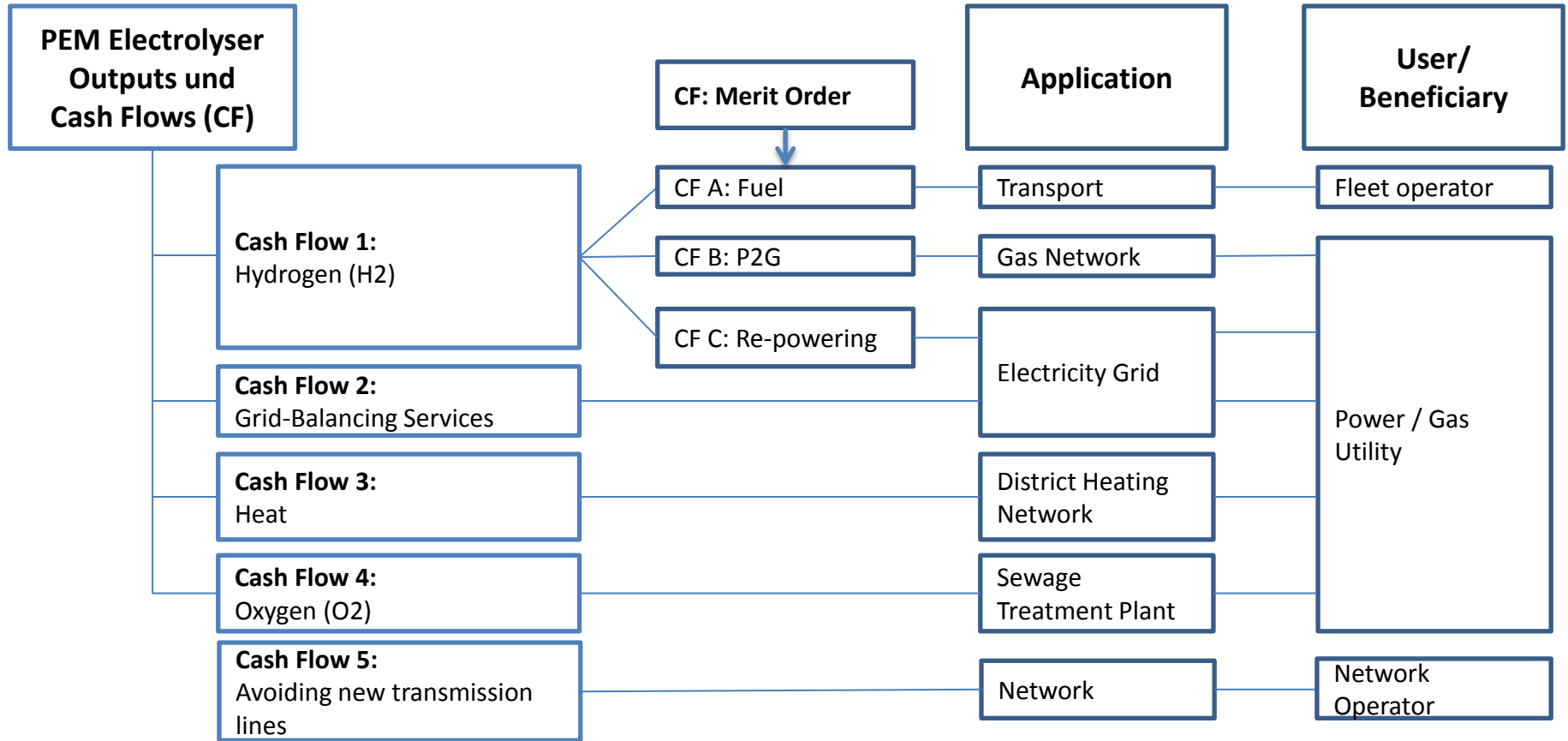
Value to the US Economy

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

P2G: ELEMENTS OF VALUE

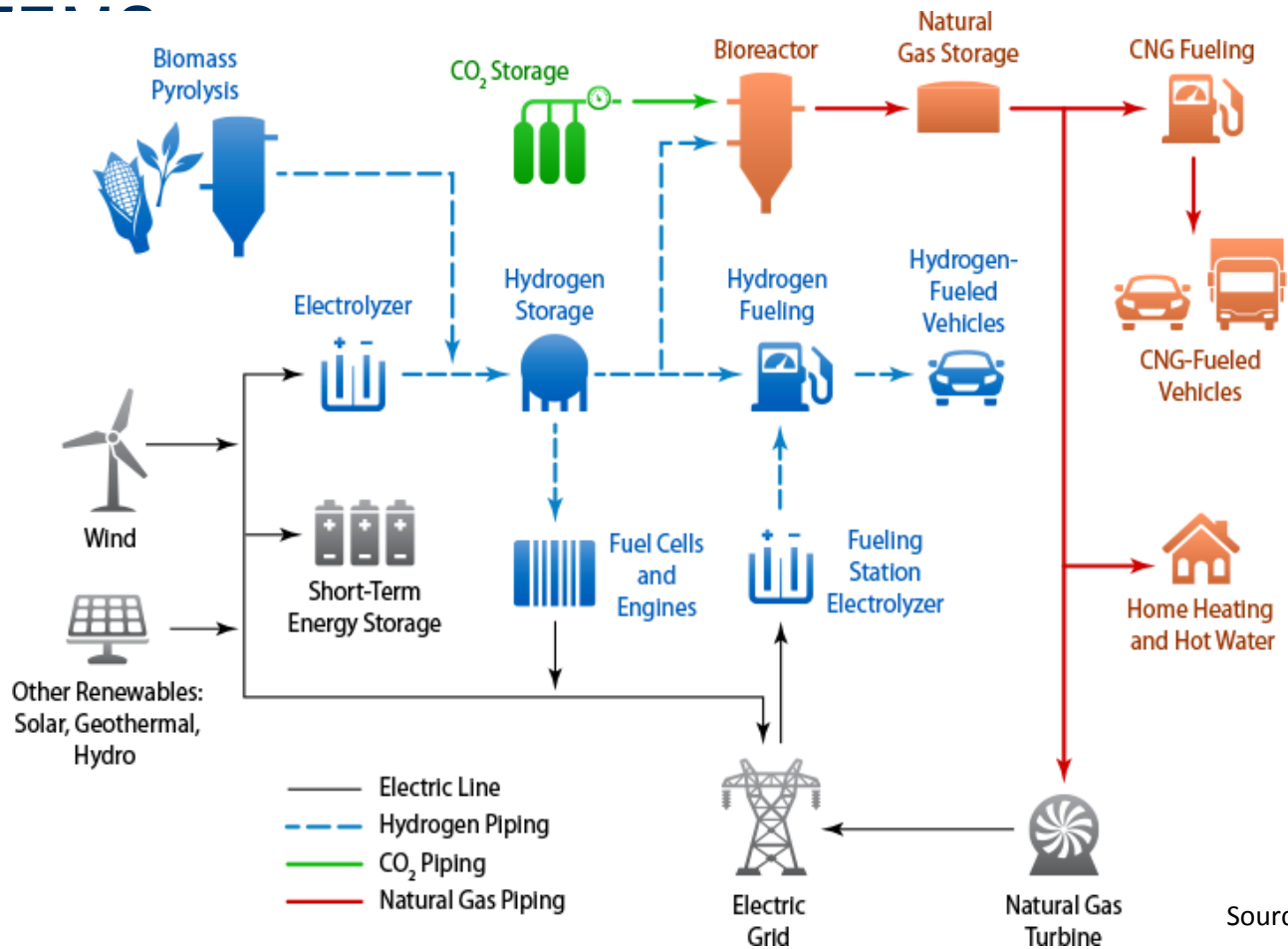
ENERGY STORAGE | CLEAN FUEL

PEM Electrolyser: A menu of operating options



Situation specific – dictated by the market dynamics + POLICY

POWER TO GAS: RATIONALE – HYBRID SYSTEM



Source - NREL

POWER TO GAS: RATIONALE HYDROGEN ENERGY SYSTEMS

Example of a H2 Hub – P2G + Grid Balancing + H2 Refueling Station

Power-to-Gas:
Gas Mixing Plant /
Methanation Plant

Electrolyser:
On-site H2 production
Grid Balancing

H2 / SNG Dispenser

PEM ELECTROLYSER HYDROGEN HUB

40kWhrs electricity = 1 therm hydrogen

DELIVERING LOWEST COST FUEL
ENERGY STORAGE | CLEAN FUEL



ITM POWER INC.

CA - a world leader for policy and action – BUT we need to break down the silos



Assembly Bill 32 Global Warming Solutions Act



State of California AB 8
Hydrogen Infrastructure
Roadmap

CPUC sets
energy
storage goals
for utilities



\$250m for 10yrs
+ Hydrogen
Infrastructure

Min. 33%
Green H₂
Legislation

Energy Storage
Mandated for
1.3 GW

ITM POWER INC.

ENERGY STORAGE | CLEAN FUEL



1.3GW ENERGY STORAGE MANDATE IN CALIFORNIA

CPUC Sets the energy storage mandate for the power sector

- Energy storage target of 1,325 megawatts
- 3 major CA utilities by 2020
- Optimization of the grid, including peak reduction
- Integration of renewable energy
- Reduction of GHG emissions to 80% below 1990 levels by 2050

“This decision represents an important first step in encouraging the storage market and supporting grid reliability,”

Commissioner Carla J. Peterman, the lead Commissioner for this proceeding.



CALIFORNIA ENERGY STORAGE

ENERGY STORAGE | CLEAN FUEL



Water use?

- Electrolysis uses water to make hydrogen gas
- Natural gas and petroleum use more water in their production
- Switching to 100% FCEVs would lead to a 0.2% increase in water consumption statewide
- Releases water vapour back into the atmosphere once the hydrogen is combusted or used in a fuel cell
- Electrolysis technology will NOT significantly impact the current drought situation in CA.



What needs to be done?

- Natural gas is cheaper and cleaner than petroleum
- CA, unlike most, strives for more
- Development needs to be focused on long term success – how to get to the end game
- Dependent on policy to drive change
- Energy storage – does P2G count? CPUC
- Mandate – CO₂ intensity – RGS
- Incentives - RGS, RINs, LCFS etc



LINK energy & fuel

What needs to be done?

HES – recognised as a viable technology in the mix

Legislated / incentivised

Links with utility providers (Gas and Electric)

Links to fuelling infrastructure

Joined up thinking

Get projects installed

Show the value



ITM POWER
ENERGY STORAGE | CLEAN FUEL

Steve Jones

Managing Director
ITM Power Inc.
Irvine, California

sj@itm-power.com

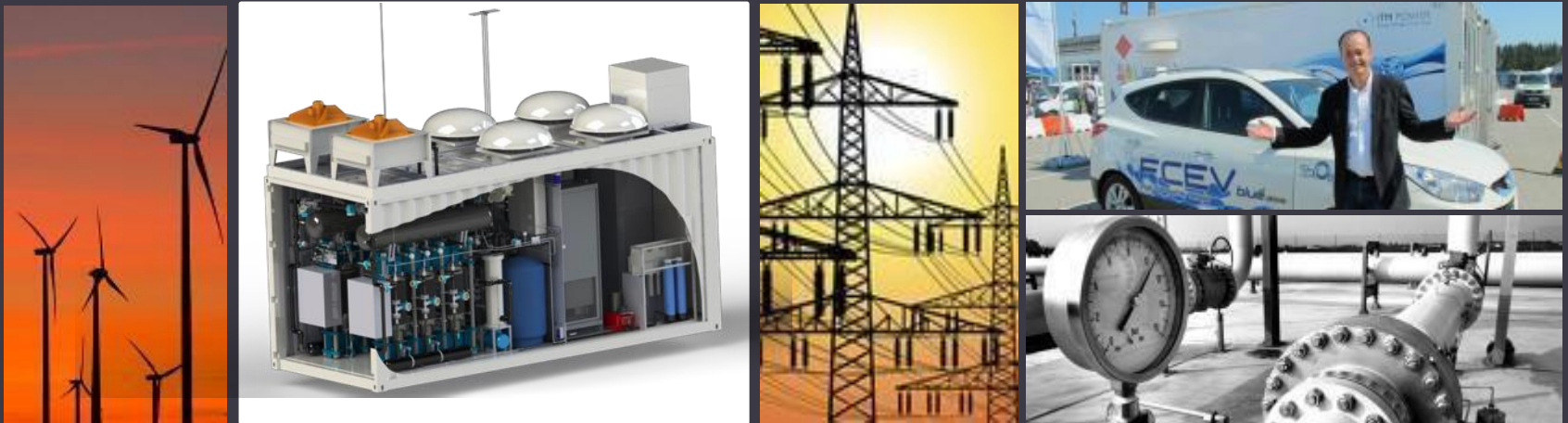
+1 (714) 453 8141

HYDROGEN = ENERGY + FUEL



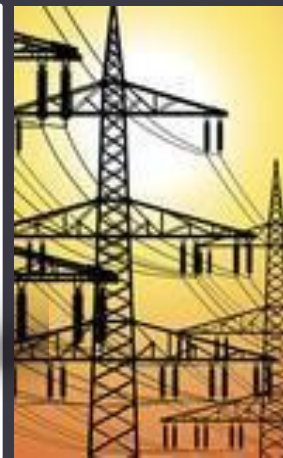
ITM POWER ENERGY STORAGE | CLEAN FUEL

Rethink Methane – June 2015, Sacramento



HYDROGEN = ENERGY + FUEL

BACK UP SLIDES



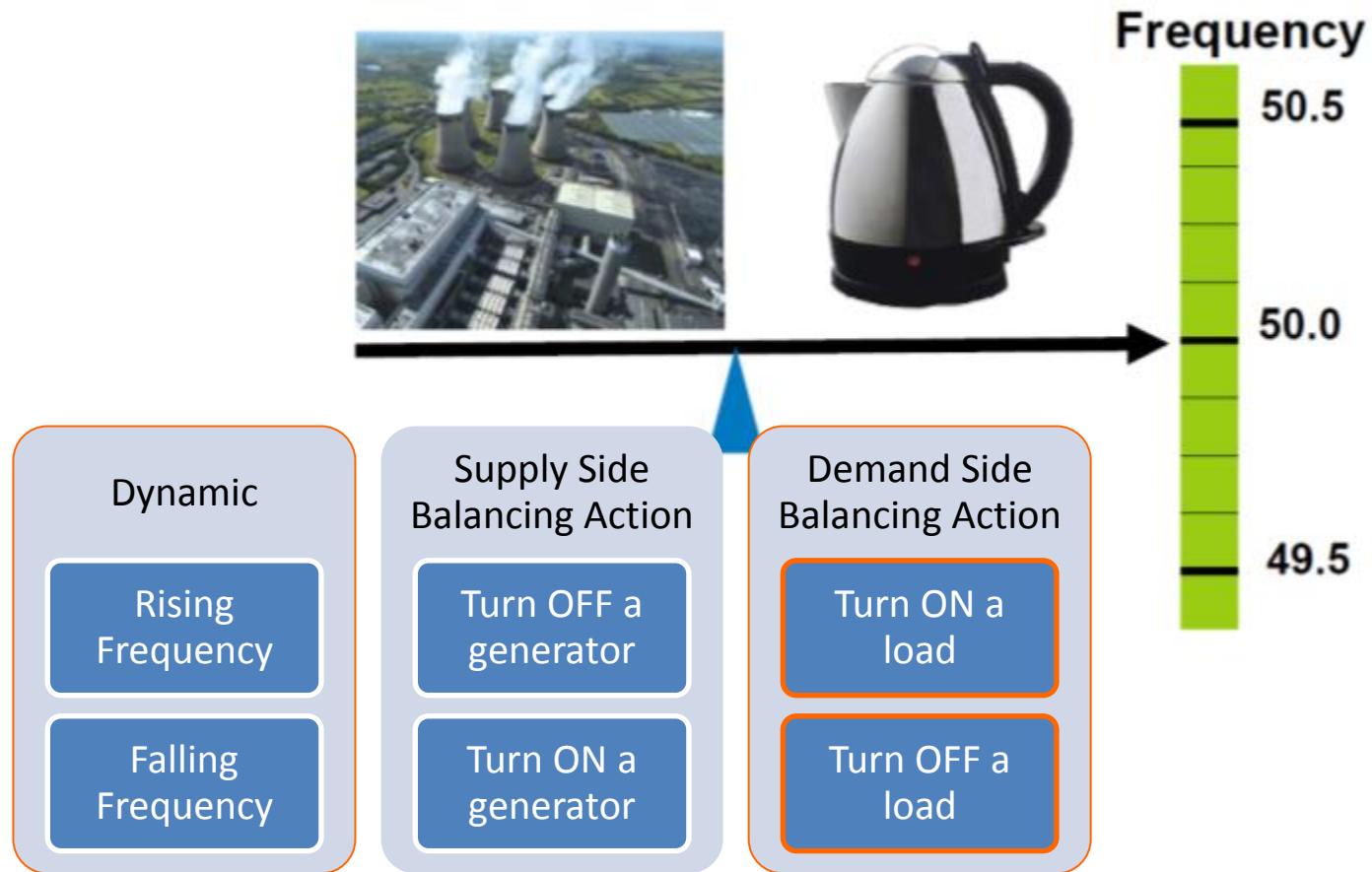
HYDROGEN = ENERGY + FUEL

P2G PROJECTS

THÜGA / REW
PROJECTS
METHANATION
UREA



BALANCING SUPPLY AND DEMAND – ANCILLARY SERVICES: SECOND BY SECOND – GRID BALANCING



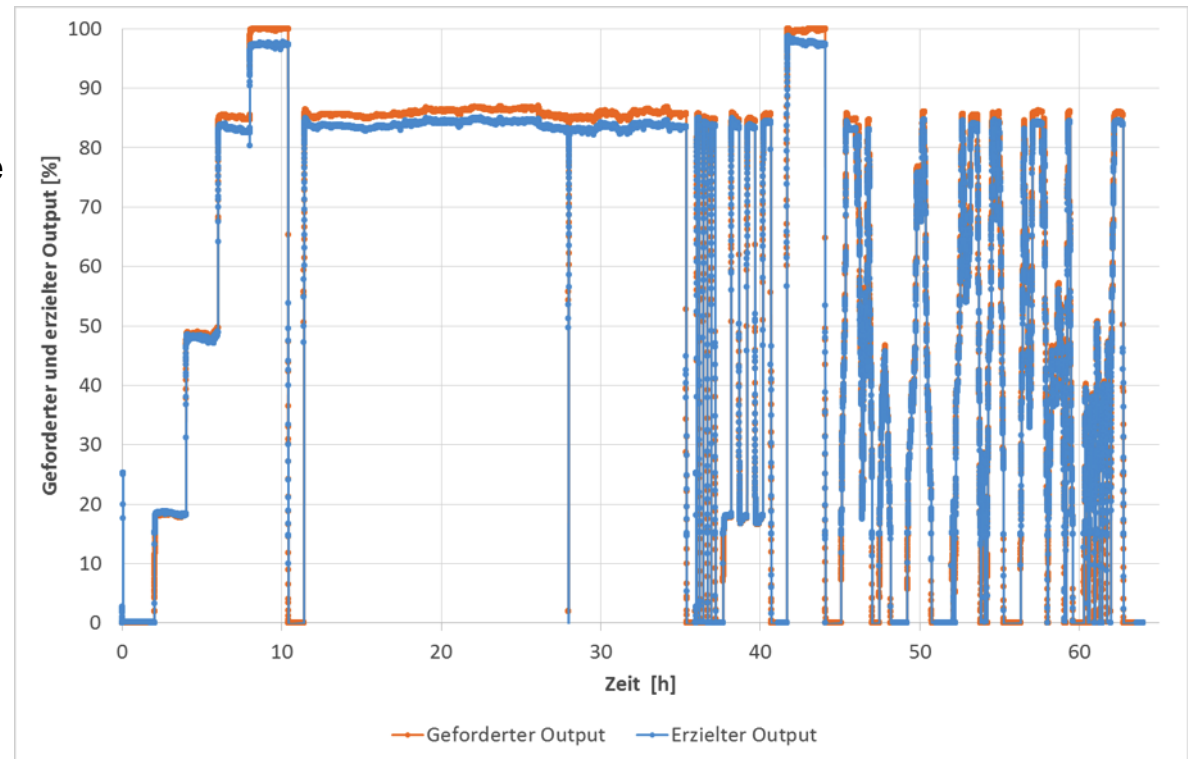
THE NEED: GRID BALANCING

ENERGY STORAGE | CLEAN FUEL

LOAD FOLLOWING

Rapid response Electrolysis

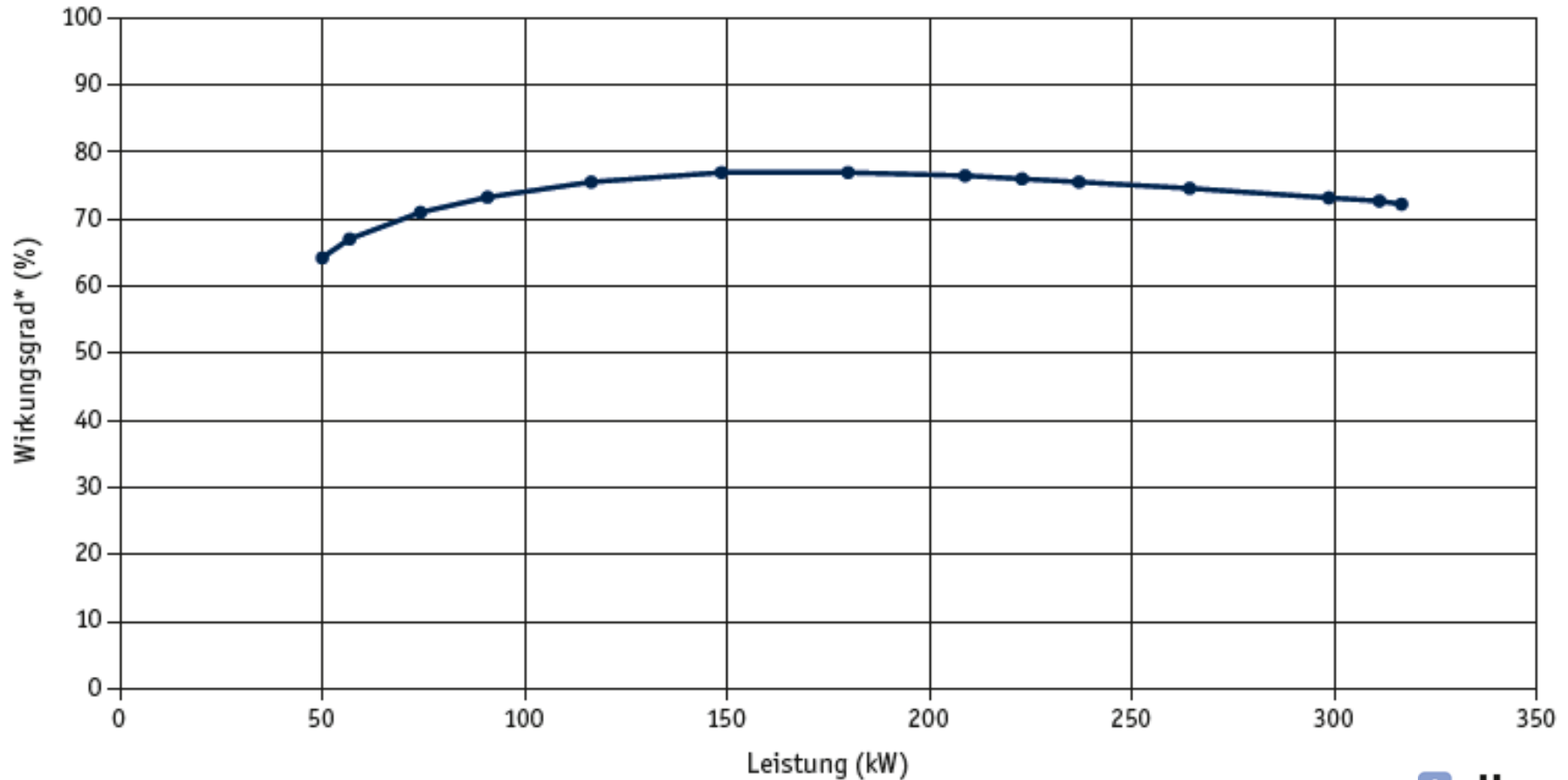
- Full system test program
- Set Point v's Actual (blue)
- Multiple start/stop tests
- Load modulation for full range
- Challenge system reliability
- Validate system to assimilate intermittent renewable power



THÜGA P-2-G PLANT PERFORMANCE

HYDROGEN ENERGY SYSTEMS

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



FIRST P2G SALE: THÜGA GROUP

Won competitive tender on performance & price

- 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 year of operation – exceeded average efficiency. Achieved up to 77%



Source: Thüga-Gruppe

360KW POWER-TO-GAS MODULE
ENERGY STORAGE | CLEAN FUEL





P2G PLANT & VISITOR CENTER THÜGA

ENERGY STORAGE | CLEAN FUEL



MIXING PLANT

HYDROGEN ENERGY SYSTEMS

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.



P2G PLANT IBBENBÜREN RWE
ENERGY STORAGE | CLEAN FUEL

 ITM POWER
Energy Storage | Clean Fuel

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 applications project for Eday Renewable Energy Ltd.



Fall of Warness tidal test site, Eday



ENERGY INDEPENDENCE

ENERGY STORAGE | CLEAN FUEL



HELES PROJECT

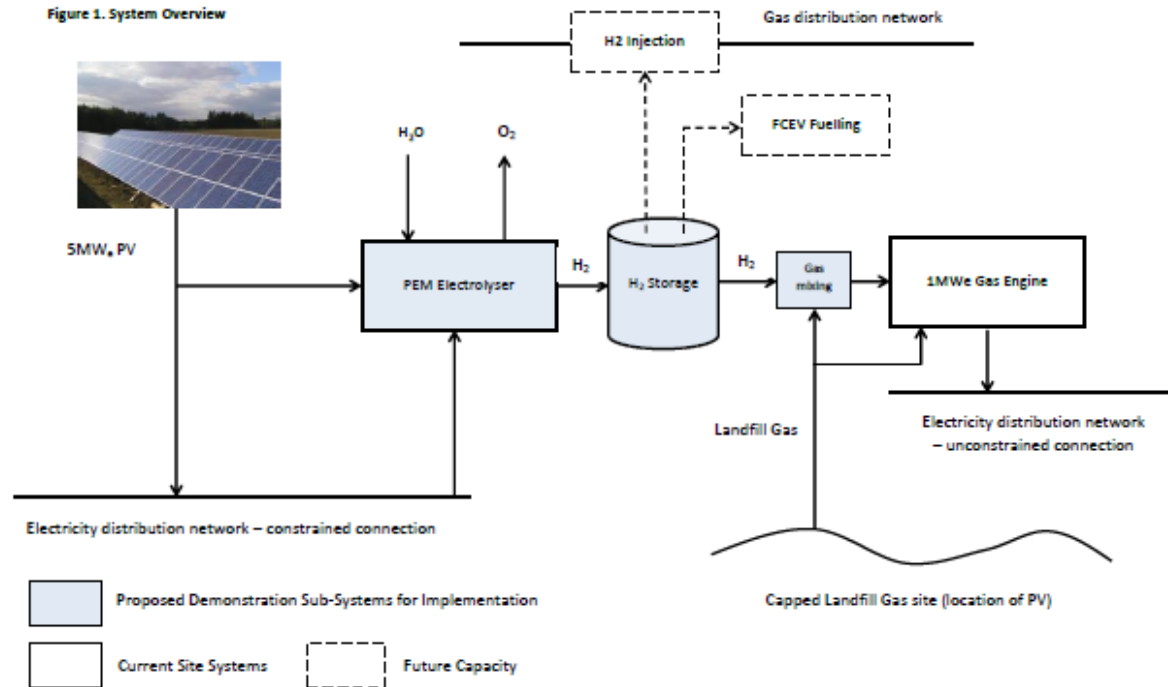
Rapid Response PEM electrolysis, Solar PV , Landfill gas

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



Innovate UK
Technology Strategy Board

Figure 1. System Overview



HYDROGEN ENABLED LOCAL ENERGY SYSTEMS

ENERGY STORAGE | CLEAN FUEL

CLEAN FUEL

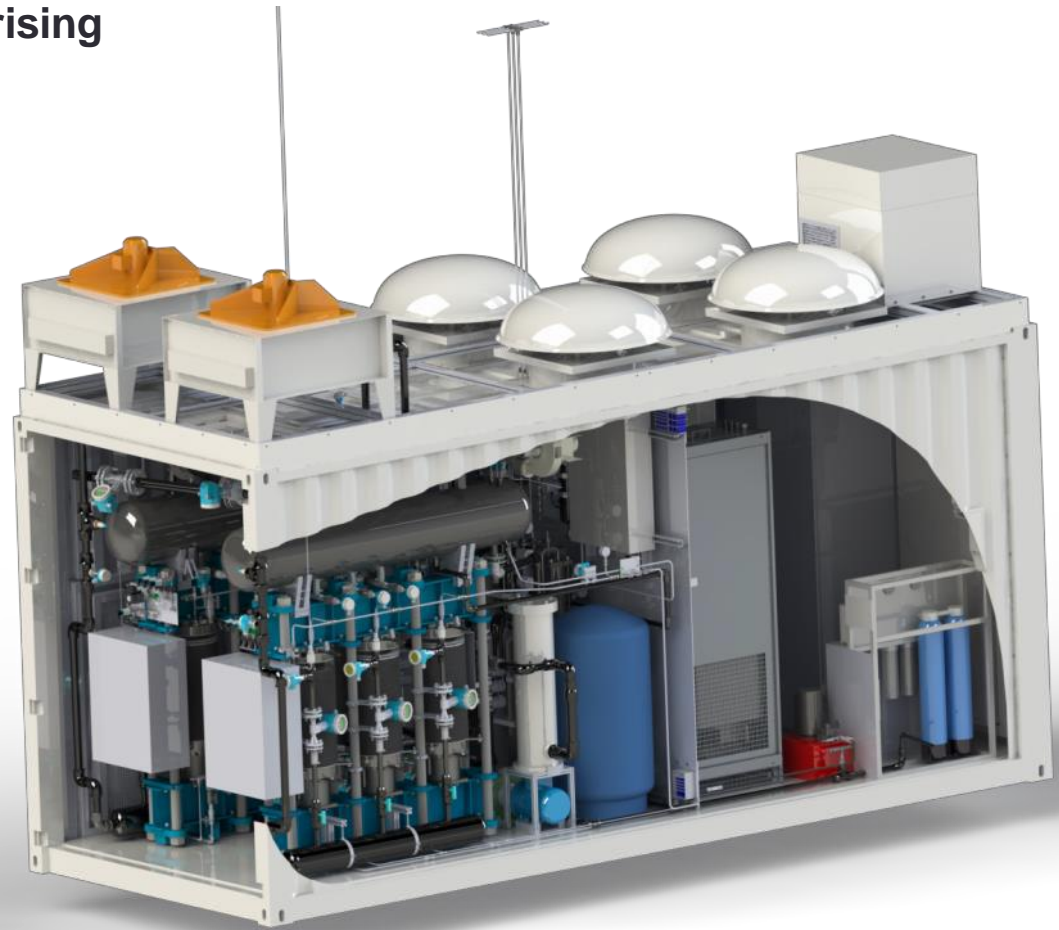
HYDROGEN REFUELLING STATIONS



WHAT'S UNIQUE ABOUT ITM ELECTROLYZERS?

Rapid response | Self pressurising

- 1 sec response time
- 80bar self pressurising
- 1MW and modular



 **ITM POWER**
Energy Storage | Clean Fuel

AEG
POWER SOLUTIONS

HES MODULE
ENERGY STORAGE | CLEAN FUEL

 **ITM POWER**
Energy Storage | Clean Fuel



H2 Frontier Inc



STATION LOCATION
ENERGY STORAGE | CLEAN FUEL



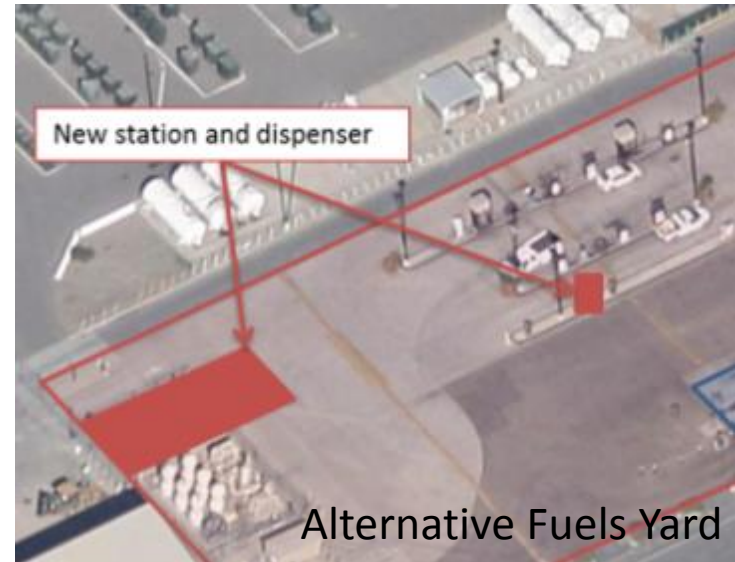
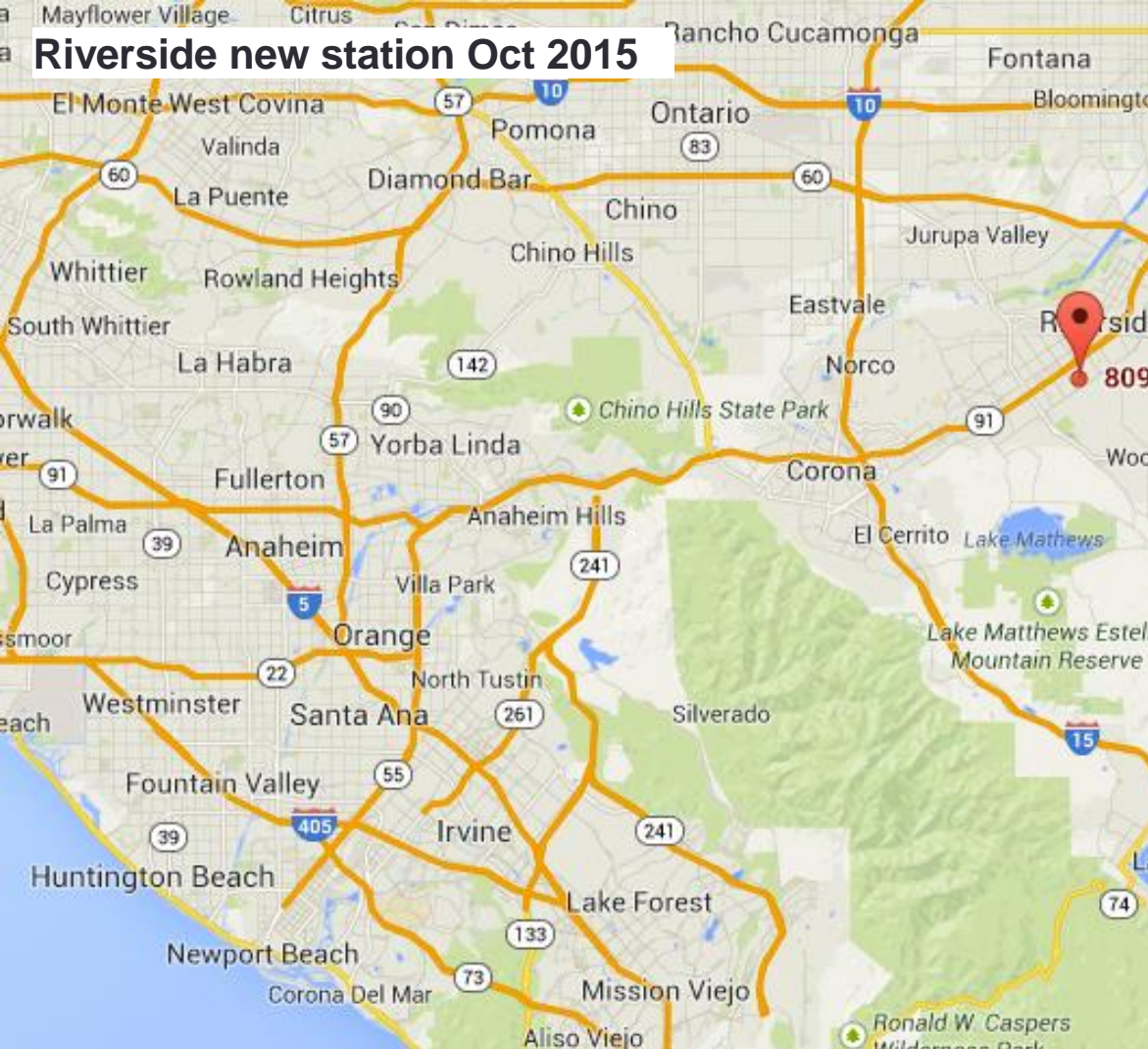
Hyundai, Chino 100% Renewable Hydrogen Station



H2 Frontier Inc



Riverside new station Oct 2015



H2 Frontier Inc



ITM POWER | REFUELLING STATIONS

Code	Status	Project	Location	Specification	Funding	Contract Value	Ownership
HRS 001	Operating	Nottingham	Univ of Notts	5kg/day 350 bar	TSB (UK Gov)	£275k	Univ of Notts
HRS 002	Operating	HOST	Mobile refueller	15kg/day 350 bar	TSB (UK Gov)	£326k	ITM Power
HRS 003	Operating	Ecoisland marine	Ventnor, Isle of Wight	15kg/day 350 Bar	TSB (UK Gov)	£326k	ITM Power
HRS 004	Commissioned	M1 vehicle	M1 Junction 33	80kg/day 350Bar	TSB (UK Gov)	£1.2m	ITM Power
HRS 005	In Build	HyFive	3 stations in London	80kg/day 700 bar	FCH JU (EU)	£1.55m	ITM Power
HRS 006	In Build	HyFive	3 stations in London	80kg/day 700 bar	FCH JU (EU)	£1.55m	ITM Power
HRS 007	In Build	HyFive	3 stations in London	80kg/day 700 bar	FCH JU (EU)	£1.55m	ITM Power
HRS 008	In Build	CHINO Hyundai	Chino, California	100 kg/day 700bar	CEC	£812k	Hyundai
HRS 009	In Build	Riverside	Riverside, California	33kg/day 700 bar	CEC	£1.7m	ITM Power
HRS 010	Contracts	UKH2M	2 stations in London	80kg/day 700 bar	OLEV FCH JU	£1.80m	ITM Power
HRS 011	Contracts	UKH2M	2 stations in London	80kg/day 700 bar	OLEV FCH JU	£1.80m	ITM Power

REFERENCE PLANT | ASSETS
HYDROGEN ENERGY SYSTEMS