RAPID RESPONSE ELECTROLYSERS

MAY 2017

ITM POWER
Energy Storage | Clean Fuel

RAPID RESPONSE ELECTROLYSERS

MAT 2017

Contents:

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- The problem
- Product solutions
- Examples in the field
- Summary

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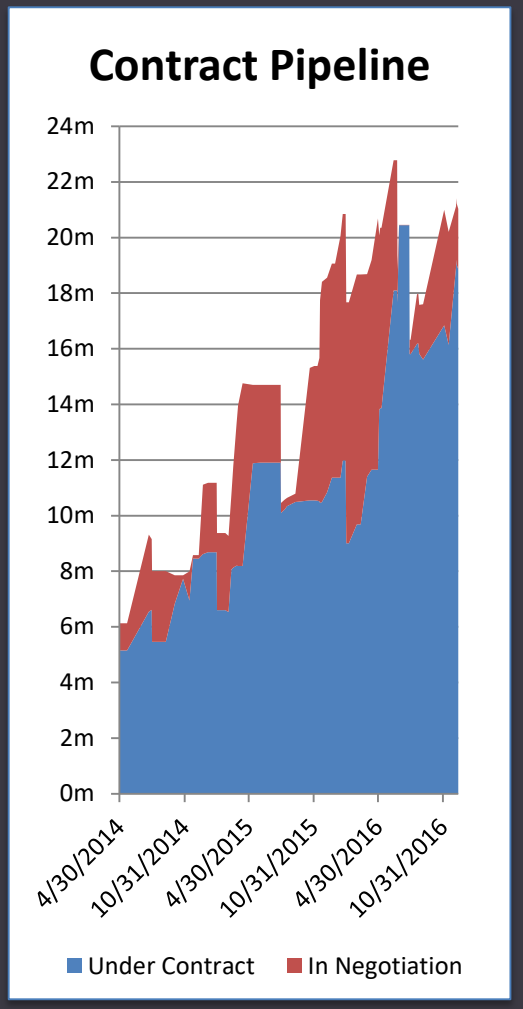
MAY 2017

ITM Power | History

- First AIM listed fuel cell & hydrogen company
- 2015 Strategic investment from JCB
- Two facilities in Sheffield | 70 staff
- Subsidiaries in Germany & California
- Manufacturing business model

£22.64m under contract | £1.72m in negotiation | £24.36m total*



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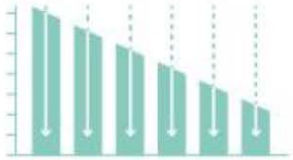
ORDERS OF
£15.68m
OVER THE LAST
12 MONTHS

UP
100%

DEAL PIPELINE OF
£21m

UP
60%
YEAR-ON-YEAR

LOSSES
DECREASED
BY
20%
YEAR-ON-YEAR

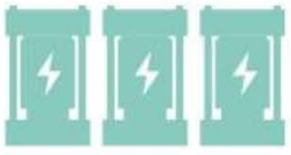


HEAD COUNT
UNCHANGED

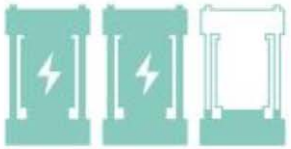
66
PERMANENT STAFF
SINCE 2012

ACHIEVED

LONG RUN
COST TARGET
€1m/MW



SOLD
5.25MW



OF LARGE SCALE
ELECTROLYSERS

1st
UK

POWER-TO-GAS
CONTRACT WITH
nationalgrid

OPENED **THREE**
NEW REFUELLING
STATIONS IN UK

AND **ONE** IN USA

FUEL CONTRACTS
WITH

TOYOTA
HYUNDAI
COMMERCIAL GROUP
arcola energy
ARVAL BNP PARIBAS GROUP
Europcar
ANGLO AMERICAN

Shell

1st

REFUELLING STATION
ON SHELL FORECOURT

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ENERGY STORAGE | CLEAN FUEL

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ENERGY STORAGE

THE NEED
THE CHALLENGE

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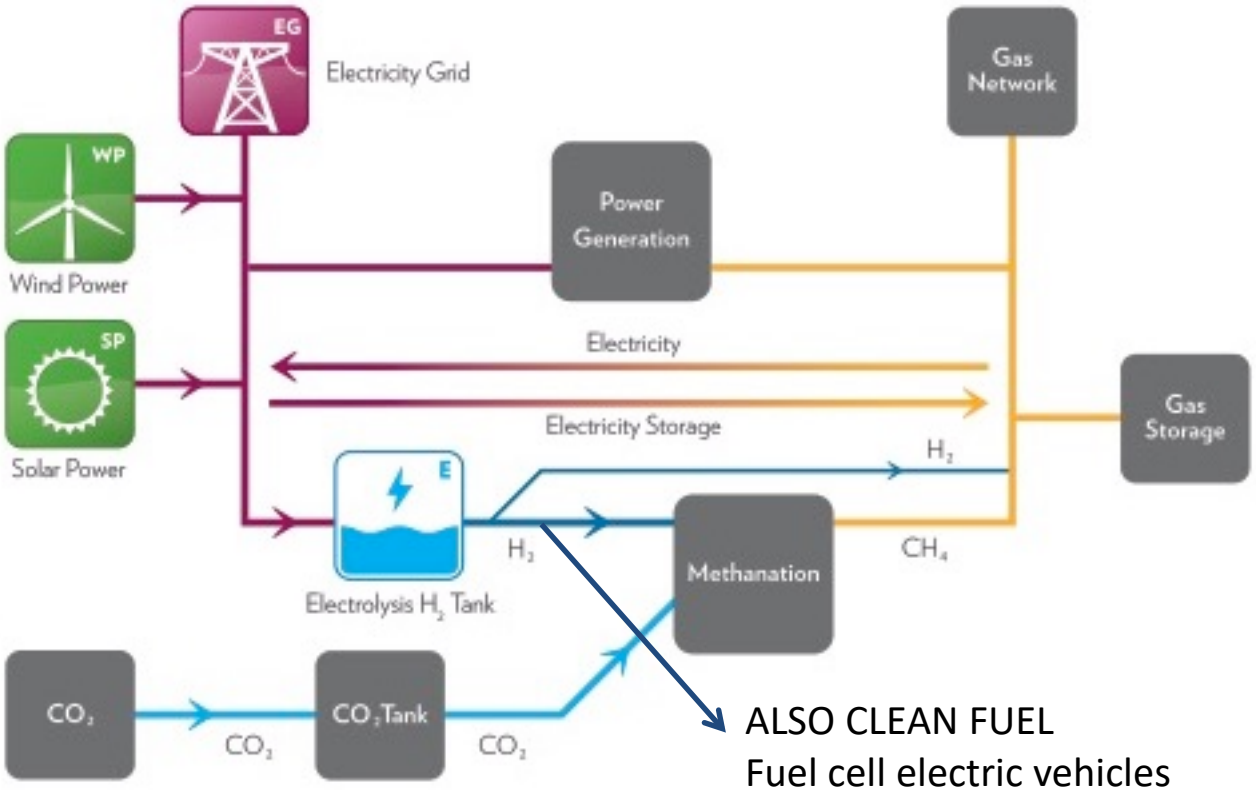
WHY POWER-TO-GAS?

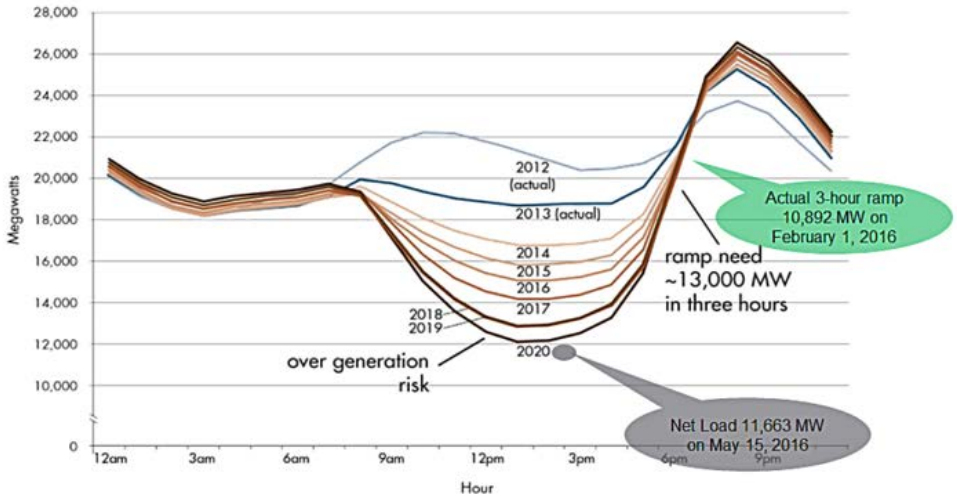
Electricity cannot be stored easily | Hydrogen can be stored easily in the gas grid

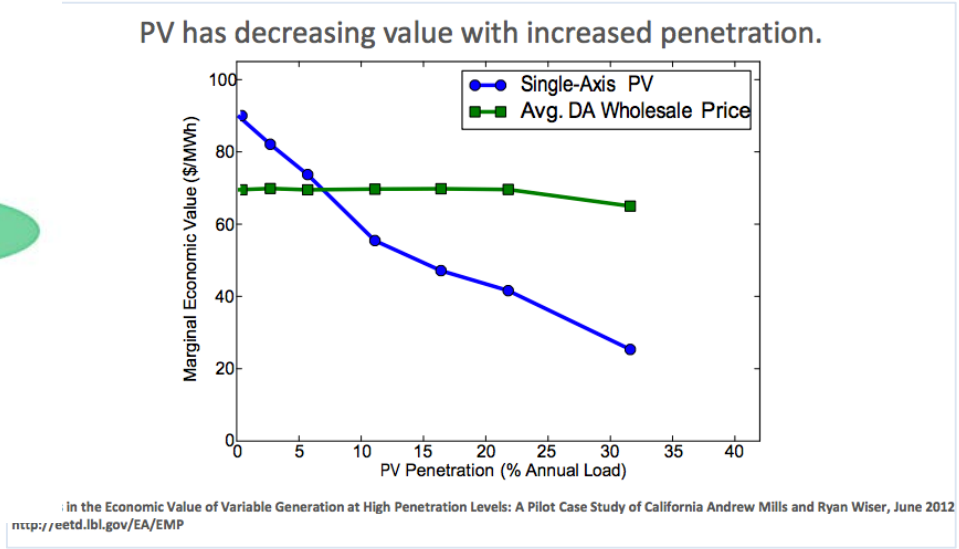


AN ENERGY REVOLUTION

Renewable Energy is Transforming the Energy Landscape

- World power generation reached 5,000GW in 2015
- Wind reached 432GW and solar reached 65GW of global installations in 2015 (~10%)
- Both need energy storage to sustain the growth rate, a variety of technologies are required
- Many US states have renewable mandate targets to increase installed capacity





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

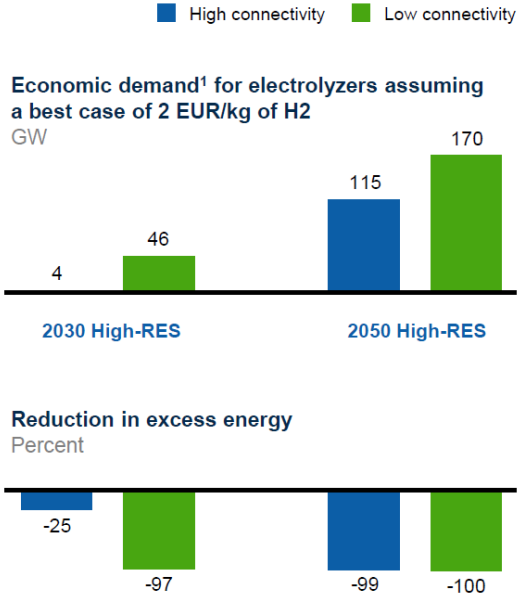
Germany archetype

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



POWER-TO-GAS

HYDROGEN ENERGY SYSTEMS

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THE VALUE OF ENERGY STORAGE

Bundled value like an iPhone

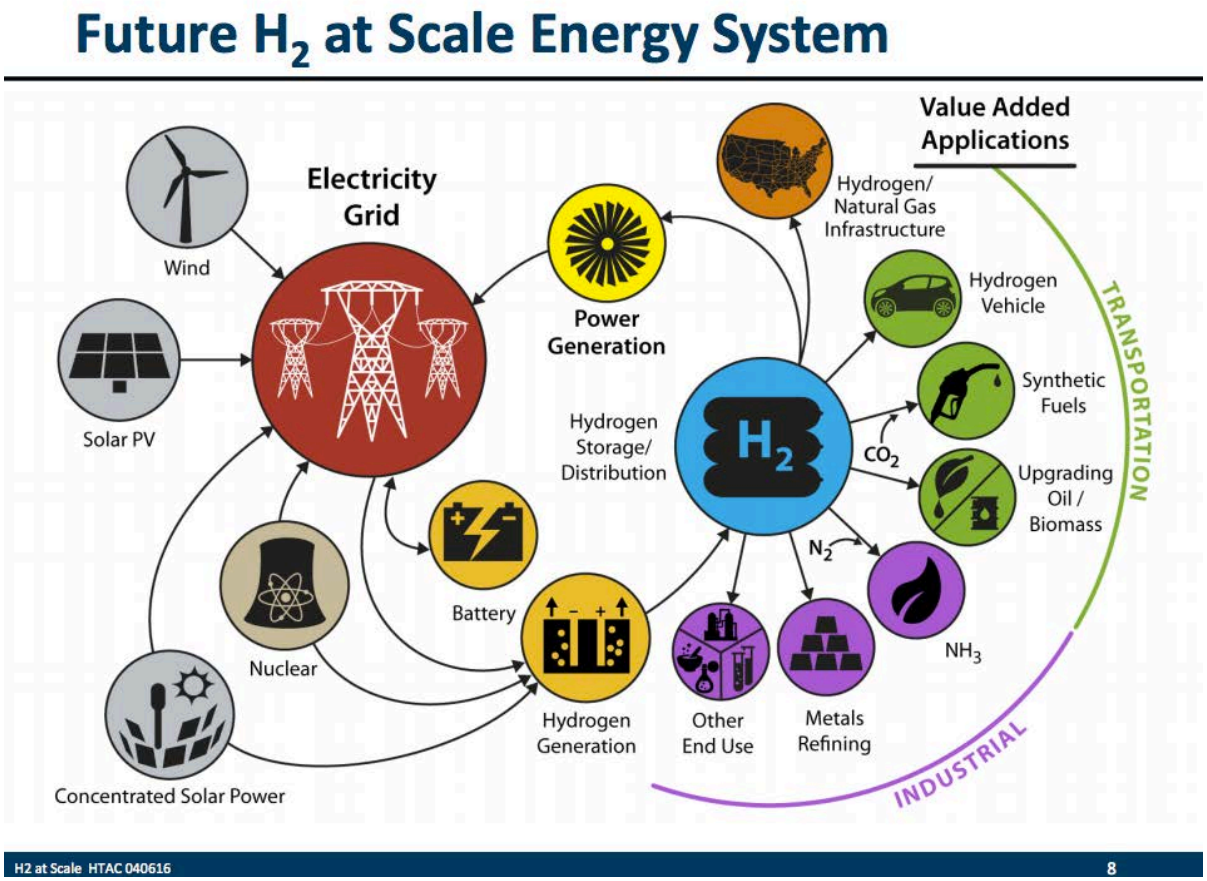
- Store and reply power | energy
- Frequency control
- Voltage stabilisation
- Load following
- Black start
- Transmission line investment deferral
- Energy Storage
- Heating decarbonisation
- Clean fuel
- Industrial feedstock

Specific to the location and tariff landscape to get maximum benefits

Both a benefit and a problem – multiple strands

US SUPPORT

- DOE backed initiative – H2@ scale looking at using large scale renewables to generate hydrogen
- Hydrogen produced at low price with zero emissions
- Pathway to millions of HFCEVs on the US roads
- Predicting ~4 Quads hydrogen demand by 2050 for vehicles
- (8 billion gal gasoline) equiv.



ENERGY STORAGE: THE NEED

HYDROGEN ENERGY SYSTEMS

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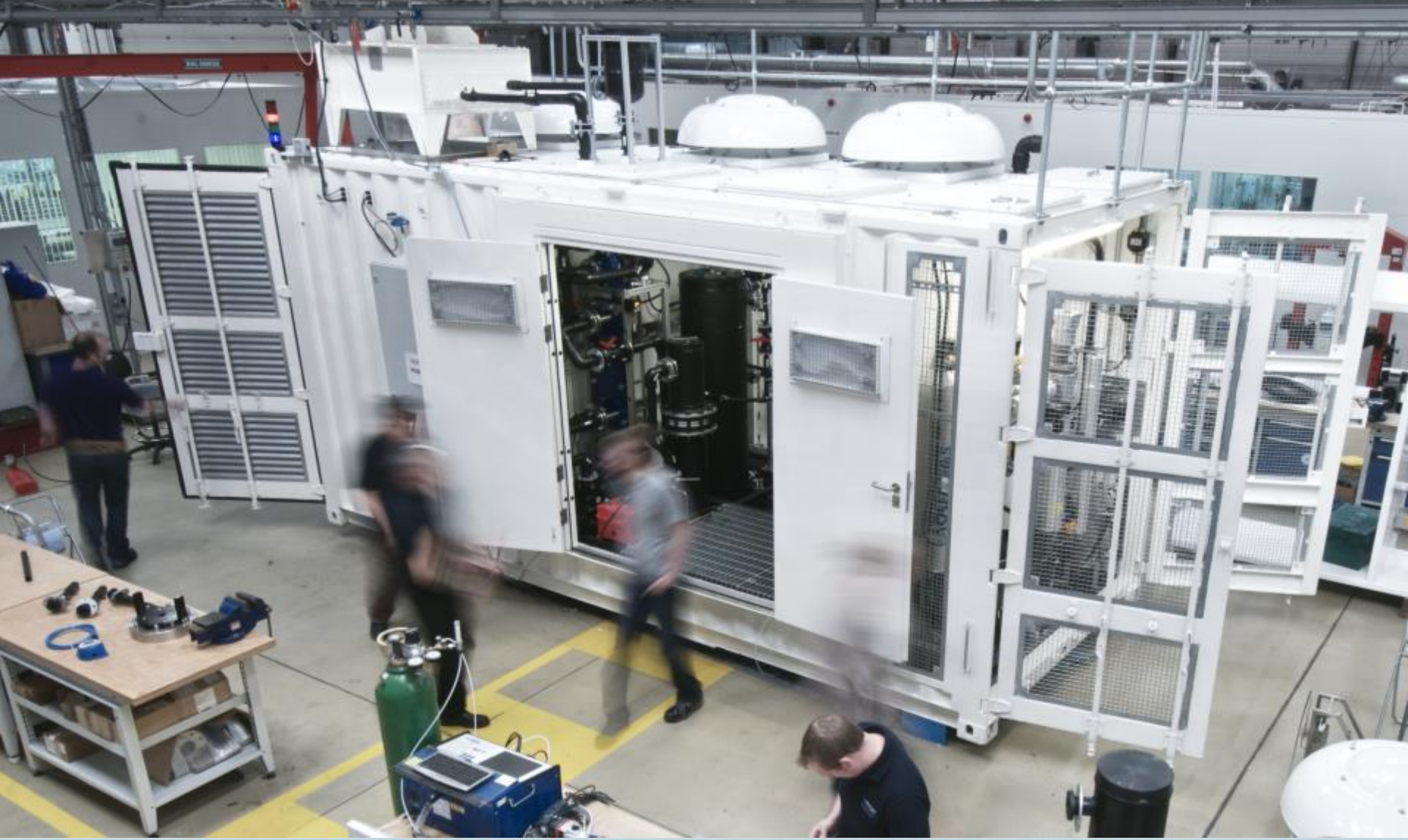

INTEGRATED ELECTROLYSER SYSTEM

ENERGY STORAGE | CLEAN FUEL

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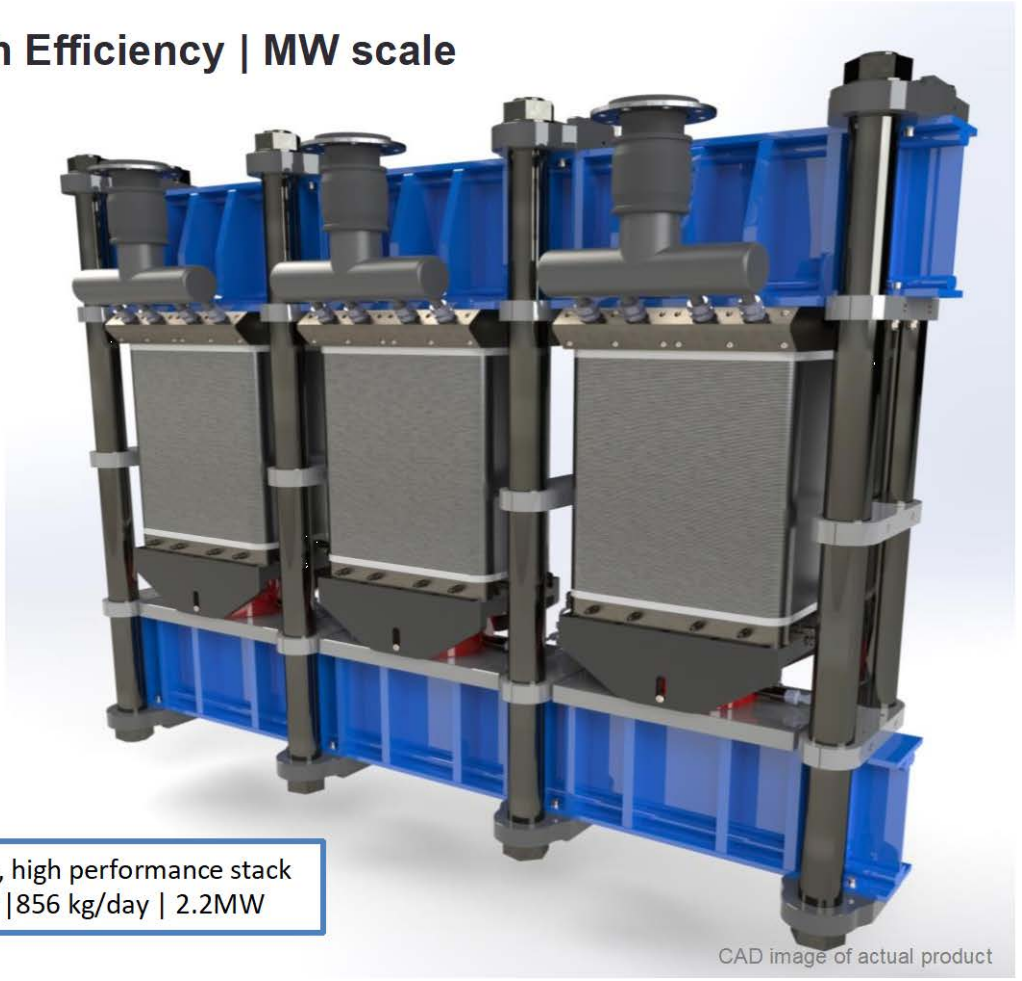
Energy Storage | Clean Fuel

MARKET OFFERING

Rapid Response | High Pressure | High Efficiency | MW scale

- Rapid response: less than 1s
- High pressure: up to 80bar
- High efficiency: 75% measured
- MW scale: 1MW modules
- Compliant: EU and USA

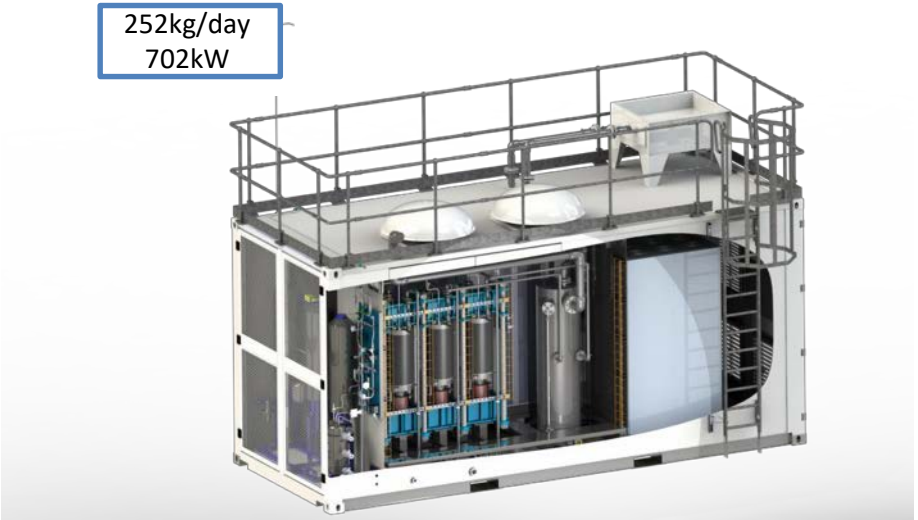


CAD image of actual product

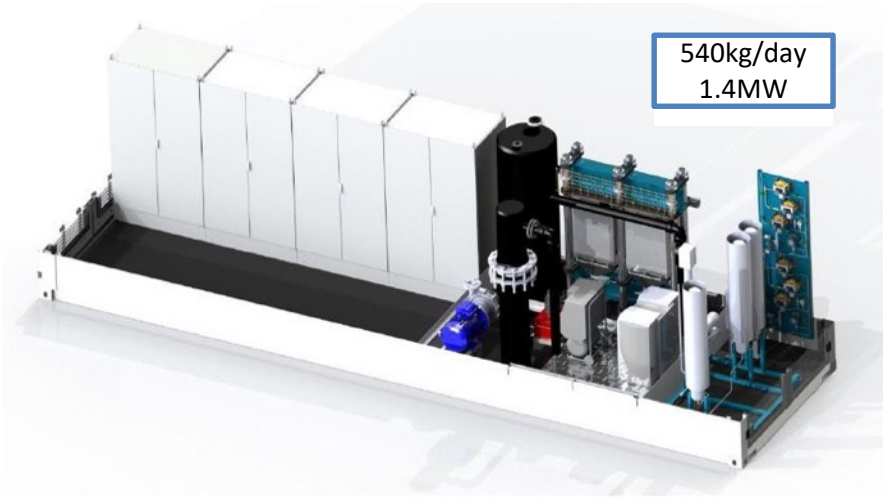
New low cost, high performance stack technology |856 kg/day | 2.2MW

STANDARD PRODUCTS

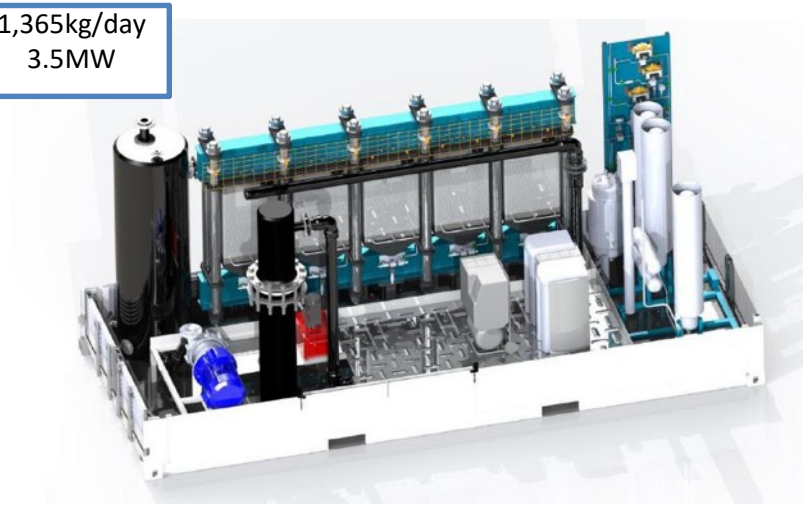
84kg/day
240kW



252kg/day
702kW



540kg/day
1.4MW



1,365kg/day
3.5MW

PEM OFFERING

ENERGY STORAGE | CLEAN FUEL

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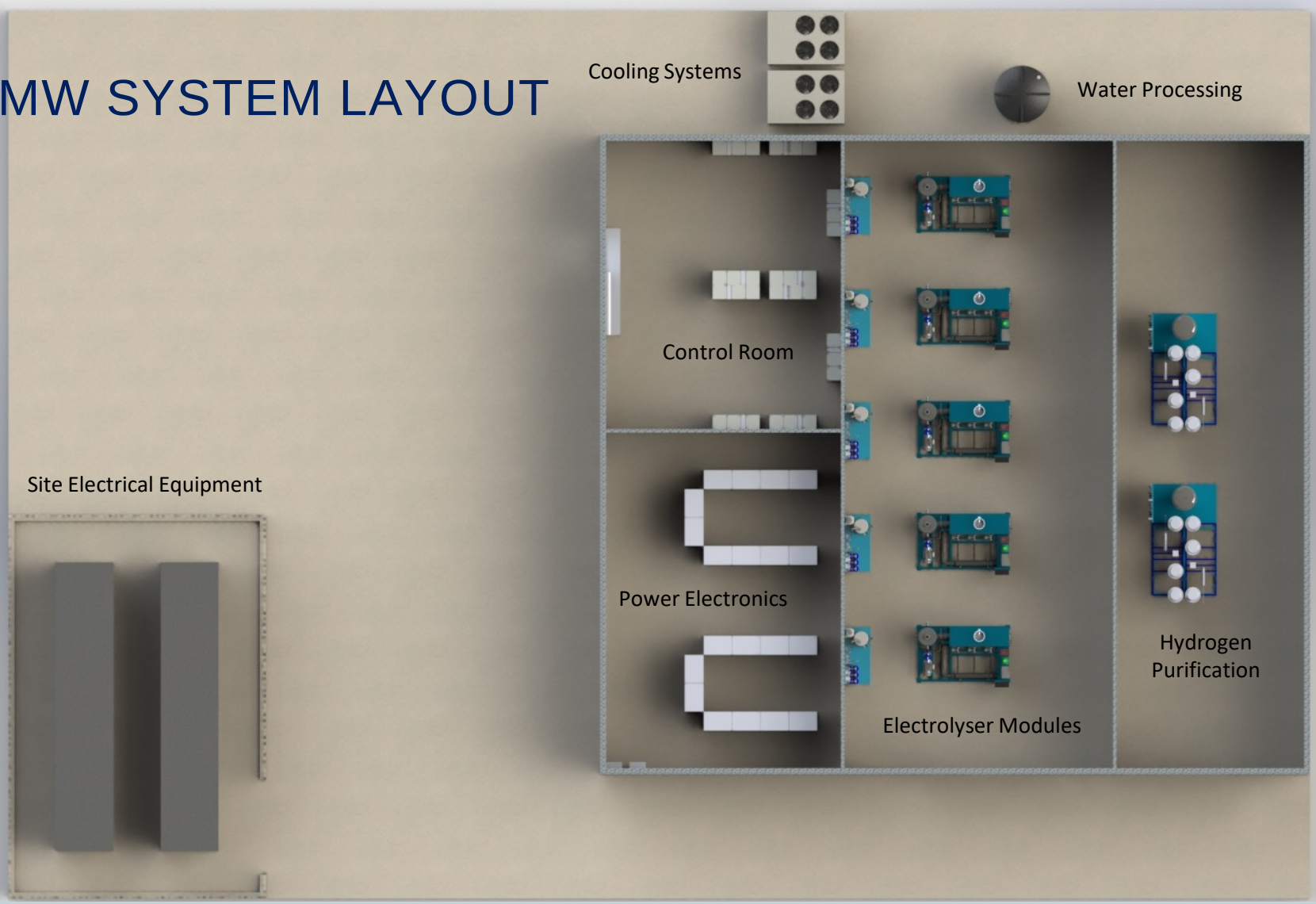
10MW SYSTEM LAYOUT



SYSTEM ARRANGEMENT

HYDROGEN ENERGY SYSTEMS

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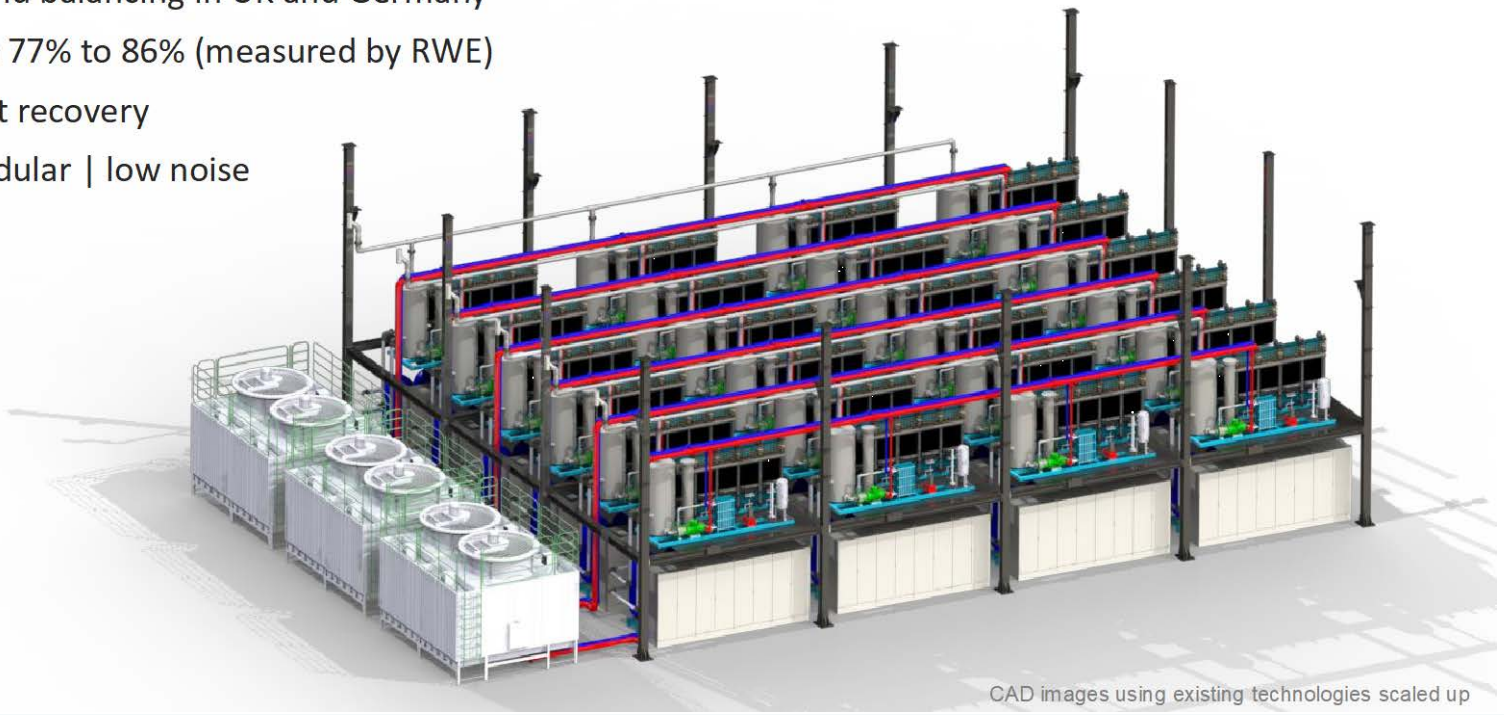
100MW DESIGN | COMPLETE TURN KEY SOLUTION

Modular Design | Thermal Integration | Heat Recovery

- Avoids compounding container costs | Enables two storey construction
- Modular approach | wide capacity offering | Pathway to large scale without technology risk
- Qualified for grid balancing in UK and Germany
- Efficiency from 77% to 86% (measured by RWE)
- Integrated heat recovery
- Compact | modular | low noise



CAD images using existing technologies scaled up

SYSTEM ARRANGEMENT

HYDROGEN ENERGY SYSTEMS

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EXAMPLES

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hhuga
Das große Plus für alle

ITM Power's HGas System brings together rapid response and self-pressurising PEM electrolysis into a fully integrated package which injects hydrogen into the gas distribution network at the Mainova Aktiengesellschaftsite, Frankfurt, utilising pre-existing compliant gas mixing and grid injection infrastructure. The plant has undergone an extensive acceptance, compliance and commissioning phase before going live in December 2013. The sale was the result of a competitive tender, based on price and performance, and was commissioned ahead of schedule. Capable of addressing MW scale Power-to-Gas applications, and accommodates fluctuating power profiles while generating hydrogen at pressures suitable for either direct injection into natural gas networks or via methanation processes without additional compression.

THE FIRST PEM P2G UNIT IN THE FIELD IN GERMANY

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NRM: MIXING PLANT

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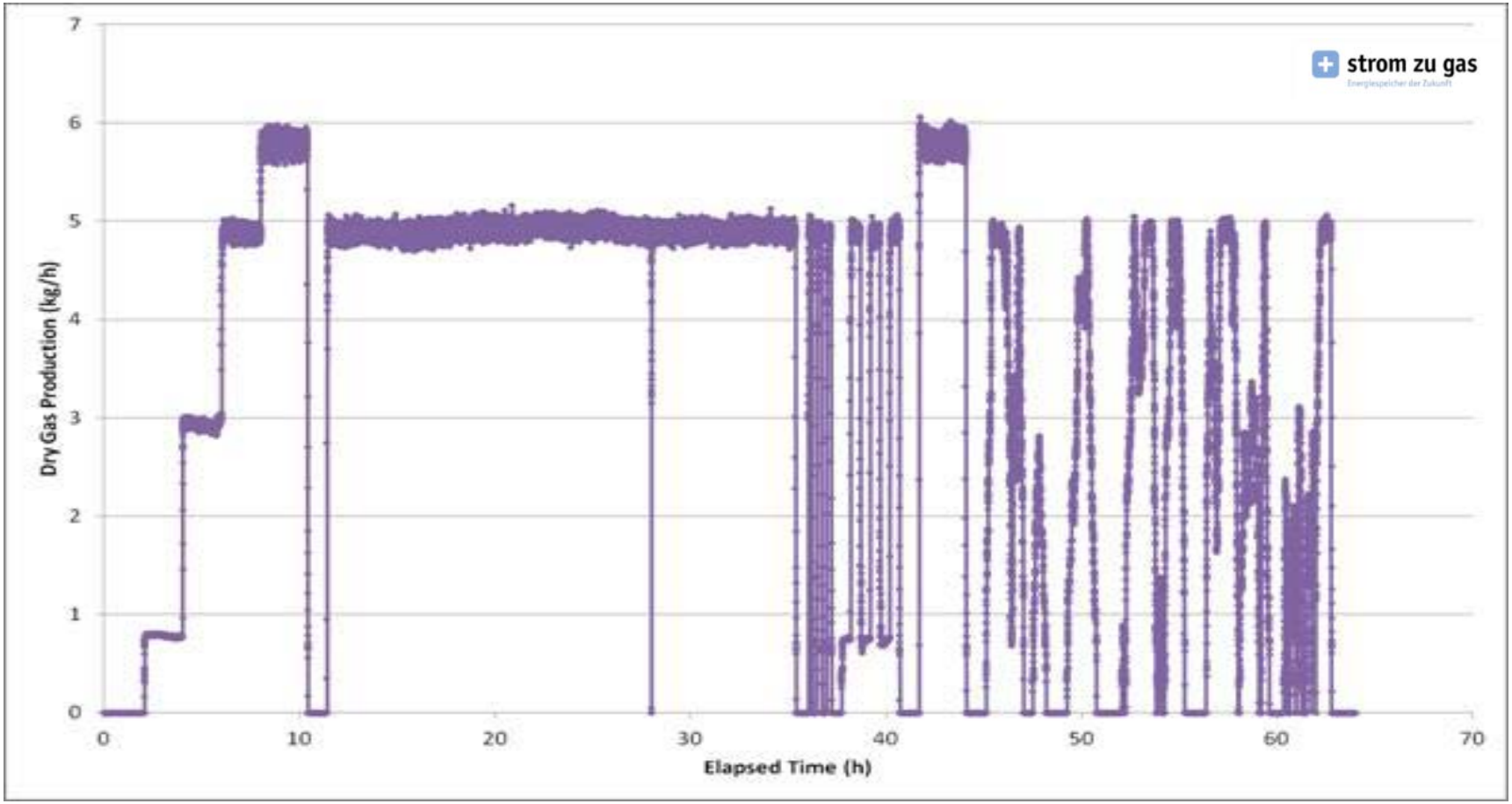
ERFOLGREICHE AUTOMATISIERTE ABNAHMETEST:



THÜGA STROM-ZU-GAS ANLAGE

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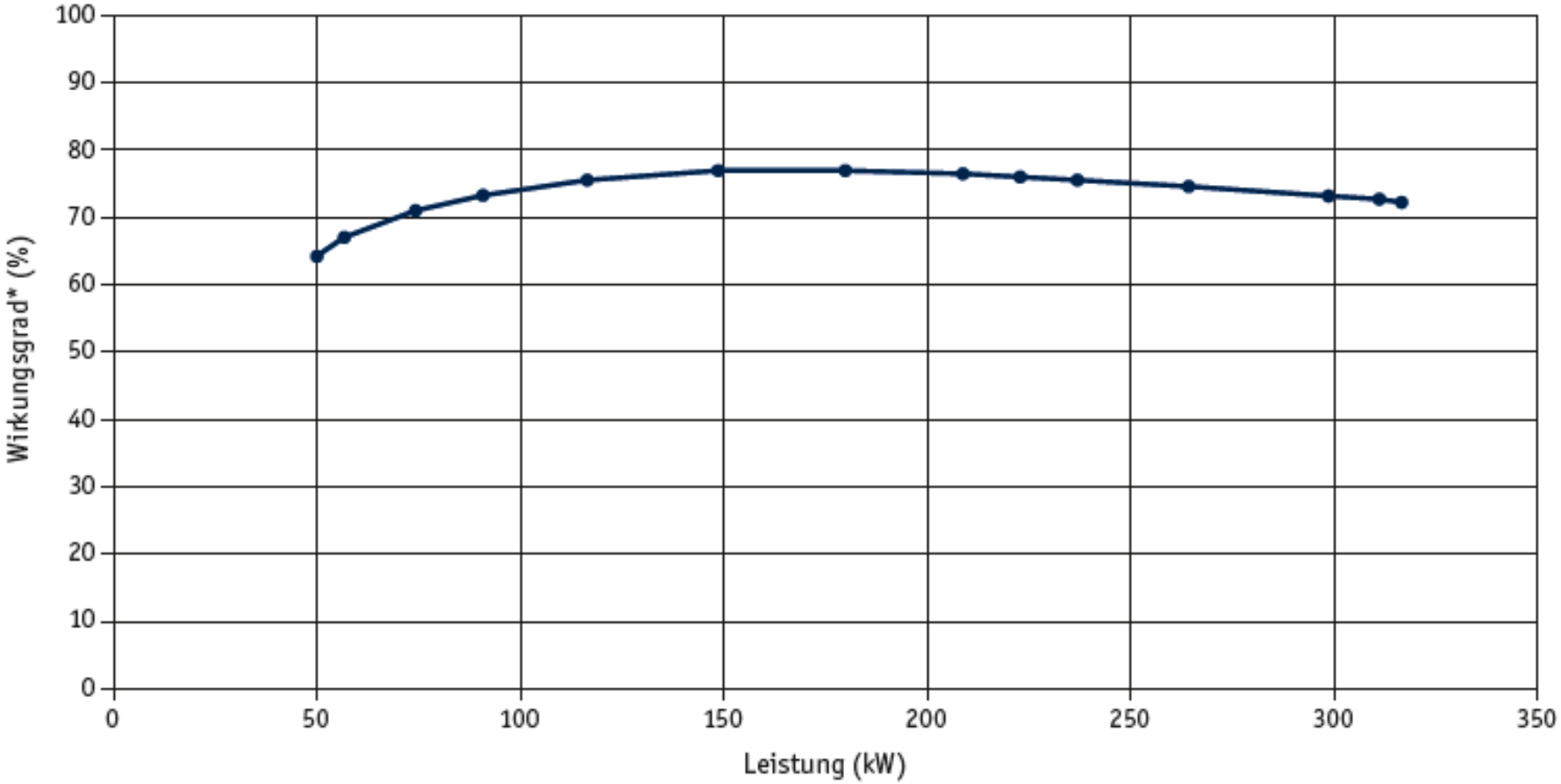
Wirkungsgrad bei unterschiedlicher Auslastung der Thüga Strom zu Gas-Anlage



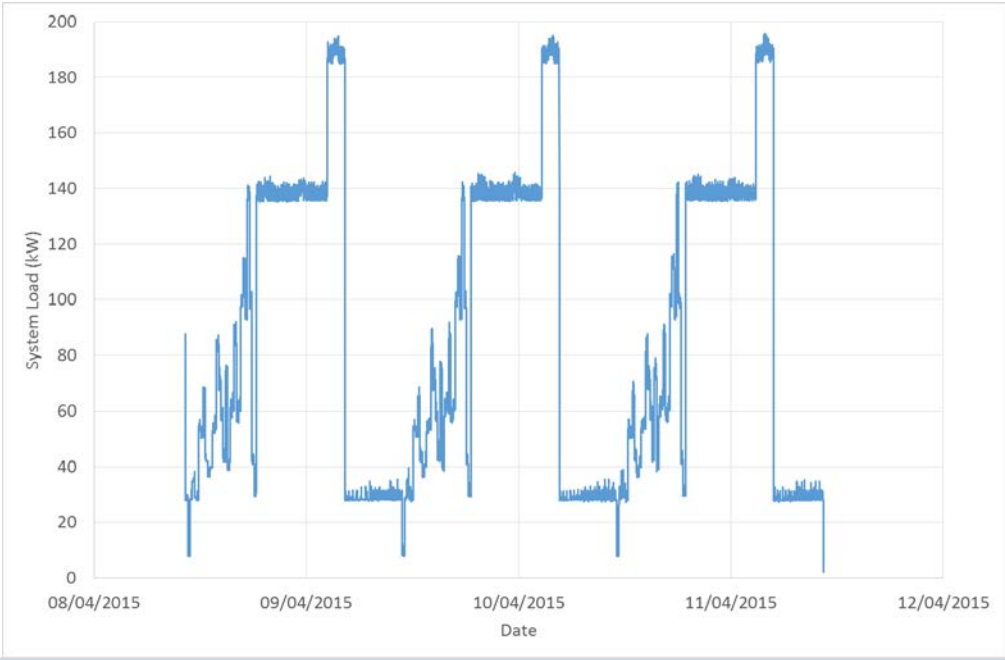
*Die angegebenen Werte zum Wirkungsgrad sind auf den Brennwert bezogen

Quelle: Thüga, http://www.szg-energiespeicher.de/fileadmin/media/Strom_zu_Gas/PDF/Pressegrafik_150210_SzG_Wirkungsgrad.pdf

RWE DEPLOYMENT

Highest recorded electrolyser system efficiency

- 2nd generation HGas180 product
- Integration of waste heat recovery
- 86% system efficiency achieved
- Over 1 year operation



FIRST P2G IN THE UK

HyDeploy Project Scope

- Demonstrate first injection of hydrogen into a representative UK gas distribution network & establish practical operational limits
- Co-sponsored by National Grid Gas Distribution & Northern Gas Networks
- Keele University campus is a closed private network
- 0.5MW electrolyser delivering up to 20% hydrogen into the gas network servicing a population of 9000 people
- Project timeline 30-36 months:

HyDeploy

nationalgrid

Northern Gas Networks

Keele University

HEALTH & SAFETY LABORATORY

ofgem

Progressive energy

BIRMINGHAM FCEB

Tysley Energy Park | 3MW | 1,500kg/day

- 3MW Grid Balancing Electrolyser Funded by InnovateUK
- Linde ionic compression & 350 bar dispenser
- Grant led by ITM Power
- Subject to final confirmation
- 20 buses funded by FCH JU

Birmingham City Council

national express

BOC Member of the Linde Group

ENGIE by people for people

ITM POWER | BUS REFUELLER

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FCEV REFUELLING STATION

VEHICLES | ROLL OUT

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CA PROBLEMS

- Mismatch between funding for vehicles and stations Vs production routes
- Mismatch between fuel pathways for electrons and gas molecules – LCFS
  - Location of facility, age of RE asset, RECs
  - Price instability for LCFS

- Little recognition for energy storage potential in state vision – ES mandate
- Lack of recognition to value add that electrolysis can play alongside EVs in grid management

- Lack of value for greening the natural gas network

SUMMARY

- Increased renewable electricity requires storage
- Grid resiliency is compromised by renewable integration
- PEM electrolysers can store energy in vast amounts and for long duration
- PEM electrolysers link electricity and gas sectors and allows energy shifting
- PEM electrolysers decarbonise electricity, heat and transport
- Renewable gas needs cannot be met by just biogas
- Energy storage needs cannot be met by just batteries
- Policy needs education on h_2

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