RESILIENT POWER

A project of CleanEnergyGroup

Hydrogen and Fuel Cells for Resiliency: Hydrogen for Power-to-Gas Energy Storage

May 12, 2016

CleanEnergyGroup
Innovation in Finance, Technology & Policy

Northeast Electrochemical energy storage Cluster

Housekeeping

All participants are in "Listen-Only" mode. Select "Use Mic & Speakers" to avoid toll charges and use your computer's VOIP capabilities. Or select "Use Telephone" and enter your PIN onto your phone key pad.

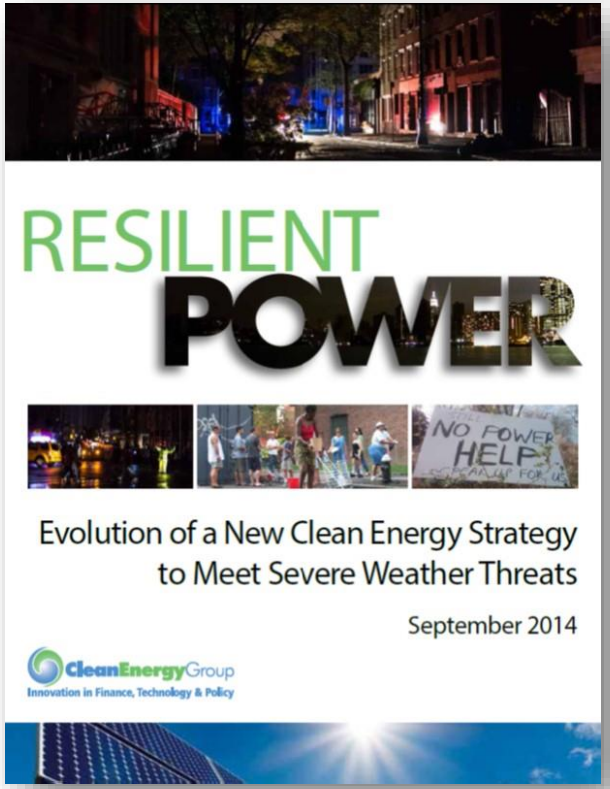
Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

You will find a recording of this webinar, as well as previous Resilient Power Project webinars, online at:

www.resilient-power.org

Who We Are



www.cleanegroup.org

www.resilient-power.org

CleanEnergyGroup
Innovation in Finance, Technology & Policy

Meridian Institute
Connecting People to Solve Problems

CleanEnergy States Alliance

THE JPB FOUNDATION

Barr Foundation

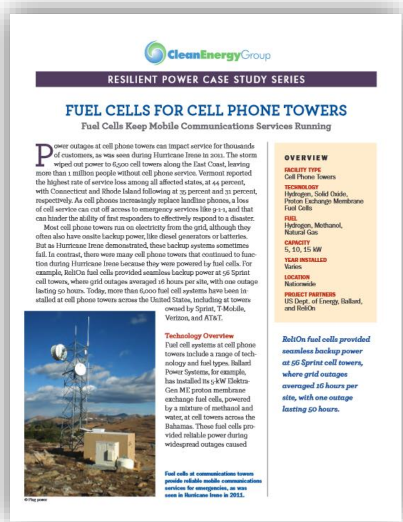
Cummings Foundation

THE KRESGE FOUNDATION

SURDNA FOUNDATION
Fostering sustainable communities in the United States

Resilient Power Project

- Increase public/private investment in clean, resilient power systems
- Engage city officials to develop resilient power policies/programs
- Protect low-income and vulnerable communities
- Focus on affordable housing and critical public facilities
- Advocate for state and federal supportive policies and programs
- Technical assistance for pre-development costs to help agencies/project developers get deals done
- See www.resilient-power.org for reports, newsletters, webinars, and more.



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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR CELL PHONE TOWERS

Fuel Cells Keep Mobile Communications Services Running

Power outages at cell phone towers can impact service for thousands of customers, as was seen during Hurricane Irene in 2011. The storm wiped out power to 6,500 cell towers along the East Coast, leaving more than 1 million people without cell phone service. Vermont reported the highest rate of service loss among all affected states, at 44 percent, with Connecticut and Rhode Island following at 35 percent and 31 percent, respectively. As cell phones increasingly replace landline phones, a loss of cell service can cut off access to emergency services like 9-1-1, and that can hinder the ability of first responders to effectively respond to a disaster.

Most cell phone towers run on electricity from the grid, although they often also have onsite backup power, like diesel generators or batteries. But as Hurricane Irene demonstrated, these backup systems sometimes fail. In contrast, there were many cell phone towers that continued to function during Hurricane Irene because they were powered by fuel cells. For example, ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours. Today, more than 6,000 fuel cell systems have been installed at cell phone towers across the United States, including at towers owned by Sprint, T-Mobile, Verizon, and AT&T.

Technology Overview

Fuel cell systems at cell phone towers include a range of technology and fuel types. Ballard Power Systems, for example, has installed its 5-kW Elektra-Gen ME proton membrane exchange fuel cells, powered by a mixture of methanol and water, at cell towers across the Bahamas. These fuel cells provided reliable power during widespread outages caused

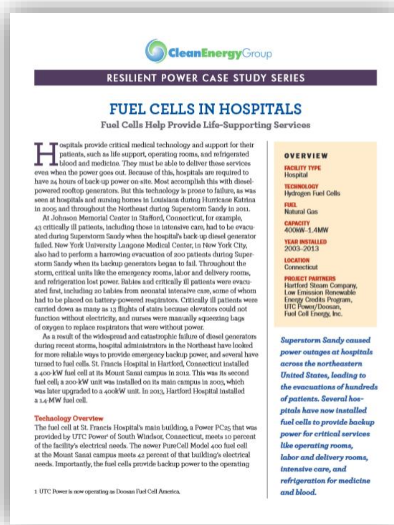
Fuel cells at communications towers provide reliable mobile communications services for emergencies, as was seen in Hurricane Irene in 2011.

© Plug power

OVERVIEW

FACILITY TYPE: Cell Phone Towers
TECHNOLOGY: Hydrogen, Solid Oxide, Proton Exchange Membrane Fuel Cells
FUEL: Hydrogen, Methanol, Natural Gas
CAPACITY: 5, 10, 15 kW
YEAR INSTALLED: Varies
LOCATION: Nationwide
PROJECT PARTNERS: US Dept. of Energy, Ballard, and ReliOn

ReliOn fuel cells provided seamless backup power at 56 Sprint cell towers, where grid outages averaged 16 hours per site, with one outage lasting 50 hours.



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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS IN HOSPITALS

Fuel Cells Help Provide Life-Supporting Services

Hospitals provide critical medical technology and support for their patients, such as life support, operating rooms, and refrigerated blood and medicine. They must be able to deliver these services even when the power goes out. Because of this, hospitals are required to have 24 hours of back-up power on-site. Most accomplish this with diesel-powered rooftop generators. But this technology is prone to failure, as was seen at hospitals and nursing homes in Louisiana during Hurricane Katrina in 2005 and throughout the Northeast during Superstorm Sandy in 2011.

At Johnson Memorial Center in Stafford, Connecticut, for example, 43 critically ill patients, including those in intensive care, had to be evacuated during Superstorm Sandy when the hospital's back-up diesel generator failed. New York University Langone Medical Center, in New York City, also had to perform a harrowing evacuation of 200 patients during Superstorm Sandy when its backup generators began to fail. Throughout the storm, critical units like the emergency rooms, labor and delivery rooms, and refrigeration lost power. Babies and critically ill patients were evacuated first, including 20 babies from neonatal intensive care, some of whom had to be placed on battery-powered respirators. Critically ill patients were carried down as many as 13 flights of stairs because elevators could not function without electricity, and nurses were manually squeezing bags of oxygen to replace respirators that were without power.

As a result of the widespread and catastrophic failure of diesel generators during recent storms, hospital administrators in the Northeast have looked for more reliable ways to provide emergency backup power, and several have turned to fuel cells. St. Francis Hospital in Hartford, Connecticut installed a 400-kW fuel cell at its Mount Sanai campus in 2012. This was its second fuel cell; a 200-kW unit was installed on its main campus in 2003, which was later upgraded to a 400kW unit. In 2013, Hartford Hospital installed a 1.4-MW fuel cell.

Technology Overview

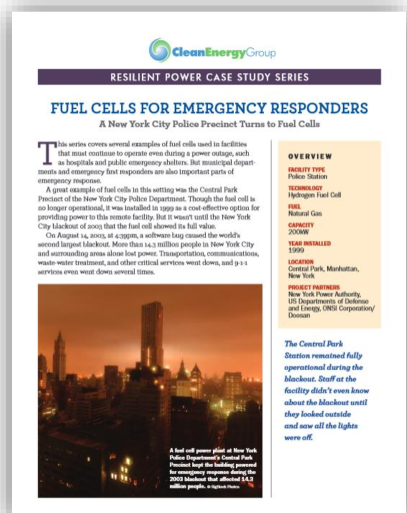
The fuel cell at St. Francis Hospital's main building, a Power PC25 that was provided by UTC Power[1] of South Windsor, Connecticut, meets 10 percent of the facility's electrical needs. The newer PureCell Model 400 fuel cell at the Mount Sanai campus meets 42 percent of that building's electrical needs. Importantly, the fuel cells provide backup power to the operating

1 UTC Power is now operating as Doosan Fuel Cell America.

OVERVIEW

FACILITY TYPE: Hospital
TECHNOLOGY: Hydrogen Fuel Cells
FUEL: Natural Gas
CAPACITY: 400kW–1.4MW
YEAR INSTALLED: 2003–2013
LOCATION: Connecticut
PROJECT PARTNERS: Hartford Steam Company, Low Emission Renewable Energy Credits Program, UTC Power/Doosan, Fuel Cell Energy, Inc.

Superstorm Sandy caused power outages at hospitals across the northeastern United States, leading to the evacuations of hundreds of patients. Several hospitals have now installed fuel cells to provide backup power for critical services like operating rooms, labor and delivery rooms, intensive care, and refrigeration for medicine and blood.



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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR EMERGENCY RESPONDERS

A New York City Police Precinct Turns to Fuel Cells

This series covers several examples of fuel cells used in facilities that must continue to operate even during a power outage, such as hospitals and public emergency shelters. But municipal departments and emergency first responders are also important parts of emergency response.

A great example of fuel cells in this setting was the Central Park Precinct of the New York City Police Department. Though the fuel cell is no longer operational, it was installed in 1999 as a cost-effective option for providing power to this remote facility. But it wasn't until the New York City blackout of 2003 that the fuel cell showed its full value.

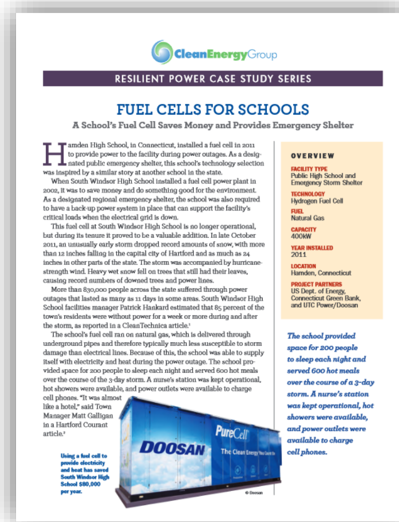
On August 14, 2003, at 4:39pm, a software bug caused the world's second largest blackout. More than 14.3 million people in New York City and surrounding areas alone lost power. Transportation, communications, waste-water treatment, and other critical services went down, and 9-1-1 services even went down several times.

A fuel cell power plant at New York Police Department's Central Park Precinct kept the building powered for emergency response during the 2003 blackout that affected 14.3 million people. © BigStock Photos

OVERVIEW

FACILITY TYPE: Police Station
TECHNOLOGY: Hydrogen Fuel Cell
FUEL: Natural Gas
CAPACITY: 200kW
YEAR INSTALLED: 1999
LOCATION: Central Park, Manhattan, New York
PROJECT PARTNERS: New York Power Authority, US Departments of Defense and Energy, ONSI Corporation/Doosan

The Central Park Station remained fully operational during the blackout. Staff at the facility didn't even know about the blackout until they looked outside and saw all the lights were off.



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RESILIENT POWER CASE STUDY SERIES

FUEL CELLS FOR SCHOOLS

A School's Fuel Cell Saves Money and Provides Emergency Shelter

Hamden High School, in Connecticut, installed a fuel cell in 2011 to provide power to the facility during power outages. As a designated public emergency shelter, this school's technology selection was inspired by a similar story at another school in the state.

When South Windsor High School installed a fuel cell power plant in 2002, it was to save money and do something good for the environment. As a designated regional emergency shelter, the school was also required to have a back-up power system in place that can support the facility's critical loads when the electrical grid is down.

This fuel cell at South Windsor High School is no longer operational, but during its tenure it proved to be a valuable addition. In late October 2011, an unusually early storm dropped record amounts of snow, with more than 12 inches falling in the capital city of Hartford and as much as 24 inches in other parts of the state. The storm was accompanied by hurricane-strength wind. Heavy wet snow fell on trees that still had their leaves, causing record numbers of downed trees and power lines.

More than 830,000 people across the state suffered through power outages that lasted as many as 11 days in some areas. South Windsor High School facilities manager Patrick Hankard estimated that 85 percent of the town's residents were without power for a week or more during and after the storm, as reported in a CleanTechnica article.[1]

The school's fuel cell ran on natural gas, which is delivered through underground pipes and therefore typically much less susceptible to storm damage than electrical lines. Because of this, the school was able to supply itself with electricity and heat during the power outage. The school provided space for 200 people to sleep each night and served 600 hot meals over the course of the 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones. "It was almost like a hotel," said Town Manager Matt Galligan in a Hartford Courant article.[2]

Using a fuel cell to provide electricity and heat has saved South Windsor High School $80,000 per year.

© Doosan

OVERVIEW

FACILITY TYPE: Public High School and Emergency Storm Shelter
TECHNOLOGY: Hydrogen Fuel Cell
FUEL: Natural Gas
CAPACITY: 400kW
YEAR INSTALLED: 2011
LOCATION: Hamden, Connecticut
PROJECT PARTNERS: US Dept. of Energy, Connecticut Green Bank, and UTC Power/Doosan

The school provided space for 200 people to sleep each night and served 600 hot meals over the course of a 3-day storm. A nurse's station was kept operational, hot showers were available, and power outlets were available to charge cell phones.

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Resilient Power Project

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RESILIENT POWER
A Project of Clean Energy Group

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seth@cleanegroup.org

With the Resilient Power Project, Clean Energy Group and Meridian Institute are working to accelerate market development of clean energy technologies for resilient power applications that serve low-income communities and vulnerable populations during disasters and power disruptions, and to address climate adaptation and mitigation goals through expansion of reliable renewable energy deployment. To reduce impacts and dangers of power outages in communities now and in the future, the Resilient Power Project works to provide technology and policy solutions to address three challenges facing the country: Community Resiliency, Climate Adaptation, and Climate Mitigation.

Clean Energy Group's role in this process is to help inform, coordinate, and support federal, state, and local officials, policy makers and developers with the goal of deploying resilient power projects in communities across the country. In addition to providing program guidance to policy makers and limited technical assistance funding

Follow the Resilient Power Project on Twitter

Tweets by @Resilient_Power

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Sierra Club
@sierraclub

#Fracking's Costs Fall Disproportionately on the Poor and Minorities in South Texas bit.ly/24aU4Fn (by @BrianBienkowski)

22 Feb

Resilient Power Retweeted

Navigant Research

Northeast Electrochemical Energy Storage Cluster (NEESC)

NEESC is a network of industry, academic, government and non-governmental leaders working together to help businesses provide energy storage solutions.

Northeast Electrochemical energy storage Cluster

www.neesc.org

Today's Guest Speakers

- **Prabhu Rao**, CEO North America, McPhy Energy
- **Steve Jones**, Managing Director, ITM Power
- **Giuseppe Artizzu**, Energy Strategy Director, Electro Power Systems (EPS)

Hydrogen Energy Storage

McPhy energy

CESA Webinar
May 12, 2016

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1st ACT: WHY ?

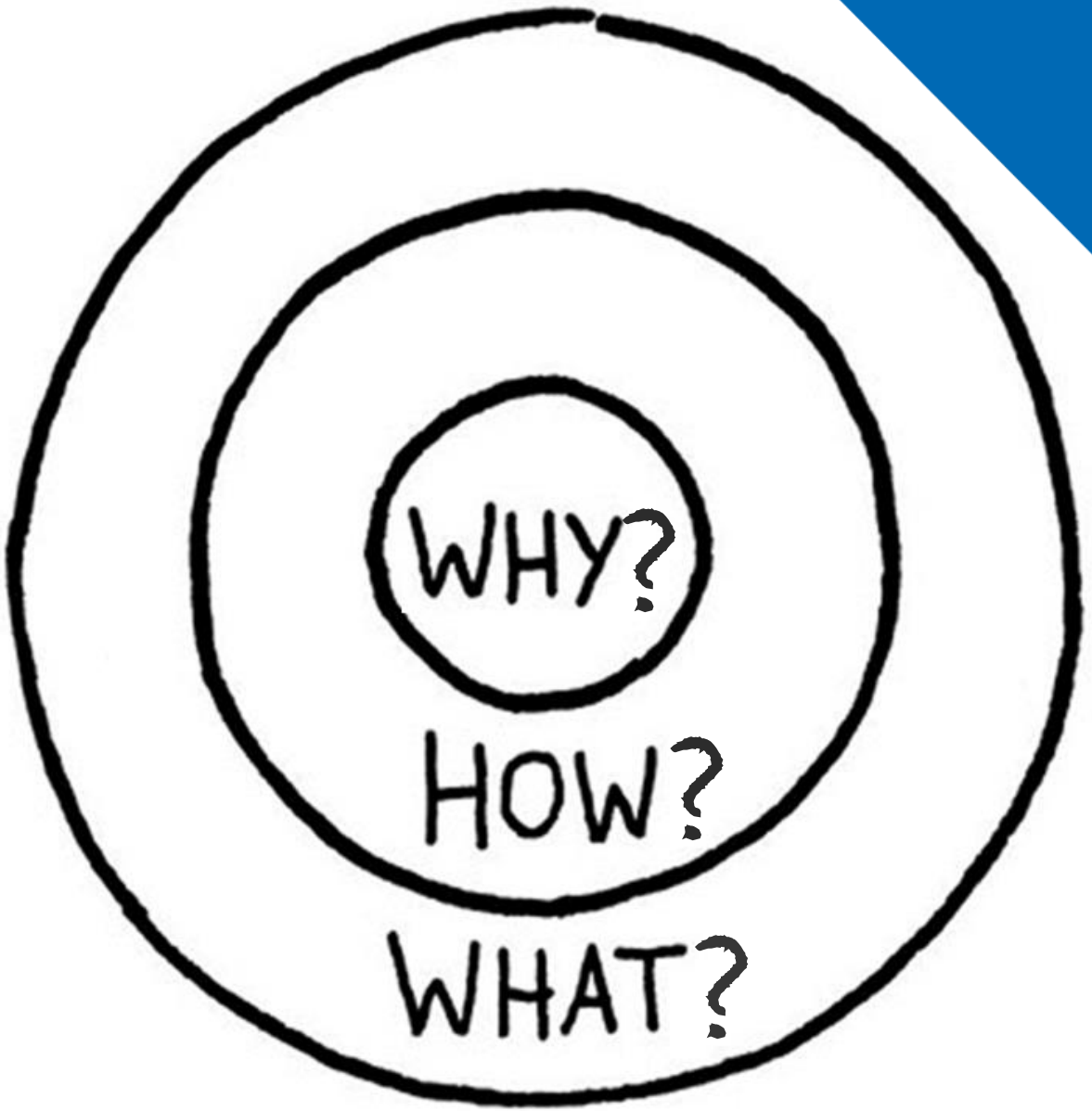
The energy revolution

2nd ACT: HOW?

- The European Experience

3rd ACT: WHAT?

- McPhy Energy solutions



1st ACT: WHY?

The energy revolution

McPhy energy

A change of paradigm

Emerging global awareness

COP21
Global consensus to limit the impact
of human activity on the climate

France
Article 121 of the French Energy Transition Act
Deployment of a hydrogen refueling infrastructure for mobility
Large-scale experimentation of energy storage using hydrogen
Environmental Mobility Priority for the "Nouvelle France Industrielle" plan
100 hydrogen refueling stations and 1,000 vehicles in 2018

Germany
Energiewende(1)
Renewables: 50% of electricity production in 2030, 80% in 2050

(1) Source: Information report of the French Senate, 18 December 2013

As a consequence: the need to reduce greenhouse gas emissions and fine particles in transportation, industry and energy production

Time for a change

Think of energy in new ways!

Energy: increased use of renewables (1/2)

The European energy giants are switching to renewable energy[1]

"Empowering customers.
Shaping markets"

30 November 2014
100% focus on renewable energy, networks and customer solutions

GDF-Suez renamed Engie

29 July 2015
Three-year strategy to become the global energy transition leader

Spinoff of businesses

1 December 2015
Creation of a new subsidiary specialized in renewable energies, networks and distribution

• • •

FOCUS

"ENGIE launches today an ambitious 3-year transformation plan to become leader in the world energy transition. This plan aims at redesigning the portfolio of activities of the Group, thanks to a EUR 22 billion Capex program and a EUR 15 billion portfolio rotation program (…). We want to focus on low carbon activities …"

Gérard Mestrallet, Chairman-CEO of ENGIE (presentation meeting for 2015 annual results)

(1) Source: company press releases

Energy: increased use of renewables (2/2)

Continuing increase of capacity in Europe for wind and solar energies (1)

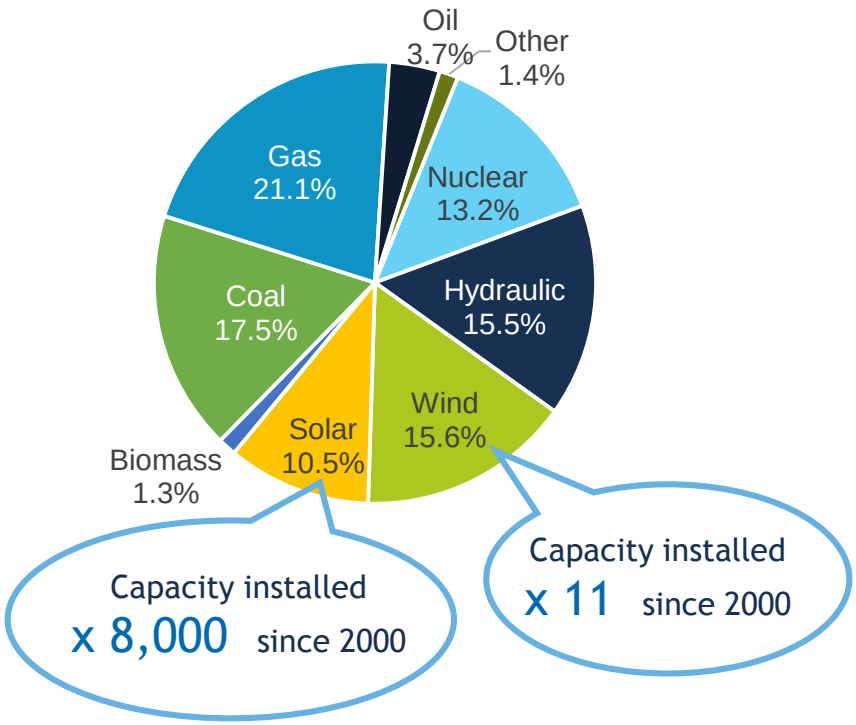
Renewable energy

77% of new installations 2015(2)
+ 22.3 GW in 2015
Eight consecutive years where renewables contributed over 55% of all additional power capacity in the EU(2)

Wind: 142 GW installed in Europe at the end of 2015
3rd source of electricity
+ 12.8 GW in 2015
44% of new installations 2015

Solar: 95 GW in Europe at the end of 2015
+ 8.5 GW in 2015
29% of new installations 2015

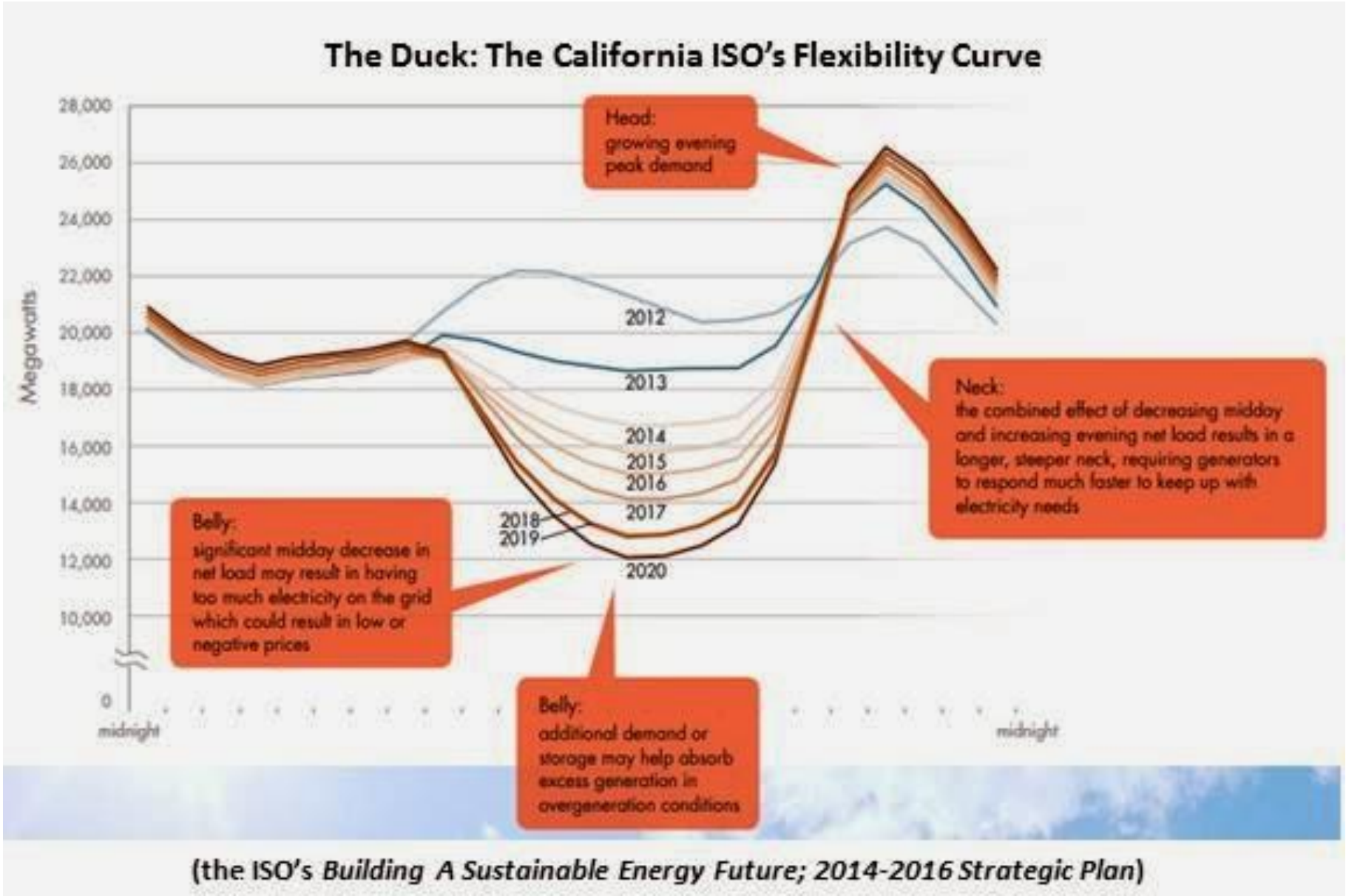
➔ **Out of 908 GW installed in Europe at the end of 2015 237 GW of wind and solar power**



(1) Source: Wind in power, 2015 European statistics, European Wind Energy Association, February 2016
(2) Percentage expressed for total capacity of new installations

Need for increased flexibility through energy storage solutions

No good deed goes unpunished!

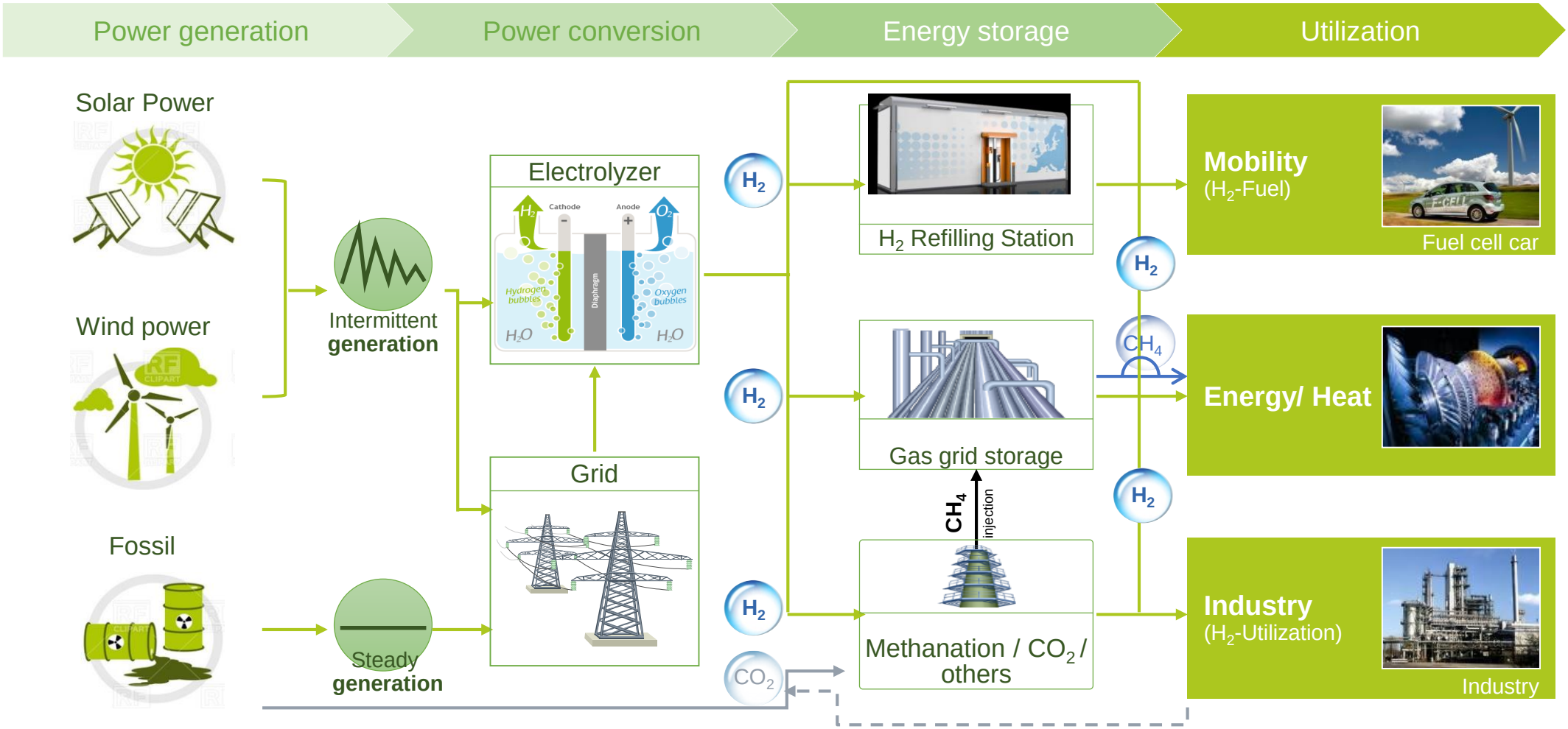


(the ISO's *Building A Sustainable Energy Future; 2014-2016 Strategic Plan*)

2nd ACT: WHAT?

Benefits of Hydrogen

H_2 : essential today, disruptive tomorrow



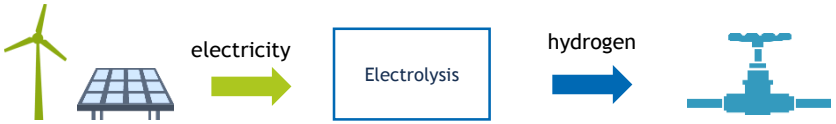
Focus on Power-to-Gas

The solution for storage selected by major energy companies

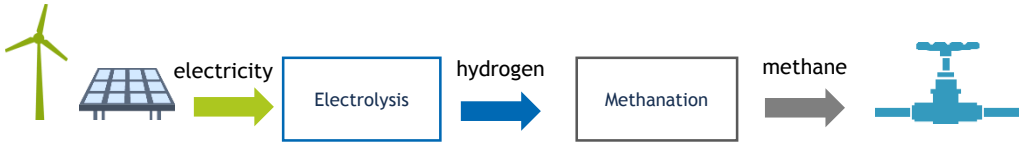
Hydrogen and the synthesis of methane
recognized as a vector for energy storage
Large-scale storage capacity
Long-term storage

FOCUS
Power-to-Gas technologies

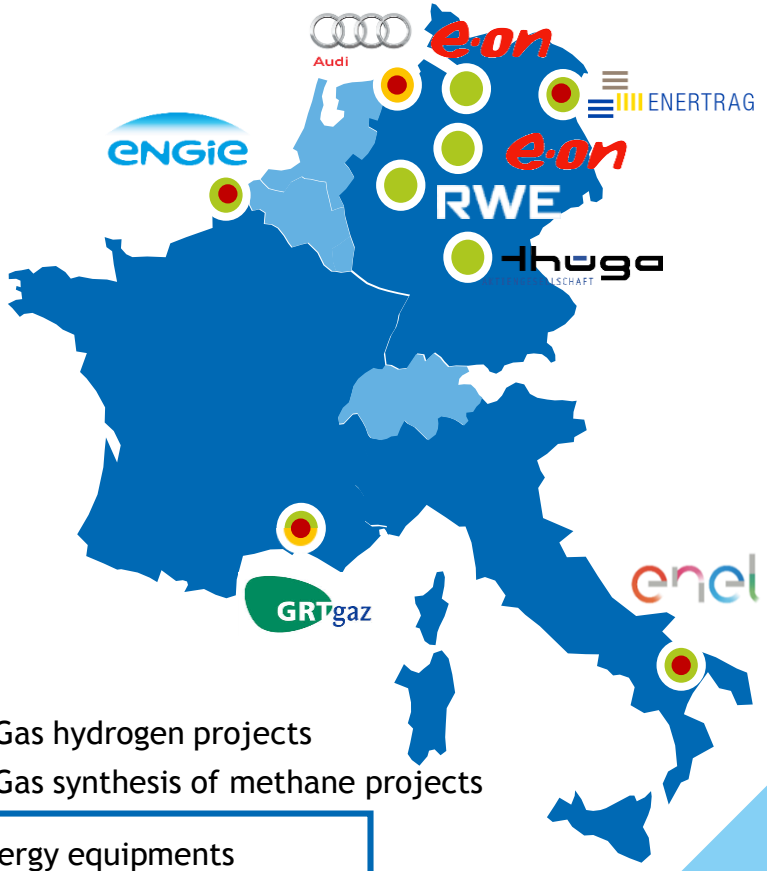
1. Injecting wind-generated hydrogen directly into the gas supply network



2. Transformation of hydrogen into synthesis of methane that is then injected in the guest network



➔ **Power-to-Gas, examples of achievements in Europe(1)**



(1) Sources: Study on hydrogen and methanation as a process for recovering surplus electricity, Ademe, September 2014 / McPhy Energy

3rd ACT: HOW?

How does McPhy address the H_2 challenges

McPhy energy

McPhy Energy value proposition

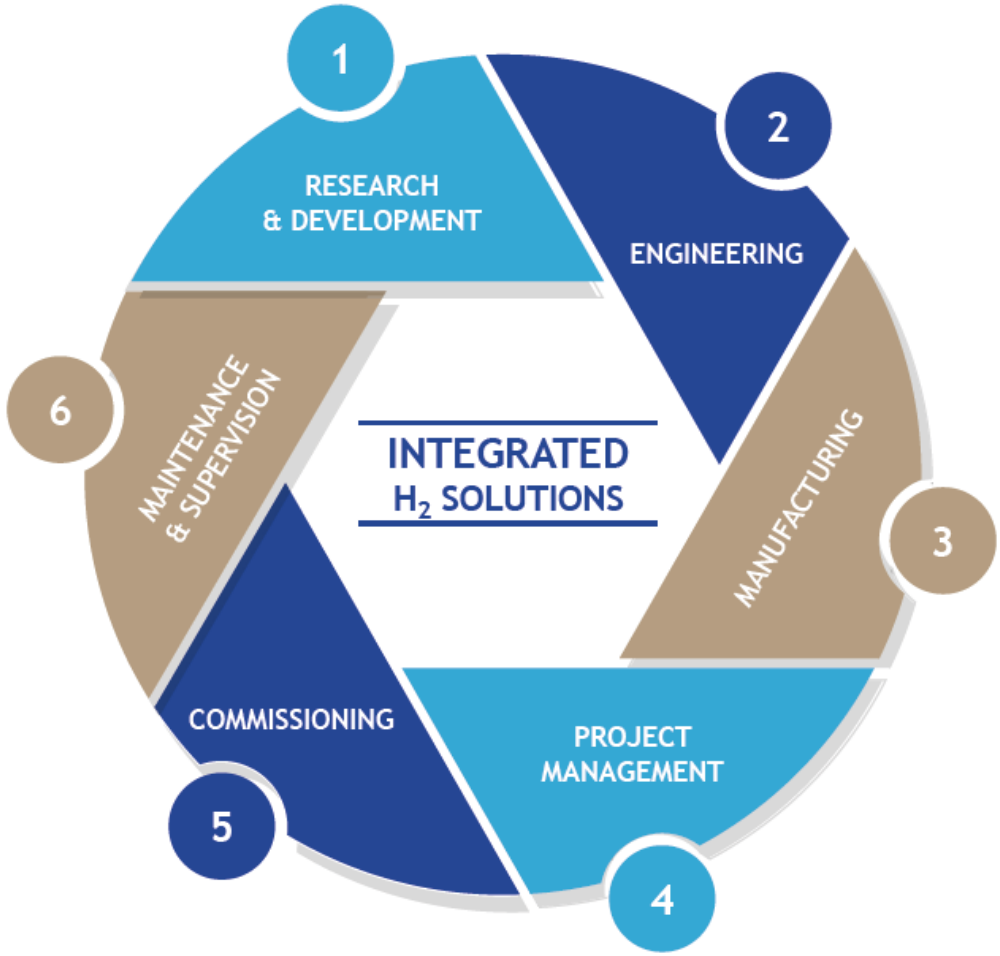
MASTERING THE WHOLE HYDROGEN VALUE CHAIN

with global solutions tailored to your needs

"As a designer, manufacturer and integrator, McPhy Energy provides sustainable & efficient hydrogen solutions, ready to be integrated into your process."

TARGETED MARKETS

- gas — *Energy*
- H_2 — *Mobility*
- *Industry*



A complete range of hydrogen equipment

McLyzer
HYDROGEN PRODUCTION

On site generators to produce "clean" hydrogen from renewable energy sources

> *Wide range of electrolyzers for all hydrogen uses*
> *Full offer of additional services*
> *Technology partnership with De Nora, the electrochemistry market leader*

McStore
HYDROGEN STORAGE

Solutions to store large amounts of hydrogen with safe / logistics free solutions

> *Full range dedicated to the energy and industry sectors*
> *Partnership with GKN Powder, the global leader in metallic powders*
> *Exclusive technology of solid-state storage*

McFilling
HYDROGEN DISTRIBUTION

Putting our energy to work for zero emission mobility

> *McFilling, our refueling station*
> *A compact, modular and upgradable solution*
> *A turnkey product*

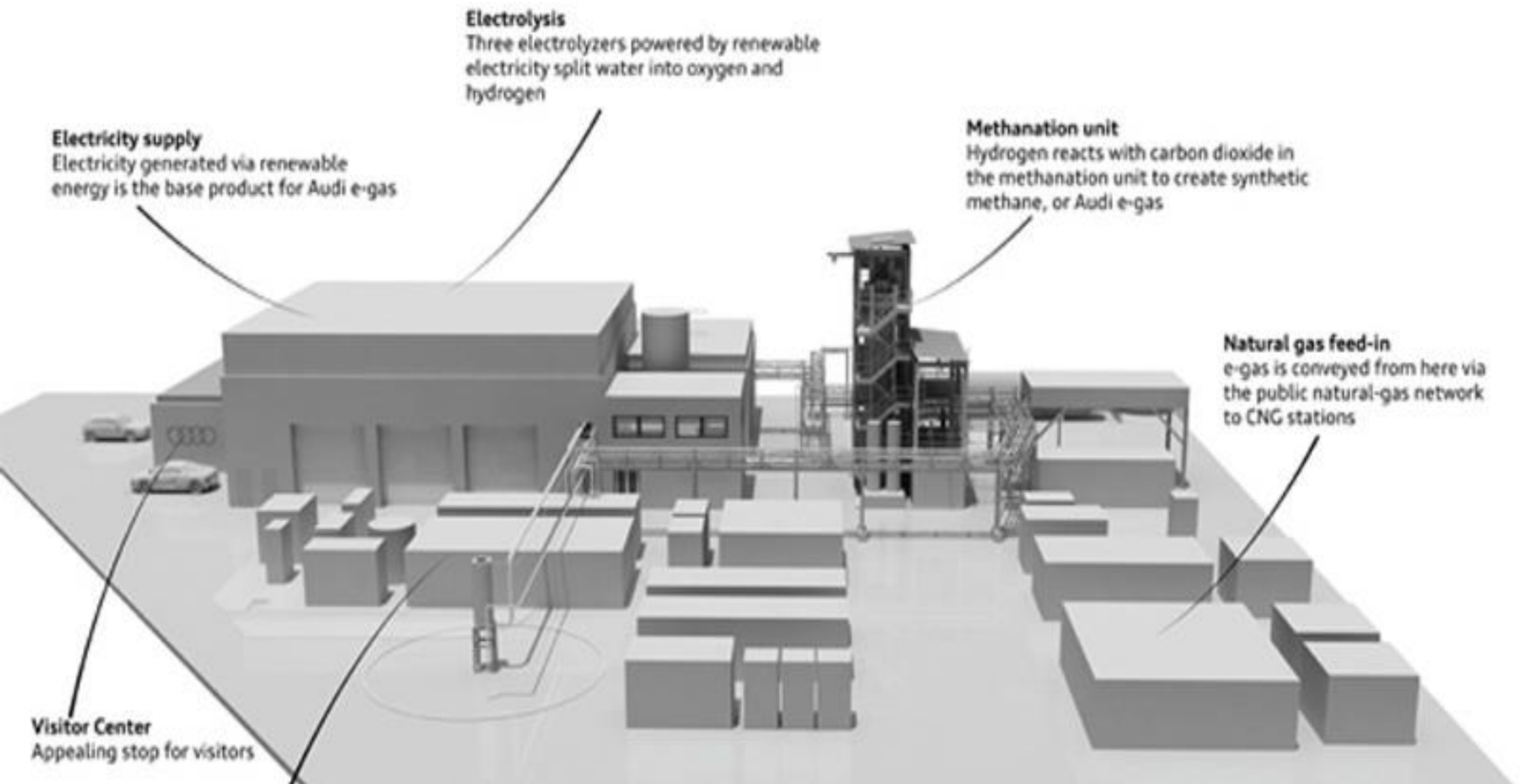
H_2 SUPPLY CHAIN
From renewable energy to a clean hydrogen power

H_2

Architect - Design-Build Manufacturer– Engineering - Prime Contractor

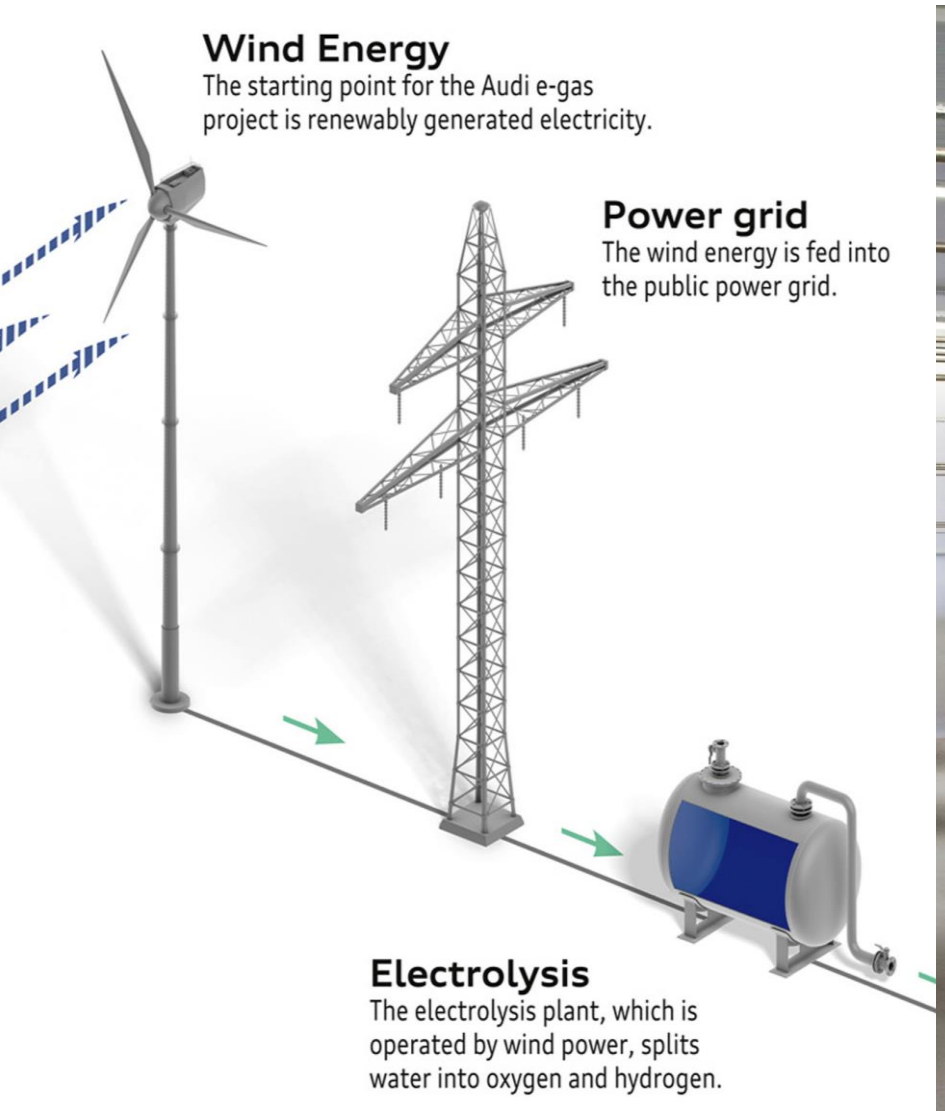
Audi e-Gas plant(Germany) 1/2

One of the first PtG project in Europe



Audi e-Gas plant(Germany) 2/2

One of the first PtG project in Europe



Operated by Etogas

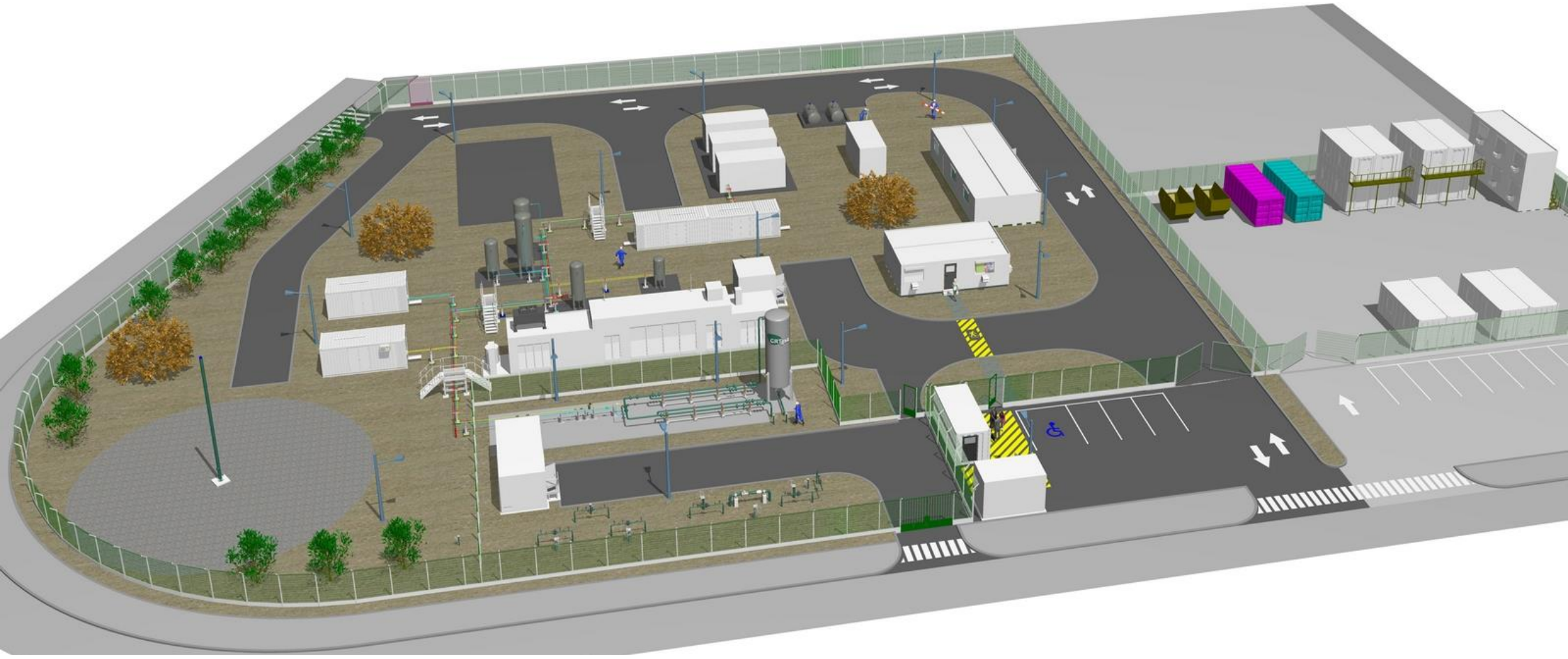
Hydrogen production equipment
with power of 6 MW

In operation since October 2013

Preventive and corrective maintenance contract

Power-to-Gas: Jupiter 1000 (France) 1/2

A large demonstrator in South of France, close to Marseille



An installed capacity of

1MW

Hydrogen injection

up to 200 m3/h

Methane production

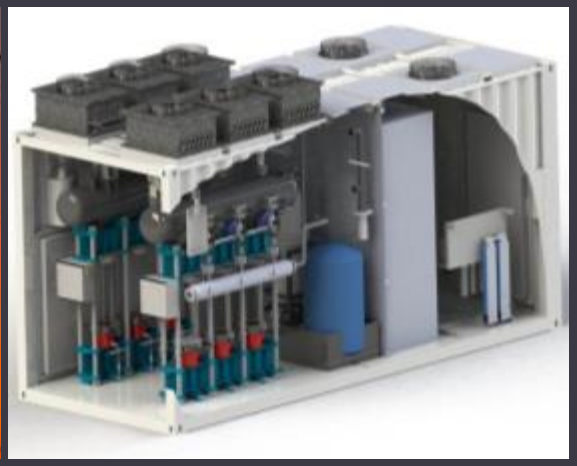
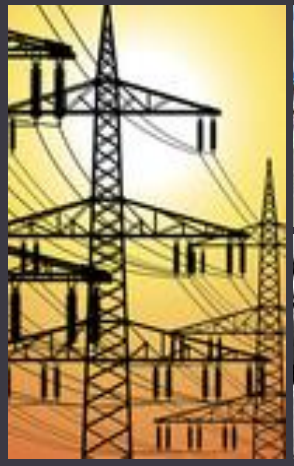
up to 25 m3/h

Commissioning

2018

POWER-TO-GAS WEBINAR

MAY 2016

ITM POWER
Energy Storage | Clean Fuel

POWER-TO-GAS WEBINAR

MAY 2016

Contents:

- Company Snapshot
- Power to gas
- Energy storage
- Economics
- Example Systems
- Summary

ITM POWER
Energy Storage | Clean Fuel

POWER-TO-GAS WEBINAR
MAY 2016

ITM Power | History

- First AIM listed fuel cell & hydrogen company
- Two facilities in Sheffield | 70 staff
- Subsidiaries in Germany & California
- Manufacturing business model
- www.itm-power.com

ITM POWER
Energy Storage | Clean Fuel

INTRODUCTION

THE NEED
GRID BALANCING
P2G RATIONALE
ENERGY STORAGE

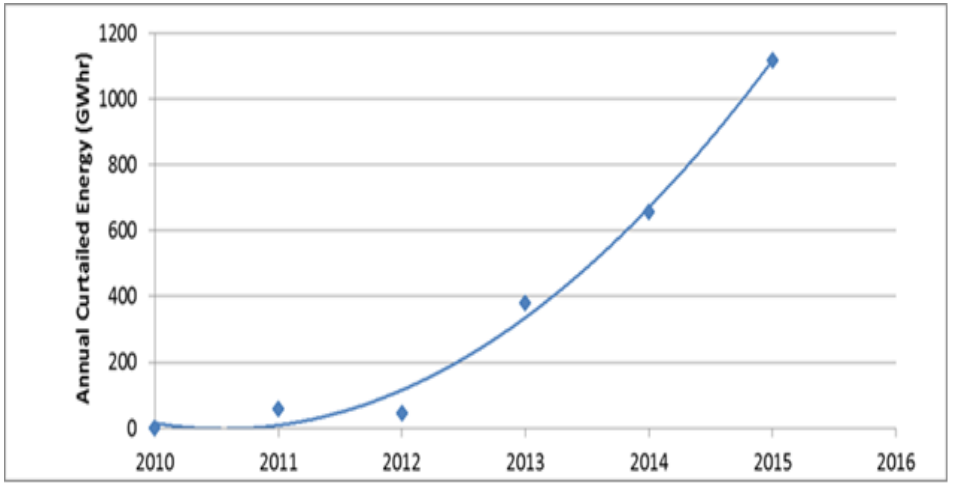
ITM POWER
Energy Storage | Clean Fuel

RENEWABLE ELECTRICITY CURTAILMENT

- Evidence of grid balancing problems from Germany and Denmark
- Problems start at 20% capacity – US approaching this in some areas
- UK hit this threshold at the end of 2013
- Wind curtailment is rising faster than wind capacity

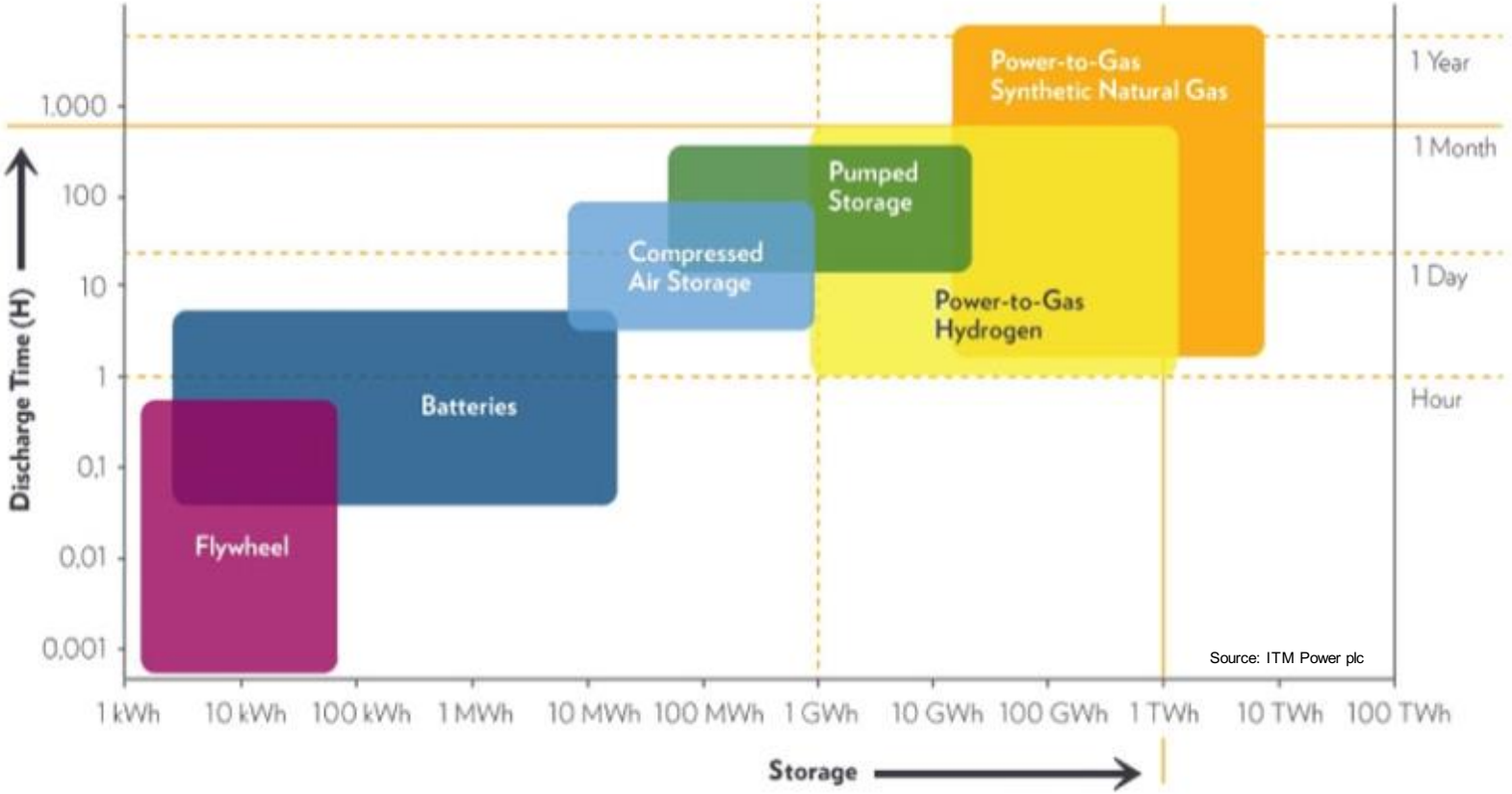
- Grid resiliency primary concern
- US RPS goals require long term storage
- East US – heating and electricity needs (like EU)
- Seasonal shifts in energy generation
- Renewable electricity generation increasing
- Electric vehicles increasing

- Long term planning required



ENERGY STORAGE TECHNOLOGIES

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



ENERGY STORAGE TECHNOLOGIES

ENERGY STORAGE | CLEAN FUEL

ITM POWER
Energy Storage | Clean Fuel

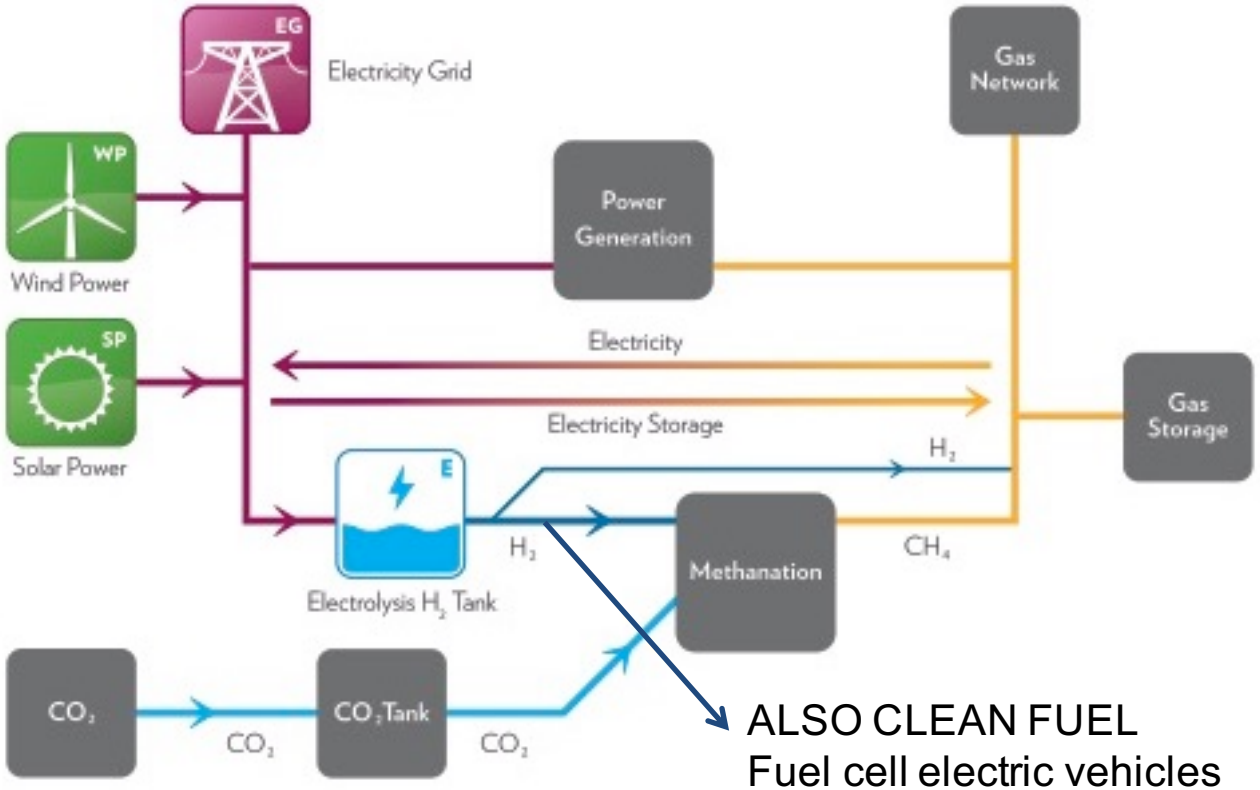
US PIPELINE ISSUES

- New & expansion Gas pipeline projects being held up
- Gas supply a potential pinch point –seasonal demand
- Renewable supply of gas required
- Distributed generation of renewable gas to ease central supply constraints
- Biogas projects can play a role but not a total solution
- RPS on the gas system too?

- Long term planning required

WHY POWER-TO-GAS?

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



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

ITM POWER
Energy Storage | Clean Fuel

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

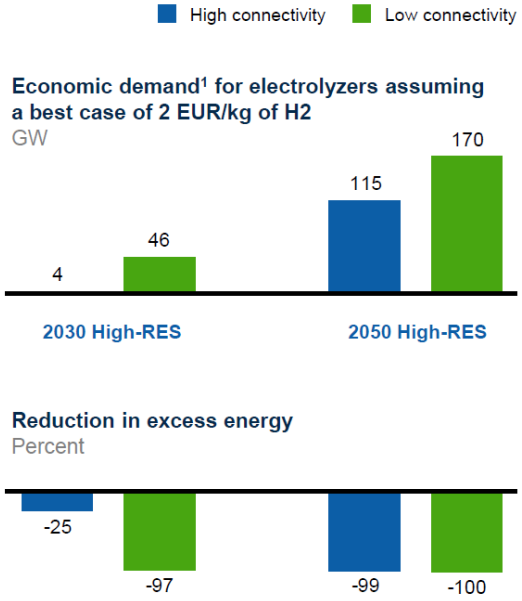
Germany archetype

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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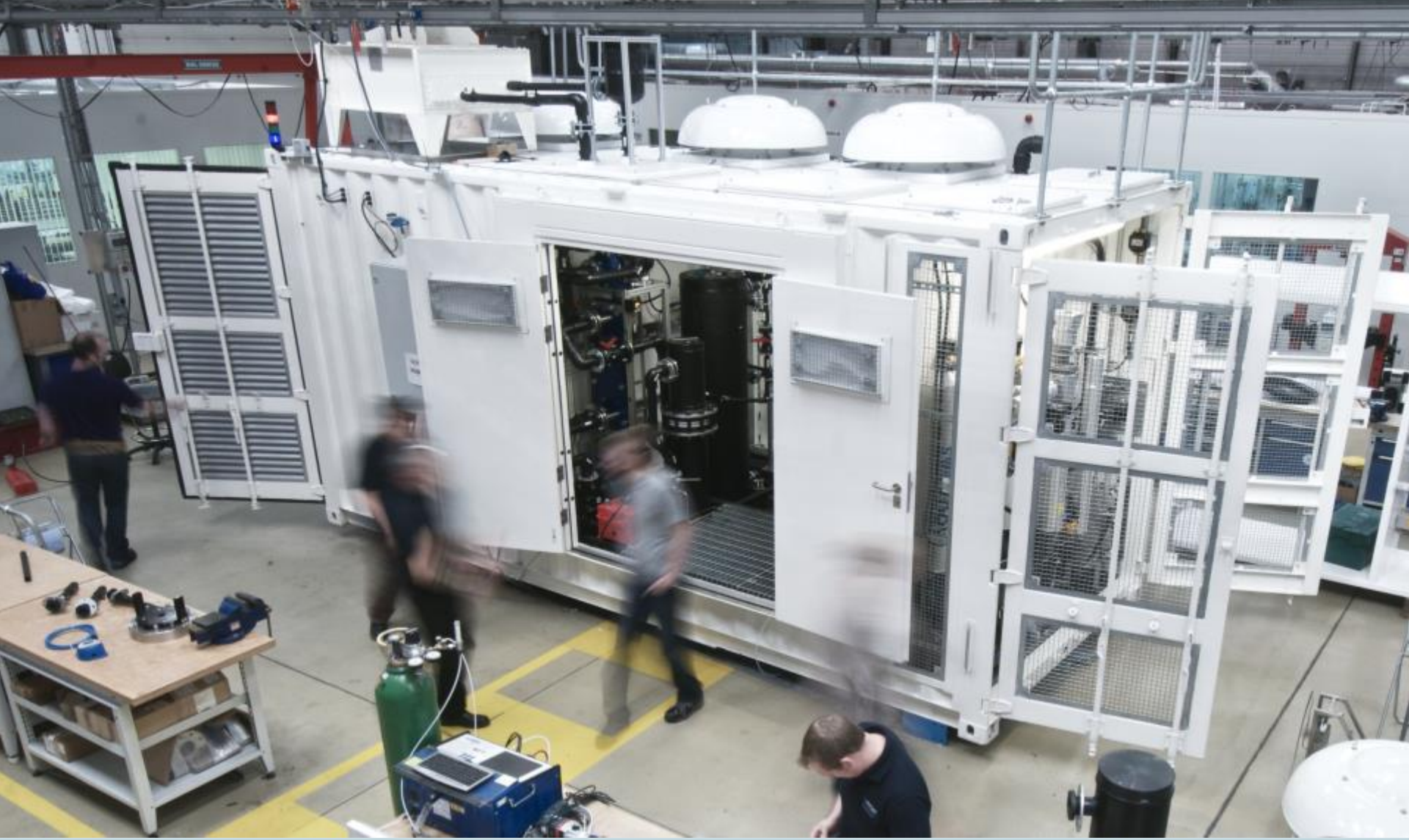
Energy Storage | Clean Fuel



INTEGRATED ELECTROLYSER SYSTEM

ENERGY STORAGE | CLEAN FUEL

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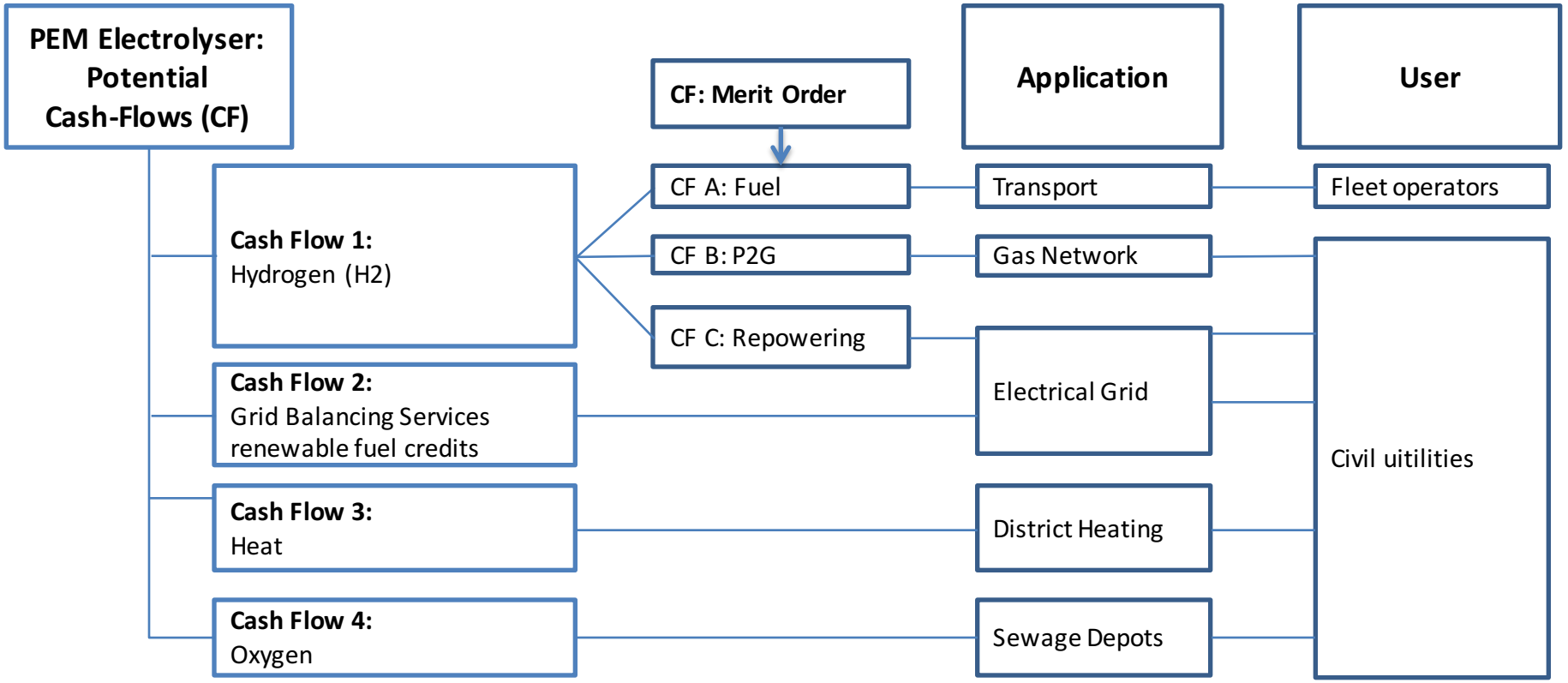
THE VALUE OF ENERGY STORAGE

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

PEM ELECTROLYSER: A DISRUPTIVE TECHNOLOGY



PEM ELECTROLYSER APPLICATIONS

ENERGY STORAGE | CLEAN FUEL

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Energy Storage | Clean Fuel

Wind Power

Grid

Solar Power

Electrolyser

Clean Fuel

Energy Storage

Renewable Heat

$$ + $$

REVENUE ON BOTH ENDS

ITM POWER
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EXAMPLE OF WHERE P2G MAKES SENSE – LONG TERM

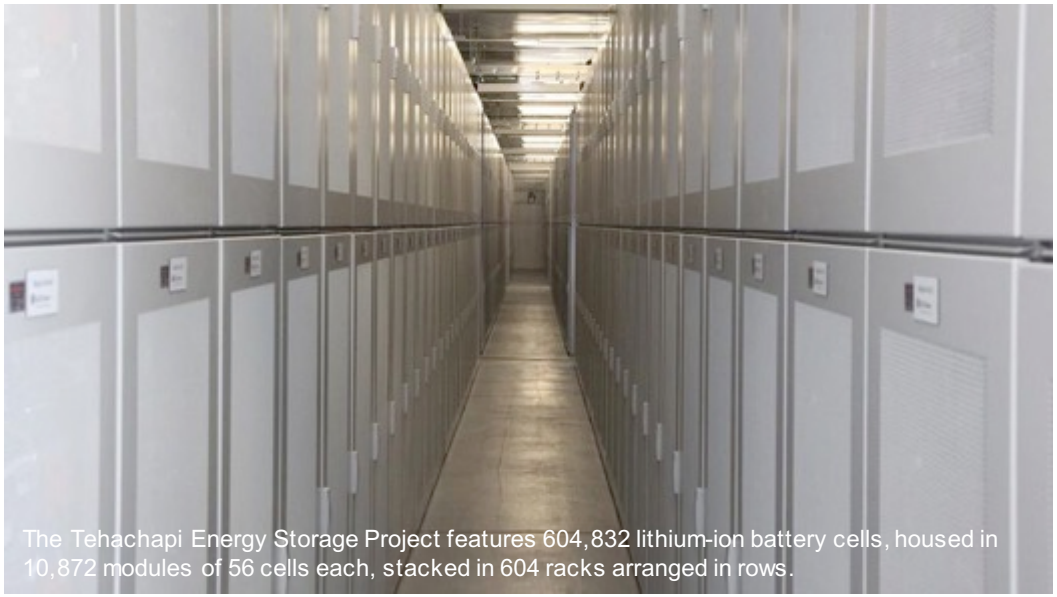
Lithium Ion System (6,300 sqft)

- Project will cost $53.5m
- 8MW with 4hr duration | 32MWh
- $6.7m/MW | $1.67m/MWh

Power-to-Gas System (3,530 sqft)

- Project will cost $21.6m
- 8MW with 4hr duration | 32MWh
- $2.7m/MW | $0.67m/MWh

- 8MW with 12hr duration | 96MWh
- $2.7m/MW | $0.22m/MWh



The Tehachapi Energy Storage Project features 604,832 lithium-ion battery cells, housed in 10,872 modules of 56 cells each, stacked in 604 racks arranged in rows.

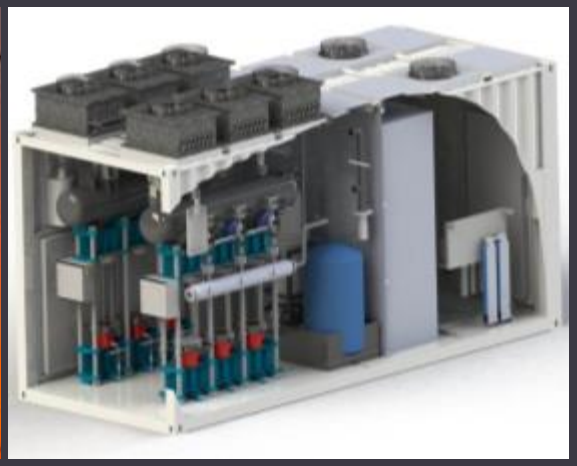
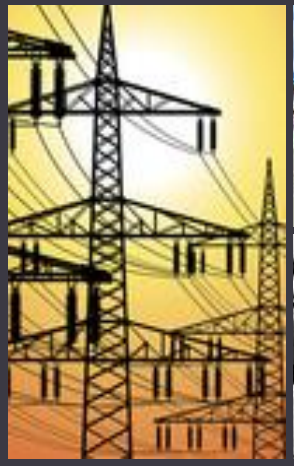
Tehachapi Energy Storage Project

SUMMARY

- Increased renewable electricity requires storage
- Grid resiliency is compromised by renewable integration
- Power-to-gas can store energy in vast amounts and for long duration
- Power-to-gas links electricity and gas sectors and allows energy shifting
- Power-to-gas decarbonises heat and transport
- Provides a synergistic benefit alongside batteries
- Long term renewables require multiple solutions

POWER-TO-GAS WEBINAR

MAY 2106

SJ@ITM-POWER.COM

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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.

POWER-TO-GAS

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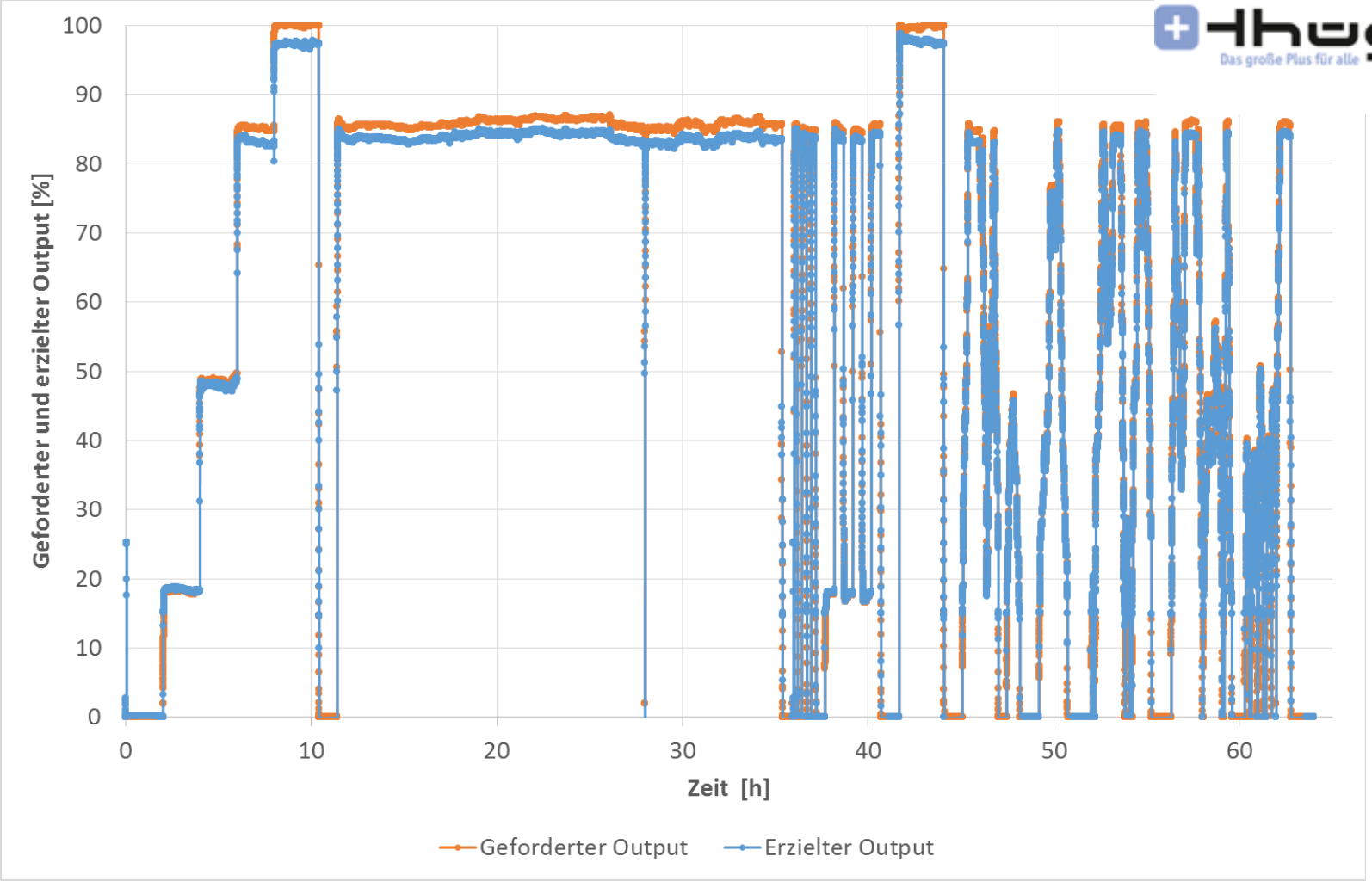
THÜGA P2G PLANT LOAD-FOLLOWING CAPABILITY



THÜGA P2G PLANT RAPID RESPONSE

© Strom zu Gas ITM Power

NRM: MIXING PLANT

HYDROGEN ENERGY SYSTEMS

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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.

CHP project
86% efficiency

POWER-TO-GAS

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Strategieplattform Power to Gas

German Energy Agency's Power-to-Gas Strategy Platform

- Official government grouping
- Excellent consortium
- Largest P2G grouping in Germany | Globally

dena Deutsche Energie-Agentur

GERMAN GOVERNMENT BACKING

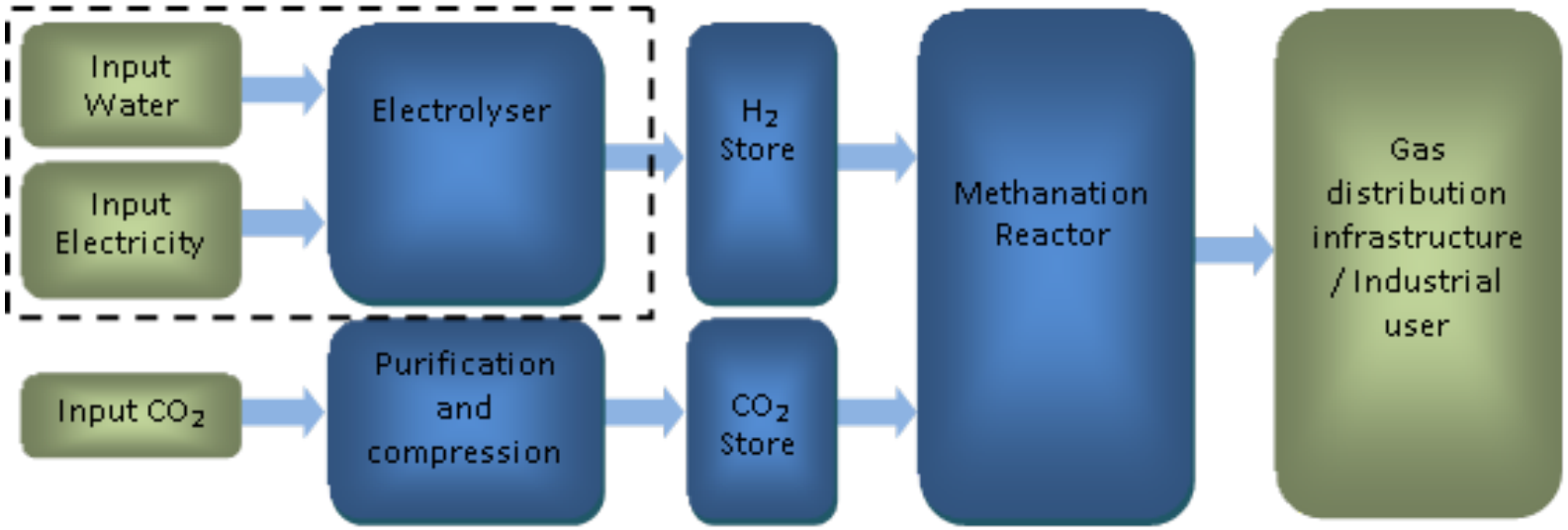
ENERGY STORAGE | CLEAN FUEL

ITM POWER Energy Storage | Clean Fuel

METHANATION

Production of SNG from Renewable Hydrogen and CO_2

- Need to source pure CO_2
- Process design can minimise or eliminate storage
- Multi stage depending on the level of H_2 compliance



HYDROGEN-BASED ENERGY STORAGE

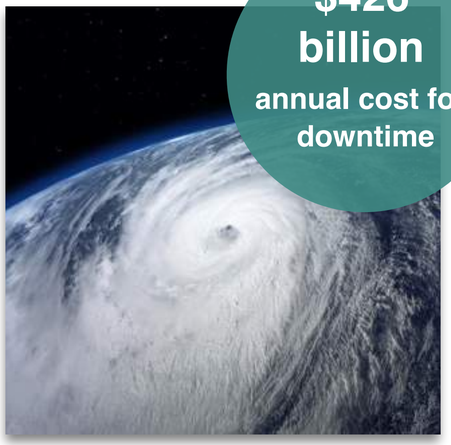
CESA Webinar

12 May 2016

Our Mission

We **unlock the energy transition**, mastering the intermittency of renewable energy sources. We advocate competitive and **technology-neutral energy and emission markets**. Through the seamless integration of the best battery technologies, and our hydrogen and oxygen platform for long autonomy, **we enable renewable energies to power society:** reliably, affordably and sustainably.

Storage is the global challenge of the Energy Transition: a mega-trend



$426 billion
annual cost for downtime

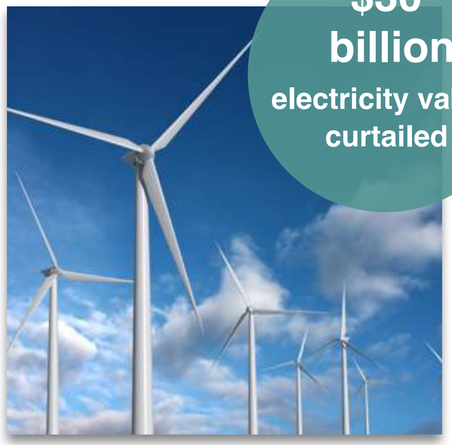
BLACKOUTS are less frequent but longer and more disruptive: natural events impact today a globalized ITC and datacenter worldwide infrastructure.

$293 billion
investment need for T&D

A CENTRALIZED ENERGY MODEL built in 1882 is not capable to manage the renewables penetration, and needs investments in transmission and distribution.

200Mio tons CO2/year
diesel generators emissions

2.4 BILLION PEOPLE, 35% of the global population, are OFF-GRID or under-electrified and generate electricity via a 600GW fleet of diesel generation.



$30 billion
electricity value curtailed

RENEWABLES INTERMITTENCY generates grid instability and a massive penetration of RES to manage global demand and base-loads is not feasible.

$280 bn

global investments in energy storage by 2030
(BCG)

up to $635bn

annual economic impact of energy storage in 2025
(McKinsey)

A technology-neutral approach to profitable storage applications

electro POWER SYSTEMS GROUP

100% 100%

elvi energy — ELECTRO POWER SYSTEMS GROUP

electro POWER SYSTEMS MANUFACTURING

FLEXIBILITY
CONTROL & GRID INTEGRATION OF ANY BATTERY ENERGY STORAGE SYSTEM (BESS)

Storage required for despatchability of large and small electricity systems featuring high penetration of intermittent energy sources:

- Frequency and voltage regulation
- Operating and contingency reserves

Storage system can be located on generation, grid or demand-side in centralized electricity systems

Storage system represents the core of microgrid operation in decentralized electricity systems

CAPACITY
HYBRID STORAGE and HYDROGEN SOLUTIONS TO REPLACE GAS AND DIESEL GENERATION

Storage required to enable a RES-intensive electricity system to serve load in non-recurring demand/supply conditions:

- Constrained or scarcity-priced supply
- Extreme demand

In centralized electricity systems, capacity is usually associated to extreme environmental conditions boosting demand and/or limiting generation

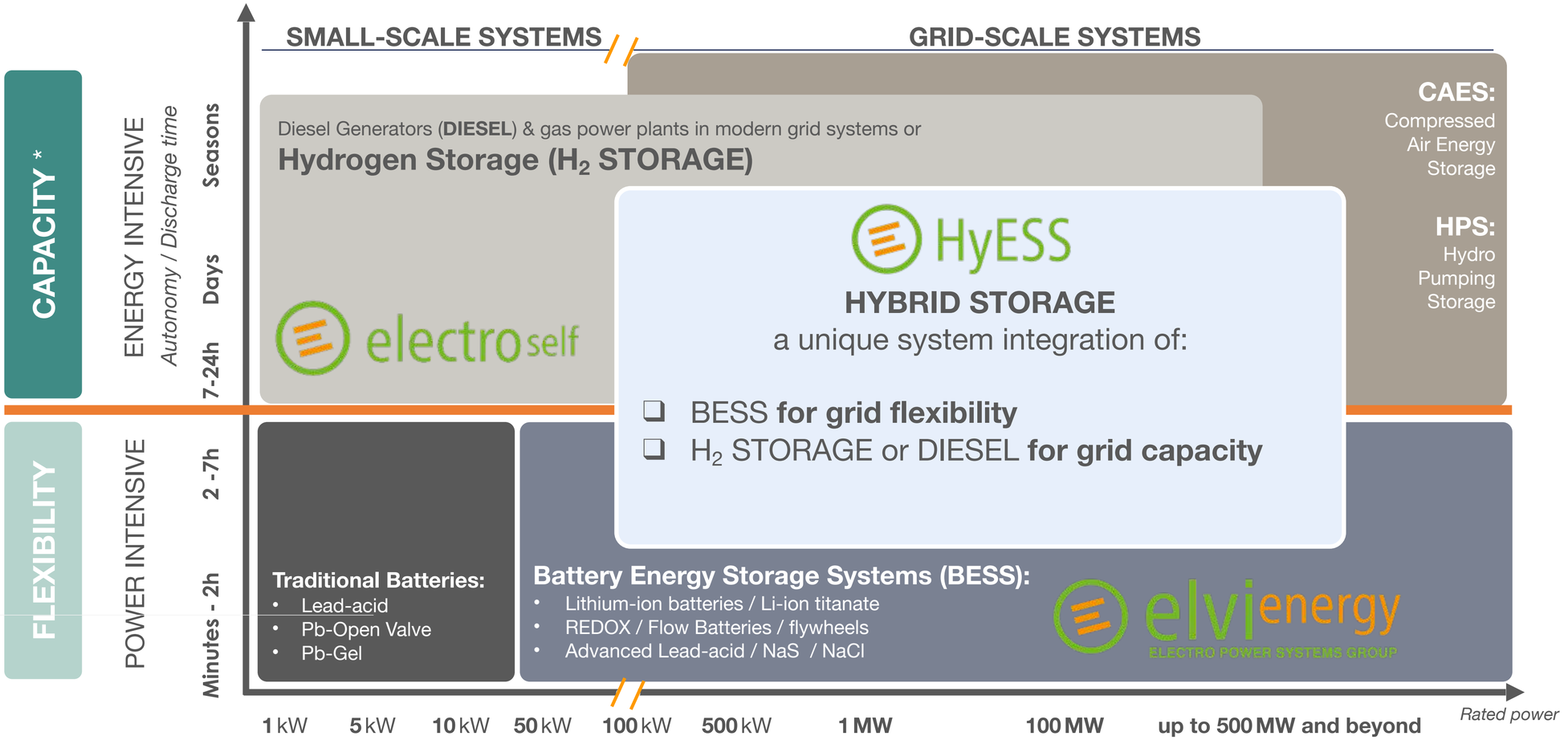
In decentralized electricity systems, capacity requirements are associated to extended scarcity of primary renewable energy resources and/or non-recurring peak demand conditions

HyESS

FLEXIBILITY + CAPACITY = HYBRID

HYBRID ENERGY STORAGE SYSTEM (HyESS)

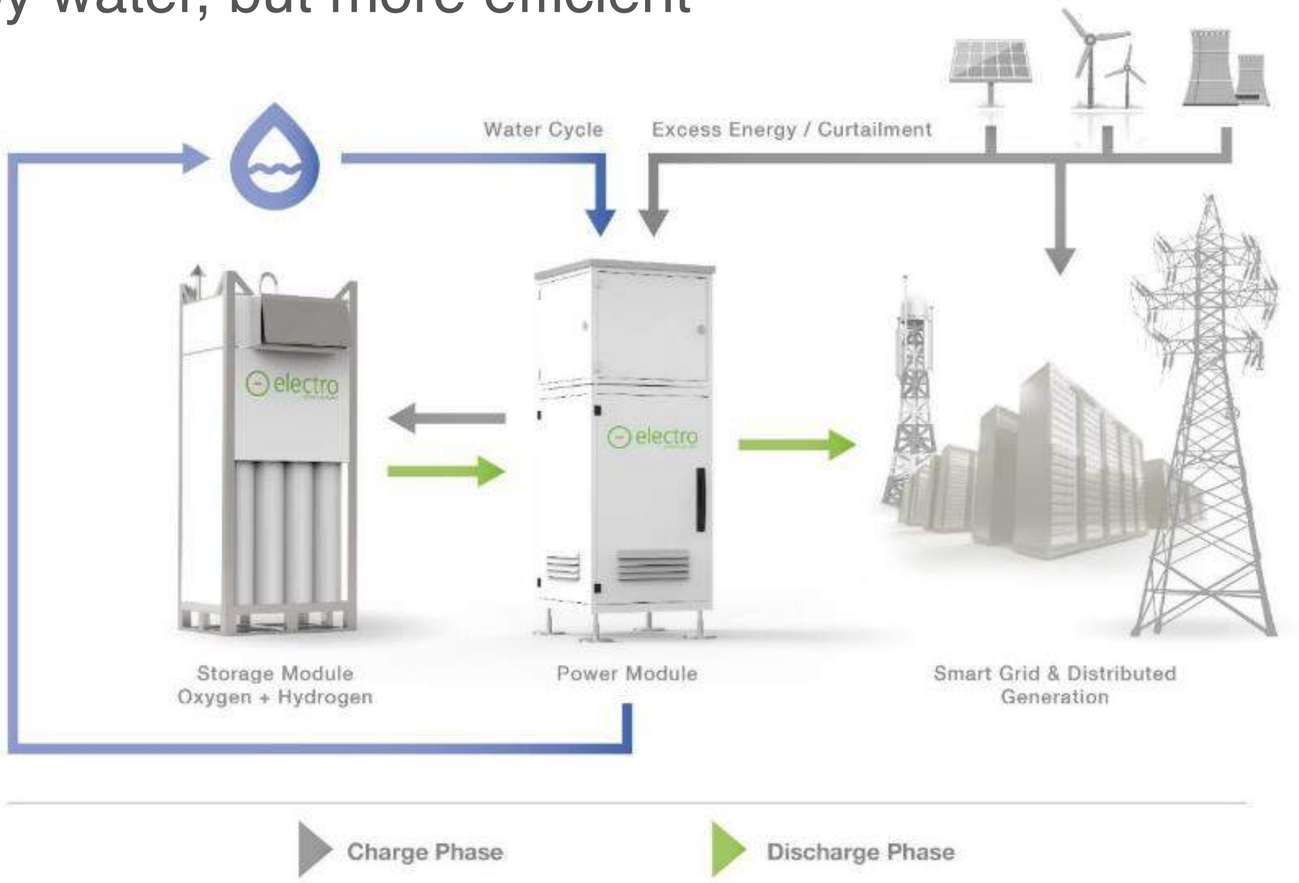
Positioning: hybrid solutions represent the core of the storage need



* Pure Energy Applications (which cannot be classified as a flexibility or capacity application), aimed at regularly time-shift energy, have not been represented as not profitable in current market environment.

Our **Capacity Technology**: like a diesel generator with a lower generation cost. Fuelled by water, but more efficient

Capacity
H2 and Hybrid Storage



125

Cleantech patents and applications in 48 countries. Unique generator running with water only

3MW

Hydrogen systems power output utilized in aggregate

607

Systems installed devoted mainly to mission critical applications and telcos

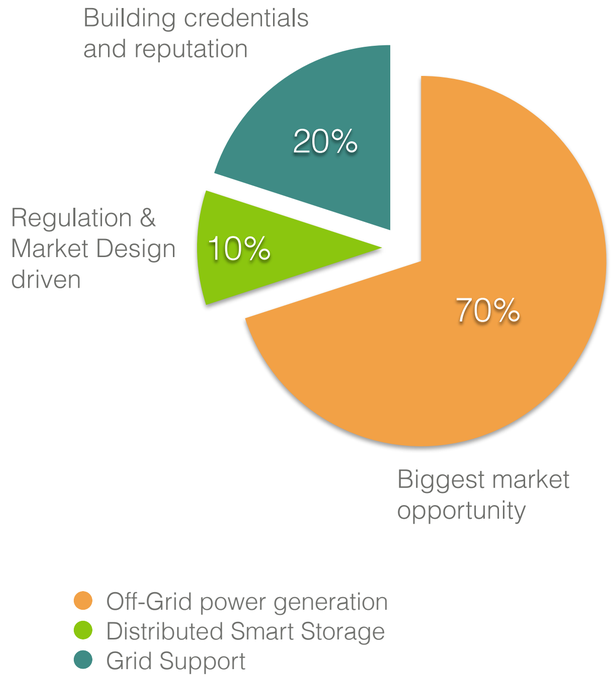
Our Markets: focus on profitable and unsubsidized business verticals

We provide grid operators and renewable energy players with **integrated storage solutions to master the intermittency of renewables**, and address the burgeoning demand for primary, secondary and tertiary reserve, reactive power and black-start capabilities, at a lower cost for consumers, **cutting electricity bills.**

We compress energy bills, by **peak-shaving the consumption profile of commercial and industrial users,** optimizing the utilization of distributed generation, enabling participation in demand response schemes, and delivering sustainable back-up power.

We enable **renewables as a reliable and affordable stand-alone power source** in emerging markets, displacing diesel and oil-fired generation. We foster a bottom-up, decentralized model of greenfield electrification, providing **clean energy 24/7 at cost lower than diesel generation**, the only alternative in such areas.

EPS Resources allocation and long term growth expectations



An Energy Company with a clear Vision

We wish to be an **Energy Company** and the world's reference for a clean energy culture and smart grid excellence.
An innovative company which creates value for stakeholders by providing net-zero solutions completely **safe, reliable, profitable and sustainable**.

Giuseppe Artizzu, EPS Group Executive Director, Global Energy Strategy
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Q&A

Moderator: Todd Olinsky-Paul, Project Director, Clean Energy Group

- **Prabhu Rao**, CEO North America, McPhy Energy
- **Steve Jones**, Managing Director, ITM Power
- **Giuseppe Artizzu**, Energy Strategy Director, Electro Power Systems (EPS)

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Northeast Electrochemical energy storage Cluster

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