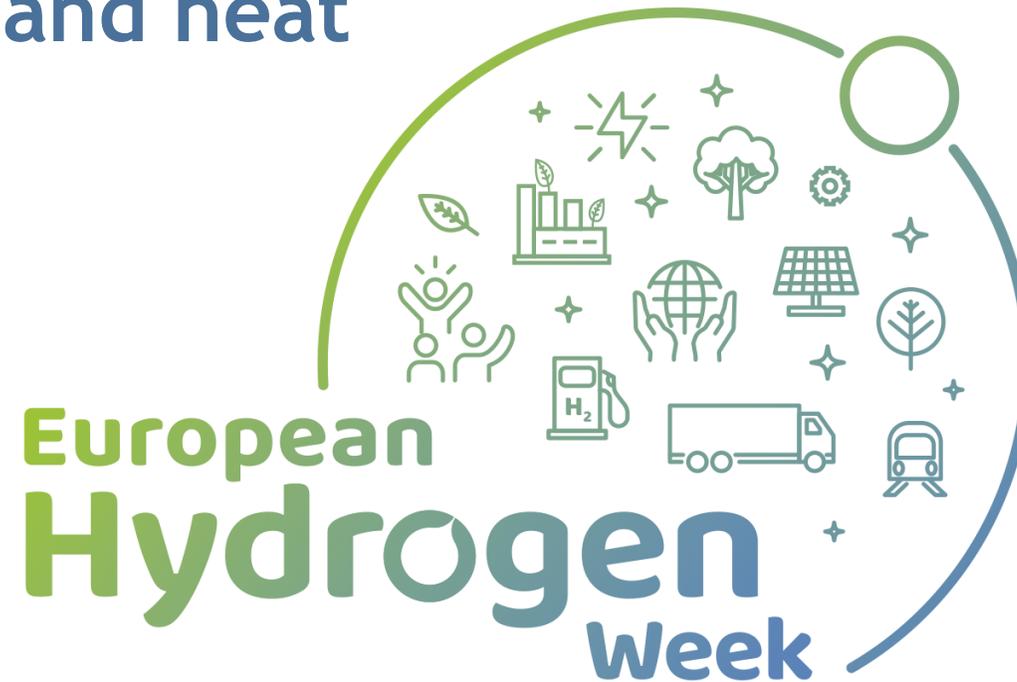


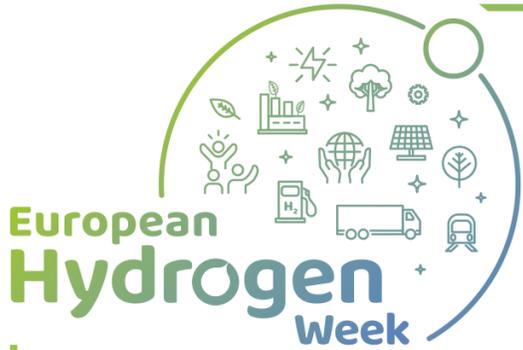
# Stationary Applications: Gas to power and heat



**A. Aguilo**  
**D. Tsimis**  
**Project Officers**

#PRD2020  
#CleanHydrogen





# PRD parallel sessions on stationary FCs

24<sup>rd</sup> Nov. 09:30 - 10:50



Stationary Applications: Gas  
to Power and Heat

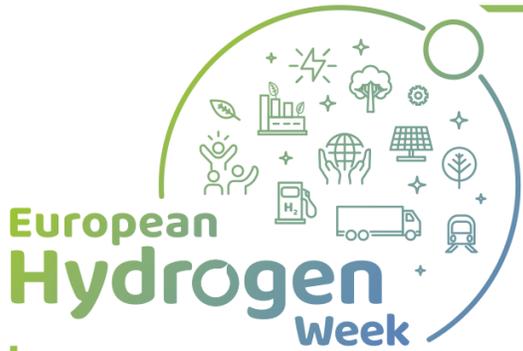
24<sup>th</sup> Nov. 11:00 - 12:20



Fuel Cell Technology  
for Stationary  
Applications

#PRD2020  
#CleanHydrogen





# FCH JU support to Stationary FCs Applications: A 12 years journey

2008 - 2020



## Research

Lifetime & performance

Monitoring & Diagnostics

Component and System aspects

Material and manufacturing

## Next generation products

## From lab to market

## New business models

## End user ready solutions

## Trials and demonstrations

## Proof of concepts

#PRD2020  
#CleanHydrogen





European  
**Hydrogen**  
Week



# Fuel cell for domestic heat and power

Europe market is in the order of 18,000s systems, 60% increase since last year



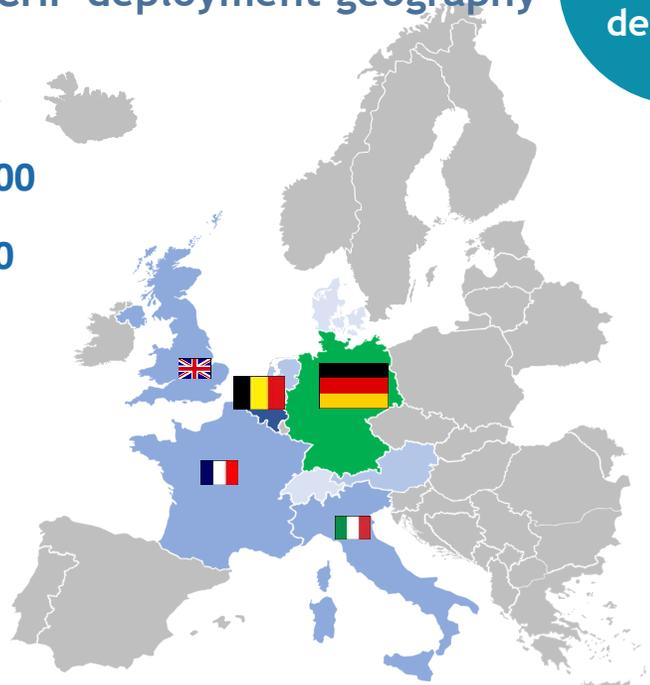
Complementary to heating system



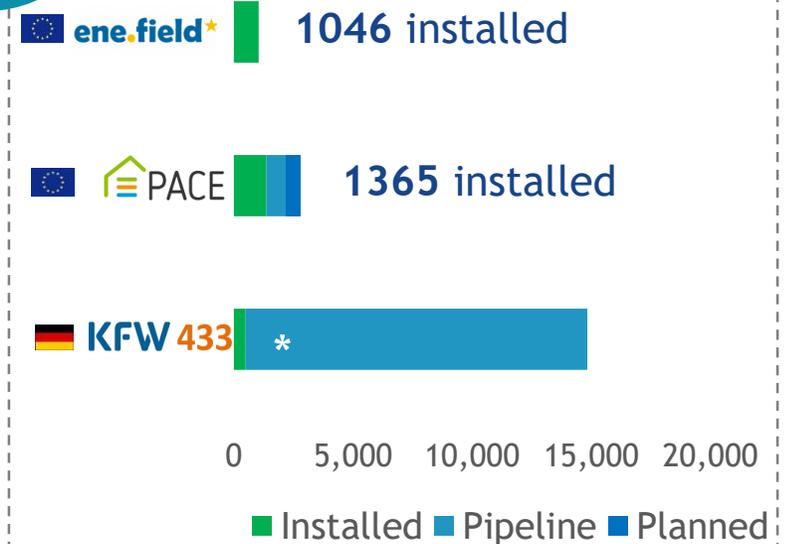
Replaces heating system

## FC Micro-CHP deployment geography

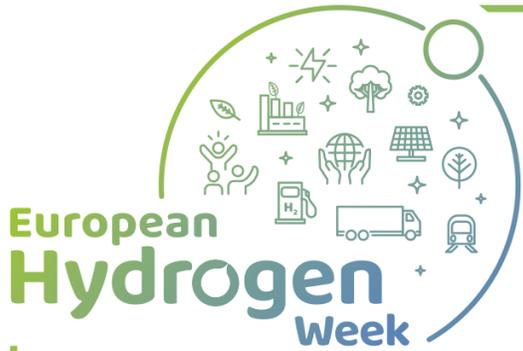
- 15000+
- 400-3000
- 200-400
- 70-200
- 1-70



Planned and deployed



\* Applications field under German KfW since 2016



# Manufacturing scale-up paving the way to competitiveness

Supporting manufacturers to deploy minimum volumes to enable shift to more efficient manufacturing processes



- Less manufacturing time
- Co replaced with Cu
- Key contributor to the **25MW/year plant** under development by SolidPower

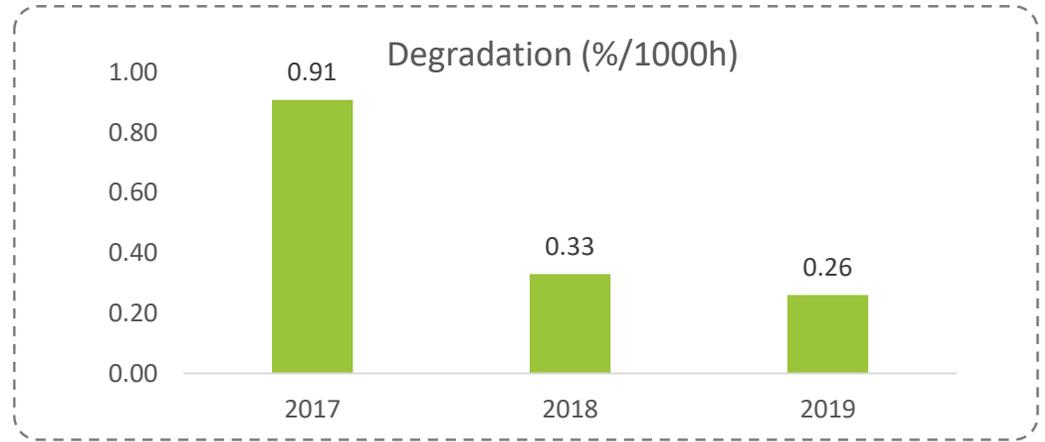
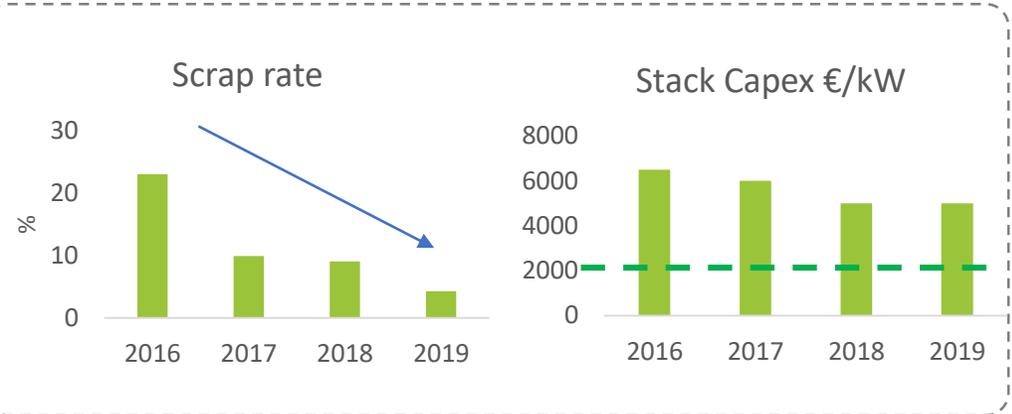


- Cost reduction on stack and CAPH
- Cathode air pre-heater and stack **ready for mass production**



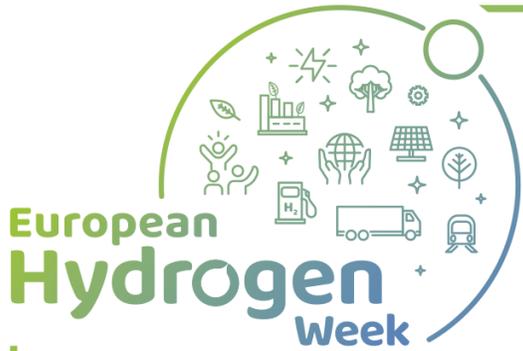
R&D improvements moving in synergy with deployment activities maximising impact

- 40% reduction on service and maintenance costs



#PRD2020  
#CleanHydrogen





# Products continue performing as expected

Looking ahead further cost reductions and 100% H<sub>2</sub> units needed

## Homes and small businesses

9.9 million hours operation

Technology neutral

Next generation units installed

New business models and routes to market adopted

## Programme targets 2020

37 to 60% Power Efficiencies

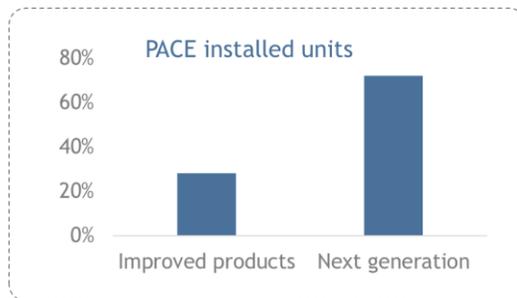
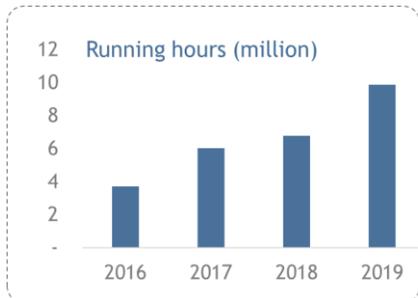
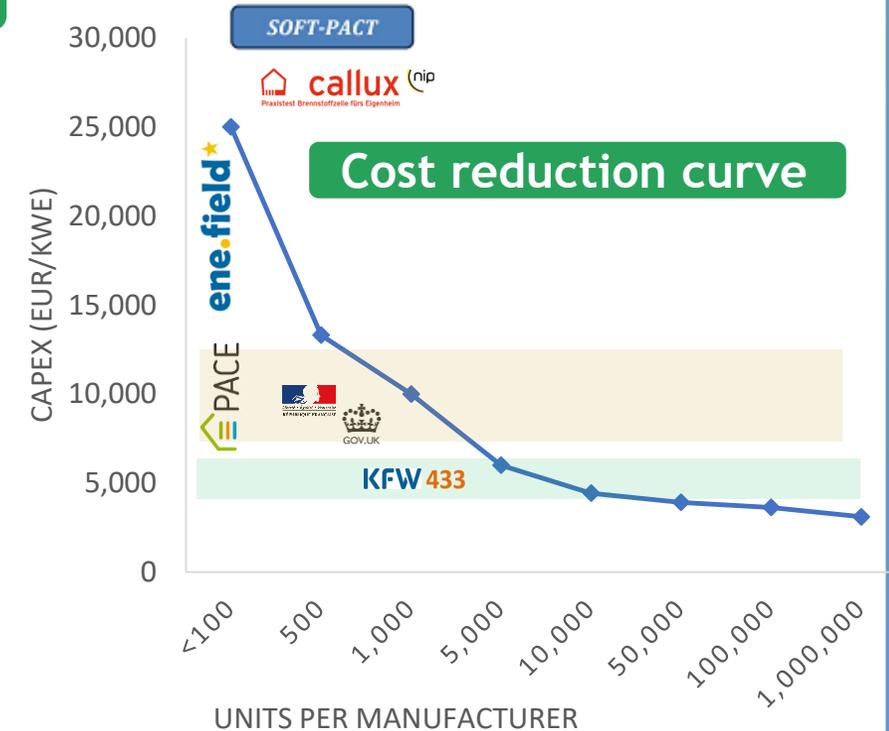
85 to 90% Total Efficiencies

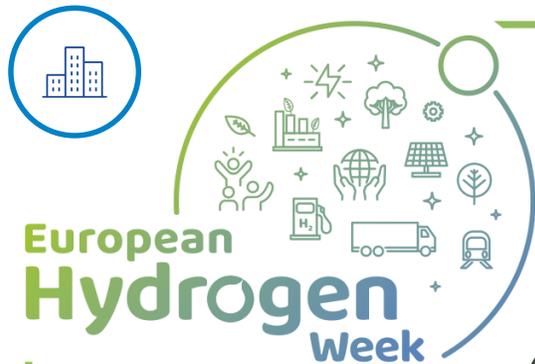
93 to 99% availability

40 to 80 khrs stack durability

<10,000 EUR/kWe CAPEX

30% H<sub>2</sub> tolerance





# Fuel cells for commercial buildings and service sectors

First demonstration ended...next demonstrations for cogeneration and prime power applications due to start using a European supply chain



Demos of FCs for cogeneration and prime power in commercial buildings - 10 to 60 kW<sub>e</sub> units



✓ Building on successes from micro CHP and early commercial demos

⚠ Units being prepared

⚠ Some units installed



Track record of performance, cost reductions and validation of business cases to be proven

✓ +10,000 h running hours

✓ 53% electrical efficiency  
 ✓ 31% thermal efficiency

⚠ Longer operational experience needed

⚠ Large market potential

# Next generation of systems: cost reduction through more efficient manufacturing

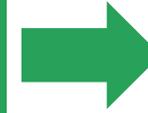
Focus on building a European supply chain for commercial size fuel cells



- **74%** Stack electrical efficiency ✓
- **Machine** vision inspection for QA
- Improved stack conditioning
- **70%** reduction stack cost
- High-speed cell manufacturing
- **1100 €/kW @10MW/year** achievable stack costs



- **Second** generation 58kW<sub>e</sub> unit ✓
- **Fewer** components
- **+60%** system electrical  $\eta$
- **4,000€/kW<sub>e</sub>** target system cost ⚠️



**Smart grid  
+ heat  
network**



# Next generation of systems: Offering flexibility with SOCs

Expected to operate in an energy system with very large variable RES generation



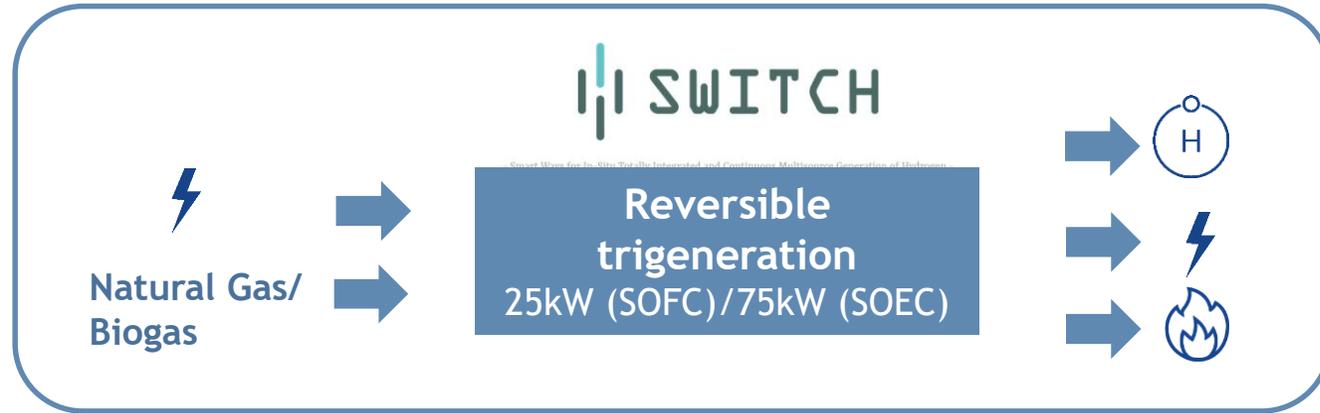
The **prototypes** will be installed at the Shell Technology Center in Amsterdam

## Targets

⚠️ 40 kgH<sub>2</sub>/day (polygeneration)

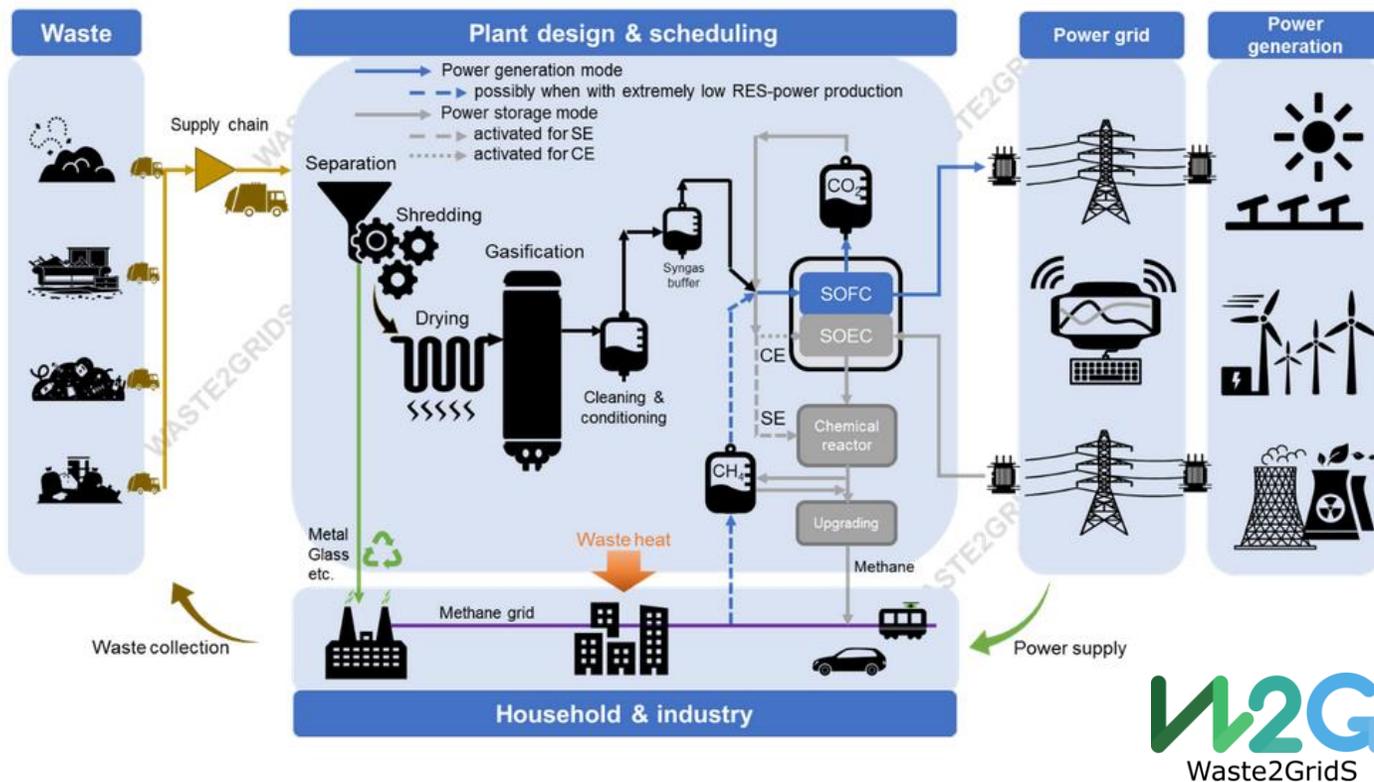
⚠️ 5 €/kg H<sub>2</sub>

⚠️ 50 kg H<sub>2</sub>/day (SOE)



# Large scale Solid Oxide Membrane Reactors

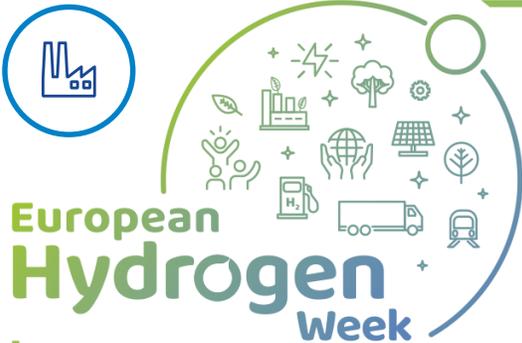
Pathway and upscale strategy of multi-MW rSOC plants



Identifying industrial pathways of waste-based solid-oxide plants for grid-balancing services

Low RES power  
-> syngas used in SOFC grid power

Excess RES power  
-> synthesize methane in SOEC injection into gas grid



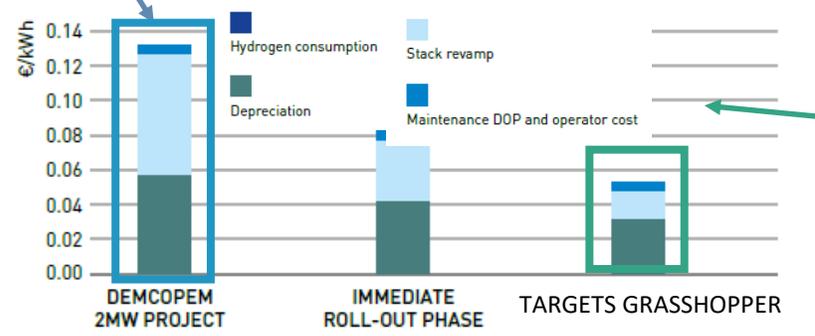
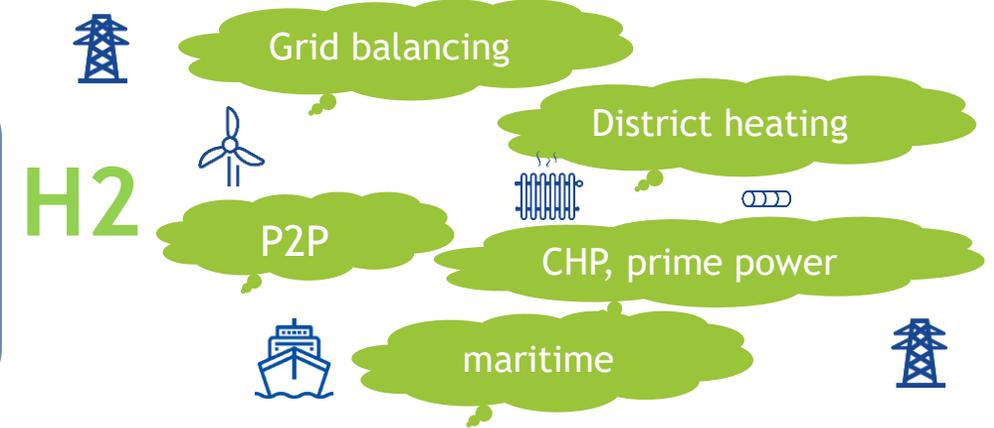
# Greening big industry using H<sub>2</sub> in MW scale FCs

Projects driven by high regional power prices abroad, further cost reductions followed with real scale demos of next generation needed

By-product H<sub>2</sub> from a refinery in Martinique, 1 MW<sub>e</sub> PEMFC

Waste H<sub>2</sub> from a chloralkali plant in China, 2 MW<sub>e</sub> PEMFC

- ✓ 50% power efficiencies
- ✓ 85% overall efficiencies
- ✓ 95%+ avail. for over 16 000 h
- ✓ 27 000 new European MEAs



**Next generation stack**

300 cm<sup>2</sup> active cell area

25 kW<sub>e</sub> capacity

20 khrs lifetime

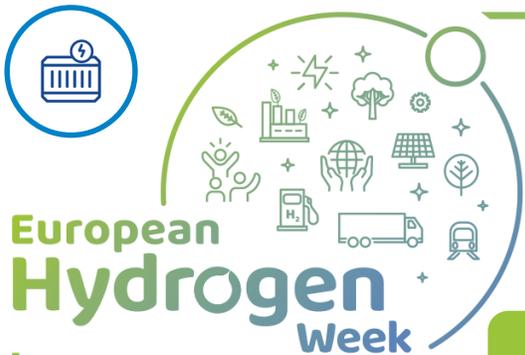
450 EUR/kW<sub>e</sub> mass product.

**Next generation system**

1500 EUR/kW<sub>e</sub>@ 25 MW/year

#PRD2020  
#CleanHydrogen





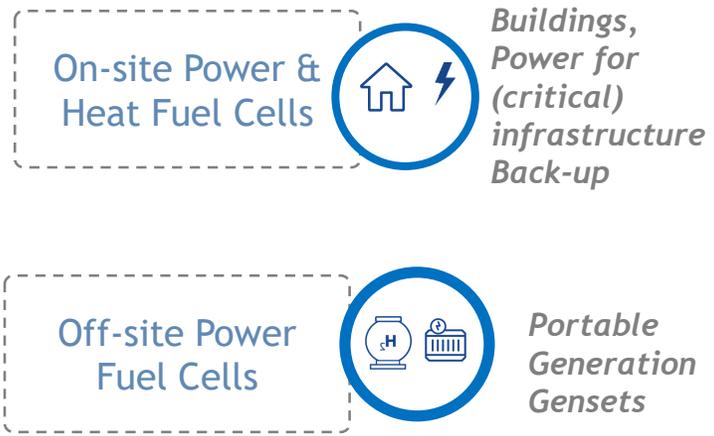
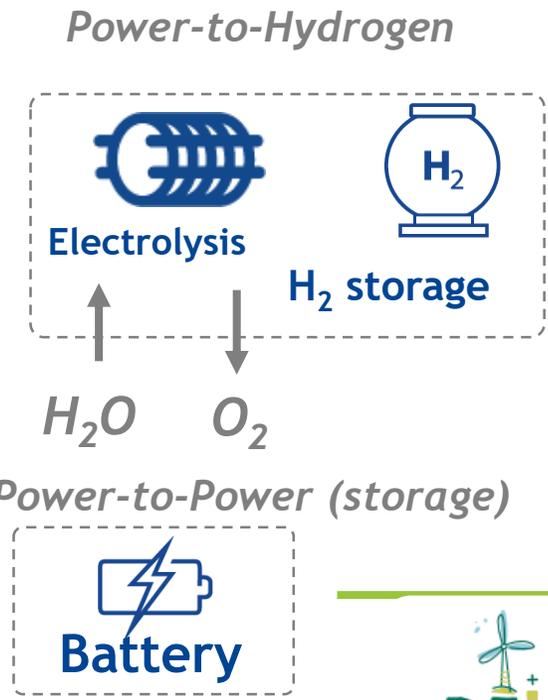
# P2P off-grid solutions and portable generation

Renewables in combination with energy storage allow fossil fuel free solutions for energy

## LOCAL GRID / REMOTE ISOLATED GRID

-  Wind turbine
-  Solar PV
-  Other RES

— Power Network  
 — Hydrogen Network



EVERYWHERE



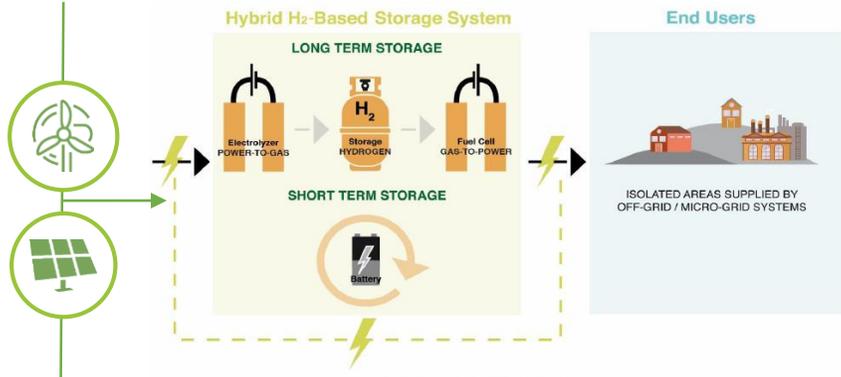
#PRD2020  
 #CleanHydrogen



# Off-grid, gensets and remote power demonstrations to start soon

100% remote communities and H<sub>2</sub> gensets replacing dirty diesel generation

## P2P



Autonomous, 100% renewables, modular

Zero local air emissions

High CAPEX, low OPEX

First demo site operational in Greece  
Hydro power, 25kW ELY, 50 kW<sub>e</sub> FC

4 demo sites

## Portable generation

25kW<sub>e</sub>, 100kW<sub>e</sub>   
 >500kW<sub>e</sub> planned  
 2 H<sub>2</sub> gensets built

Festivals, construction sites, shore power

low-cost   
 European alkaline fuel cell system

## Remote Power

+50 units planned, <5 kW<sub>e</sub> units

First systems installed

Remote gas/oil infrastructure

Telecom towers

# Conclusions 1: Mainstreaming FCs for domestic heat and power

Products available, strong European supply chain actors, supporting European competitiveness



Developing the market: from 100s to 10,000s

Next generation products available and demonstrated in real installations

Strong European SOFC players throughout the supply chain

Offered by established heating equipment suppliers



© SenerTec



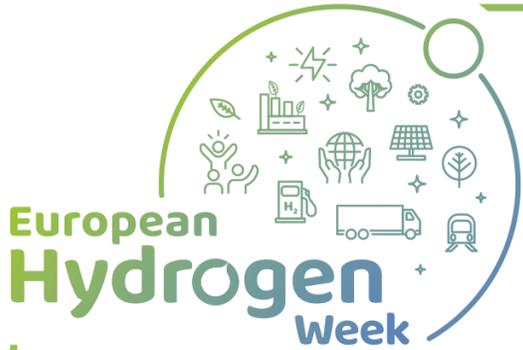
© Viessmann



© Solid power



© Sunfire



## Conclusions 2: Fuel cells for energy applications are diverse

Supporting the decarbonisation of the commercial building, service and industry sectors

Contributing to clean air for cities and remote locations



Fuel cell demos in commercial buildings and service sectors started

Combined rSOFC + polygeneration solutions being developed



MW scale demo results -> opening up markets abroad & new end use applications

Cost reductions & real scale demos of next generation systems needed



Niche markets for off-grid, gensets and remote power remain to be unlocked