



**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING

# **Fuel cells applications for energy**

*Next generation of  
products, trials and  
development*

**Antonio Aguilo Rullan**  
**Dionisis Tsimis**

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# Trials and Deployment of Fuel Cells for Energy

Sustainable heat and power with fuel cells

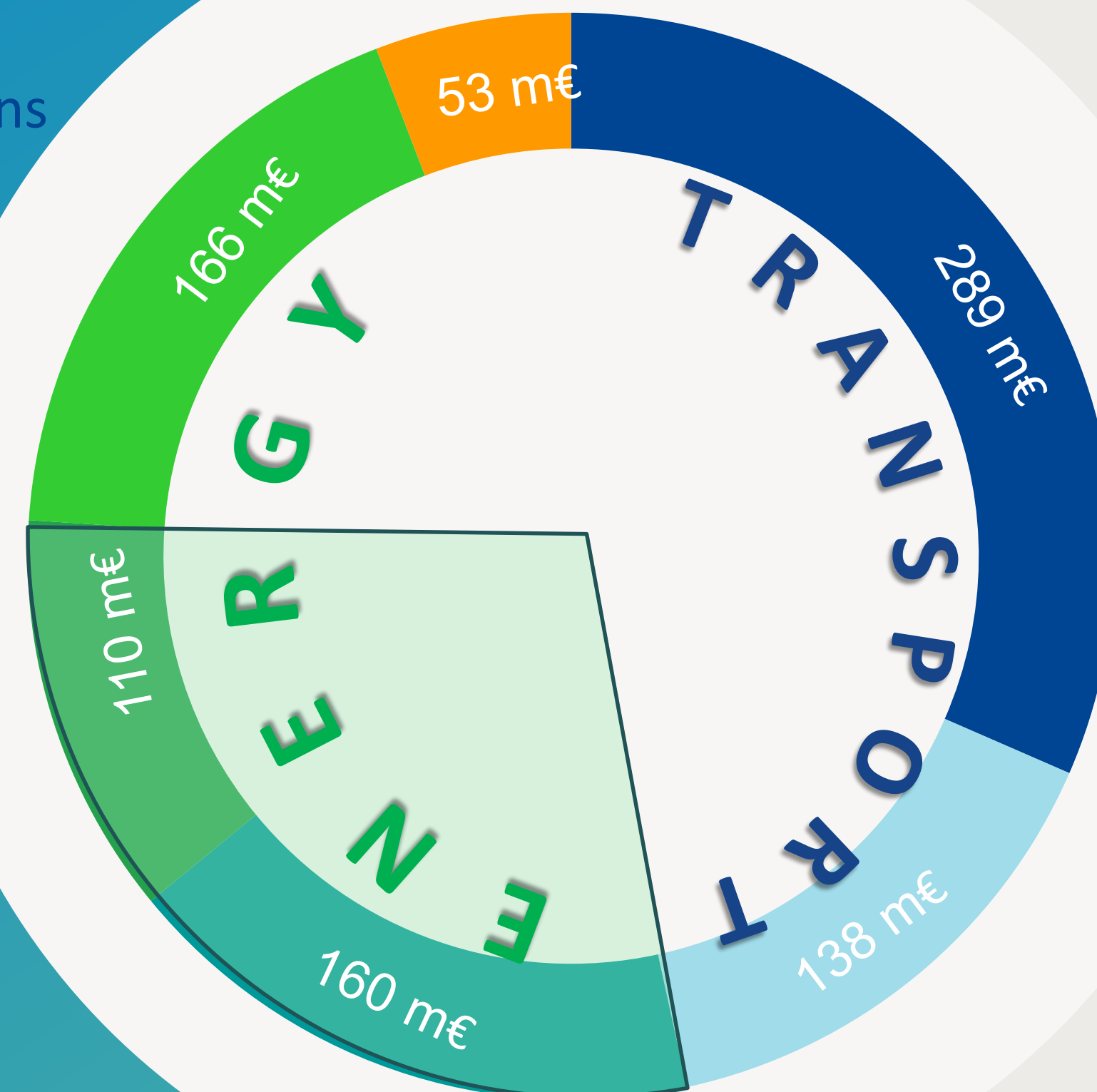


Related FCH JU objectives



Increase the efficiency and the durability of fuel cells for power production, while reducing costs

Applications



## Stationary - Total

**270** M€

**79** Projects

**30 %**



Trials & Deployment



**160** M€

**30** Projects

Next Generation



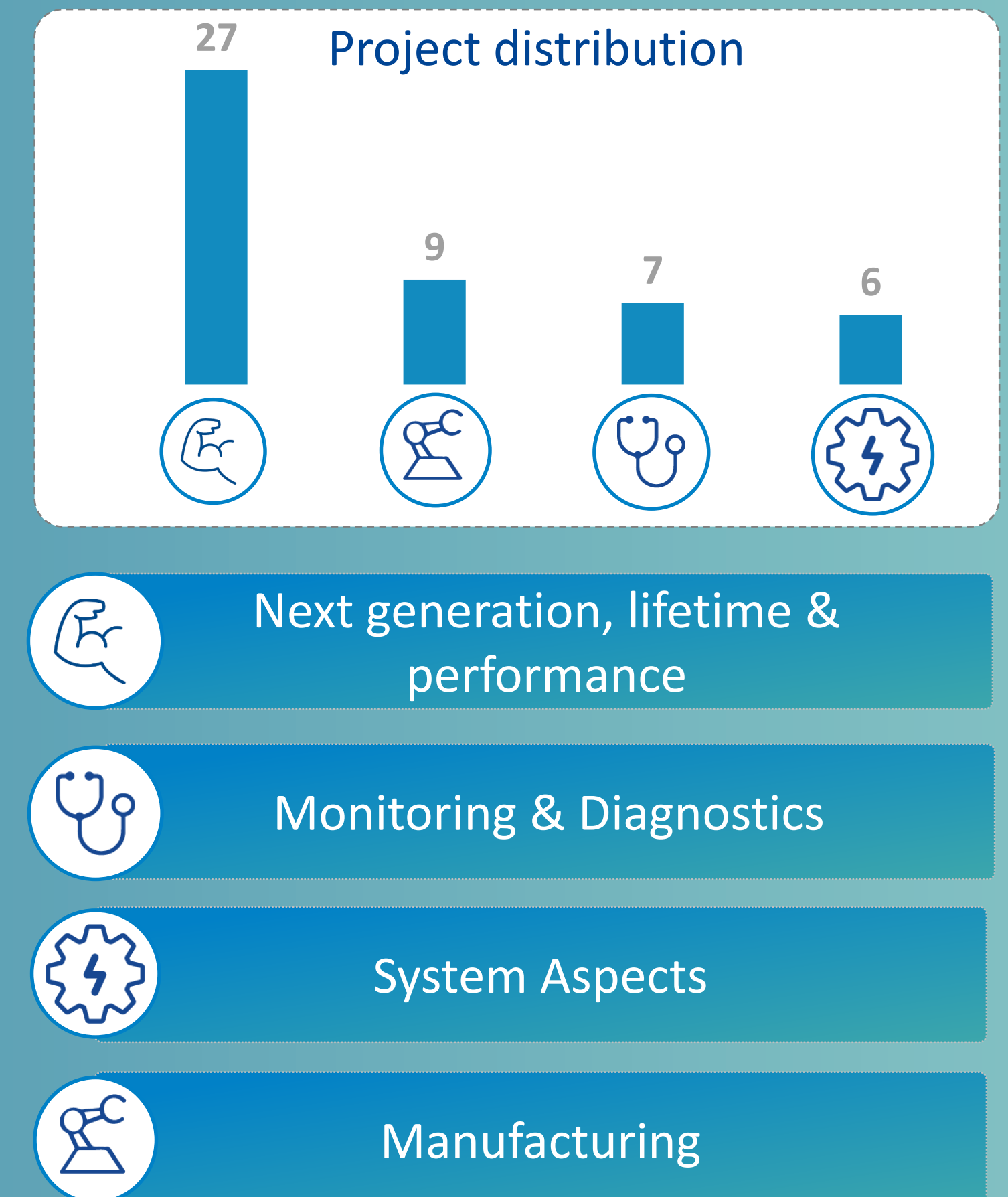
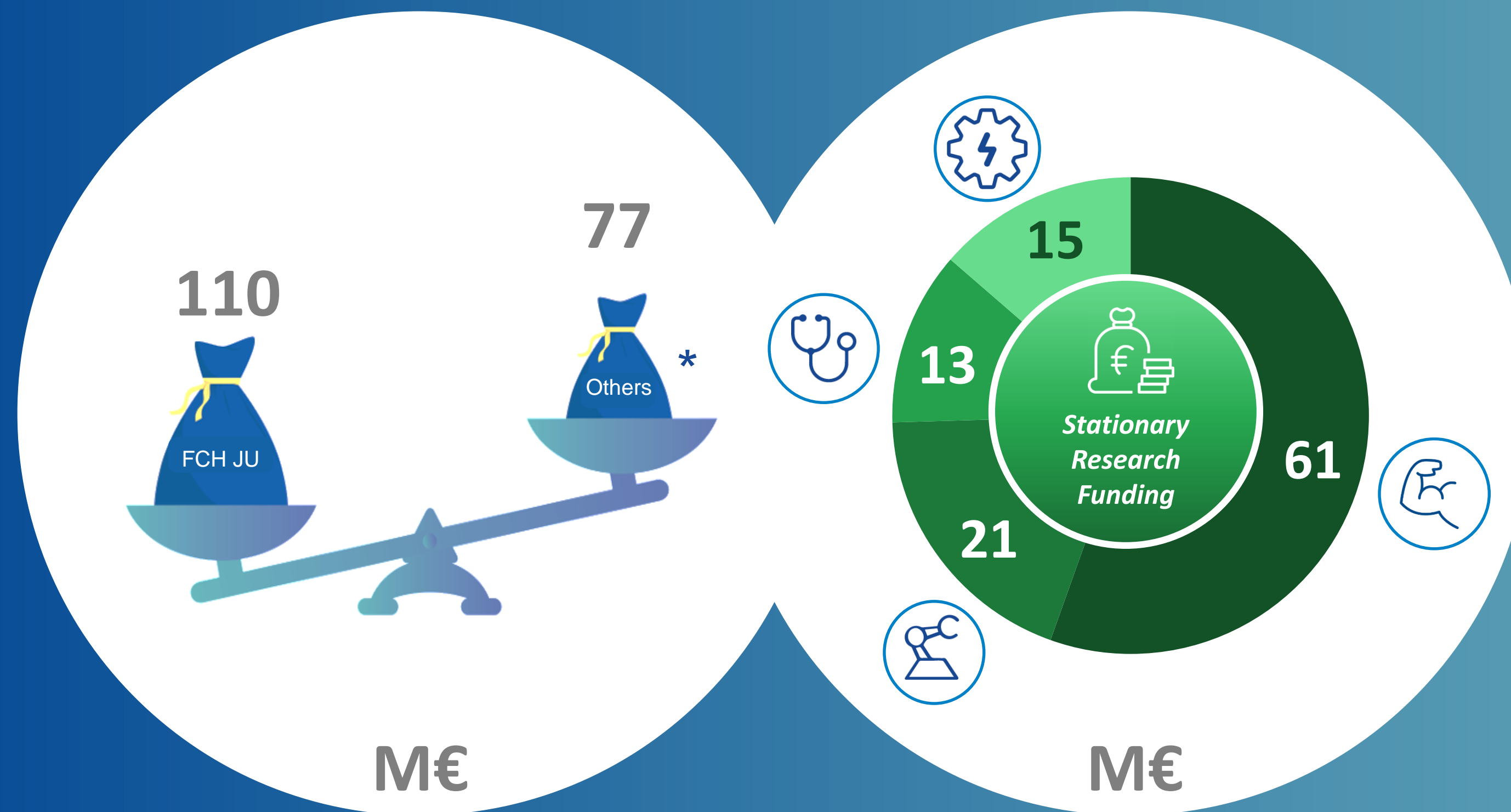
**110** M€

**49** Projects



# Research portfolio

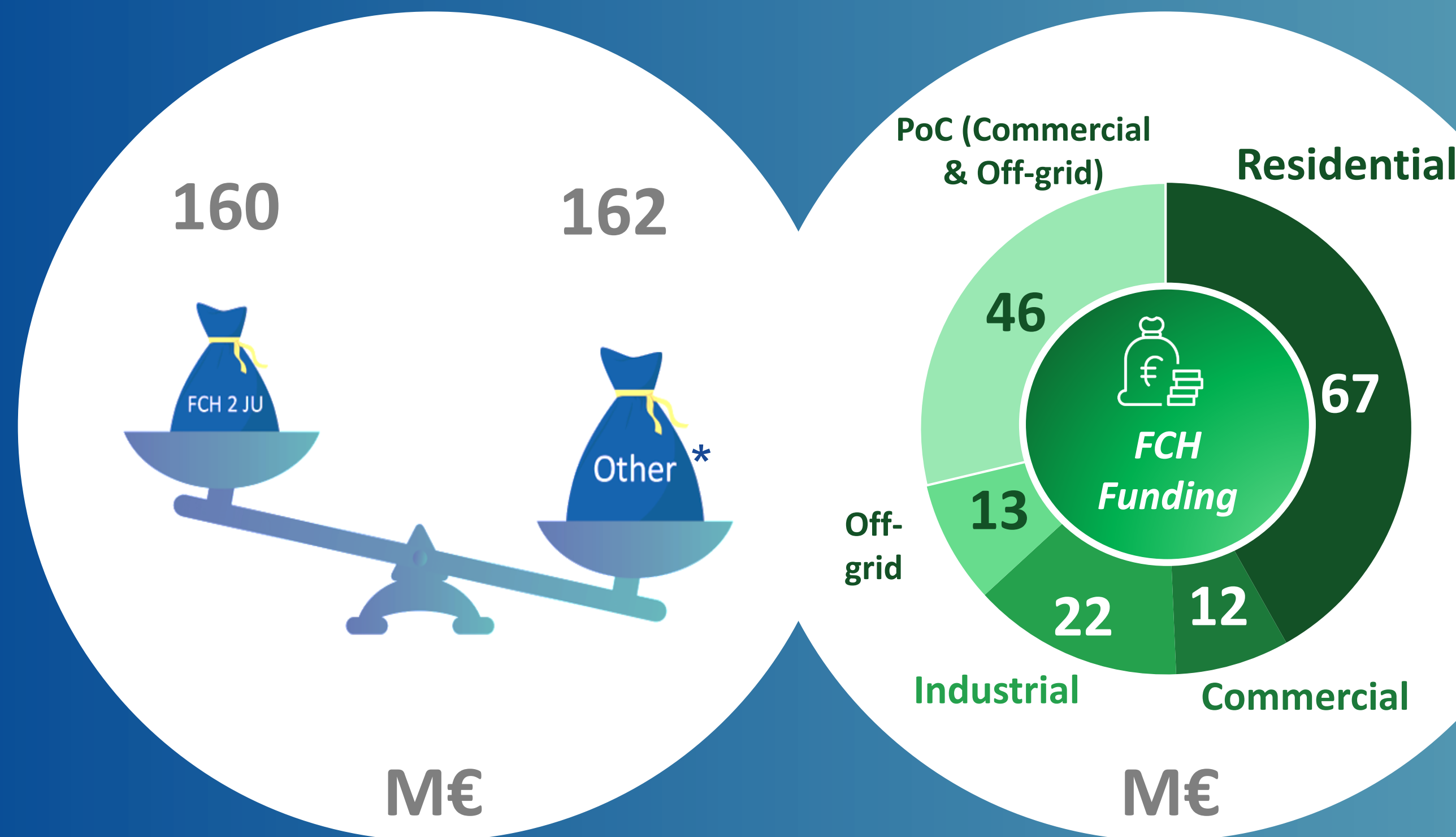
49 projects – 187 M€



\* Other resources including private and national/regional funding

# Trials and deployment (demonstration)

30 projects – 322 M€



Domestic solutions:  
commercially  
available



Clean solutions  
for commercial  
buildings and  
service sectors



Exporting  
industrial CHP  
and opening  
new markets

## DEPLOYING:

**3,900**  $\mu$ -CHP units  
**1** MW<sub>e</sub> commercial  
**3** MW<sub>e</sub> industrial  
**1** MW off-grid/backup



\* Other resources including private and national/regional funding

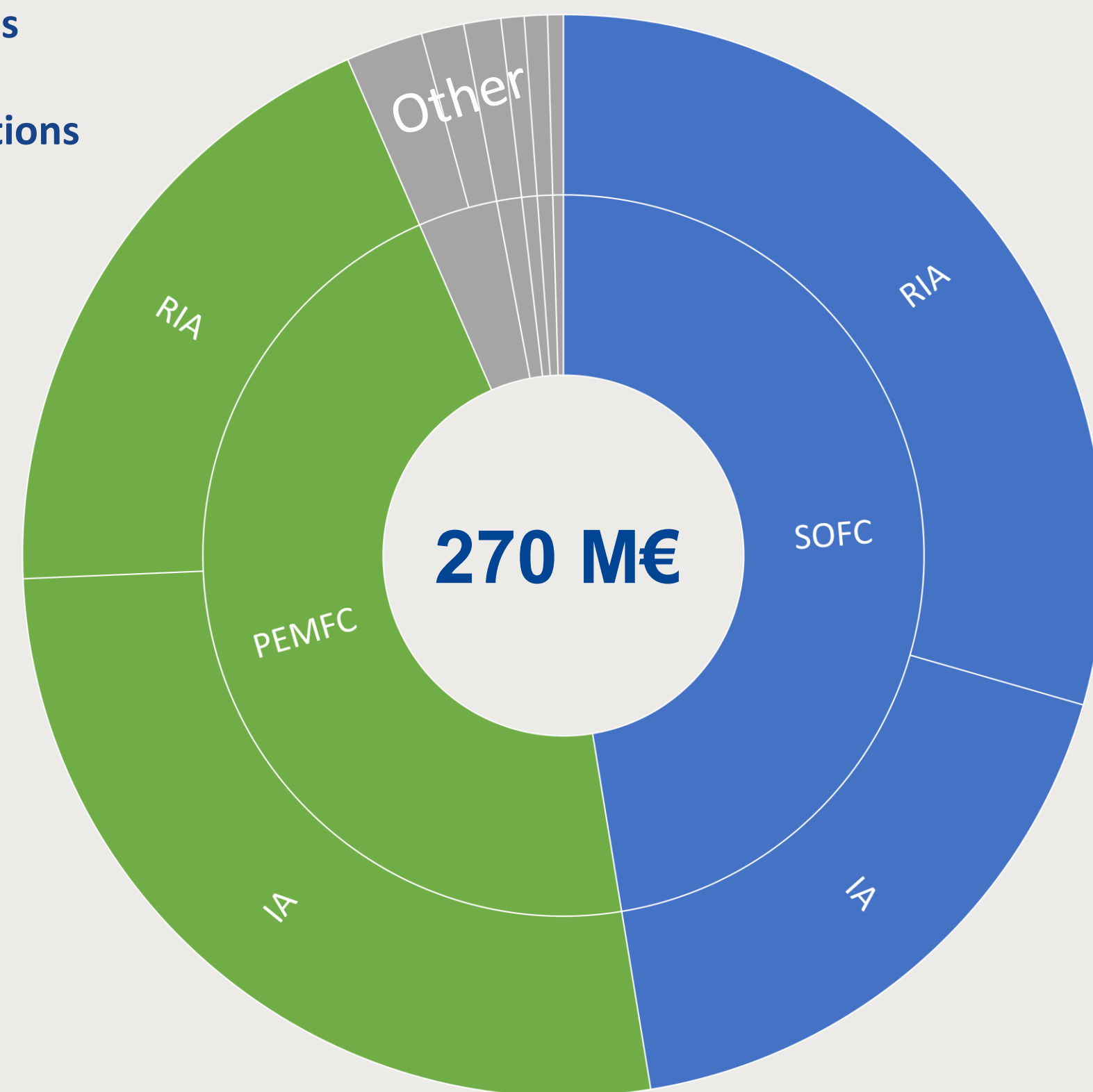
# Stationary Fuel Cell Research and Demonstration



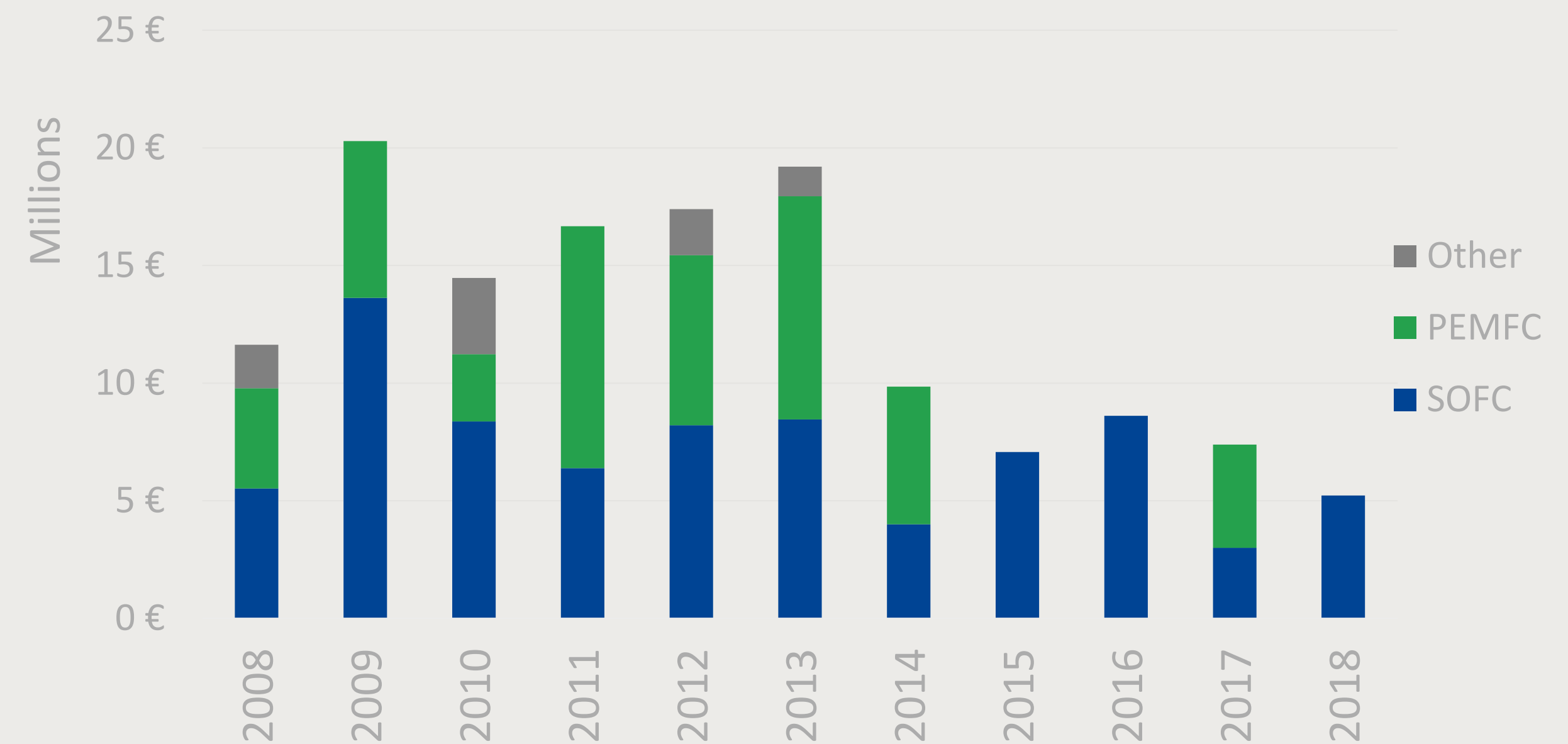
Technology neutral approach – research for SOFCs showing growing dominance specially in the last years

## Fuel Cells Stationary, M€ FCH JU Support

RIA: Research & Innovation Actions (RTD)  
IA: Innovation Actions (Demo)



## Research FCH JU Funding to for stationary apps





# Residential sector and small commercial buildings

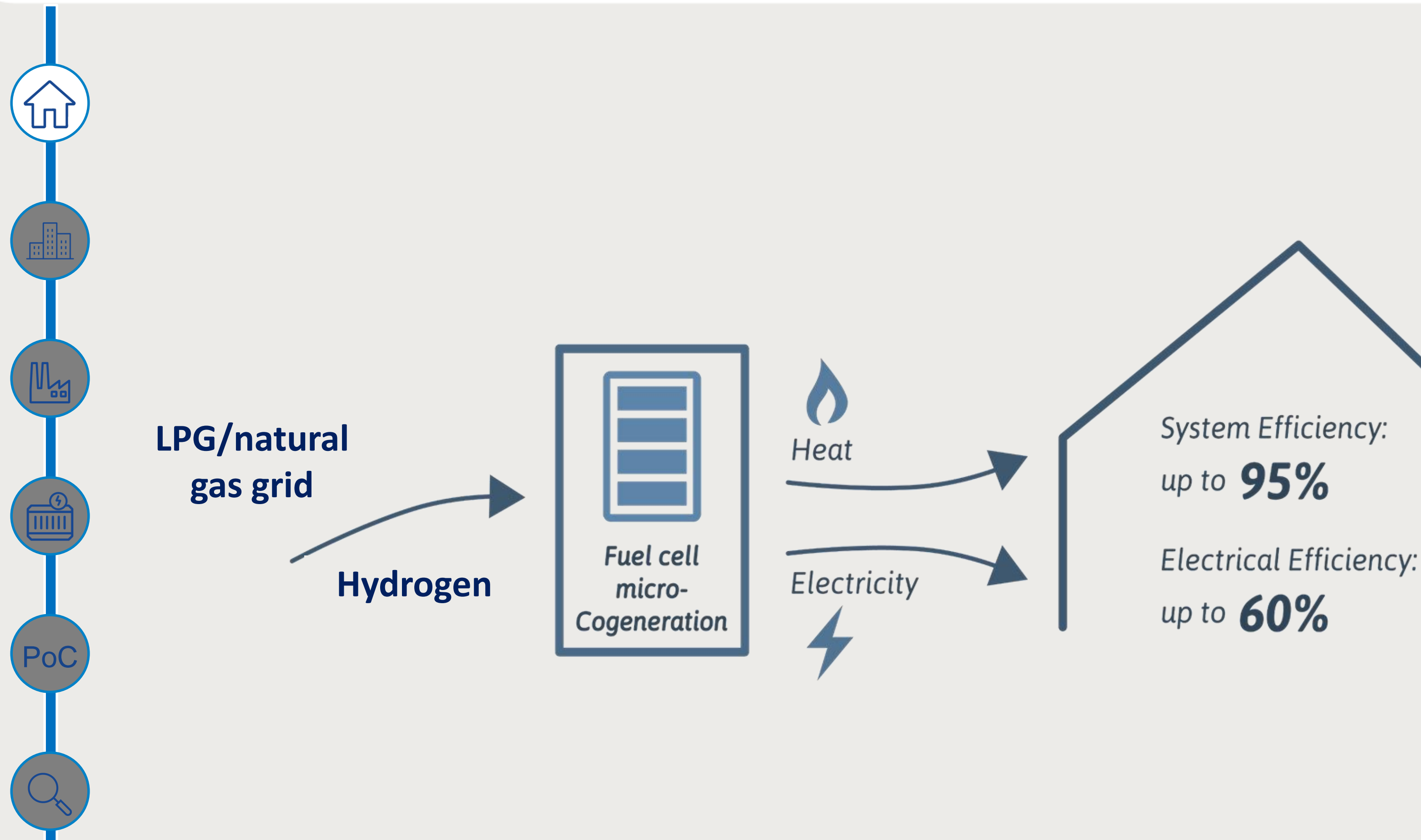
~ 25% of the energy in the EU is consumed in the household sector





# Clean heat and power for homes and small buildings

Highly efficient heat and power supply at the domestic scale



*High efficiencies*



*Clean / silent*



*Grid balancing*



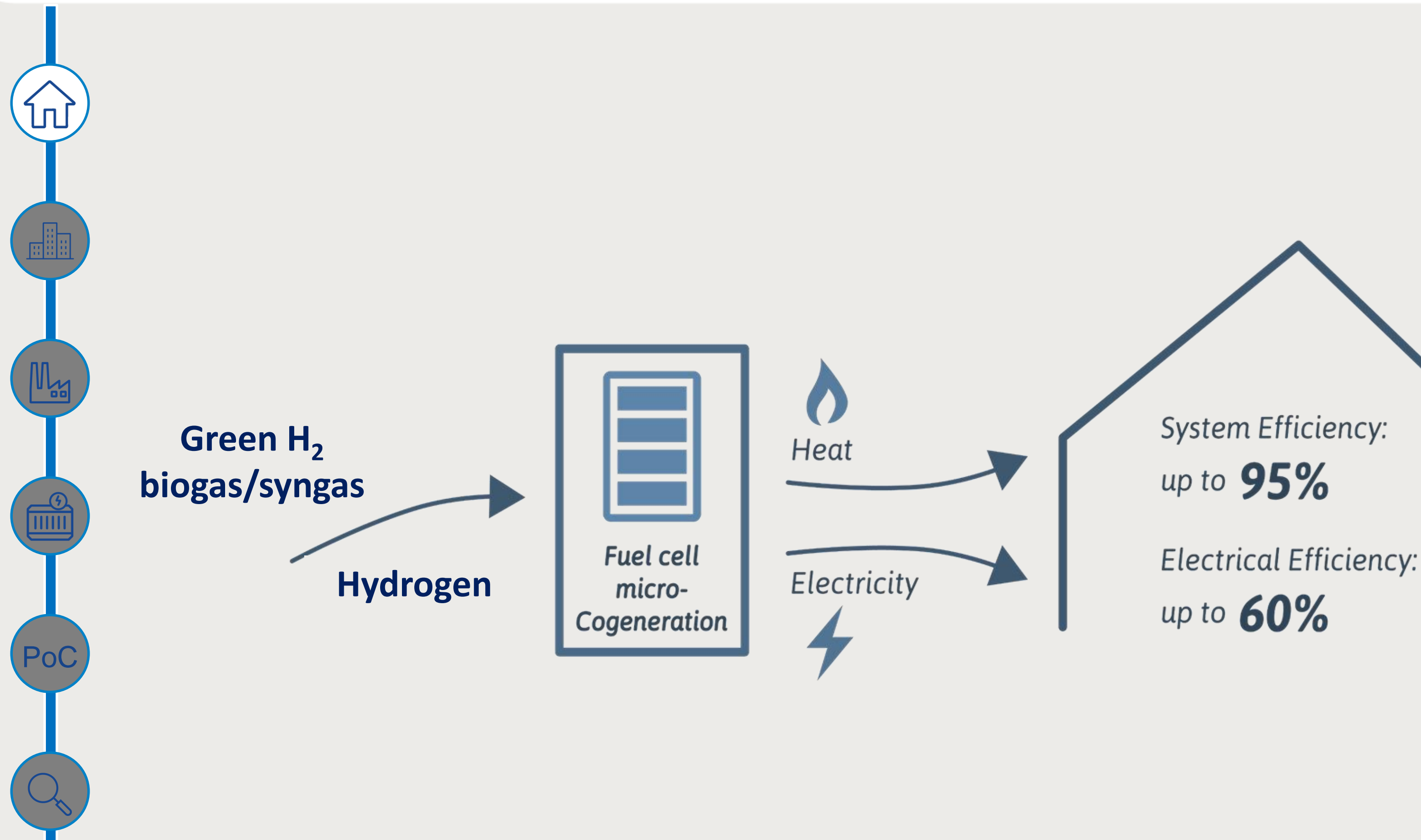
*Fuel flexible*



Image adapted from PACE project

# Clean heat and power for homes and small buildings

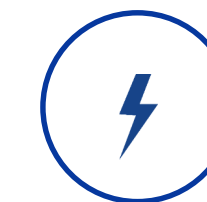
Forward compatible with a fully decarbonised energy system



*High efficiencies*



*Clean / silent*



*Grid balancing*



*Fuel flexible*

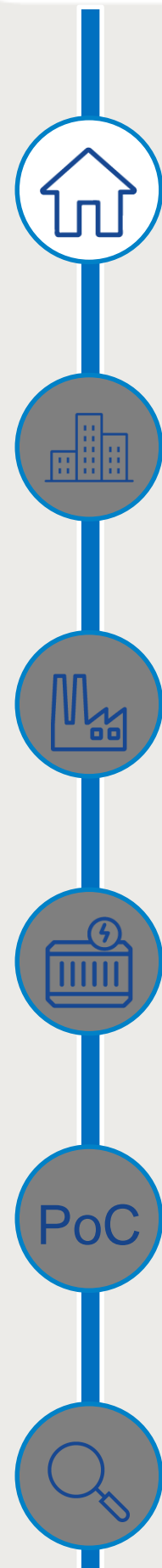


Image adapted from PACE project



# Socio-economic benefits of fuel cell $\mu$ CHP sector are significant

Maintaining and increasing European value-added depends on deployment levels in Europe



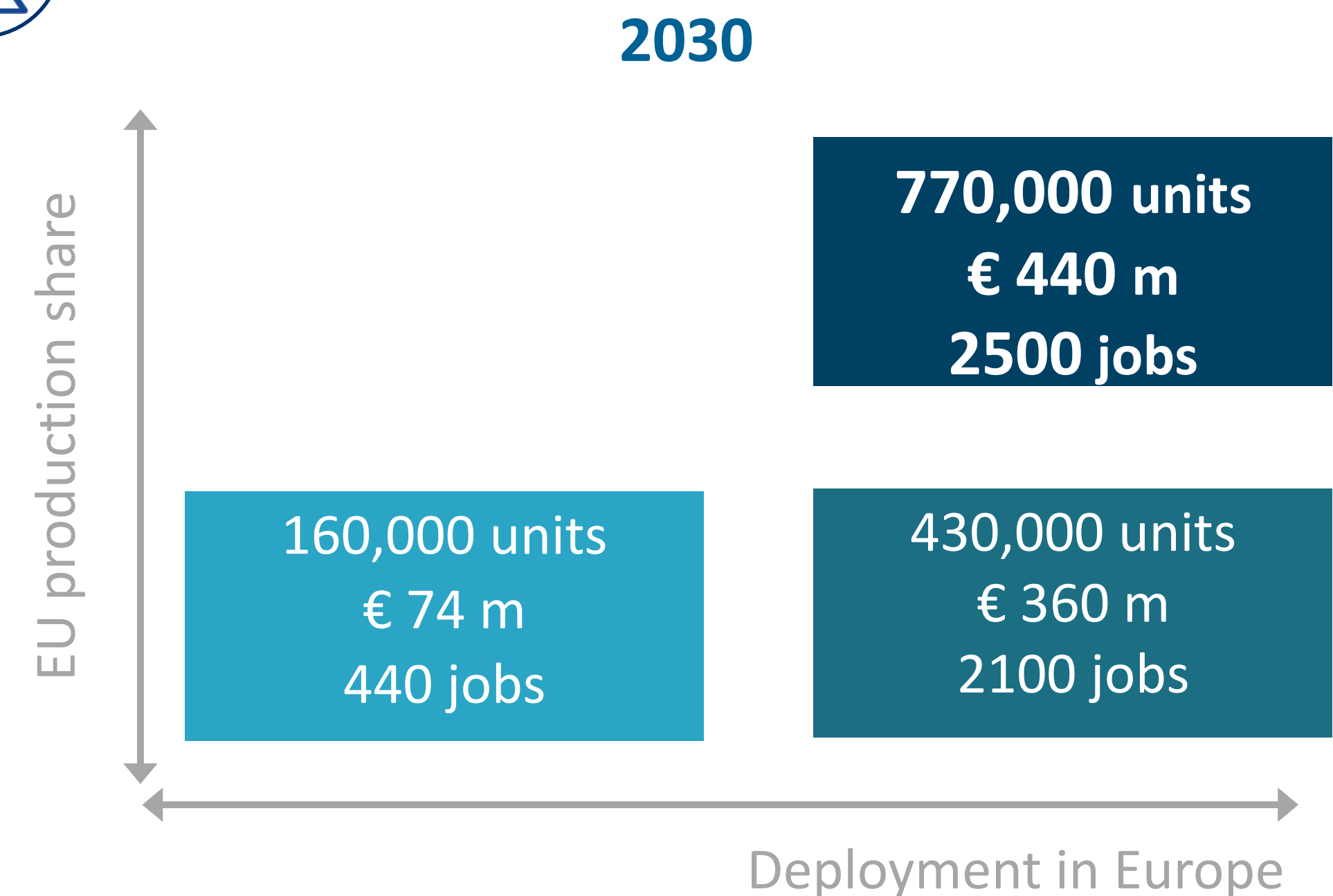
European **system integrators** include **SMEs** and established **heating equipment suppliers**

**Strong European SOFC players** throughout the supply chain

**Europe is strong on HT-PEMFC** but limited commercial availability

**European companies** could have more EU content going into **overseas systems**

Threat of **overseas companies** developing EU-specific systems and **competing in EU**



# European market is in the order of 10,000s FC $\mu$ CHP units

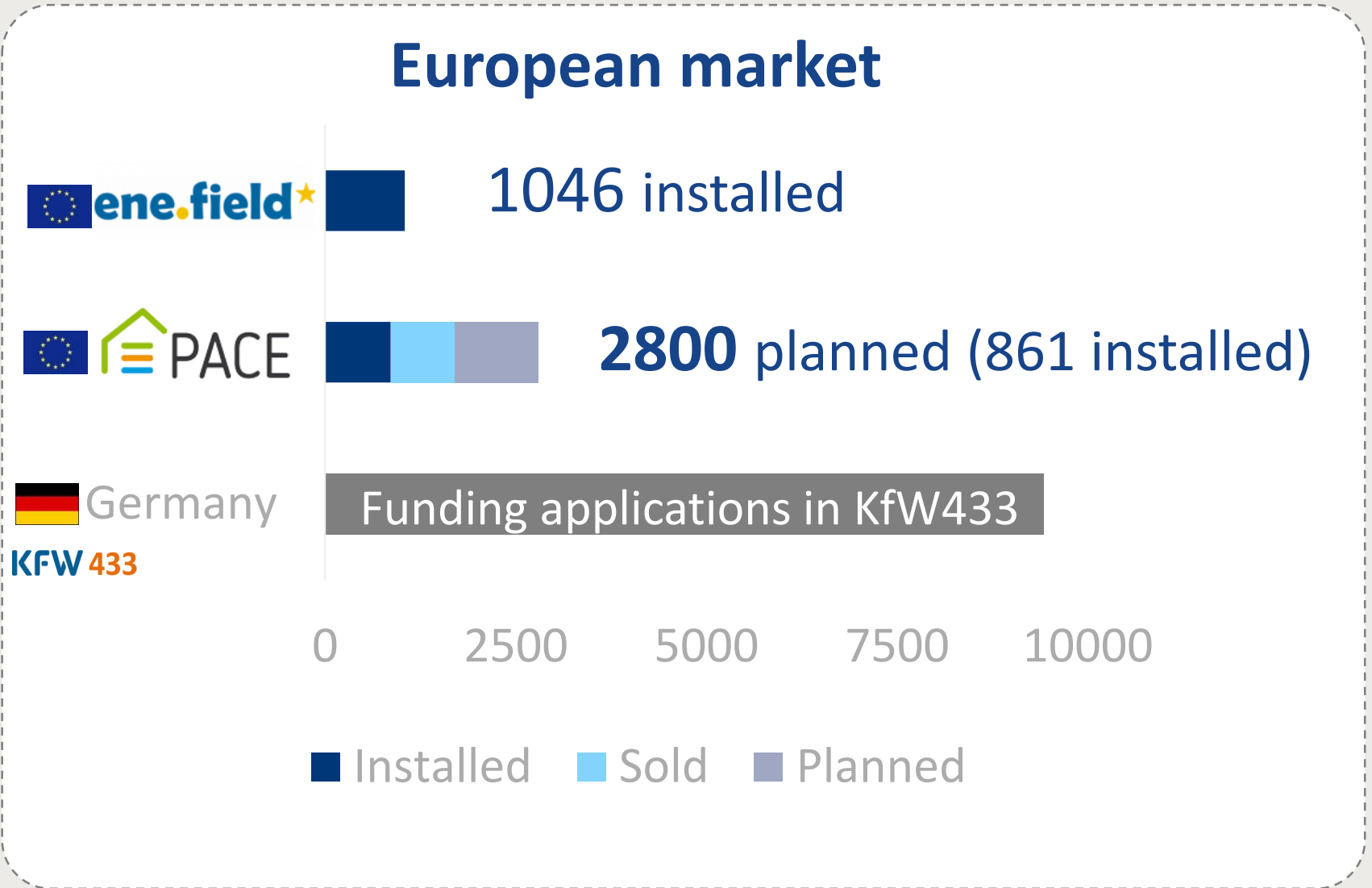
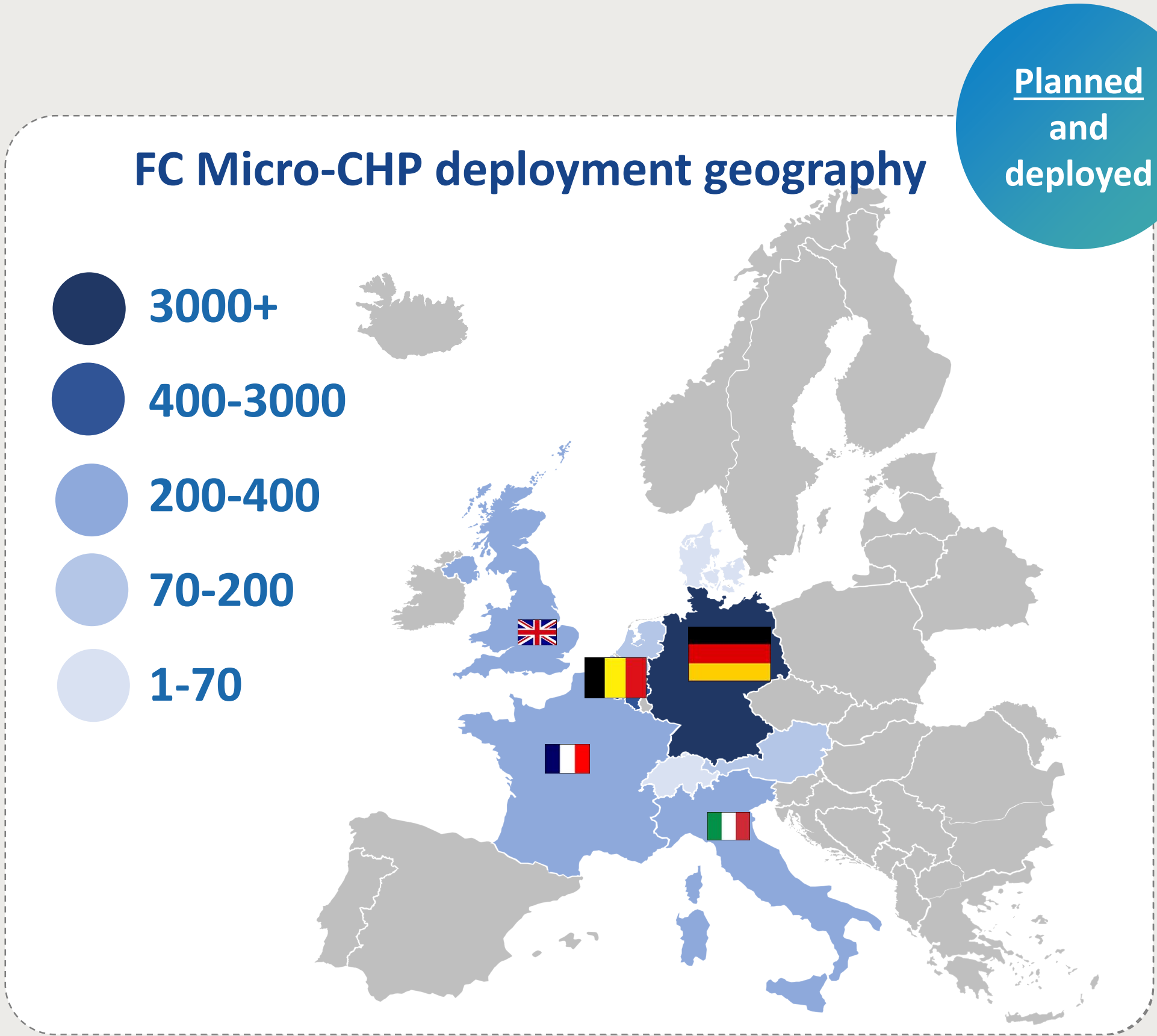
European support is helping to increase country coverage beyond Germany



Complementary to heating system



Replaces heating system



Top left image: © Solid Power  
Bottom left image: © Viessmann Group



# μCHP – Manufacturing scale-up paving the way to competitiveness

Manufacturing taking a central role, Consolidated research results for first generation products utilised for scaling up production volumes

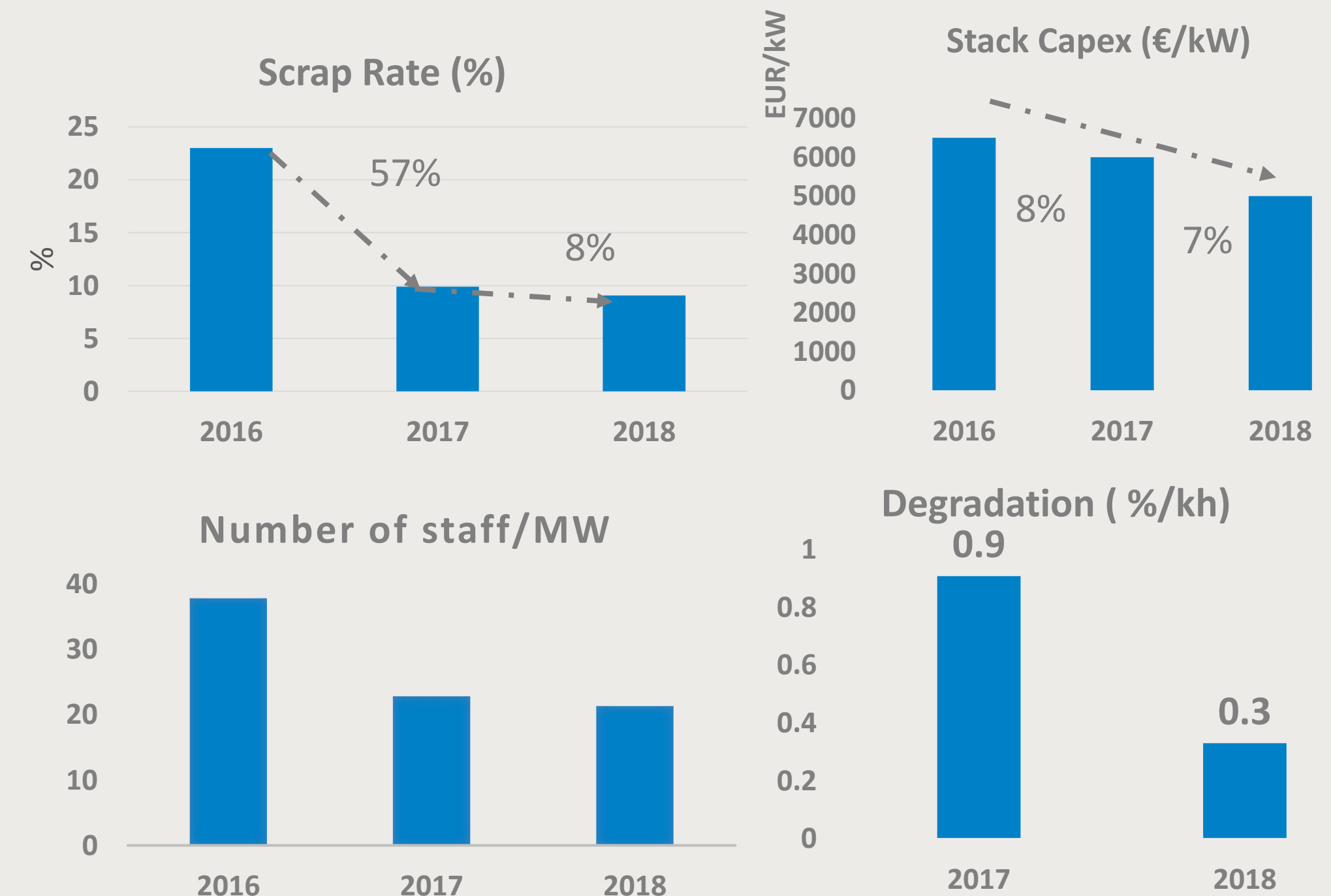


- Overall **reduction of manufacturing time** and of number of steps
- Material replacement of Co with Cu
- Key contributor to the **25MW/year plant** currently under development by SolidPower

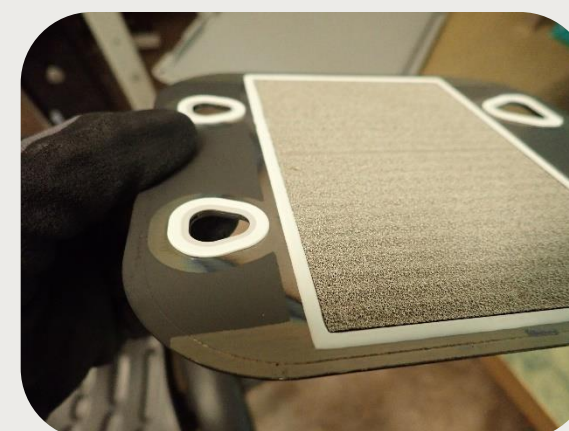


- Focused on a 60% cost reduction on two key components, stack and CAPH
- Cathode air pre-heater ready for mass production

Positive trends in TRUST overall



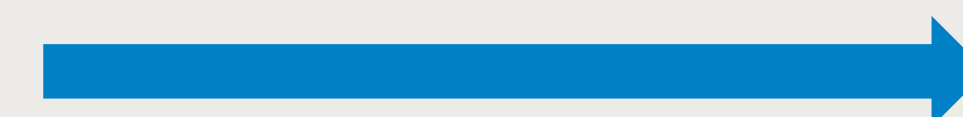
Source: Solid Power



Source: Sunfire

Manufacturing improvements moving in synergy with deployment activities maximising impact

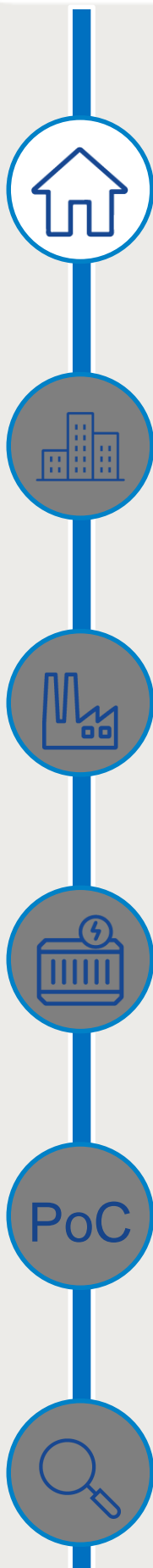
FCH JU support has been crucial for the development of the next generation of products deployed in



Automation increasing Volumes

# Results from the field confirm product performance

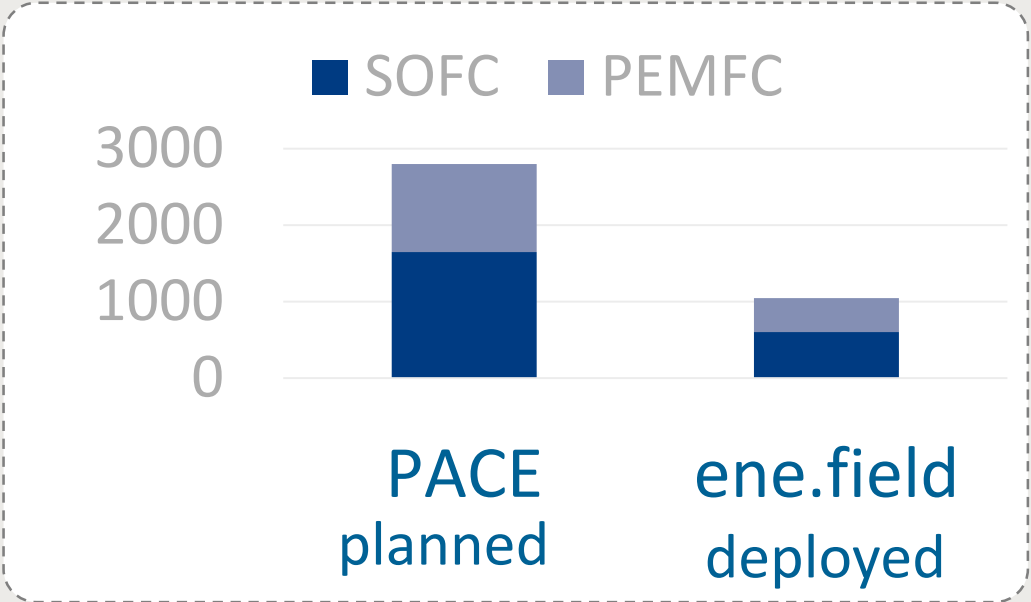
Track record of installations key to increase market confidence in the technology



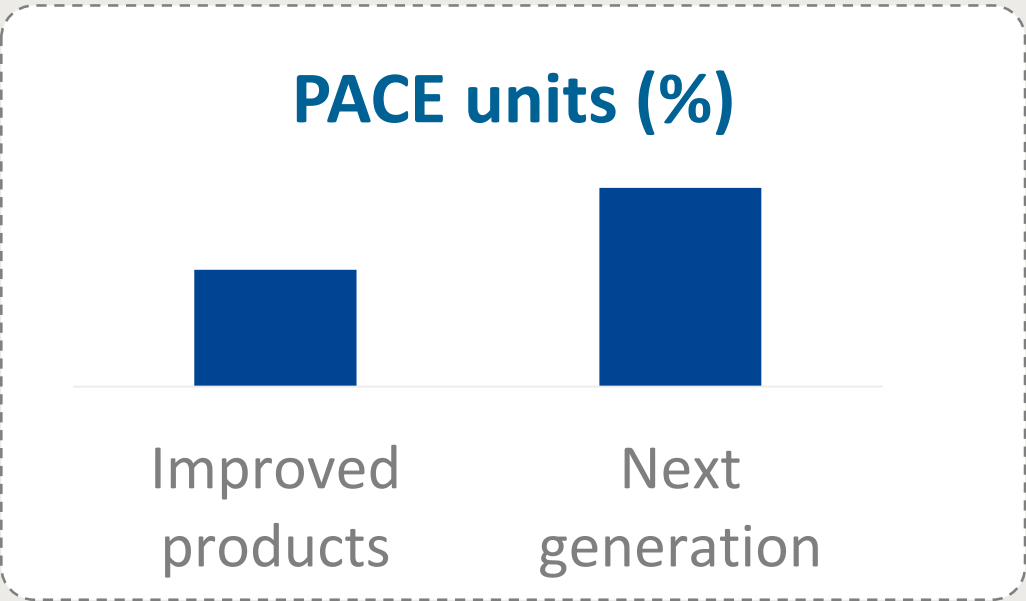
Supplying homes and small businesses

6.8 million hours operation

Technology neutral



Shift to next generation



✓ 37 to 60% Power Efficiencies



✓ 85 to 90% Total Efficiencies



✓ 93 to 99% availabilities



✓ 40 to 80 khrs stack durability



✓ 948 installers trained



✓ customer satisfaction



⚠ installation costs



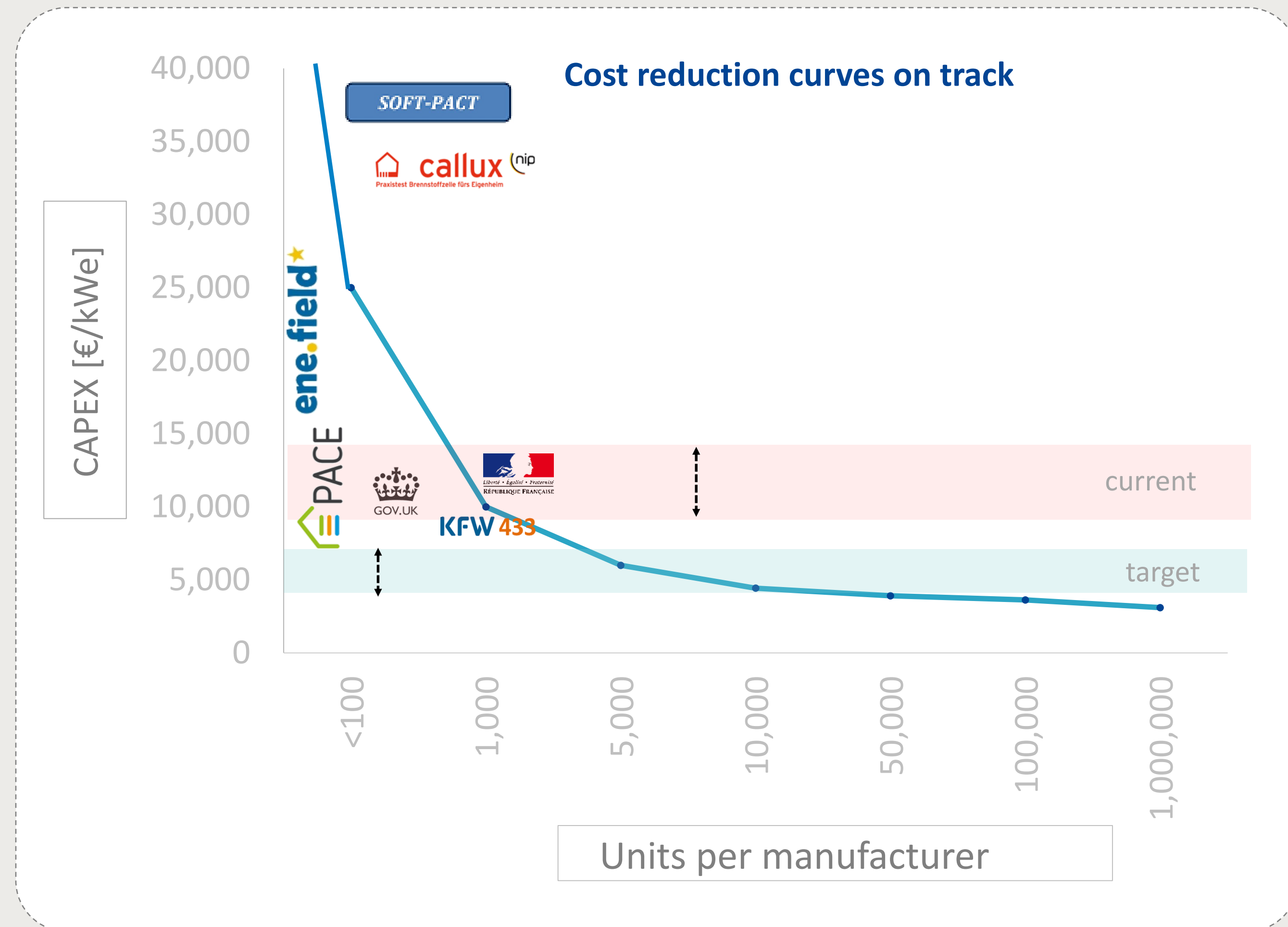
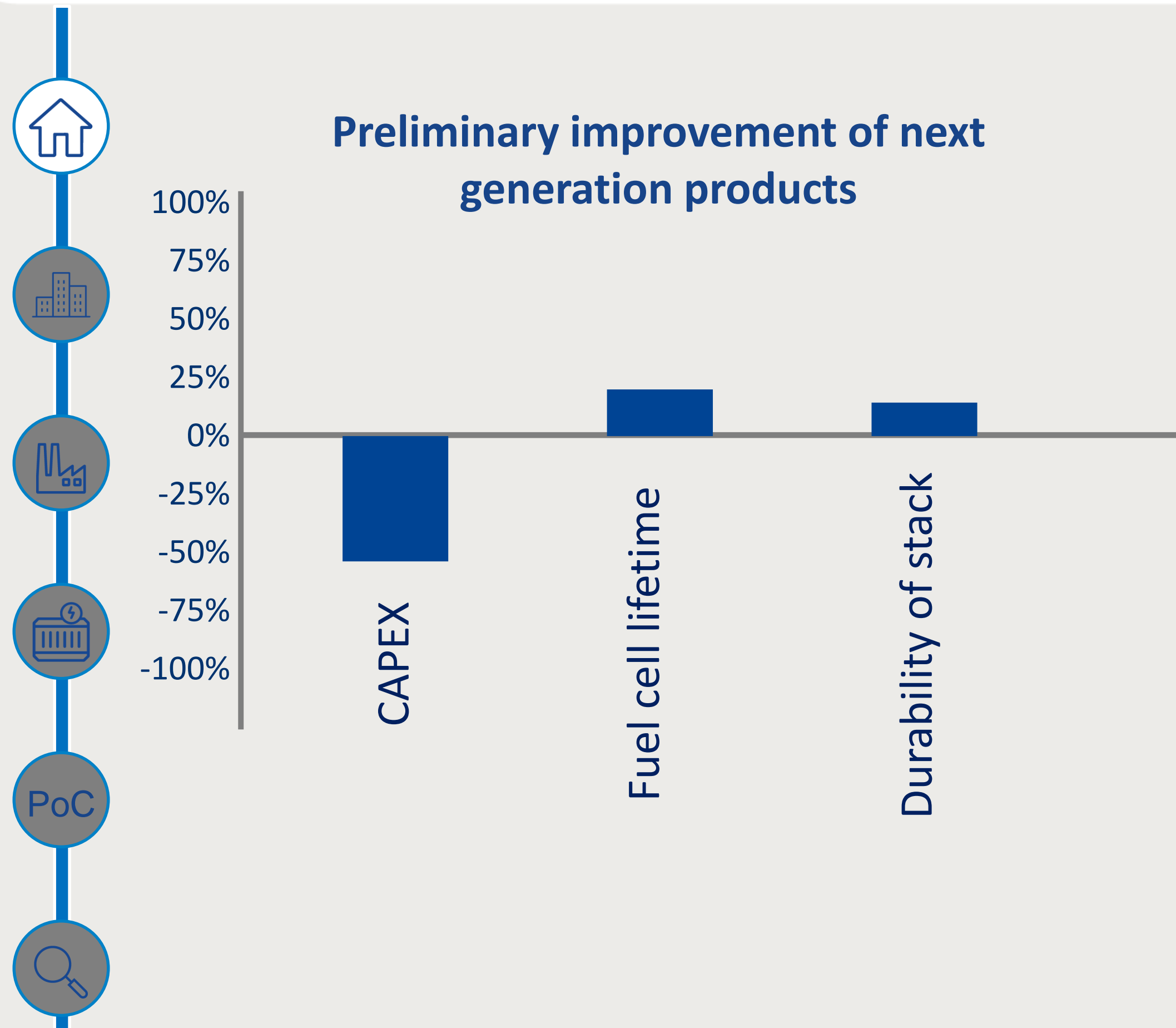
⚠ innovative business models





# Improving performances and reducing costs

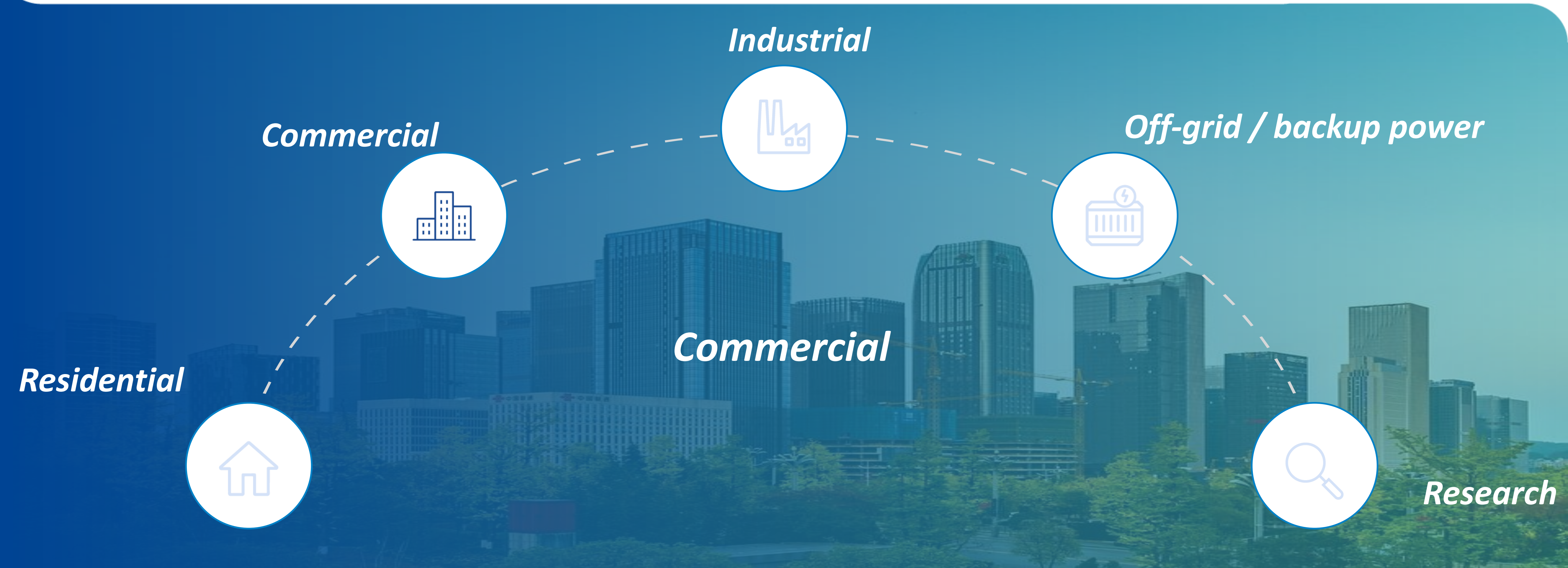
Reducing costs by optimising design and increasing volumes



Cost reduction curves adapted from the study "Advancing Europe's energy system: Stationary Fuel Cells in distributed generation". Study prepared for the FCH JU prepared by Roland Berger. 2015.

# Demonstration portfolio

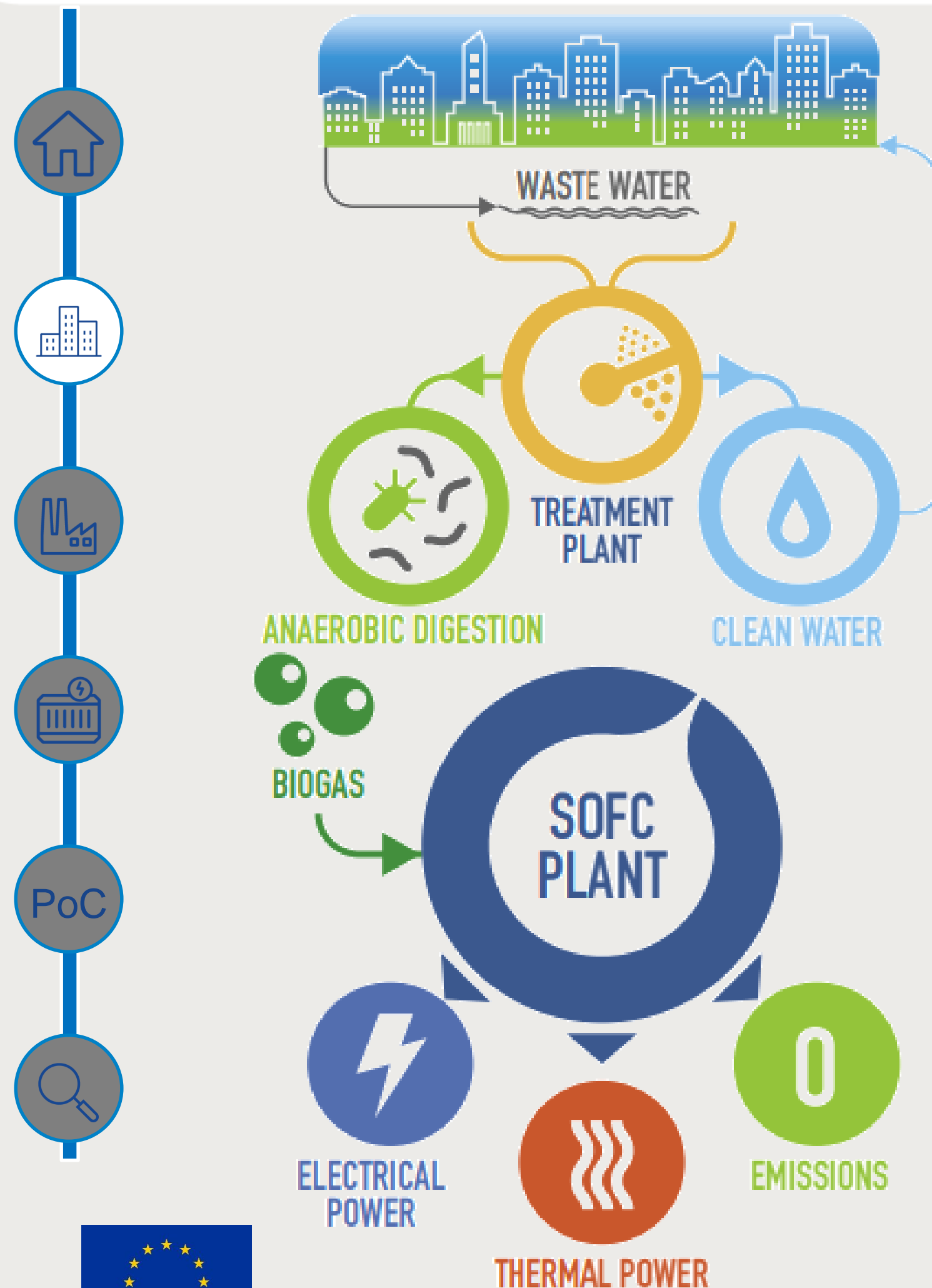
~ 13% of the energy in the EU is consumed in the commercial building and services sector





# Fuel cells in commercial buildings and service sector

Demonstrations in real installations are providing good results



✓ 7470h running to date

✓ *Achieved in 2018*  
-53% electrical efficiency  
-31% thermal efficiency

⚠ Additional hours needed to conclude on stack durability and availability

✓ Real operation experiences feeding development of next generation of products

⚠ 2.5GW potential for replication in WWTP in EU

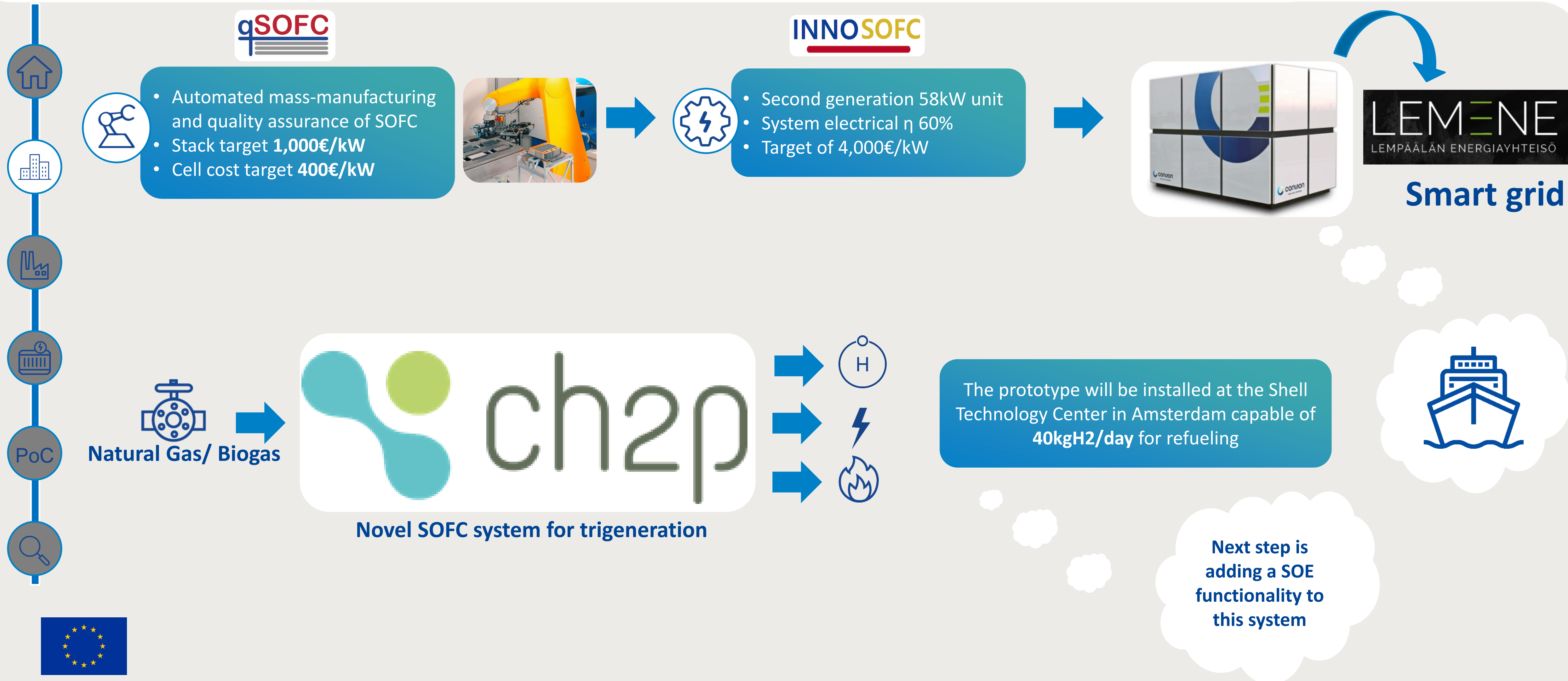


Source of the pictures: DEMOSOFC project



# Commercial Size brings second generation products

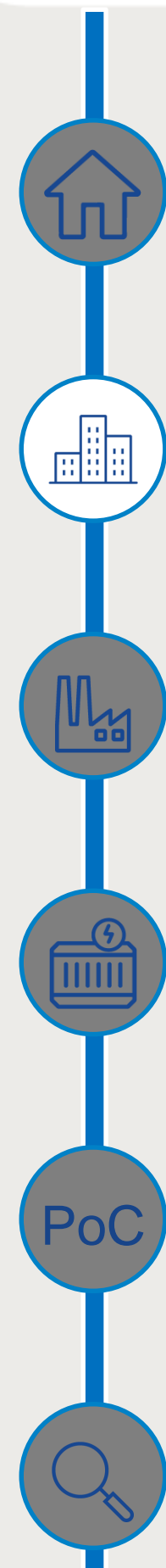
First business cases appearing on the horizon for this sector – New concepts also explored





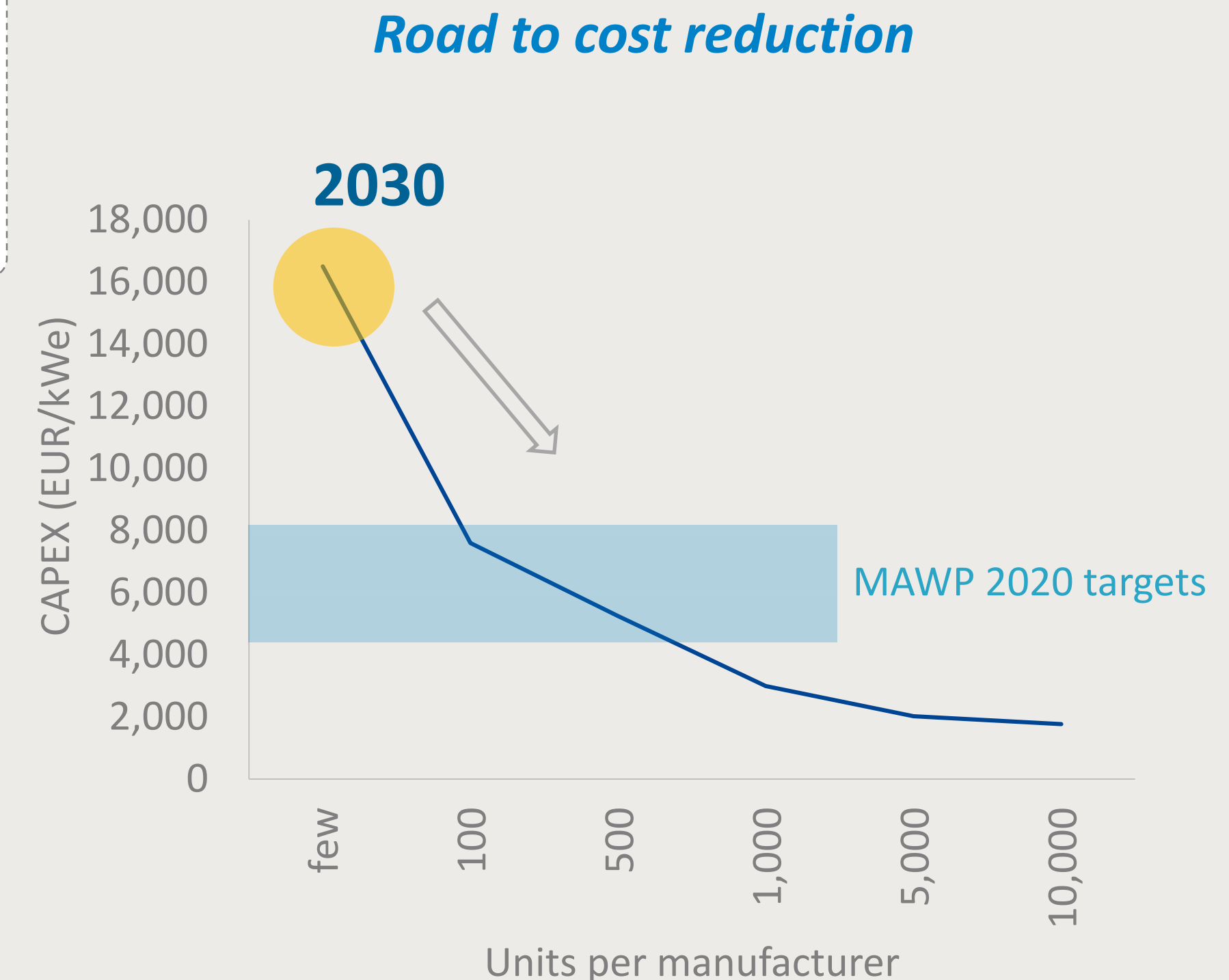
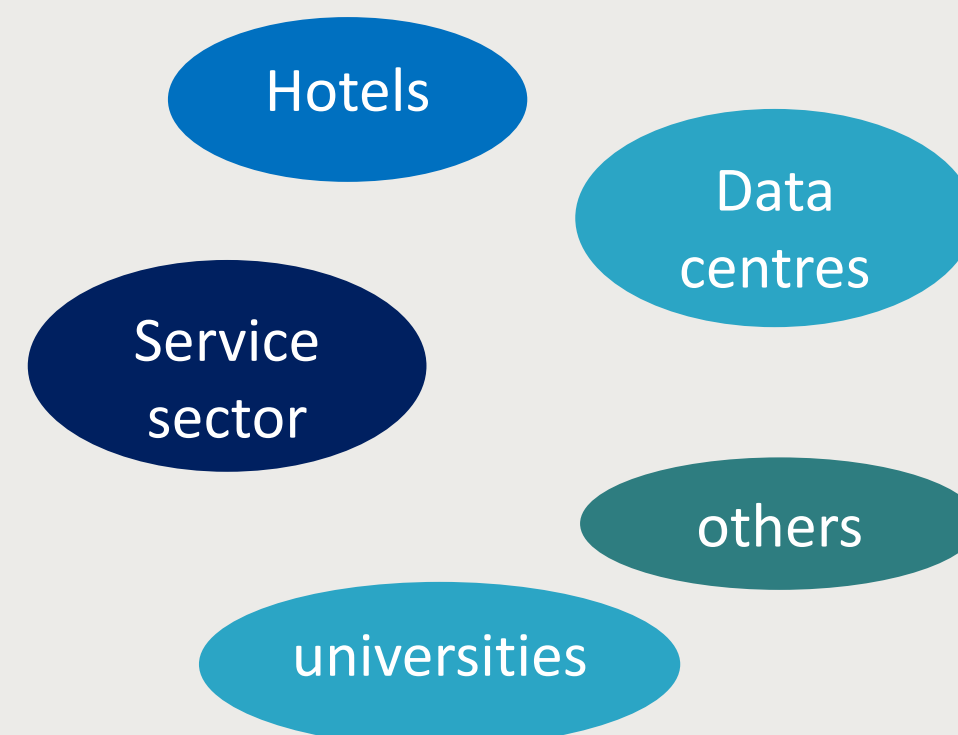
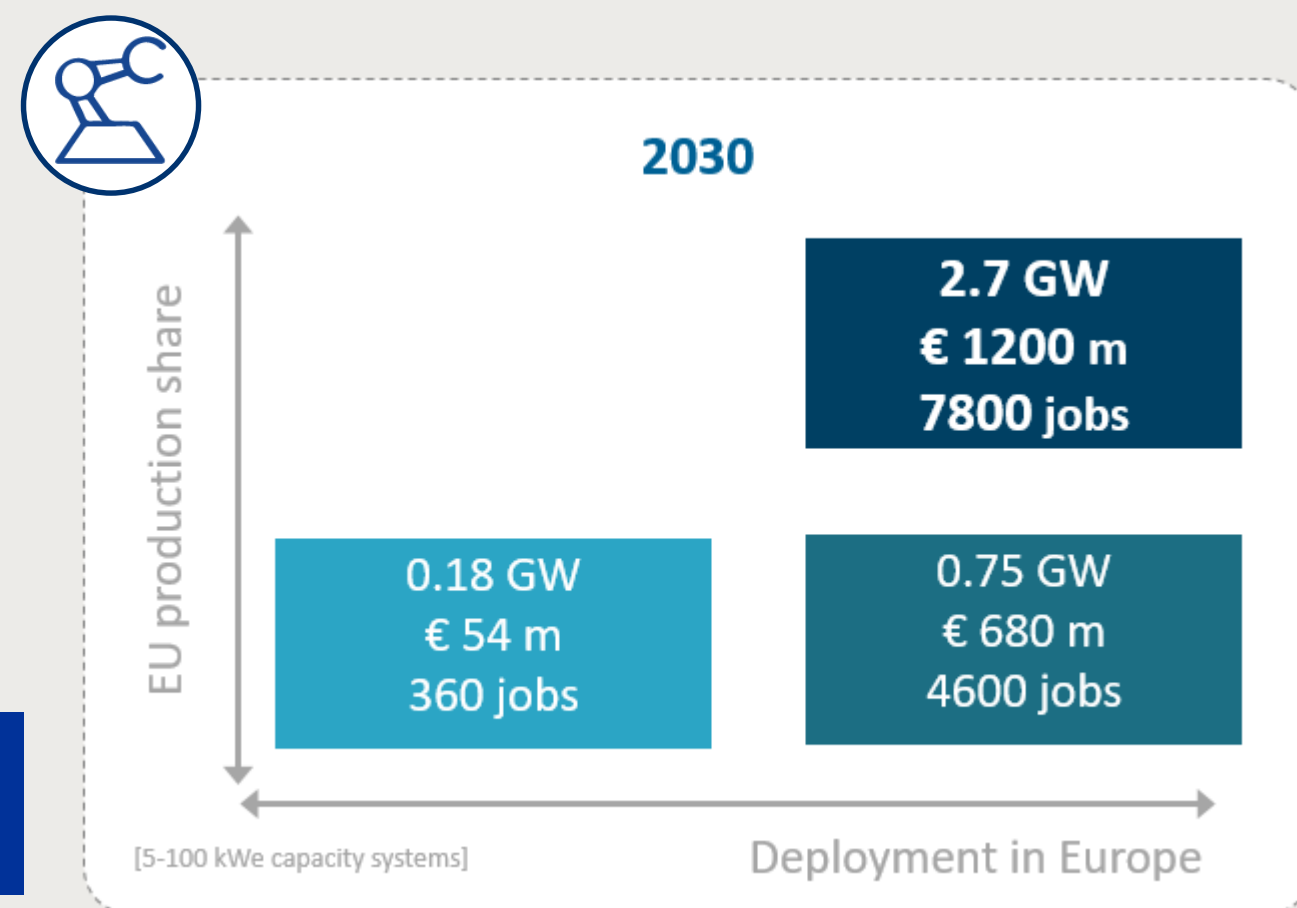
# Commercial FC CHP bring new opportunities but also challenges

Large deployment necessary to replicate the success of domestic applications in the commercial segment



- ✓ Early units performing well
- ✓ High power efficiencies demonstrated
- ✓ Building on successes from smaller apps
- ⚠ Challenge remains to reduce costs
- ⚠ New gen. units being finalised
- ⚠ Real installations will follow soon

**Demonstration of fuel cell for  
heat and power in commercial  
buildings**  
**10 to 60 kWe units**



Source Study on Value Chain and Manufacturing Competitiveness. Study undertaken for the FCH 2 JU by E4tech in partnership with Ecorys and Strategic Analysis Inc.

Cost reduction curves adapted from the study "Advancing Europe's energy system: Stationary Fuel Cells in distributed generation". Study prepared for the FCH JU prepared by Roland Berger. 2015.





# Demonstration portfolio

~ 25% of the energy in the EU is consumed in the industry sector





# Greening big industry by using waste hydrogen

Exporting EU technology opening, opening new markets applications

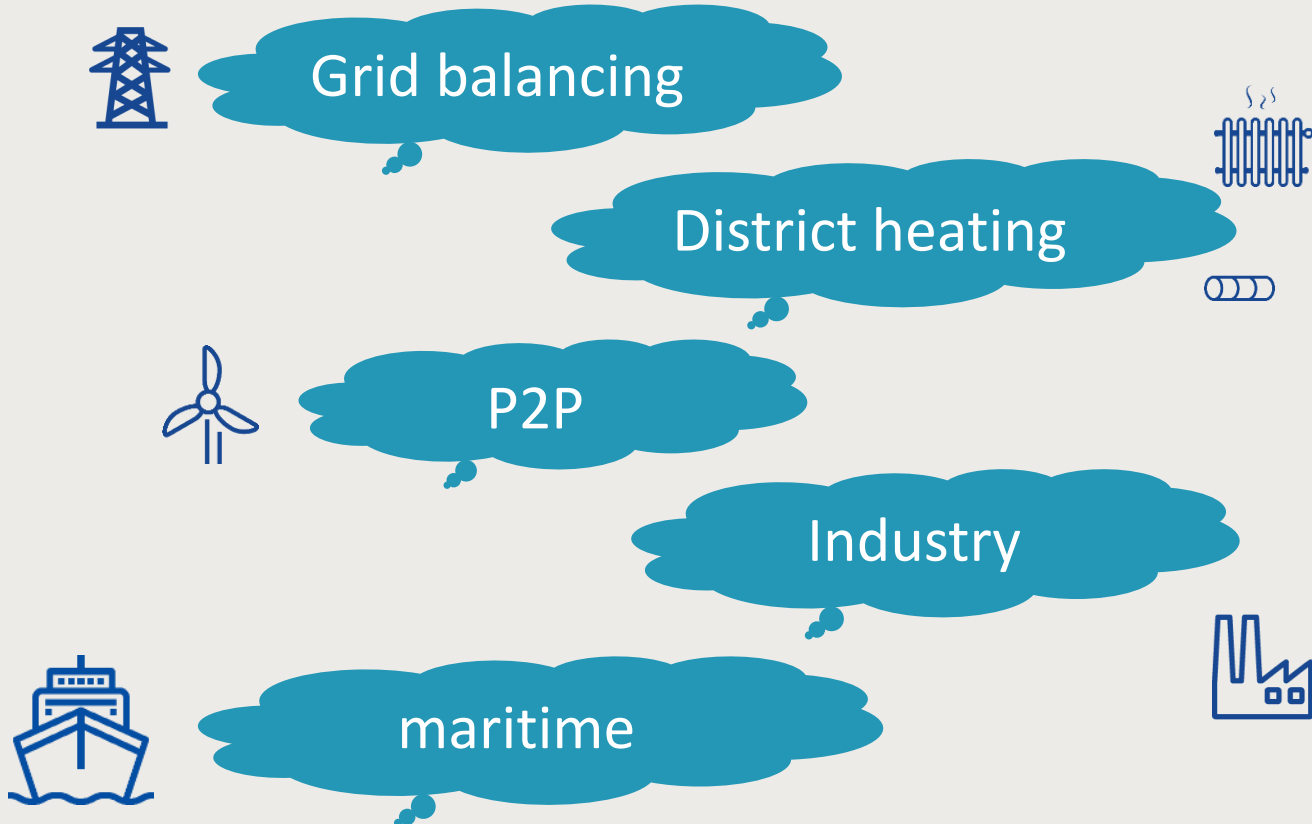


By-product H2 from a refinery in Martinique, 1 MW<sub>e</sub> PEMFC



CG Démo

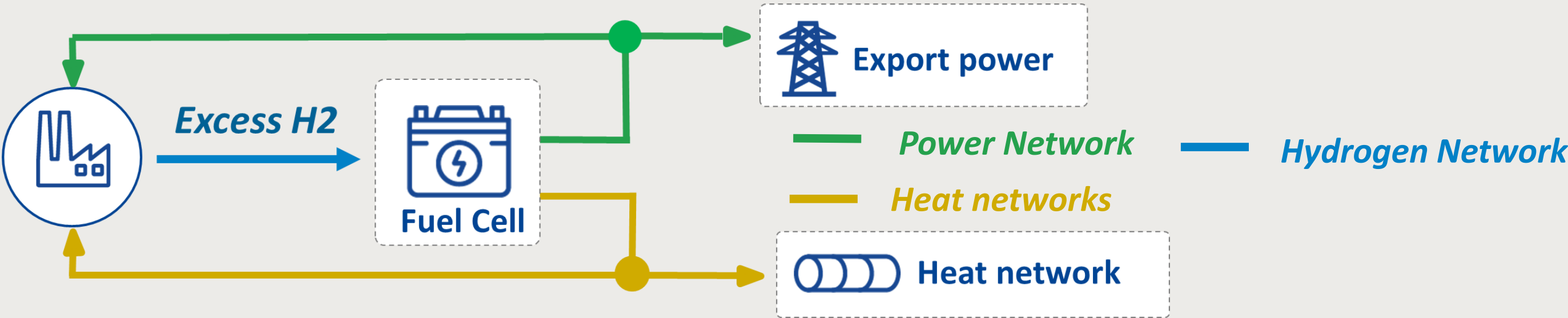
Projects driven by high regional power prices



By-product H2 in a chlor-alkali 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





# Exporting EU fuel cell technology for industrial applications

Significant progress to date ....but further work is needed to achieve targets



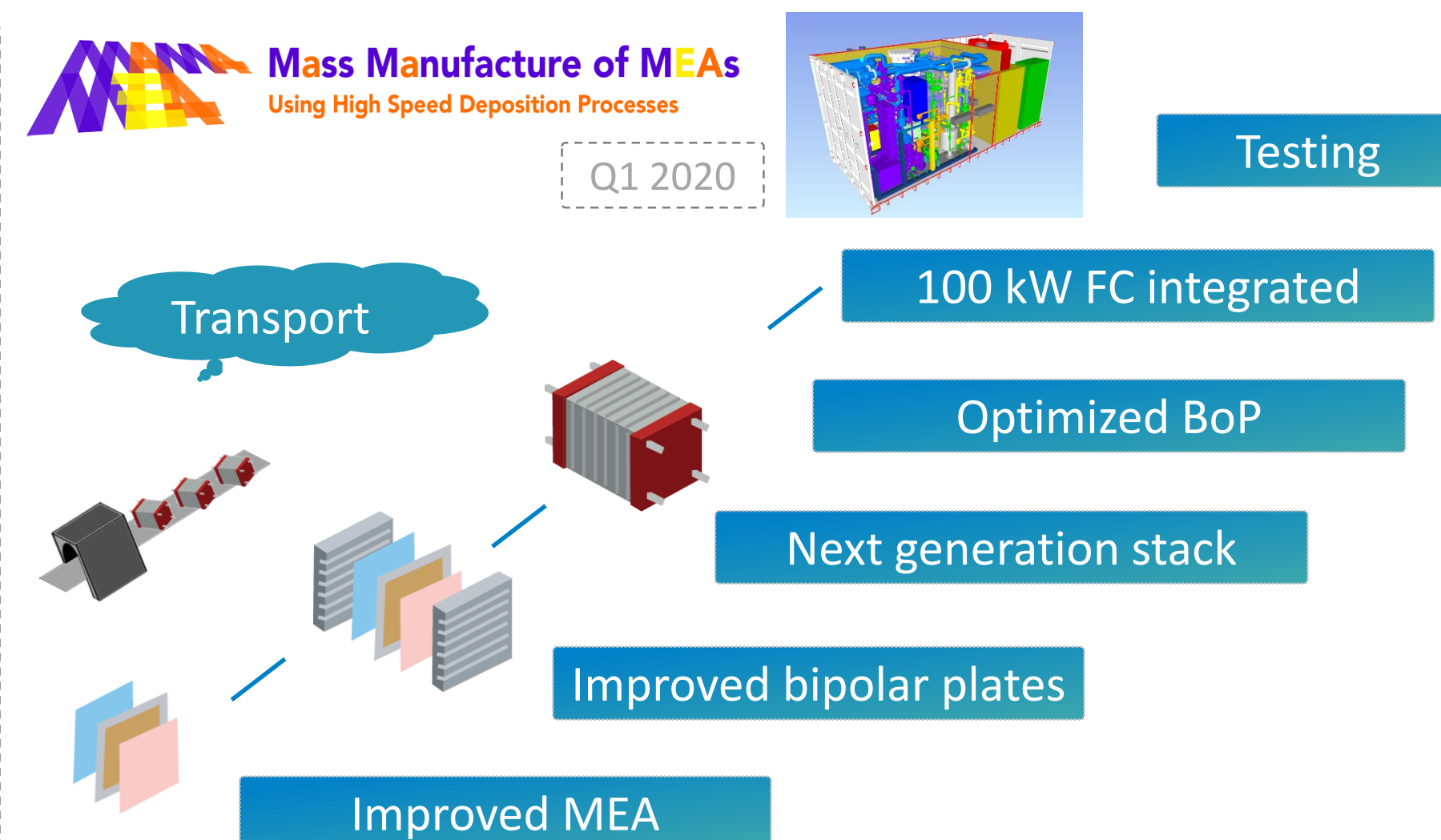
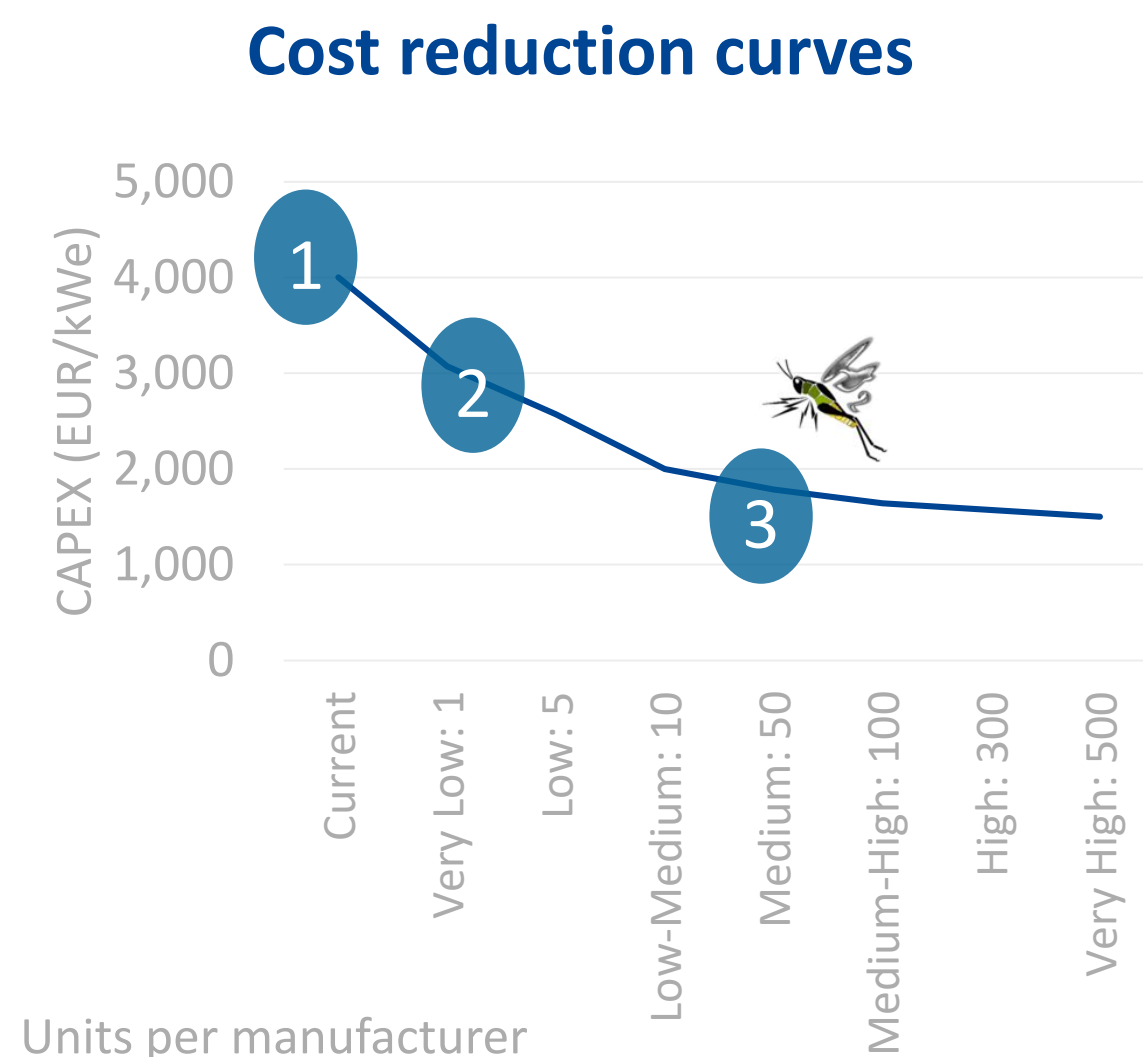
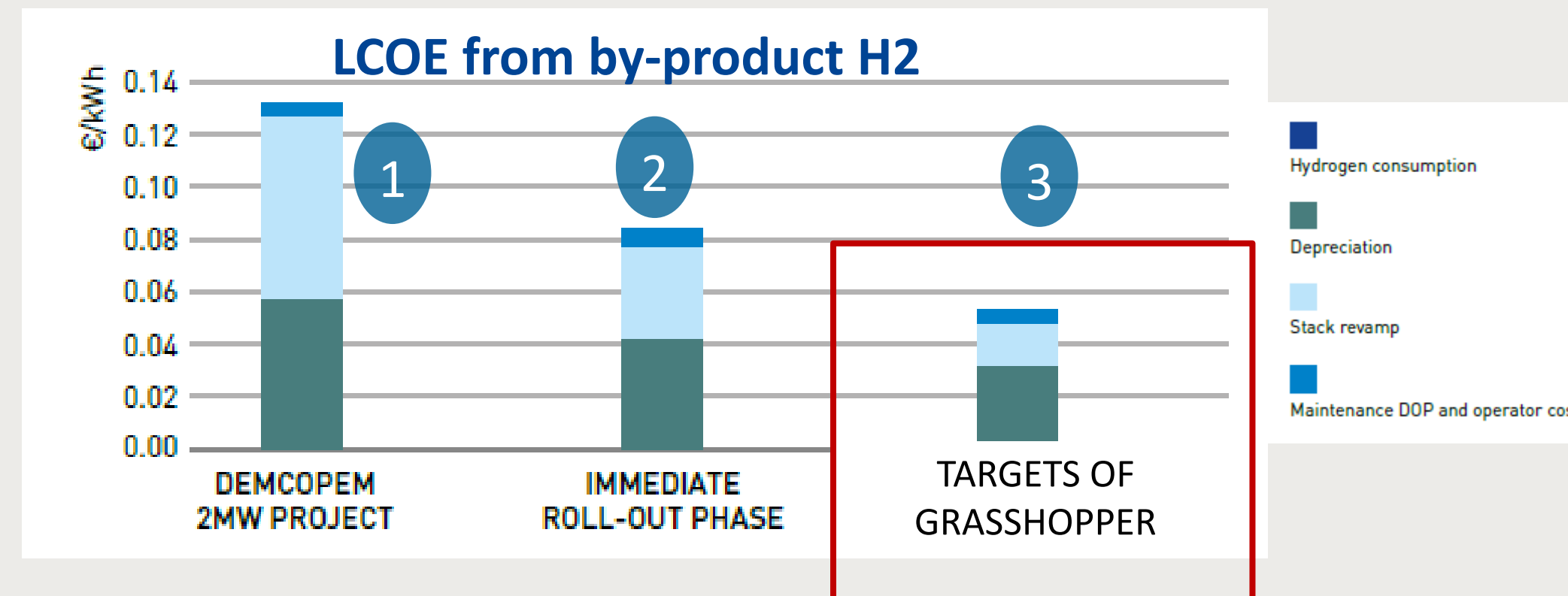
KPI	SoA (2017)	MAWP 2020 Objectives	MAWP 2024 Objectives
CAPEX, €/kW	3000-3500 ✓	2000-3000 ⚠	1500-2500
Lifetime (y)	15 ✓	25 ⚠	25
Availability (%)	98	98 ⚠	98
Durability stack (khrs)	20-60	20-60 ⚠	20-60
Reliability (hrs)	n/a	25,000 ⚠	30,000
Elect. Ef.	45	45 ✓	45
Thermal. Ef.	20-40	22-40 ✓	22-40





# Reducing the costs of PEMFC MW applications

Bringing actors across the supply chain together, designing for multi-applications



Next generation

**1500 €/kW<sub>e</sub> CAPEX < at capacity of 25 MW/year**

**Next generation**  
fuel cell design

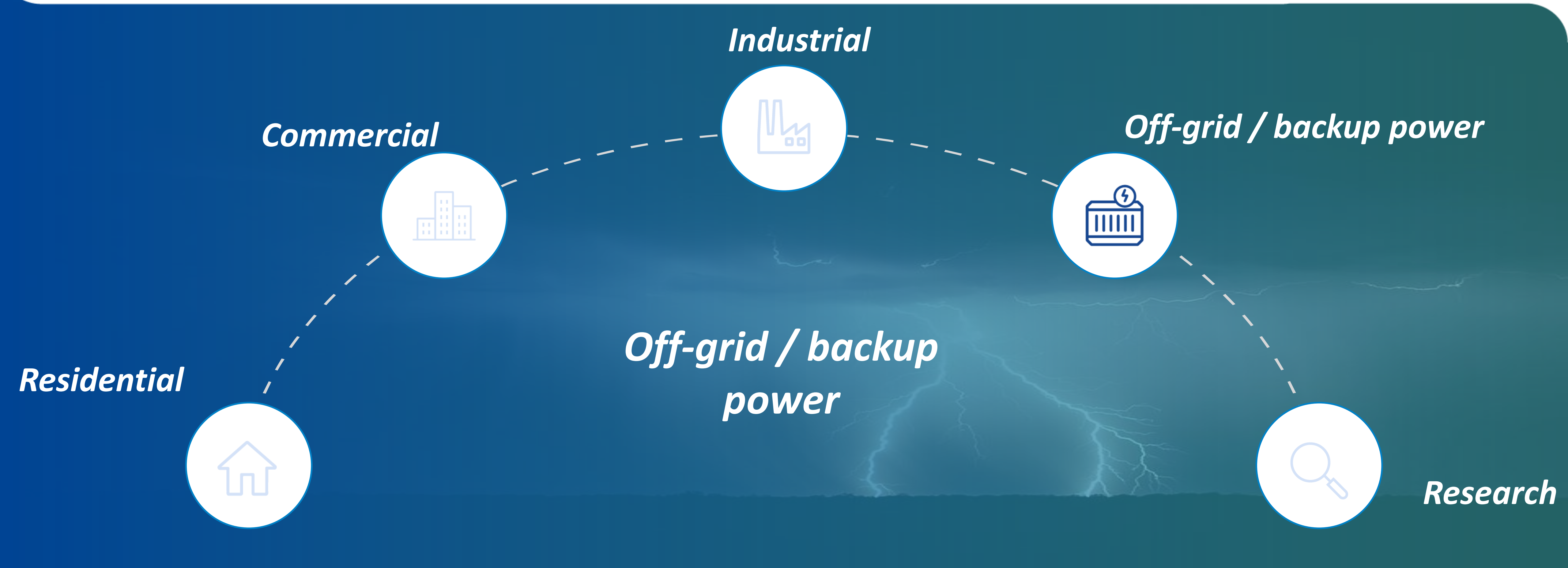
**Cell active area** larger  
**Power density** increased  
**4 times** stack power

**>20,000h** stack lifetime

**Variable** response

# Demonstration portfolio

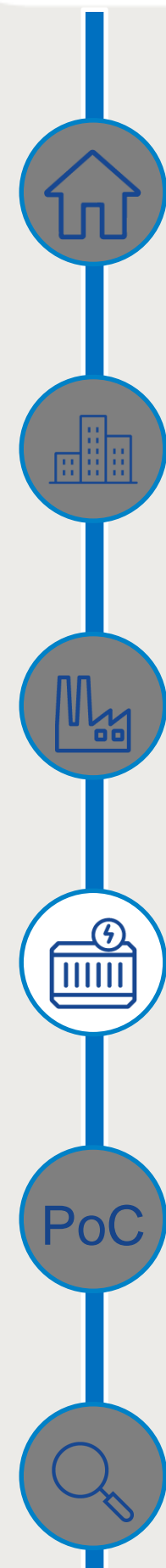
Delivering reliable, clean and silent power supply





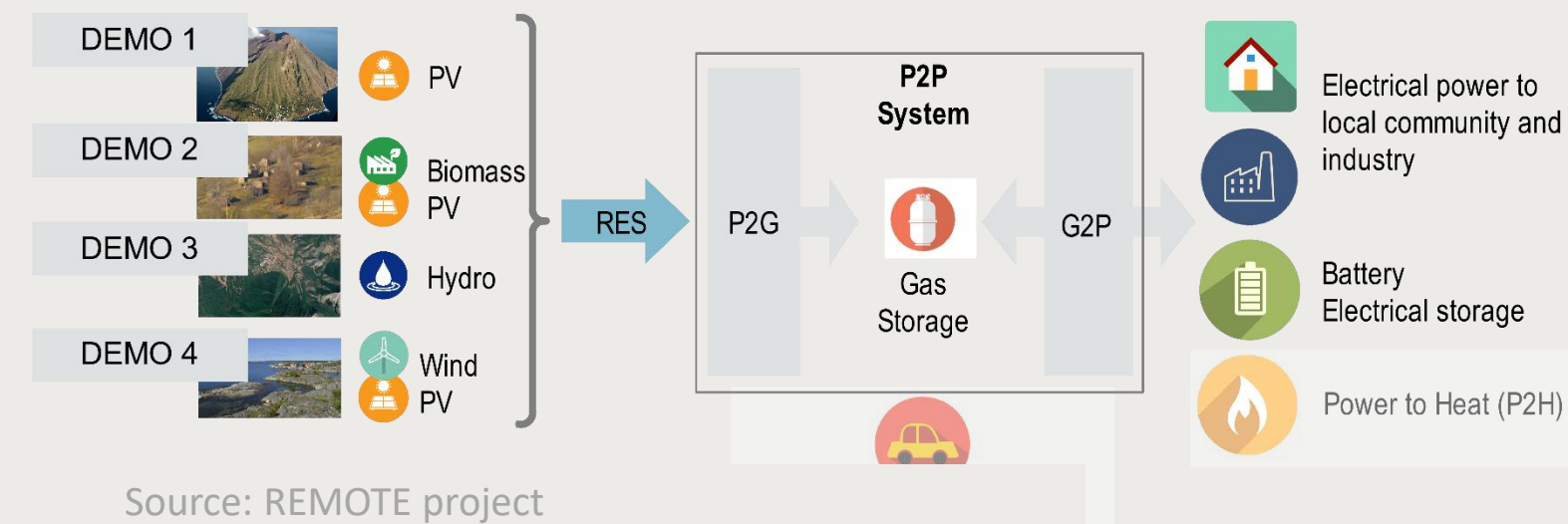
# Off-grid and back-up power FC demonstrations to start soon

Substituting diesel and other non-environmentally friendly solutions with hydrogen and fuel cells



## Power to Power

100% RES solution (H<sub>2</sub> storage)  
Large replication potential



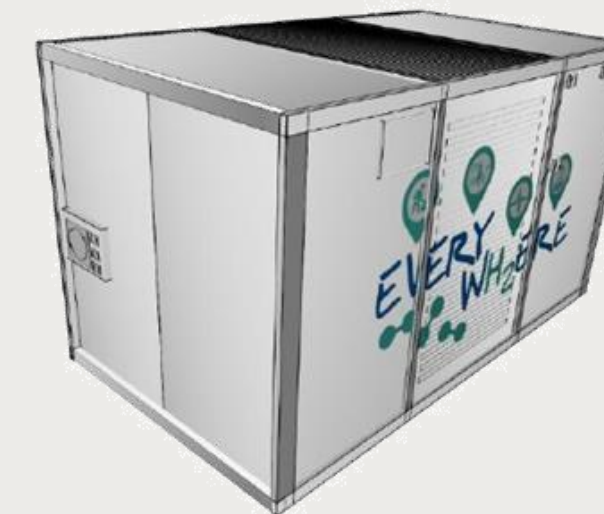
isolated micro-grids

off-grid remote areas.



## Containerized portable PEMFC gensets

25 kW<sub>e</sub>, 100 kW<sub>e</sub> gensets units  
>500 kW<sub>e</sub> cumulative power



temporary events

festivals

construction sector



SOFC



## SOFC for remote power applications

Sub-5 kW<sub>e</sub> units, 15+ units  
Harsh climate conditions



remote gas/oil infrastructure

telecom towers



# Fuel cells for $\mu$ CHP..a success story

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



Products are available off-the-shelf

Next generation products ready to be demonstrated

On the road to market uptake at large scale → cost reduction

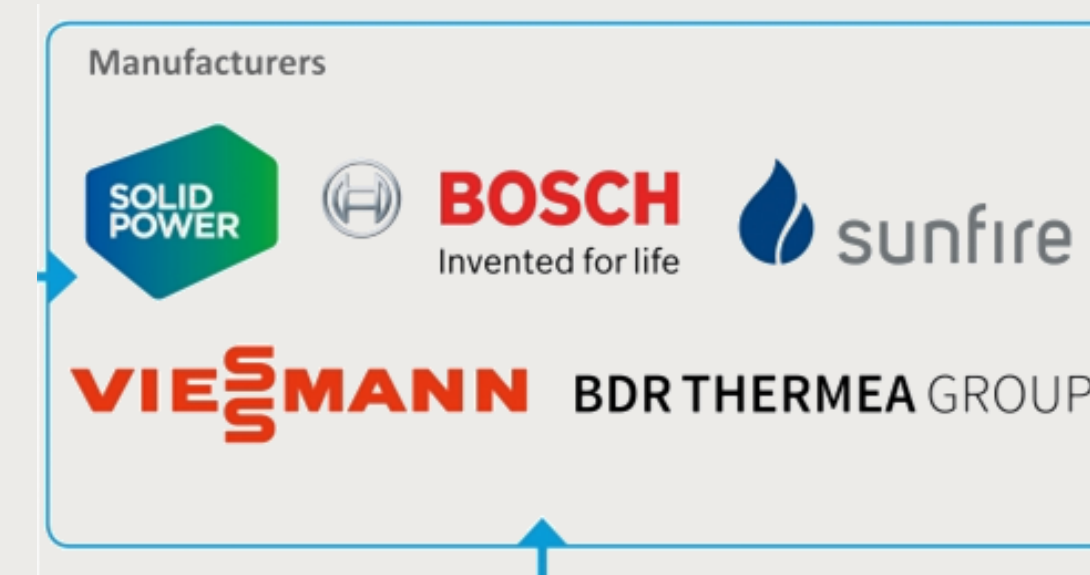
Significant socio-economic benefits for Europe



© Solid power



© Viessmann Group



Manufacturers in PACE project





# 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



Exporting EU fuel cell technology for industrial applications

Foundation for new applications of fuel cells (e.g maritime, district heating)



Replacing dirty power generation with 100% RES P2P & clean genset solutions





**FUEL CELLS AND HYDROGEN**  
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**Antonio Aguilo-Rullan, Project Officer**  
**Dionisis Tsimis, Project Officer**

Antonio.aguilo-rullan@fch.europa.eu  
Dionisis.tsimis@fch.europa.eu

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**For futher information**

[www.fch.europa.eu](http://www.fch.europa.eu)



@fch\_ju



Fch-ju@fch.europa.eu



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