



**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING

## **PACE**

Pathway to a Competitive  
European Fuel Cell micro-CHP  
Market



Pathway to a Competitive European  
Fuel Cell micro-CHP Market

**Olivier Bucheli**

**CBDO SOLIDpower / Committee  
Leader CT4**

[www.pace-energy.eu](http://www.pace-energy.eu)

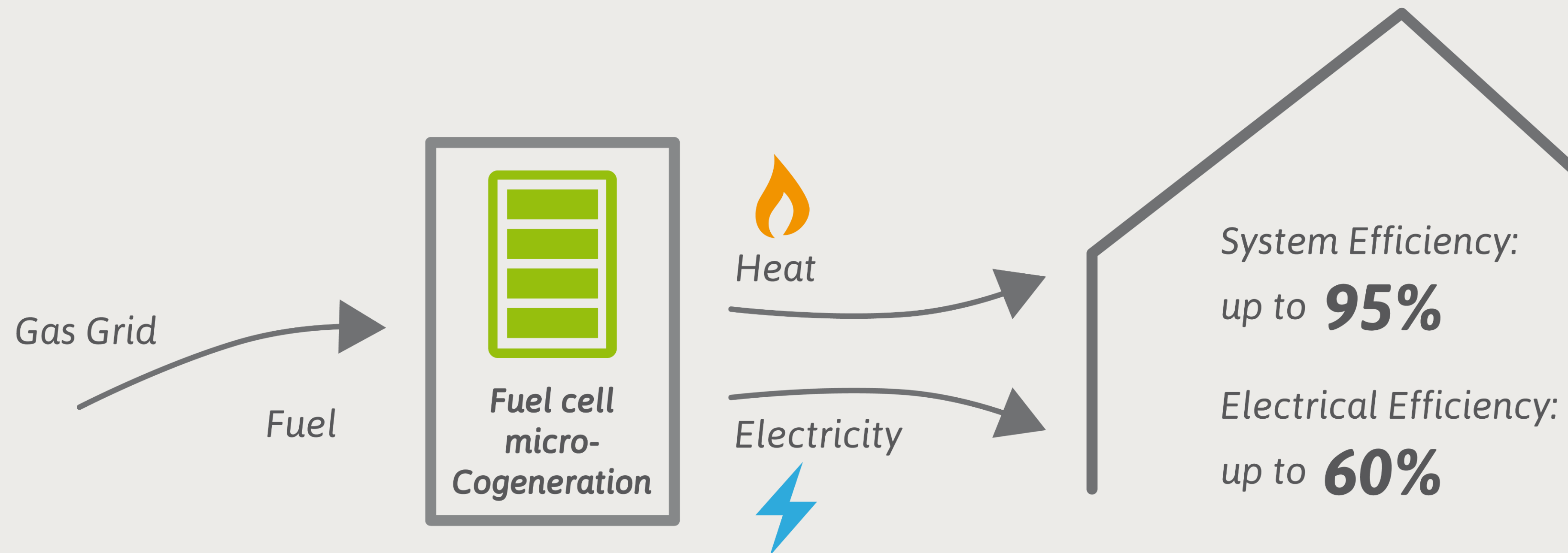
[projects@cogeneurope.eu](mailto:projects@cogeneurope.eu)

**Programme Review Days 2018**

Brussels, 14-15 November 2018

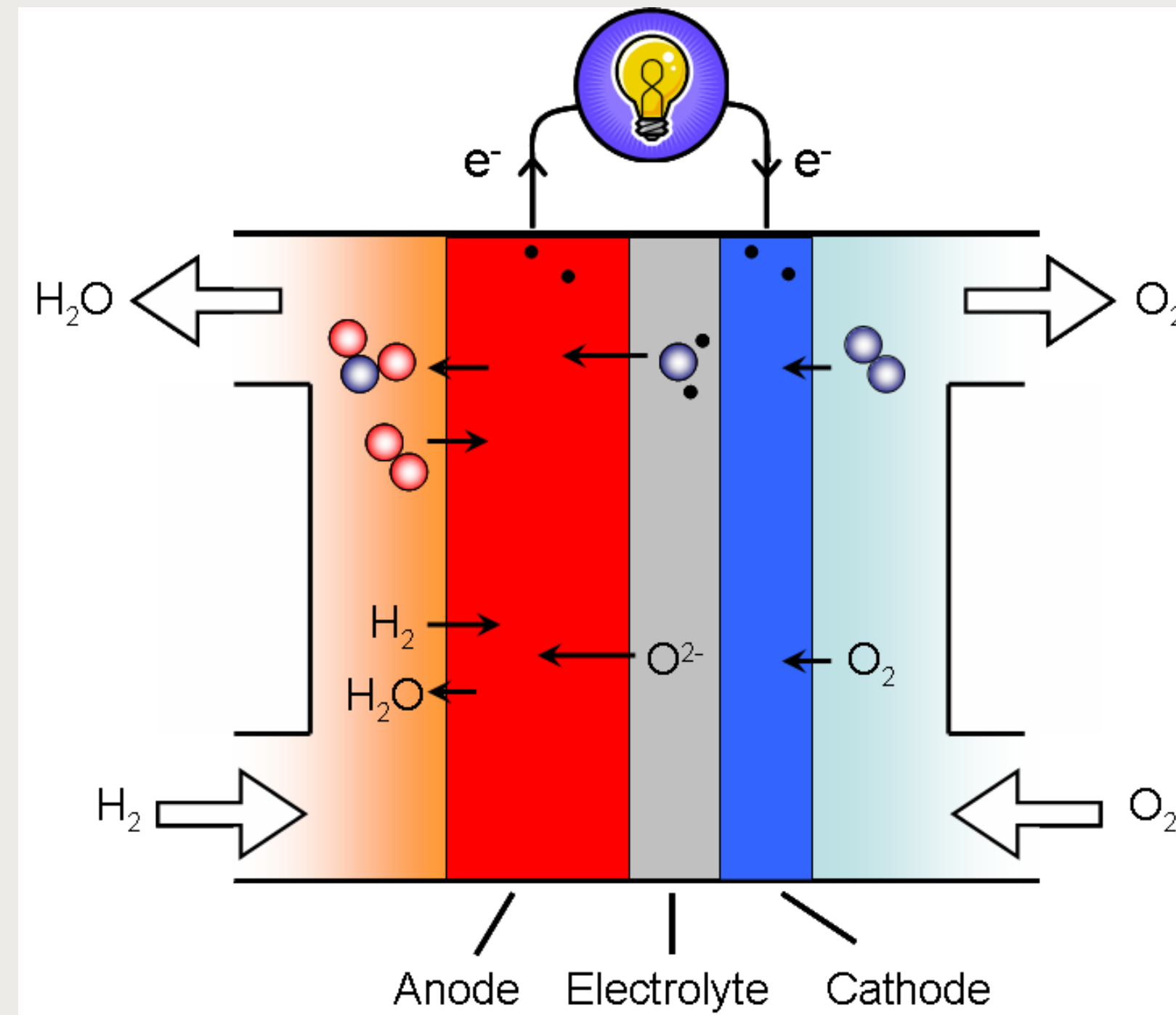
# What is Fuel Cell micro-Cogeneration?

Fuel Cell micro-Cogeneration is a highly efficient home energy system that simultaneously produces heat and electricity



# Principle of a Fuel Cell – Electrochemical Energy Conversion

## Solid Oxide Fuel Cell, SOFC external circuit



electrochemical  
oxidation



oxygen-ions migrate  
via vacancy  
mechanism



electrochemically  
reduction of oxygen



No NO<sub>x</sub>  
No SO<sub>x</sub>  
No PM



No Noise  
No vibration

Fuel flexible

Technology neutral!



# Principle of co-generation

Immediate savings, with any fuel

ALL  
ENERGY  
SOURCES\*



## Stationary Cells offer:

- Primary energy reduction
- Reliability
- Modularity
- Distributed generation
- Power at low-voltage level

\* Including, but not limited to, biomass, biogas, coal, geothermal, hydrogen, (bio-)LPG, natural gas, residual waste and solar thermal

# Why Fuel Cell micro-Cogeneration?

Heating and Powering your Home



**Empowers consumers**



**Supports the European  
energy transition**



**Provides greater flexibility  
for the energy system**



**Fosters innovation  
and high-value jobs**

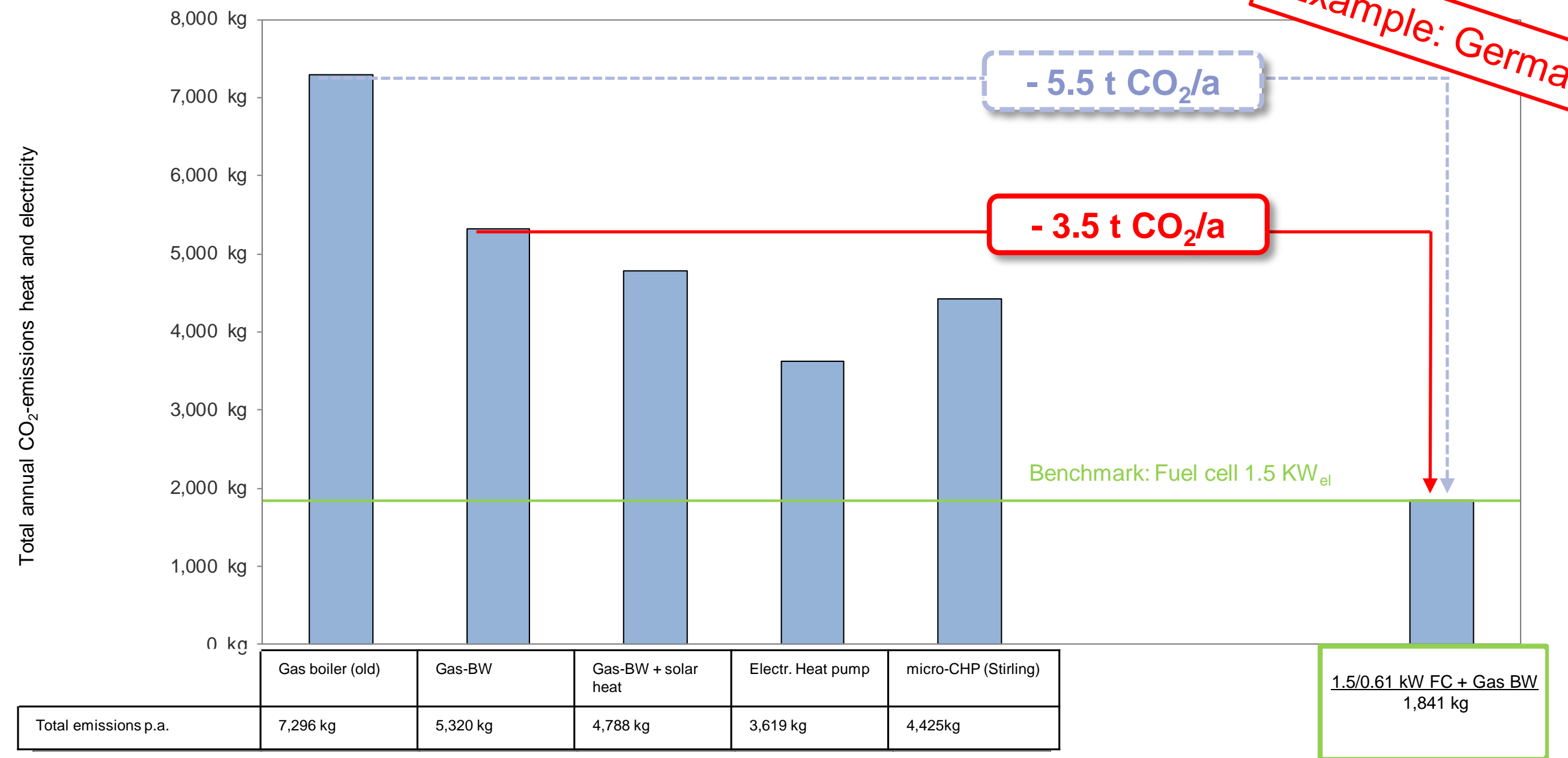


# We offer CO2 savings TODAY!

Fuel Cell CHP vs. alternative solutions\*



**Calculation (example)\*:** single family house, annual heat demand 22,500 kWh<sub>th</sub>



**Emission factors:** Oil: 337 gCO<sub>2</sub>/kWh; Natural gas: 227 gCO<sub>2</sub>/kWh; Electricity: 563 gCO<sub>2</sub>/kWh<sub>el</sub>; **Technical specifications:** **Gas fired boiler (old):** therm. efficiency: 70 %; **Gas-condensing boiler (Gas BW):** therm. efficiency: 96 % (if applicable: 10 % fuel savings by solar water heating); **Electric heat pump:** COP: 3,5; **micro-CHP (Stirling):** elect. output: 1 kW<sub>el</sub>; elect efficiency.: 11 %; therm. output: 8 kW<sub>th</sub>; therm efficiency.: 85 %; annual operating hours: 2,813; **Fuel cell:** elect. output: 1,5 kW<sub>el</sub>; electr. efficiency: 60 %; therm. output: 0,61 kW<sub>th</sub>; therm. efficiency.: 25 %; annual operating hours: 8,000; additional heat generator: Gas-Condensing boiler: efficiency of 96 %.

Compared to conventional heating technologies, a great amount of CO<sub>2</sub> can be saved through the application of fuel cells

**BlueGEN** 60%

Multi-MW gas power plants 50%

Coal plants 35%

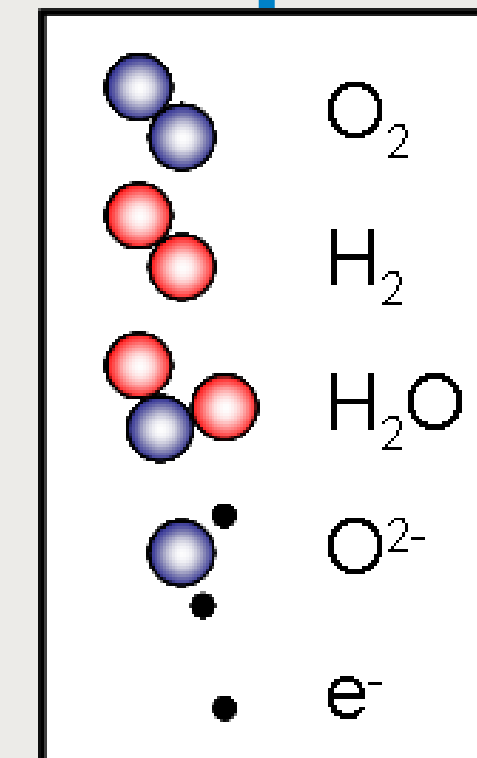
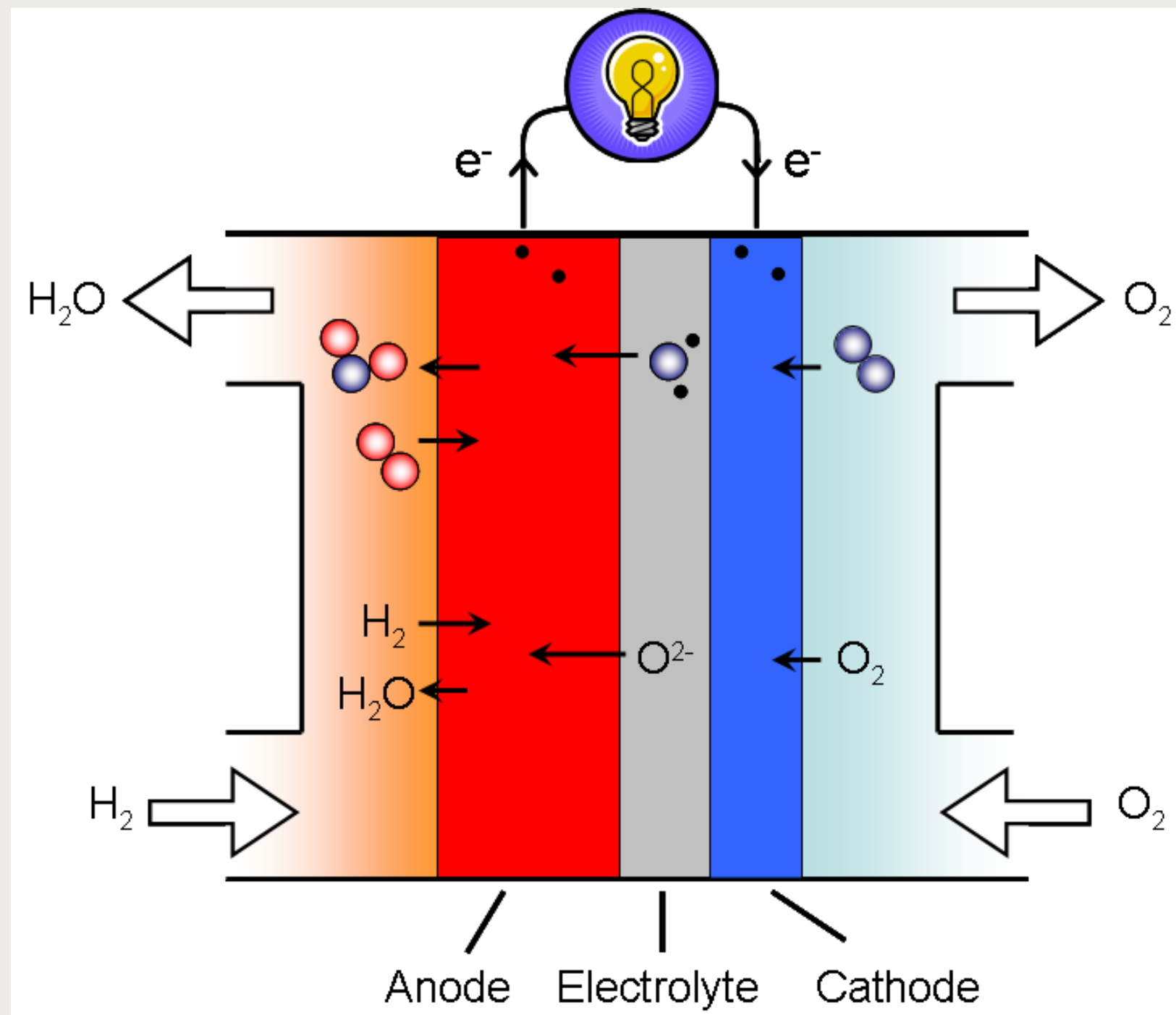
Stirling engines 15%



# Efficiency - Reversibility

From energy conversion to energy storage

## Solid Oxide Fuel Cell, SOFC external circuit



electrochemical  
oxidation

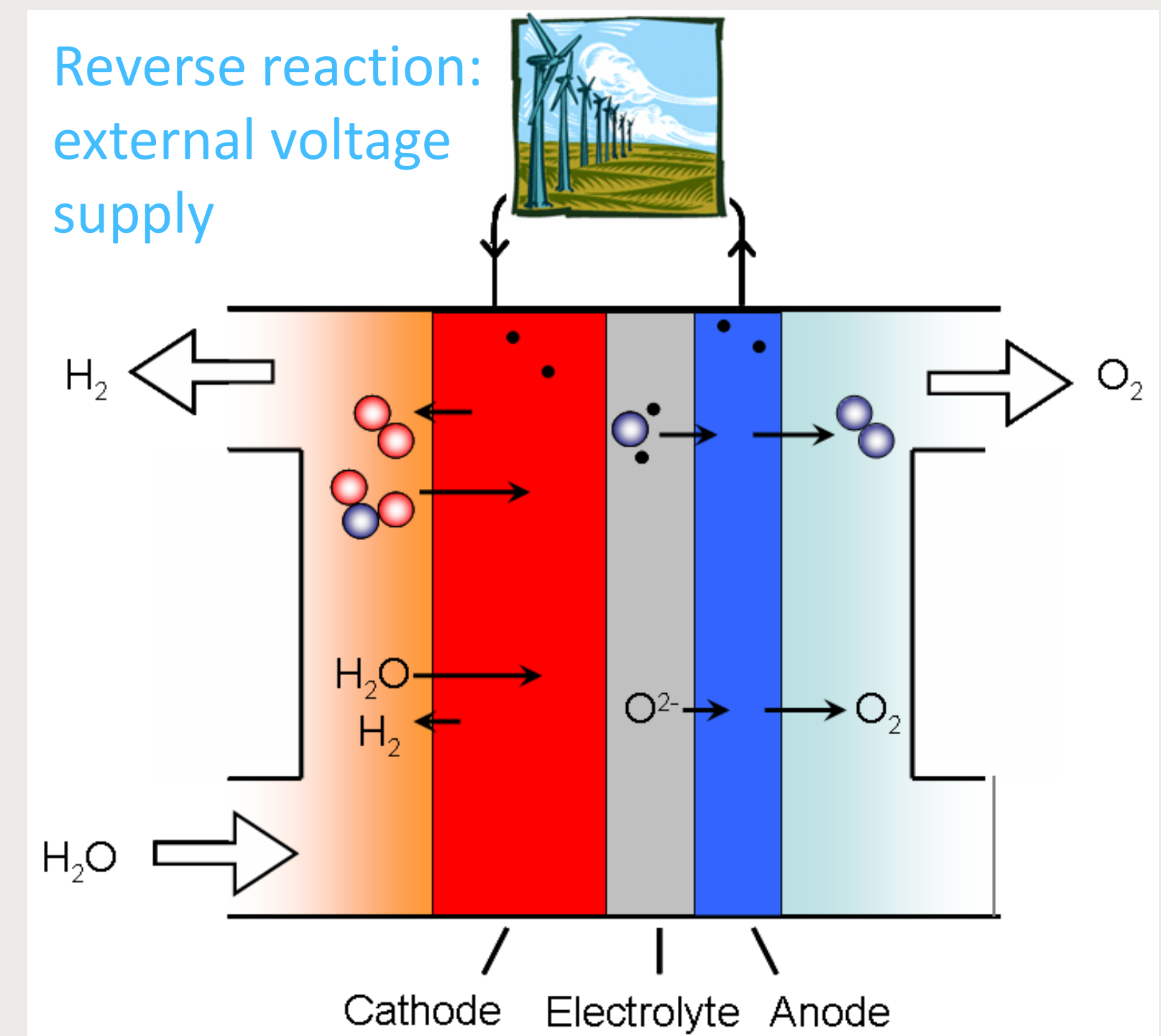


oxygen-ions migrate  
via vacancy



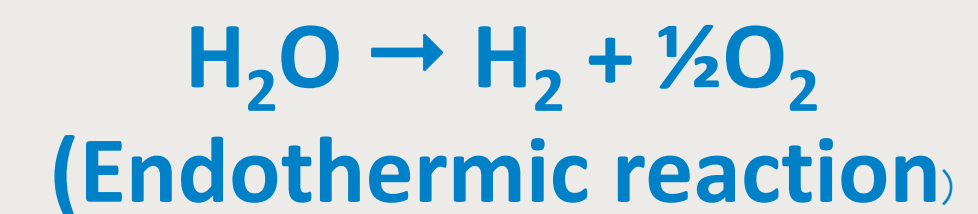
electrochemically  
reduction of oxygen

## Solid Oxide Electrolyser, SOE



Dissociation of steam

Recombination of O<sup>2-</sup>



# PROJECT OVERVIEW

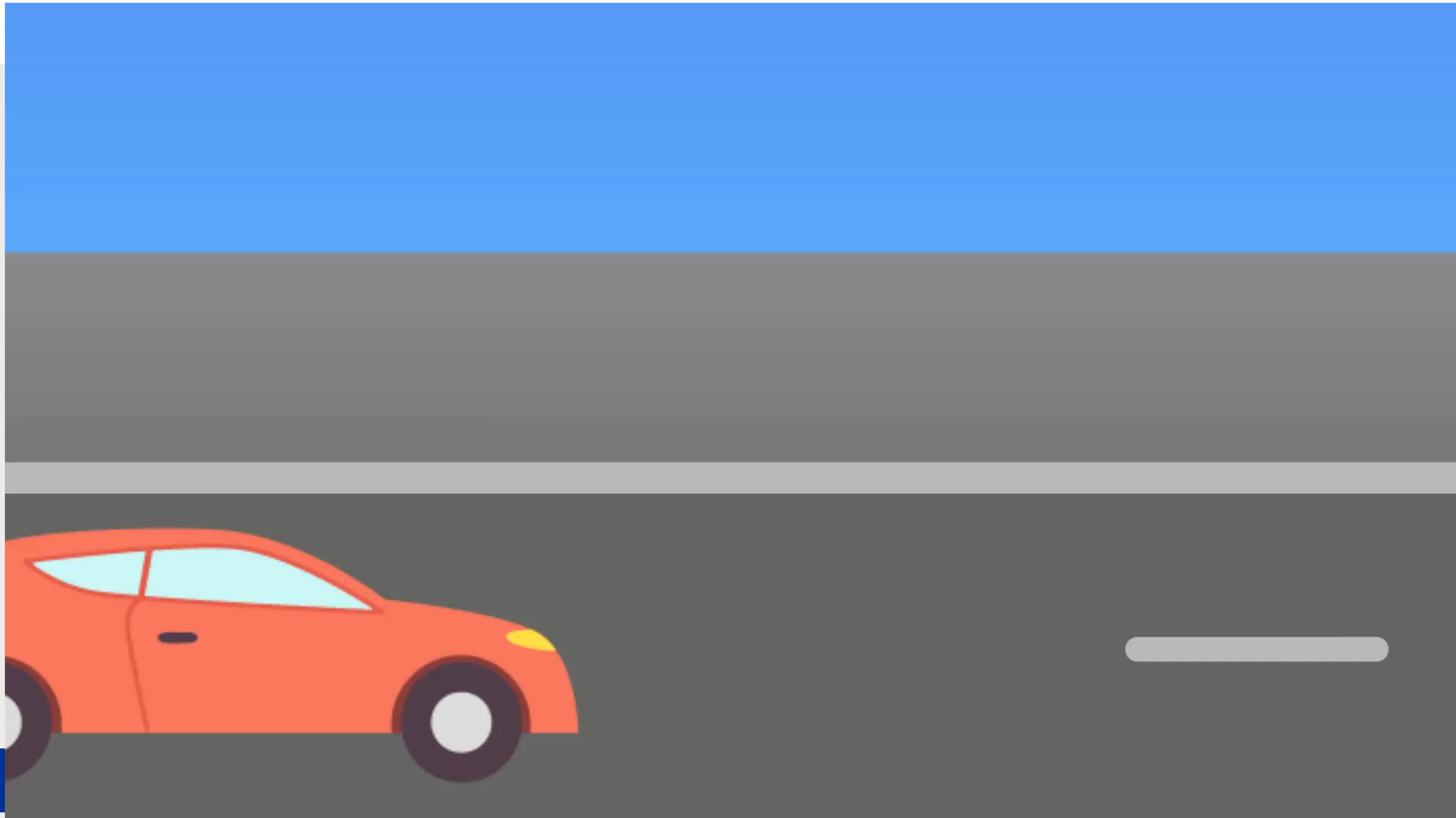


- **Call year: 2016**
- **Call topic: Large scale demonstration of  $\mu$ CHP fuel cells**
- **Project dates: 01/06/2016 – 31/08/2021**
- **% stage of implementation 01/11/2017: 46% as of 01/11/2018**
- **Total project budget: EUR 90,307,094.50**
- **FCH JU max. contribution: EUR 33,932,752.75**
- **Other financial contribution: EUR 56,374,341.75**
- **Partners: BDR Thermea, Bosch, COGEN Europe, DTU, Element Energy, EWE, SOLIDpower, Sunfire, Viessmann**



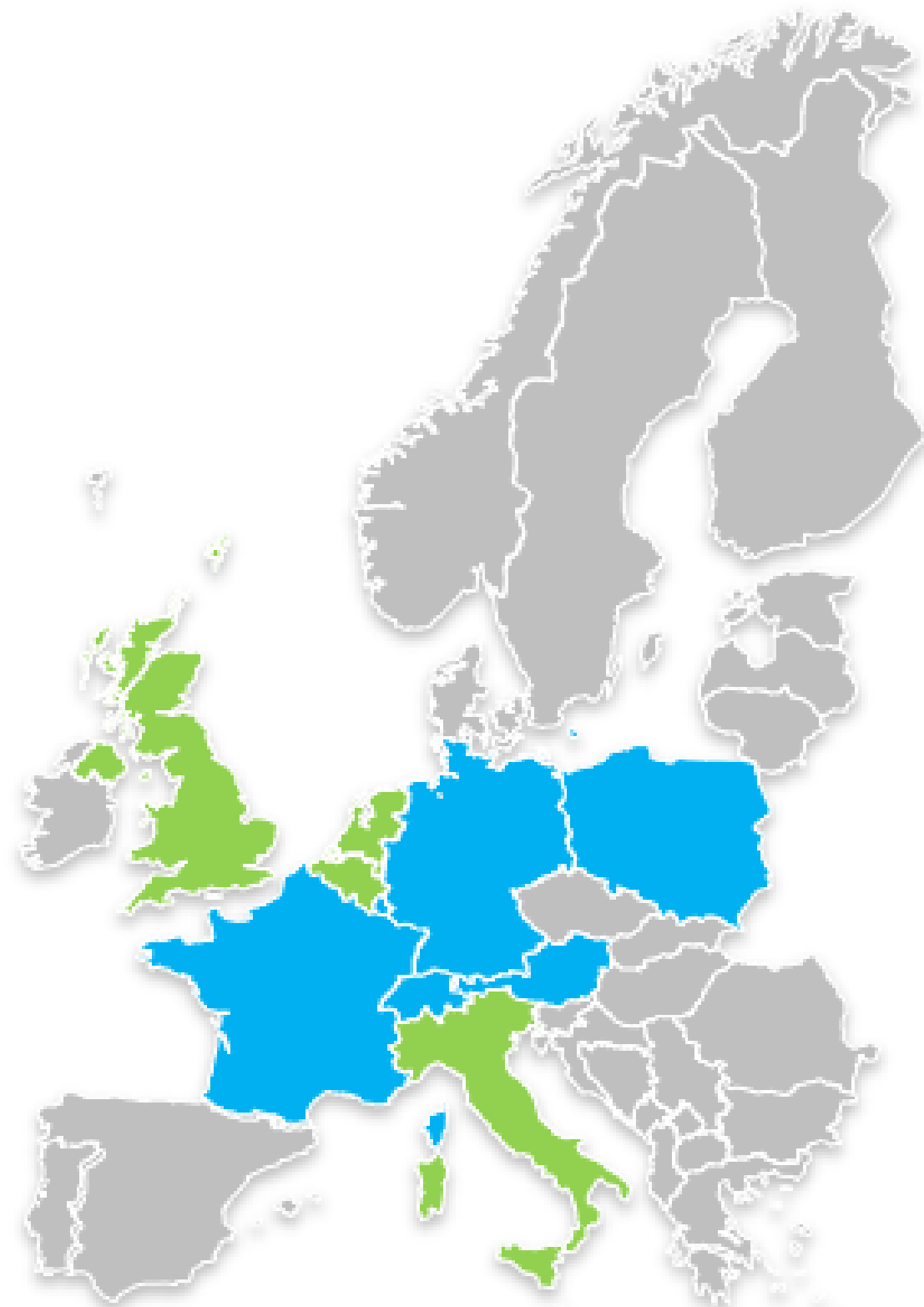


# Fuel Cell micro-Cogeneration empowering consumers towards a low-carbon future



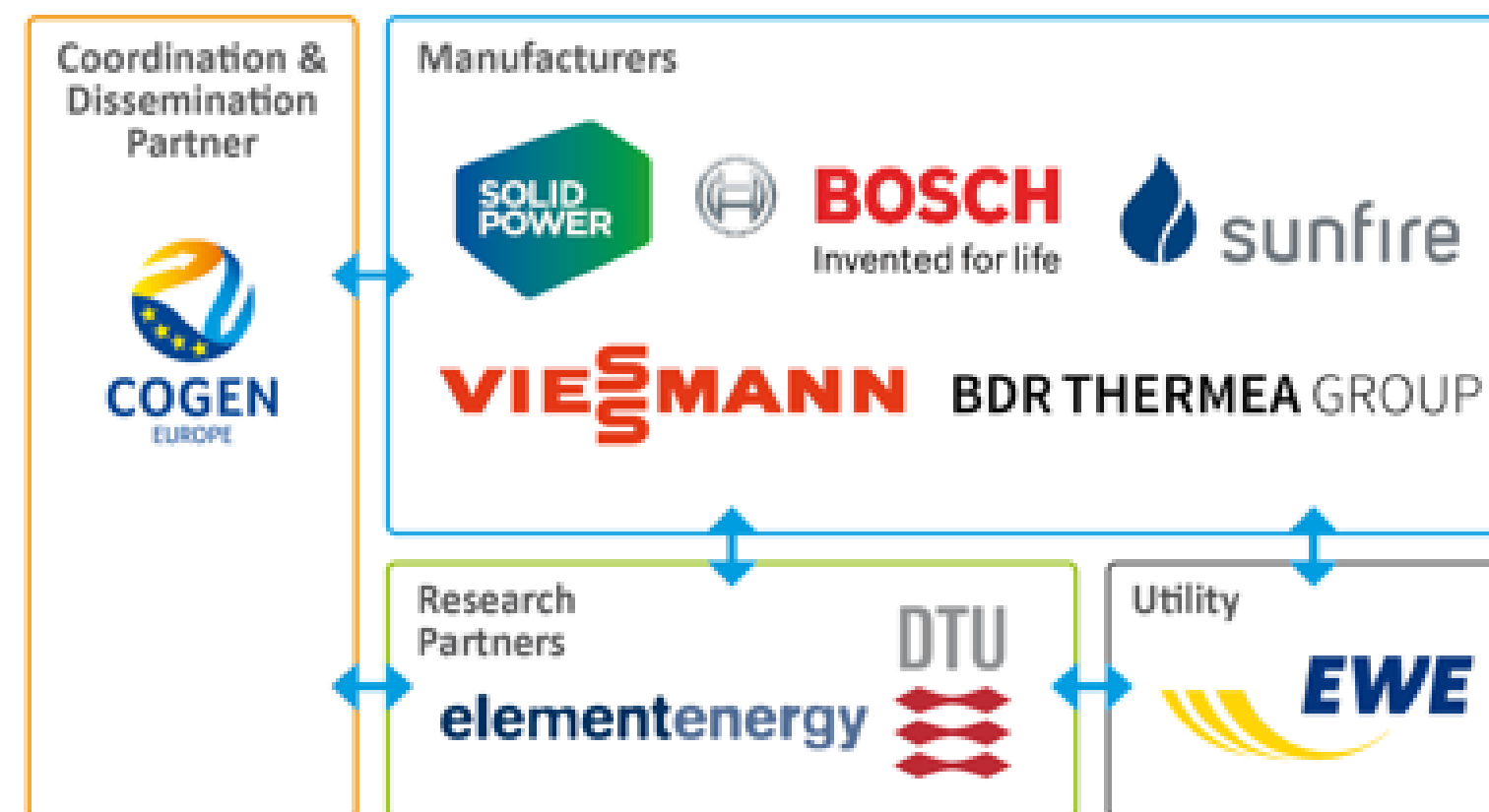
# PACE at a glance

Promoting a successful transition to the large scale uptake of Fuel Cell micro-Cogeneration across Europe



- Field trial + installer training + targeted market & policy development activities
- Field trial + local installer training

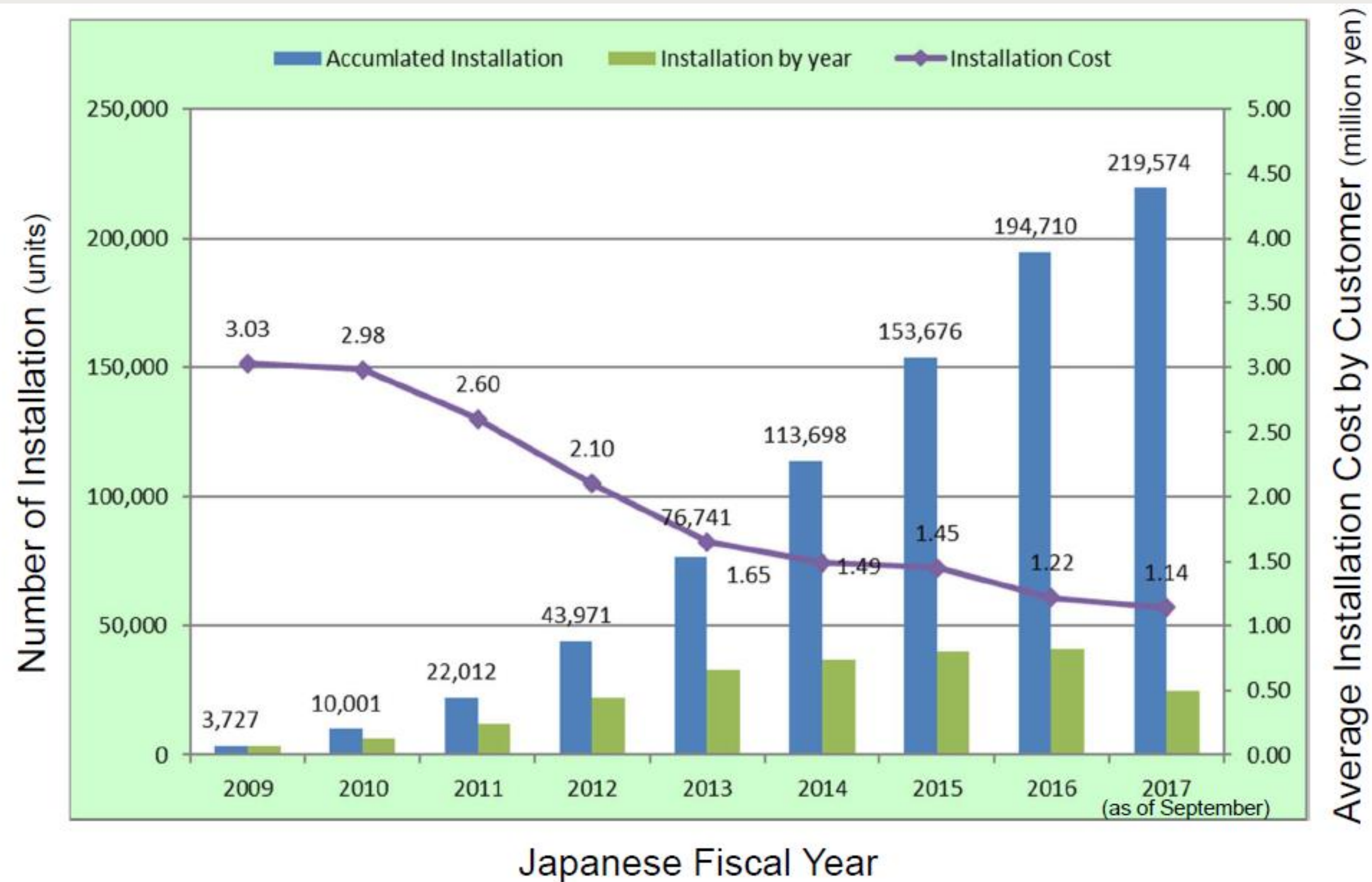
<b>9</b>	<b>&gt; 2,800</b>	<b>&gt;500</b>	<b>10</b>	<b>4</b>	<b>€90m</b>
Partners	Fuel Cell micro-Cogeneration units	Systems per manufacturer	Countries	Countries	Total budget
Representing manufacturers, utilities & research community	To be deployed across Europe between 2016-2021	Established production capacity per manufacturer	Where the units will be installed	Selected for policy & market development (Belgium, Italy, Netherlands and UK)	Including €33.9m Horizon 2020 funding via FCH JU



**>10,000**  
FC micro-cogeneration units/year post 2020

# State of the Art: The Japanese case

Fuel Cell micro-Cogeneration: Best practices

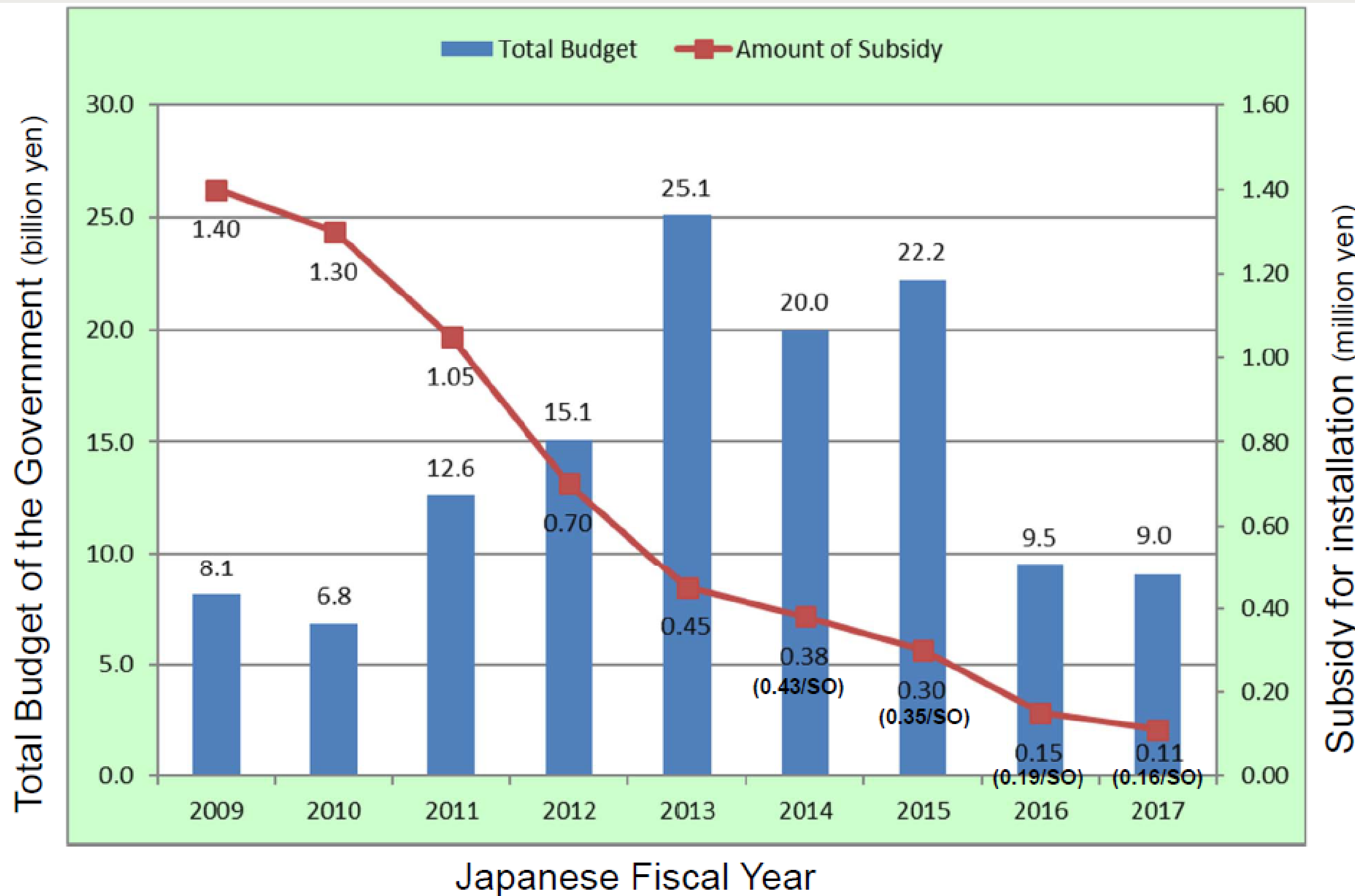


## Ene-Farm programme

- In September 2018, 260,000 micro-CHP units had been installed in Japan under the Ene-Farm programme.
- By 2030 the Japanese government aims to have 5.3 million units installed.
- Thanks to Ene-Farm, the increase in volumes led a major reduction of installation costs: in 2009 the cost per unit was around EUR 24,000 (3,3 mln YEN), while in 2015 it had decreased to approximately EUR 8,500 (1,14 mln YEN).

# State of the Art: The Japanese case

## Fuel Cell micro-Cogeneration: Best practices



## Lessons learned for Europe

- The Ene-Farm programme provided a subsidy that initially covered close to 50% of the product cost.
- The predictability of Ene-Farm contributed to its success, in that support was linked to the industry's commitment to reduce product cost and reductions in the support level were announced in advance.

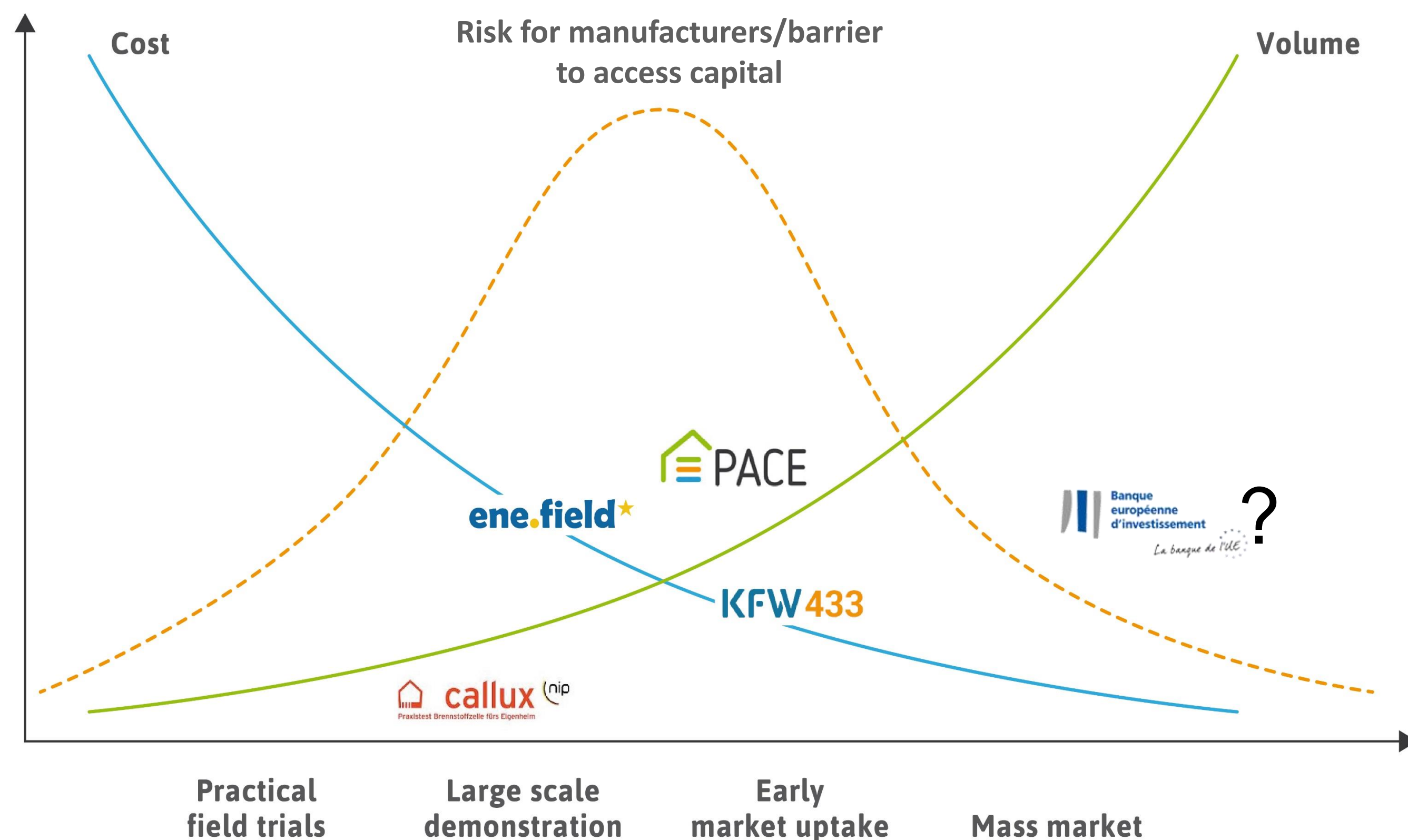
### EU specific challenges:

- Different market & policy conditions across EU countries
- Insufficient awareness of the technology
- Regulatory & policy barriers to address



# Driving the Fuel Cell micro-Cogeneration sector closer to mass market uptake

How to overcome the point of greatest risk in new product commercialisation?



Fuel Cell micro-Cogeneration units demonstrated **technology readiness** in European and national demo projects  
PACE is driving the Fuel Cell micro-Cogeneration sector closer to **mass market uptake**.

Room for testing different **business models**, like energy as a service linked to financing and lease models.

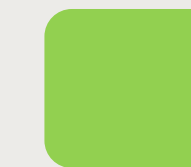
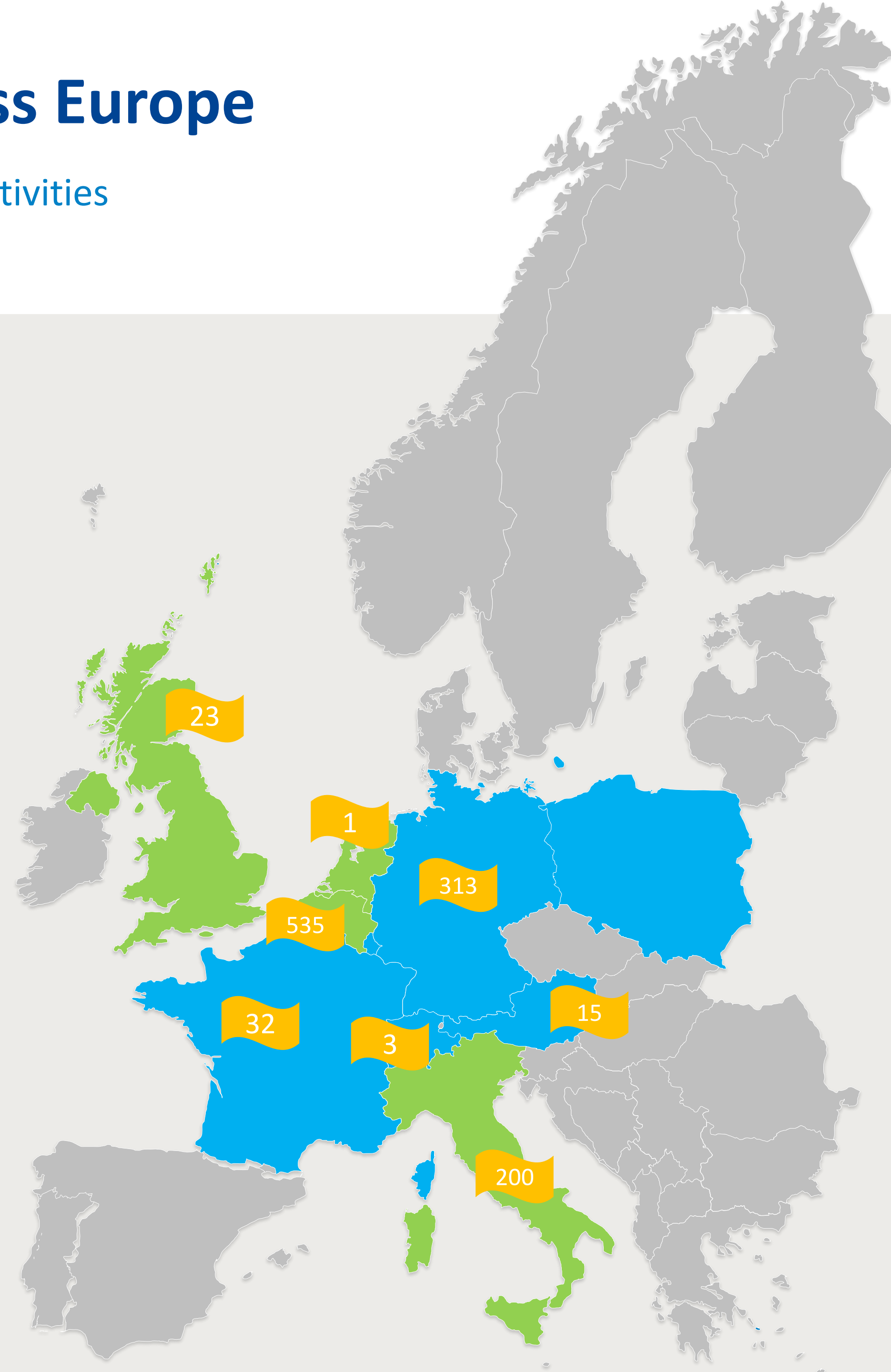
# Overview of systems in PACE

Buderus: Logapower FC10.2	BlueGEN	BlueGEN BG15	InnoGen2018	Vitovvalor	Vitovvalor SA2	Sunfire-Home 750
100	750	750	500	750	750	500
SOFC	SOFC	SOFC	LT-PEM	PEMFC	PEMFC	SOFC
0.7kW	1.5kW	1.5kW	0.7kW	0.75kW	0.75kW	0.75kW
1-2 family homes (up to end 2018)	SMEs, apartment buildings and multifamily homes	SMEs, apartment buildings and multifamily homes	1-2 family houses (for new and existing buildings)	Domestic and small commercial	Domestic and small commercial	Residential building (with LPG supply)

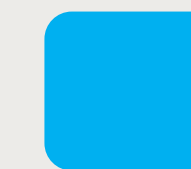


# PACE units across Europe

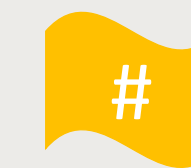
Overview of deployment activities



Field trial + installer training + targeted market & policy development activities



Field trial + local installer training



Number of units sold per country as of 09/2018



# Customer satisfaction

Surveys show that more than 90% of end users are pleased with the environmental performance, the comfort and warmth and running costs of their fuel cell micro-cogeneration unit

## Environmental performance



## Comfort and warmth



## Running costs



Source: ene.field project report  
“[Learning points from demonstration of 1000 fuel cell based micro-CHP units](#)”

“After the installation of the Fuel Cell micro-Cogeneration unit in my car dealership, my demand of energy decreased by 10.000 kWh per year and I save €2 ,200 Euro in electricity cost every year.”

Yakup Ak, managing director at Autoport Cologne



“With Fuel Cell micro-CHP we have many advantages in one single compact unit. To install a unit, households need nothing more than a gas connection and an electricity connection.”

André Bartels, CEO, Carl Cordes GmbH



90% of the FC micro-CHP systems were available for at least 95% of the time



# Conclusions and recommendations

Fuel Cell micro-Cogeneration



**No regret**

**Future compatible**

**Providing the fastest  
carbon reduction  
pathway**



**30-50% CO<sub>2</sub>  
emission  
reductions  
TODAY**



**Fuel flexible and  
technology neutral**

**FC m-CHP could be  
reversible and fully  
operated on H<sub>2</sub> in  
the future**



**Enabler of the  
integrated  
energy system  
of the future**



**Policy framework to  
create a level  
playing field on the  
pathway to  
decarbonisation,  
accounting for all  
benefits of FC m-  
CHP**



# The integrated smart energy systems of the future

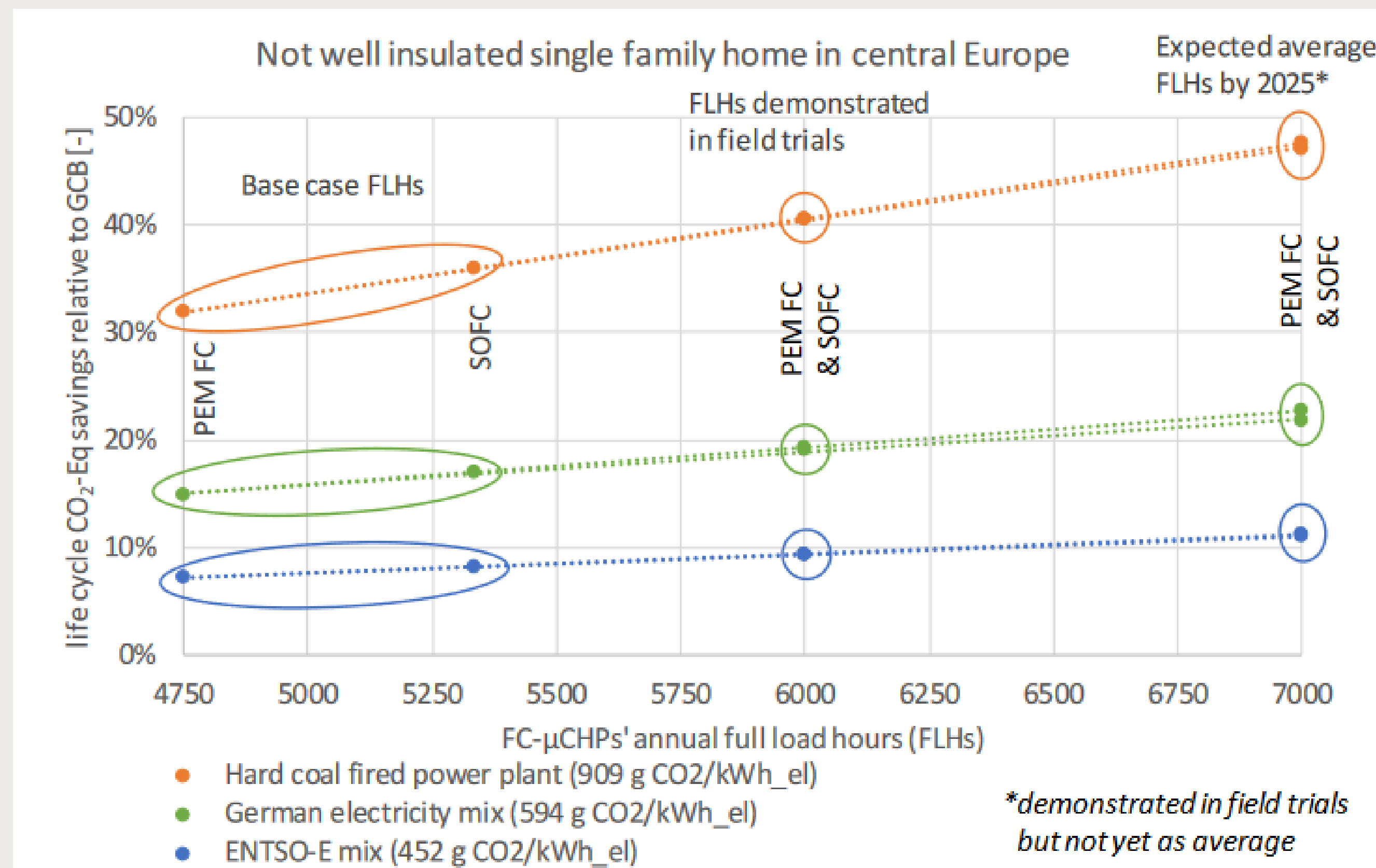


# Background slides

# Environmental life cycle assessment



- LCA GHG generally lower for fuel cell micro-CHP than alternative home energy solutions considered (i.e. gas condensing boiler, heat pump)
- Higher benefits for higher utilisation of the fuel cell & for more carbon intensive power mixes



To read the Executive Summary of the ene.field project report “Environmental Life Cycle Assessment” [click here](#).  
Case: “Not well-insulated” “single family-home” in “Central Europe”

