PACE
Pathway to a competitive European Fuel Cell micro-CHP Market

ene.field

European-wide field trials for residential fuel cell micro-CHP

Overview of ene.field and PACE projects

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The research leading to these results has received funding from the European Union´s 7th Framework Programme (FP7/2007-2013) for the Fuel Cells and Hydrogen Joint Undertaking Technology Initiative under Grant Agreement Number 303462

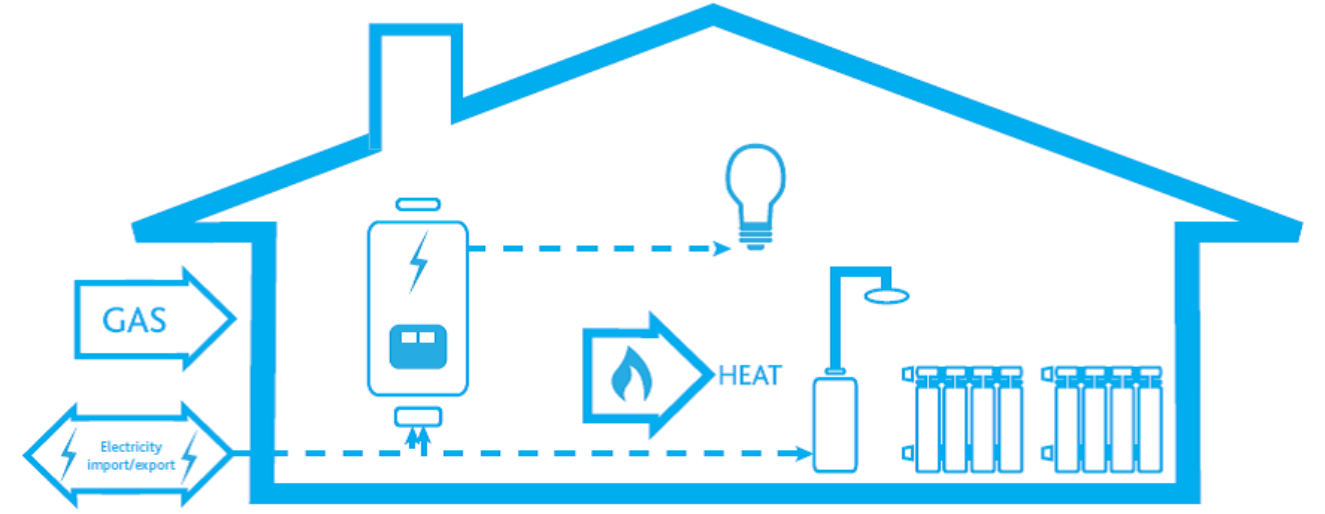
Content

1. **Fuel cell micro-CHP – Benefits & potential**
2. ene.field project – paving the way to early commercialisation
3. PACE project – the bridge to large scale market uptake

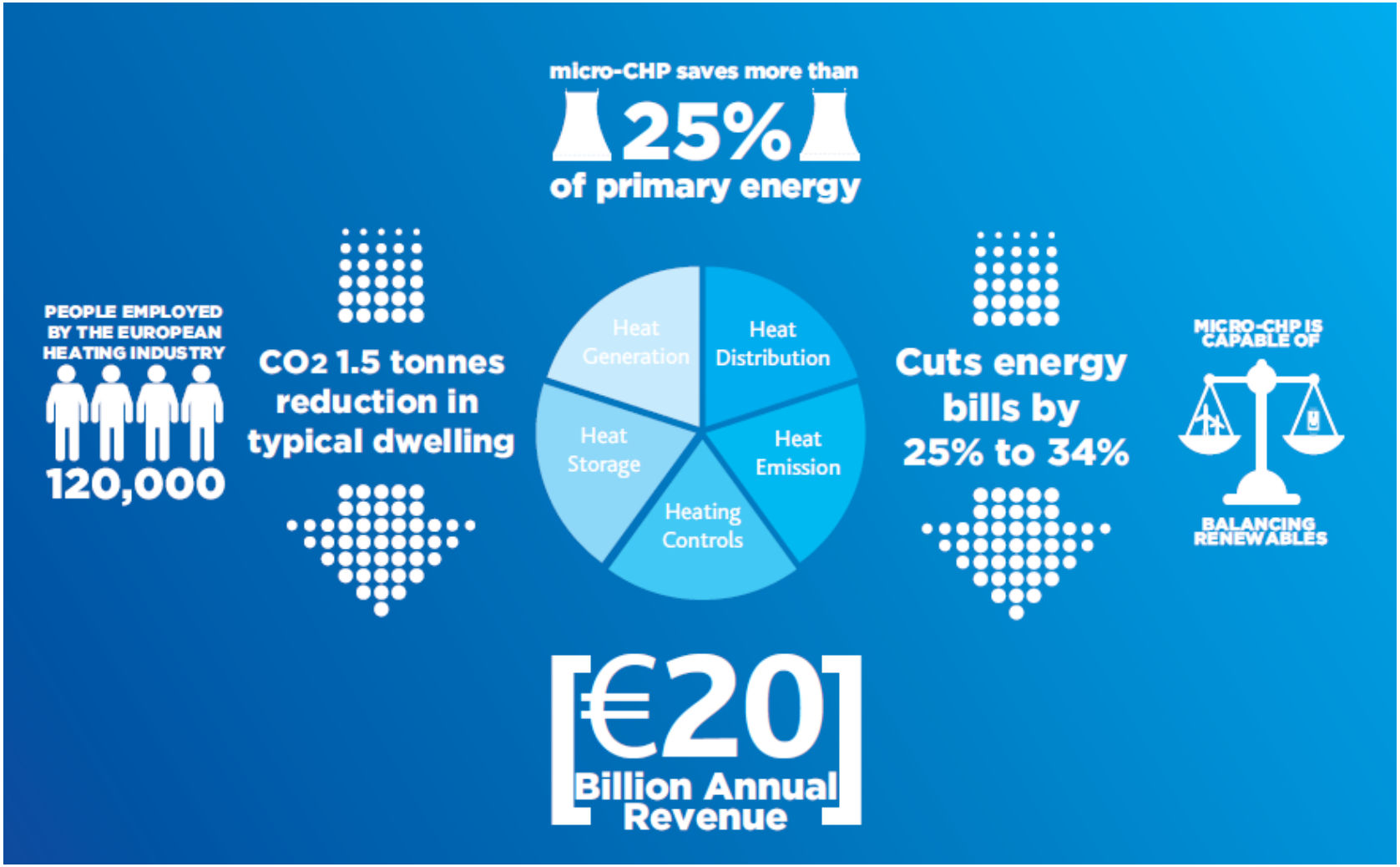
What is micro-CHP?

Micro-CHP…

- …is a highly efficient distributed energy solution, simultaneously producing heat and electricity near the point of consumption
- …meets demand for heating, hot water and/or cooling in buildings while generating electricity to replace or complement the grid supply
- …normally installed in residential and public buildings, as well as small businesses



Why micro-CHP?



Source: Delta-ee, Micro-CHP Benefits Study, 2015

FC mCHP potential to play a key role in decarbonisation of buildings

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Solution to efficient heat supply in buildings	• High electrical and overall CHP efficiency • Significant primary energy saving and reduction of CO_2 emissions compared to incumbent technologies • Very low local pollutants and noise
Large market potential across Europe	• Replacement for gas boiler market • Suitable for existing buildings and particularly well-matched to modern low heat demand housing • Straightforward integration with existing gas and electrical supplies
Complementary with national energy system transition	• Uses Europe's well-developed, existing natural gas infrastructure • Renewable and zero-carbon with clean gas sources, such as biomethane and hydrogen • Supports increasing renewable generation penetration, e.g. as balancing reserve

Advanced and innovative products benefiting the customers

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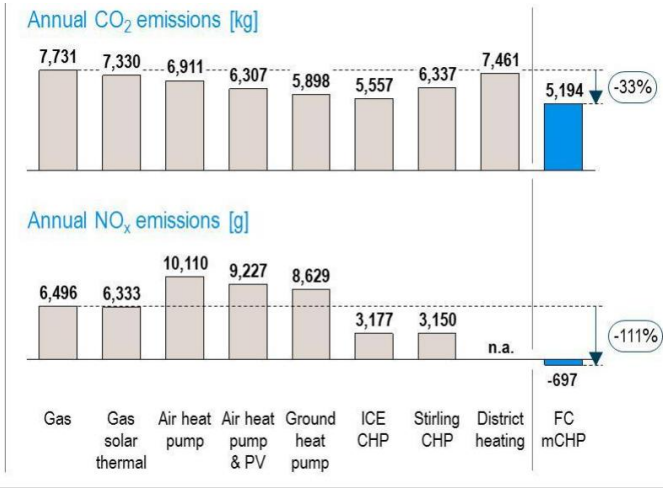
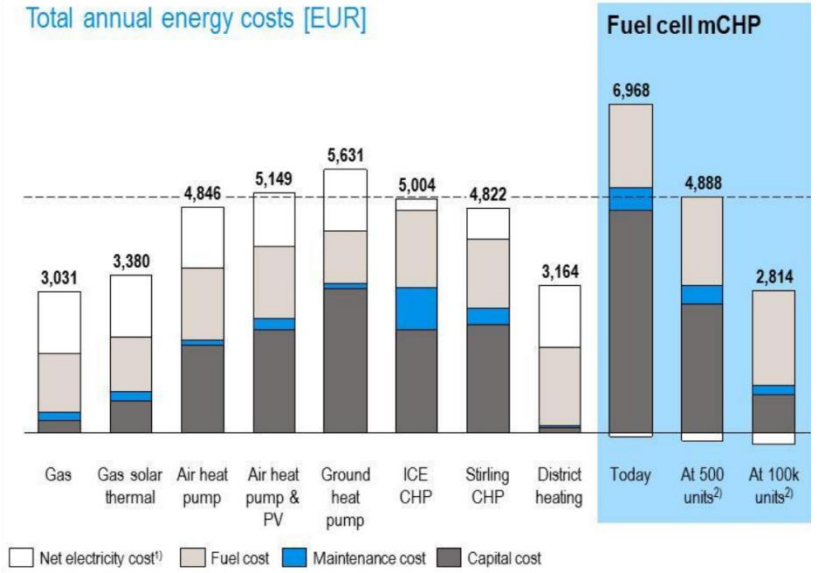
FC mCHP generates fewer harmful emissions for the environment and for health (CO_2, PM, SOx, etc.) and can contribute to achieving Europe's targets for emissions reductions

FC mCHP has a higher overall efficiency than a traditional boiler and grid electricity generation hence reducing overall primary energy consumption and potentially costs for the customer

MUNICH

Residents	4
Heated space	103 m²
Year of construction	1962
Heat demand	21,438 kWh
Electricity demand	5,200 kWh
Central heating	





A 2015 Study found that a FCmCHP could contribute to **primary energy savings equal to 24% in a typical German household** and total annual energy costs reduction (gas and electricity) by at least 10 %

Source: FCH JU Distributed Generation Study

Why are ene.field and PACE projects needed?

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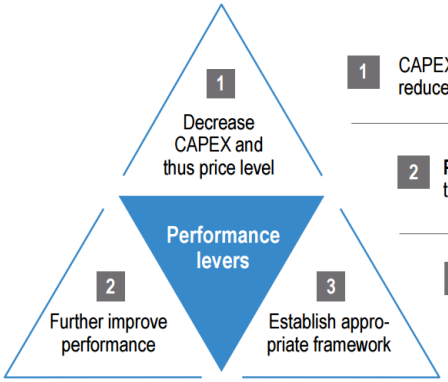
Success factors for the mCHP sector



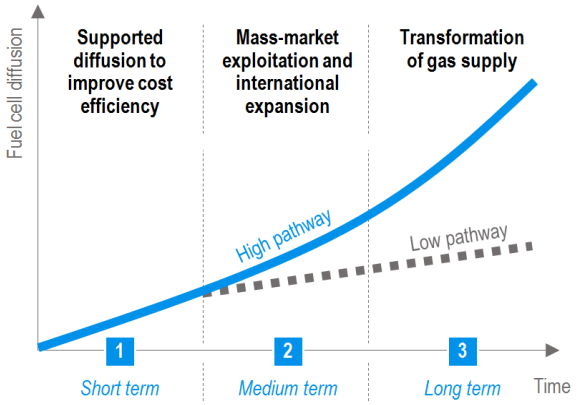
1 CAPEX and thus price level must be reduced to **enable FC competitiveness**

2 **Performance must be improved further** to prolong lifetime and increase efficiency

3 **Policy framework must allow to explore FC benefits** (e.g. funding to support initial commercialisation)

A large scale deployment enables suppliers to overcome the point of greatest risk in new product commercialisation where volumes remain low and a significant cost reduction is required to move the technology to a commercial proposition

Potential development stages for fuel cell mCHP



1 **Fuel cell systems reach competitive cost level to high-end heating solutions**
> Policy support to trigger market pick-up and thus cost reduction
> Starting point in the residential segment

2 **Fuel cell systems reach competitive cost level to mass-market solutions**
> Continuous support if cost targets are reached
> Commercial segment to be supported

3 **Fuel cell systems become a renewable technology through decarbonisation of gas supply**
> Further growth and mass-market solution possible if gas supply becomes greener and more domestic

Cooperation of EU and members states to build on initial funding with development of further incentives, following successful introduction strategy for other major energy technologies (e.g photovoltaics or heat pumps).

Putting citizens at the centre of the energy transition

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Energy efficiency, emissions reduction and cost savings are key motivations for customers and installers trialling the technology

ene.field unit installed at Family Aberl's home

FC mCHP can be a flexible solution for customers with high energy demand willing to increase the energy efficiency for their building

Historical Logherberhaus Hotel equipped with an ene.field fuel cell

FC mCHP can significantly contribute to emission reduction and costs savings for customers

Single-family home reaping the benefits of ene.field energy solutions

More end-user & installer stories at
www.enefield.eu

Reaching mass market

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- > 2500 units (mostly residential)
- €34 million – EU funding
- Further product innovation, cost reduction and policy & market development

ene.field

- Up to 1,000 units (mostly residential)
- 26 partners from industry and research
- €26 million EU funding
- Show potential of market segment and open new market

Mass market

- Fully competitive without any funding

Market uptake

- Favourable EU and national policy frameworks
- Industrial ramp up

- High level recognition under the Energy Union Framework (upcoming EED, EPBD Reviews, Electricity Market Design Initiative)

Large scale demonstration

KFW 433

- Large scale deployment of FC mCHP in Germany
- Subsidies to max 40% of eligible costs (e.g. € 10.200 for a 1 KWe unit)
- Targetting end-users (initial)

Practical field trials

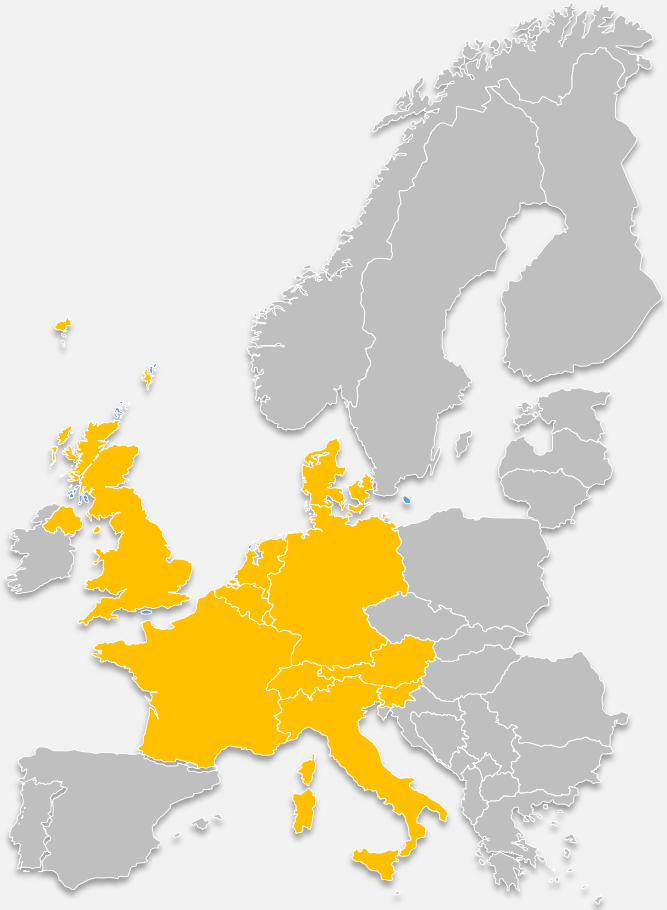
callux (nip)
Praxistest Brennstoffzelle fürs Eigenheim

- ~500 units installed
- Significant costs reduction achieved
- > 3million operating hours
- System reliability confirmed
- Subsidies unconfirmed

Content

1. Fuel cell micro-CHP – Benefits & potential
2. **ene.field project – paving the way to early commercialisation**
3. PACE project – the bridge to large scale market uptake

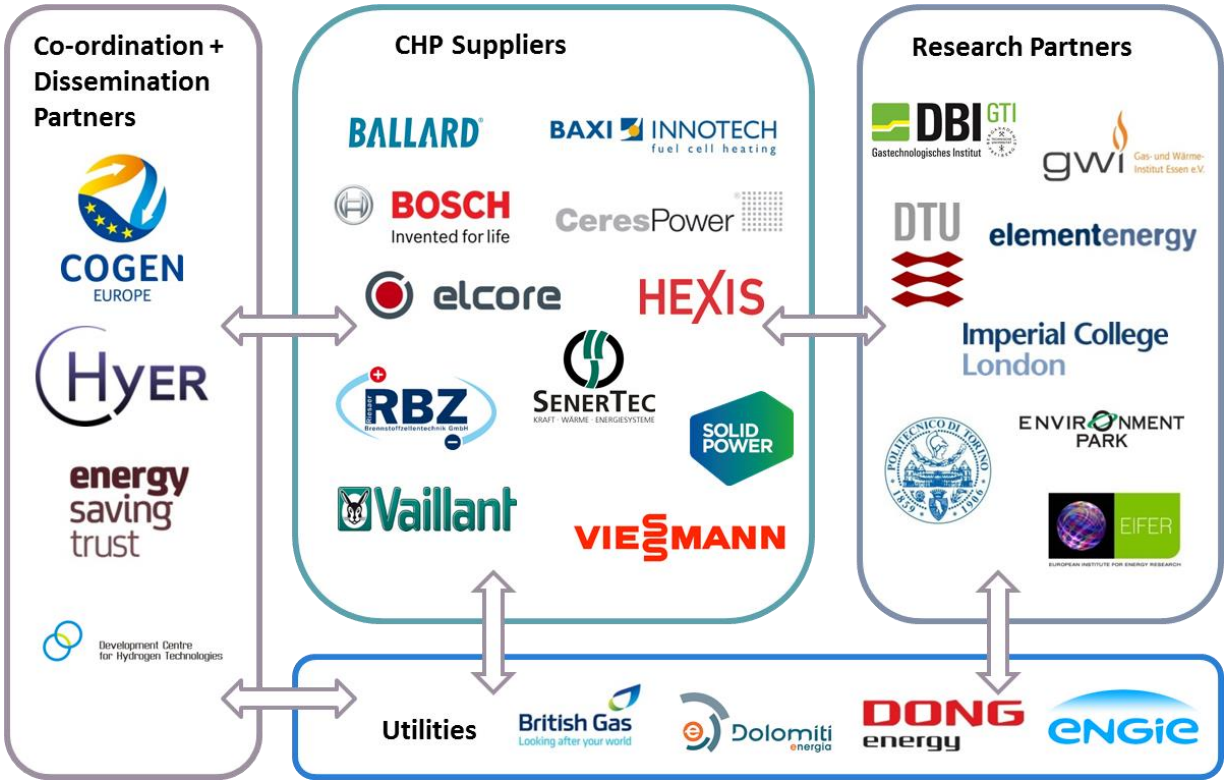
- ene.field is the **largest European demonstration** of fuel cell micro-CHP to date
- It aims to deploy up to **1,000 Fuel Cell heating systems** in 11 key European member states
- Project duration of **5 years.** Systems will be demonstrated for 2 to 3 years
- **Monitoring** for all units (incl. 10% of units with detailed monitoring)
- Outputs of the project include:
  - Detailed performance data
  - LCC & LCA assessments
  - Market analysis & commercialisation strategy
  - Policy recommendations



Countries where units are expected to be installed

Source: ene.field project

ene.field is a European platform for FC micro-CHP



The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) is committing c. €26 million to ene.field under the EU's 7th Framework Programme for funding research and development

The consortium brings together 27 partners including:

- the leading European FC micro-CHP developers,
- leading European utilities,
- leading research institutes,
- partners in charge of dissemination and coordination of the project.

ene.field FC mCHP Field trials partners and products

Vitovalor 300-P
Viessmann

FCmCHP G4
Ballard Power

Galileo 1000 N
Hexis

Cerapower
Bosch

Dachs InnoGen
Baxi Innotech

ENGEN2500
SOLIDpower

G5+
Vaillant

SteelGen
Ceres Power

Elcore 2400
Elcore

BLUEGEN
SOLIDpower

Inhouse 5000+
RBZ

Technical characteristics of systems in ene.field

- The systems deployed in ene.field include **a range of fuel cell technology**, system size and operating strategies
- **10 active suppliers** directly involved in the project and in direct interaction with their customers

Elcore 2400	Dachs InnoGen	Cerapower FC10 Logapower FC10	Vitovalor	SteelGen	Galileo 1000 N	Vaillant G5+	PEMmCHP G5	BLUEGEN	ENGEN 2500	Inhouse 5000+
										
HT PEM	LT PEM	SOFC	PEM	LT SOFC	SOFC	SOFC	LT PEM	SOFC	SOFC	LT PEM
300W	**700W**	**700W**	**700W**	**700W**	**1kW**	**1kW**	**2kW**	**2kW**	**2.5kW**	**5kW**
Natural Gas	Natural Gas	Natural Gas, Gas	Natural Gas	Natural Gas	Natural gas+ Biogas	Natural Gas	Natural Gas + Biogas	Natural Gas	Natural Gas	Natural gas + Biogas + H2
Wall	Floor	Floor	Floor	Wall	Floor	Wall	Floor	Floor	Floor	Floor
Elcore	**SenerTec**	**Bosch Thermotechnik**	**Viessmann**	**Ceres Power**	**Hexis**	**Vaillant**	**Ballard Power**	**Solid Power**		**RBZ**

Mostly one to two-family houses applications (but not limited to)

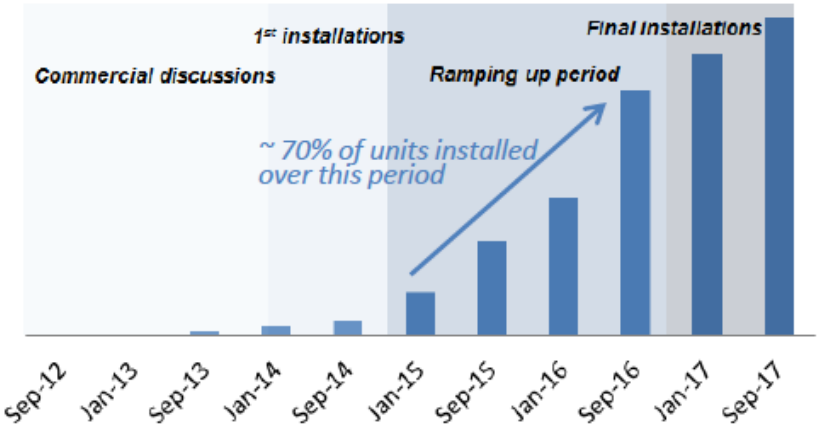
Mostly small and medium commercial buildings, block of flats applications (but not limited to)

Source: ene.field project

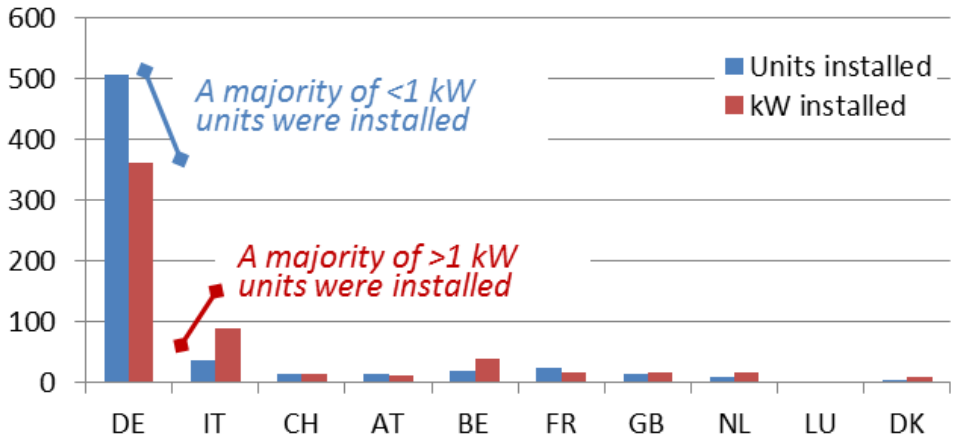
Status of field trials (Dec 2017)

- On track for **over 800 systems to be installed in 11 European countries** across the field trials
- **A rapid ramp-up in deployment occurred over 2016**, as the majority of the units were installed over 2015 and 2016
- Monitoring for all units, **10% with detailed technical monitoring**
- The project is now entering its final phase, **incl. data analysis and publication of key reports**

Ramping up of installations during project



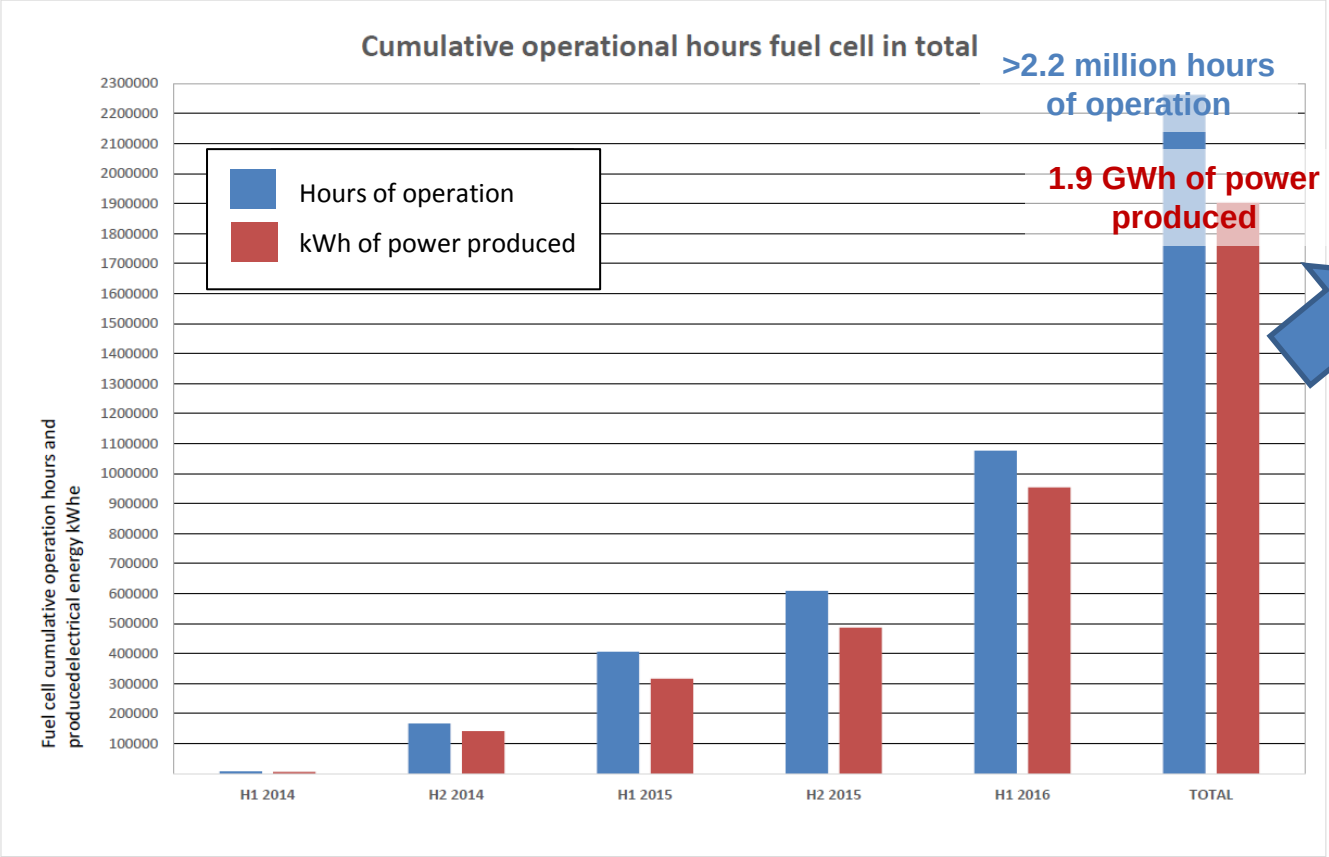
Installations per country and capacity (kW)



Source: ene.field project

Reliable performance has been demonstrated

Demonstration projects have shown reliable performance: The ene.field project has demonstrated as of today close to 3 million hours of operation and 2.5 GWh of power produced



Latest data collection exercise indicates **close to 3 million hours of operation** and **close to 2.5 GWh of power produced**

Enough electricity to cover the yearly consumption of

500 X

600 X Heat Pumps

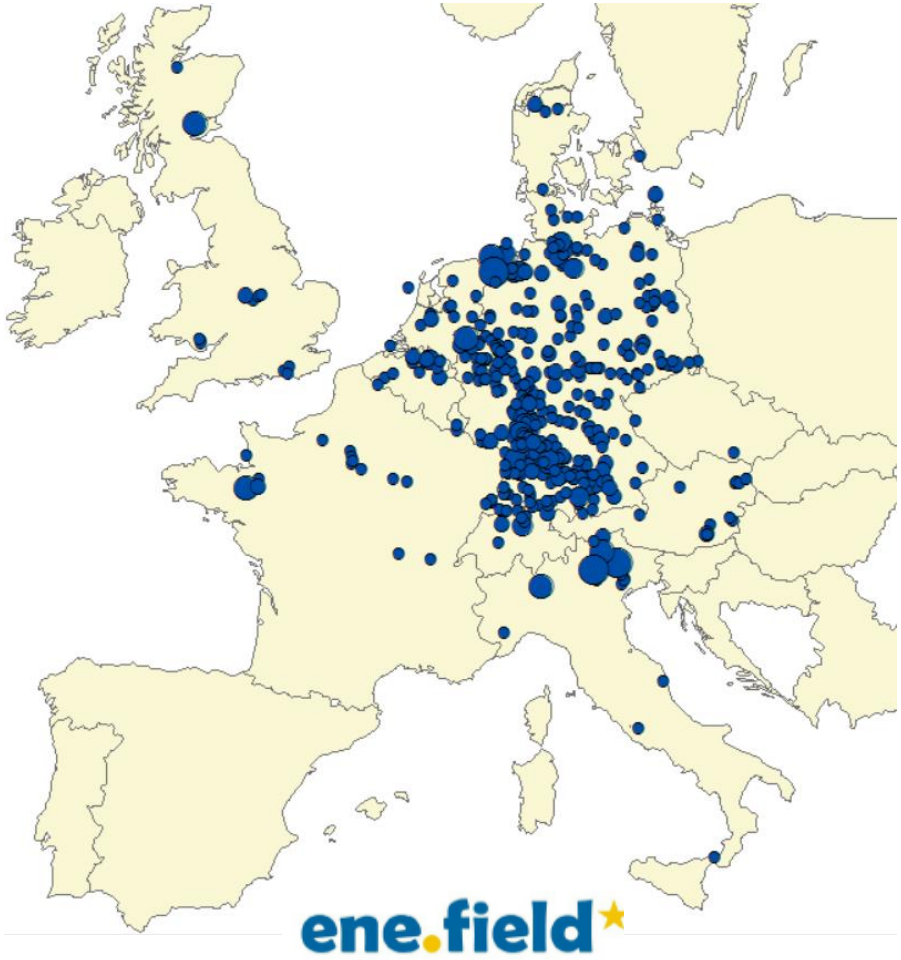
This contributes to the already >4 million hours and 2.5 million kWh of power produced recorded under Callux project in Germany

Source: ene.field project

FC mCHP suppliers are qualifying new routes to market and opening new markets via ene.field

The project is contributing to the development of new markets around Europe while developing further the more advanced German market

callux
Praxistest Brennstoffzelle fürs Eigenheim



Status as of November 2016, additional systems to be deployed

Source: Callux project / ene.field project | FC mCHP: Fuel Cell microCombined heat and Power

Lessons learned - field trials

- **Demonstration projects such as Callux and ene.field show reliable performance and advances in products quality** (reduction in appliances dimension and weight, system are now better fit for quick installations, reduction in maintenance requirements)
- **System capital costs are the major challenge for growth of the market** (running costs are competitive with incumbents).
- **Germany is the strongest early market,** this is due to regional funding opportunities, tolerance of higher cost heating systems and a more developed manufacturer and installer base, among other factors
- **Route to market via utilities has proven very difficult;** less finance available for demonstration projects – interest in only small numbers of units and limited co-financing
- **Increased manufacturing volumes is expected to be the biggest driver of capital cost reductions,** which will require a stable policy framework and high level political commitment to ensure investor confidence

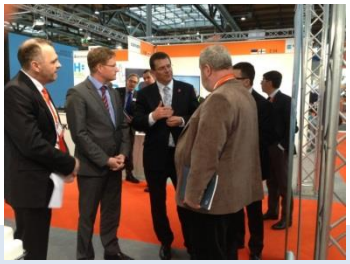
Source: ene.field project

Lessons learned: Policy readiness!

Policy framework & regulatory issues

- **High level political recognition of FC mCHP benefits** needed at the national level
- **Few dedicated support schemes** that adequately and fairly reward FC mCHP based on an agreed timeline & KPIs (exemplar is KfW 433 (TEP) in Germany)
- **Administrative barriers** preventing access to existing support schemes and funding, as well as for grid connection
- **Lack of harmonisation of standards** across Europe perceived as a barrier (e.g. gas quality, electrical and thermal size of domestic appliances)
- **Methodologies inadequate/undermining full potential** assessing FC mCHP performance vs other heating technologies (e.g. energy labelling at EU level, EPB software in Belgium)

Policy development should closely follow & complement the industry's commitment to FC mCHP cost reduction and performance improvements!!



Source: ene.field project

Key successes

- Development of **the largest European deployment of FC mCHP system to date and contributed to advances in quality of the products and opening new markets for further commercialisation activities** *e.g. PACE project*
- **Provide evidence of a suitable supply chain** and increase capability incl. scaling up **EU manufacturing capacities** for **11 products available** under commercially conditions
- Install sufficient numbers of systems to **give confidence on durability** with **expected lifetime** for products going beyond the project duration (up to **10 to 15 years**)
- **Increase the operational experience** and provide training of personnel. Provide proof of a **suitable support concept**
- **Achieve meaningful research advances** for FC mCHP *e.g Review of Field support arrangements (2013); European Supply chain analysis (2014); Regulations Codes and standards (2014); Grid Connection of Fuel Cell Based mCHP (2015) etc.*
- **Increase support by and provide advice for policy makers** *e.g RCS report used by industry stakeholders; Dialogue with DG RES and DG ENER; organisation of national workshops*

Status as of November 2016, additional systems to be deployed

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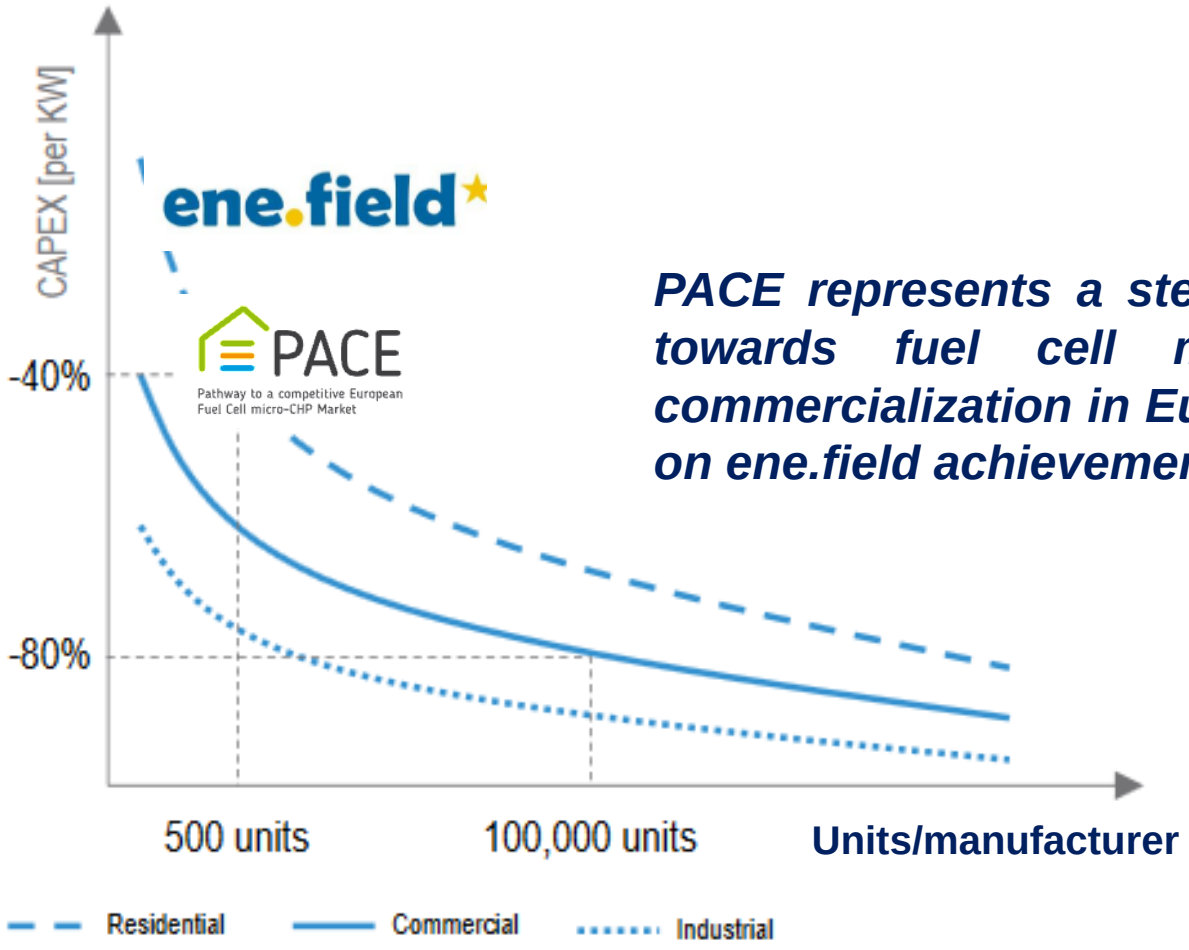
PACE – Pathway to a Competitive European FC mCHP Market



PACE represents a step up in ambition towards fuel cell micro-CHP mass commercialization in Europe, building up on ene.field achievements!

PACE – Pathway to a Competitive European FC mCHP Market

PACE
Pathway to a competitive European Fuel Cell micro-CHP Market

BDR THERMEA · BOSCH Invented for life · COGEN EUROPE · DTU · elementenergy · EWE · SOLID POWER · Vaillant · VIESMANN

Objectives:

- **Product innovation and cost reduction** – constructing and demonstrating next generation FC mCHP units, designed for cost reduction, increased performance and mass manufacture.
- **Supply chain development** – working to build a more competitive EU component supply chain.
- **Policy collaboration** – working collaboratively with member states to develop policy to enable the transition to wider roll-out.
- **Demonstrating and verifying primary energy savings, and testing grid benefits** – for innovative business model application.

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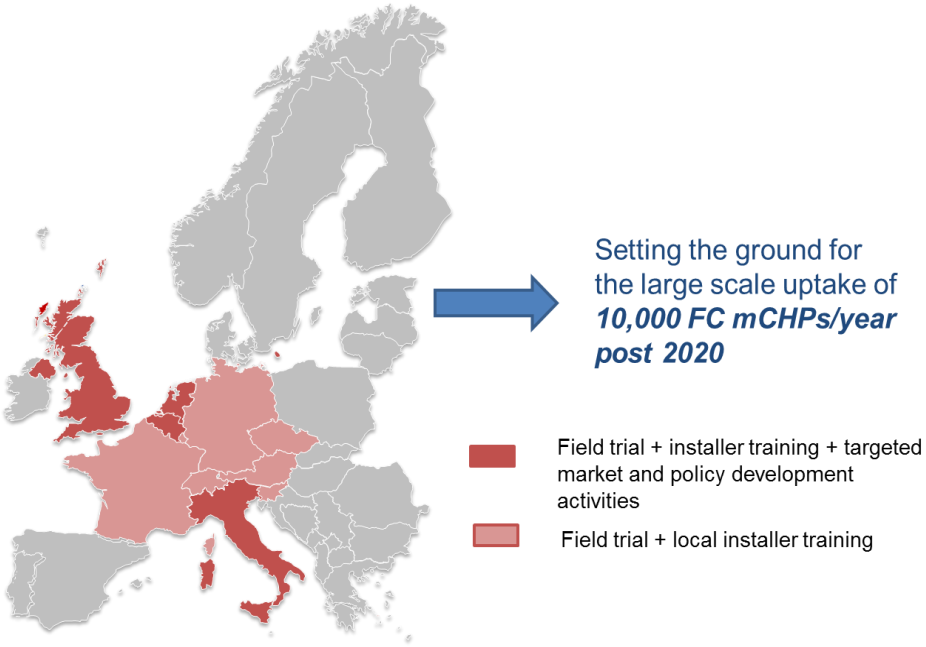
PACE – Pathway to a Competitive European FC mCHP Market

Pathway to a competitive European Fuel Cell micro-CHP Market

- PACE aims to **install more than 2,500 FC mCHP**, thus enabling several thousand consumers to actively contribute to Europe's energy transition
- PACE will unlock the market for FC mCHP large scale uptake preparing the supply chain and working with policymakers in selected member states to promote a **successful transition to volumes in the order of 10,000 units/year post 2020**.



- PACE will demonstrate that **FC mCHP products are smart grid ready** and that they **can run on renewable fuels**, thus enabling a higher uptake of renewable energy.
- PACE brings innovative **FC mCHP products to the consumer through new business models**.
- PACE will provide **up-skilling opportunities for the domestic heating sector supply chain** (i.e. installers, planners)

Conclusions

- ene.field and now PACE are **the largest European deployment of FC mCHP energy solutions** to date, contributing to **advances in quality of the products** and **opening new markets for further commercialisation activities**

- While **FC mCHP are already competitive with regards to OPEX and GHG emissions compared to other heating technologies**, CAPEX needs to be reduced significantly for the technology to be attractive to a wider group of customers.

- **Collaboration among industry, research institutes and other relevant stakeholders at European and national levels** is expected to contribute to accelerate costs reduction and tackle some key challenges around supply chain development.

- **European industry is investing substantial sums, given its belief in the potential of FC mCHP to deliver environmental and economic benefits**, however commitment needs to be sustained by high level political recognition of these benefits

- The **market uptake of FC micro-CHPs requires a coherent, steady and predictable policy framework** → Project findings show that these conditions are not in place today

- **Financial support is key during the transitional period to mass commercialisation** as shown by the European experience promoting other emerging technologies (e.g. PV, heat pumps)

Thank you for your attention!

www.enefield.eu
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