



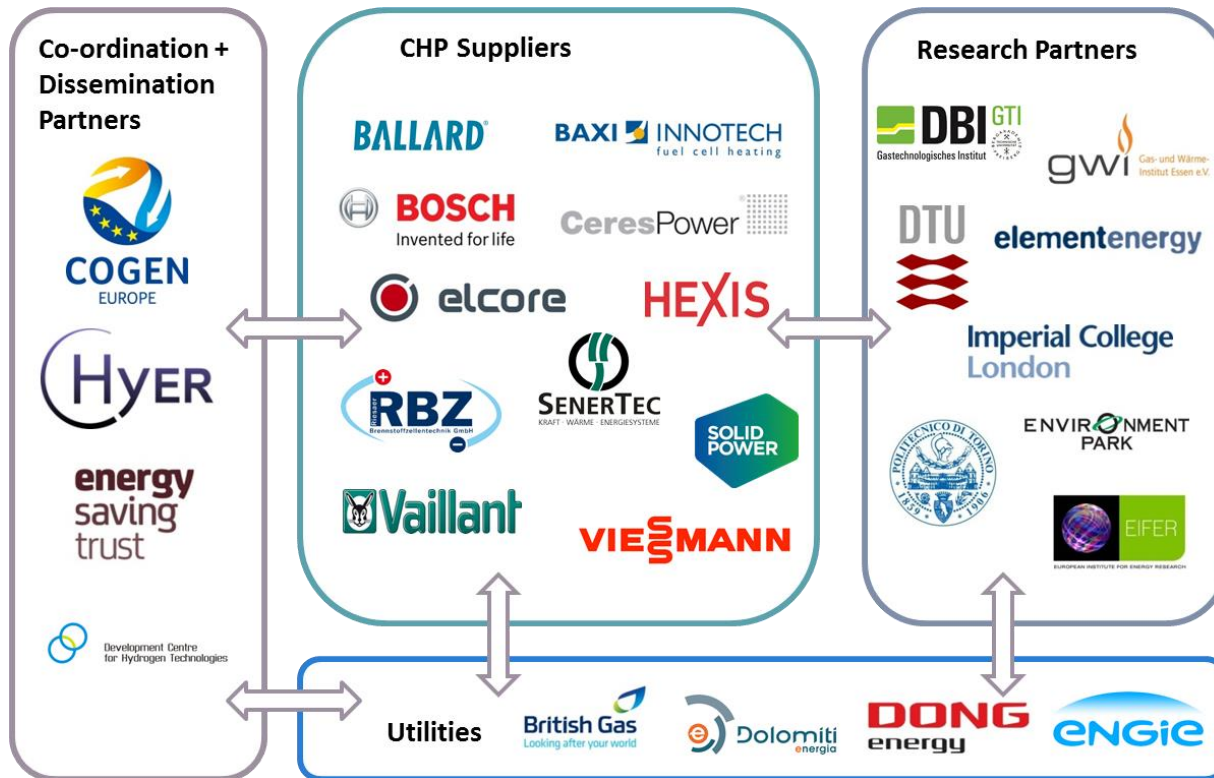
European-wide field trials for residential fuel cell micro-CHP

Introduction to ene.field project and early results
15 March, 2017



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

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

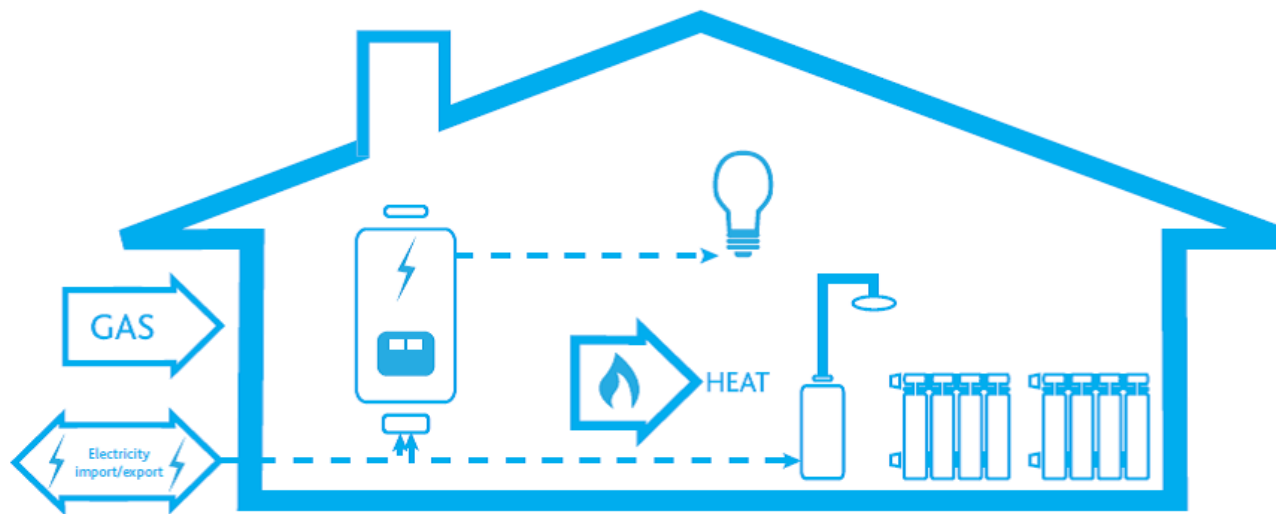


The consortium brings together 27 partners including:

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

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

- 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



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

Solution to efficient heat supply in buildings

- High electrical and overall CHP efficiency
- Significant primary energy saving and reduction of CO₂ 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

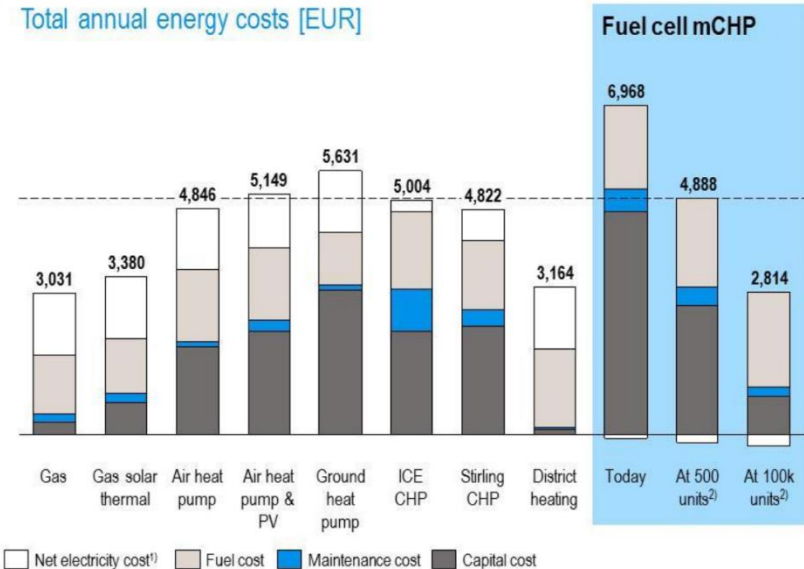
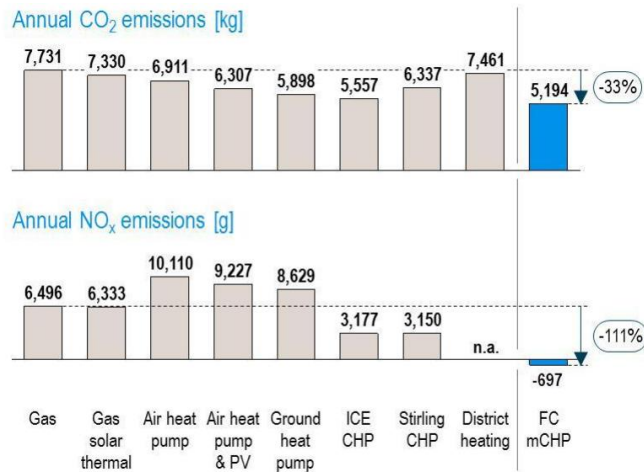
Advanced and innovative technologies benefiting the customers

FC mCHP generates fewer harmful emissions for the environment and for health (CO₂, PM, SO_x, 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

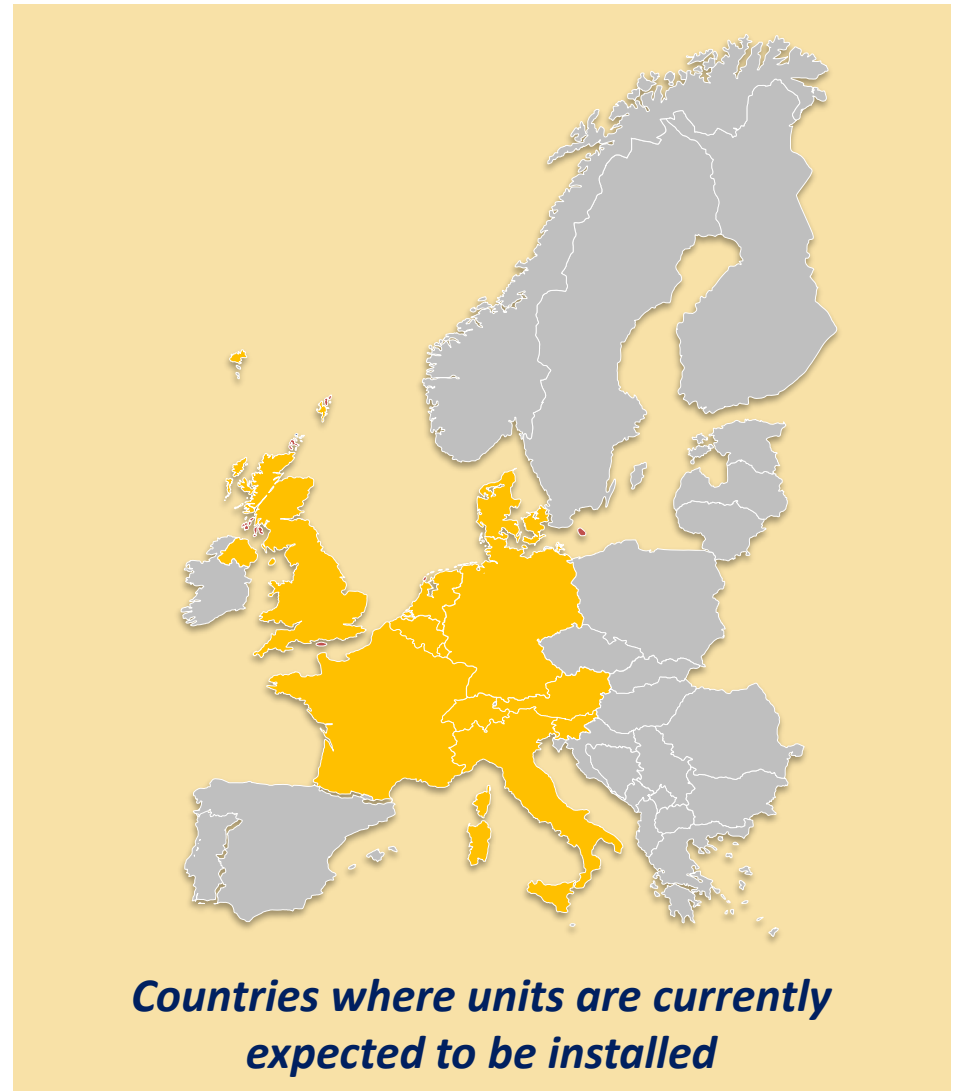


	MUNICH
Residents	4
Heated space	103 m ²
Year of construction	1962
Heat demand	21,438 kWh
Electricity demand	5,200 kWh
Central heating	



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 %

- 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** across 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



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

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

Practical field trials



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

PACE

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

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)

Market uptake

- Favourable EU and national policy frameworks
- Industrial ramp up

Mass market

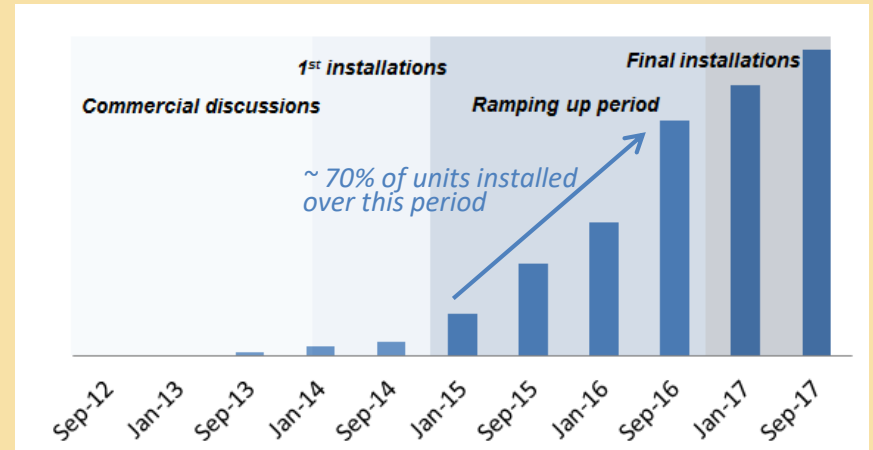
- Fully competitive without any funding

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

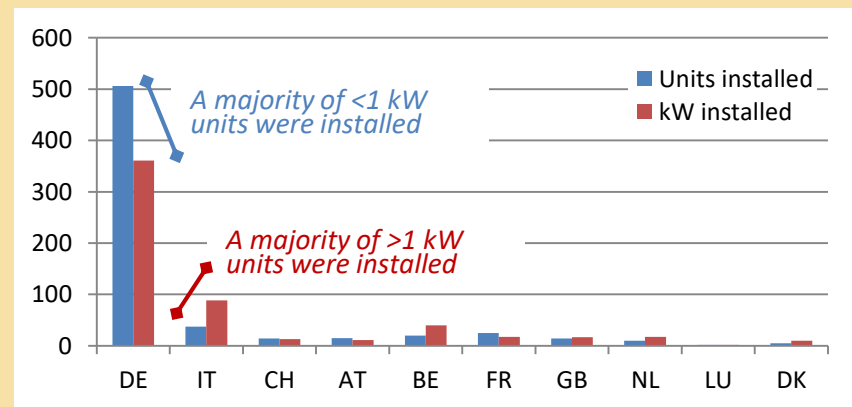
Status of field trial (February 2017) – deployment overview

- The 1st /2nd phase of the project focussed on developing strategies for field trials and finalising contractual agreements and installations.
- **847 systems installed** so far in **10 countries** across the field trials
- **A rapid ramp-up in deployment occurred over 2016** – the majority of the units were installed over 2015 and 2016
- Monitoring for all units
- 10% of units undergo detailed technical monitoring

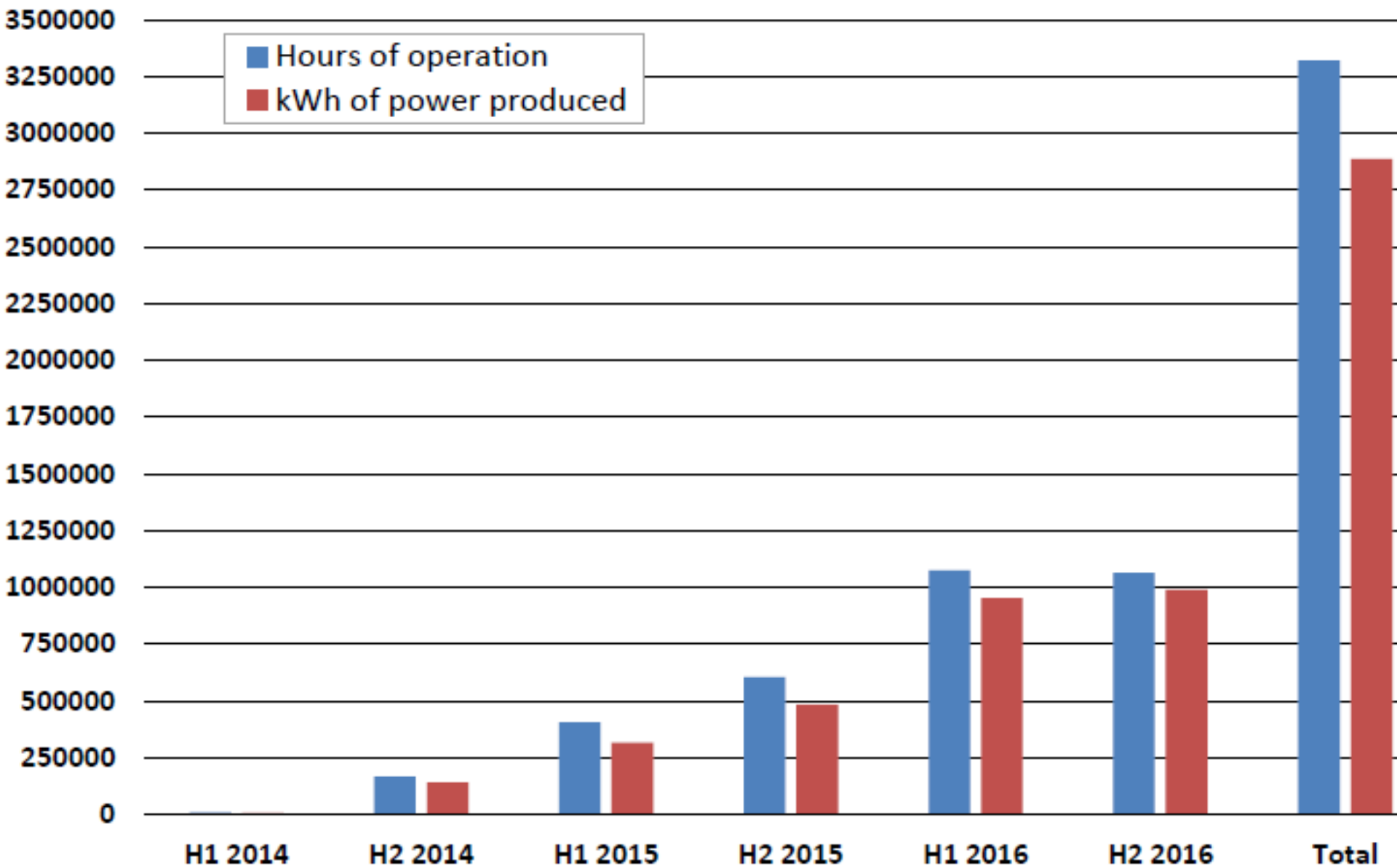
Ramping up of installations during project



Installations per country and capacity (kW)

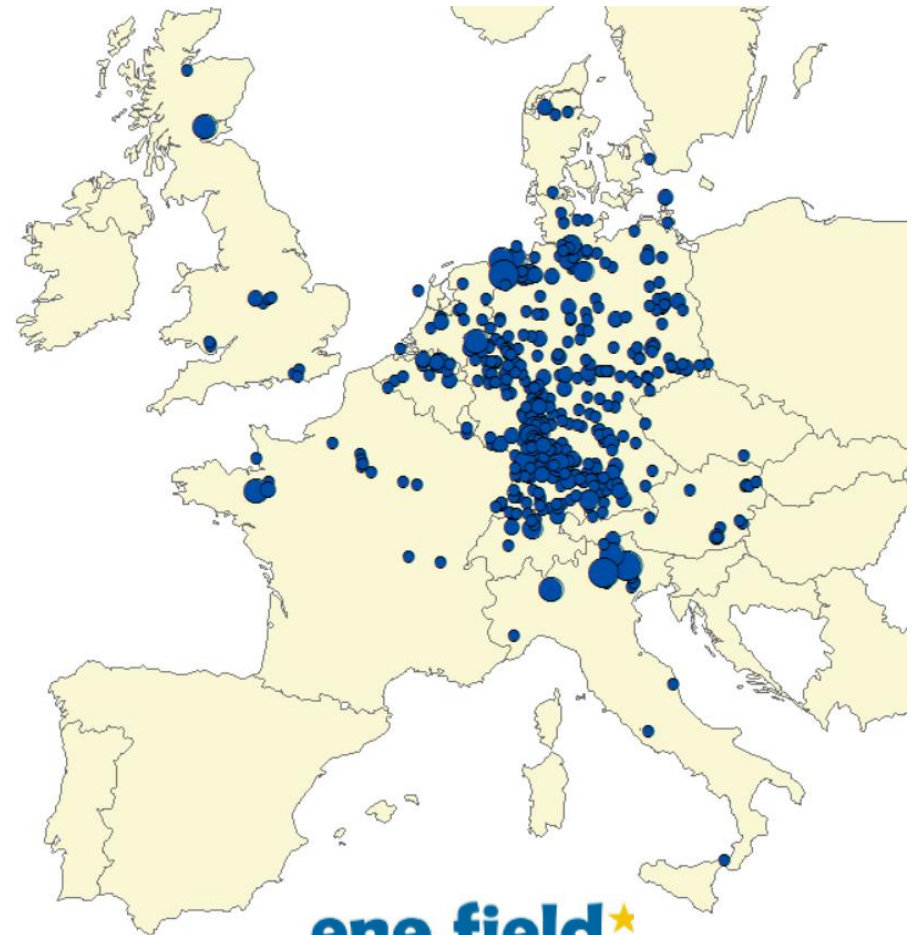
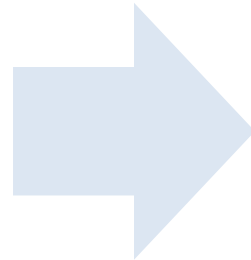


Cumulative operational hours fuel cell in total



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



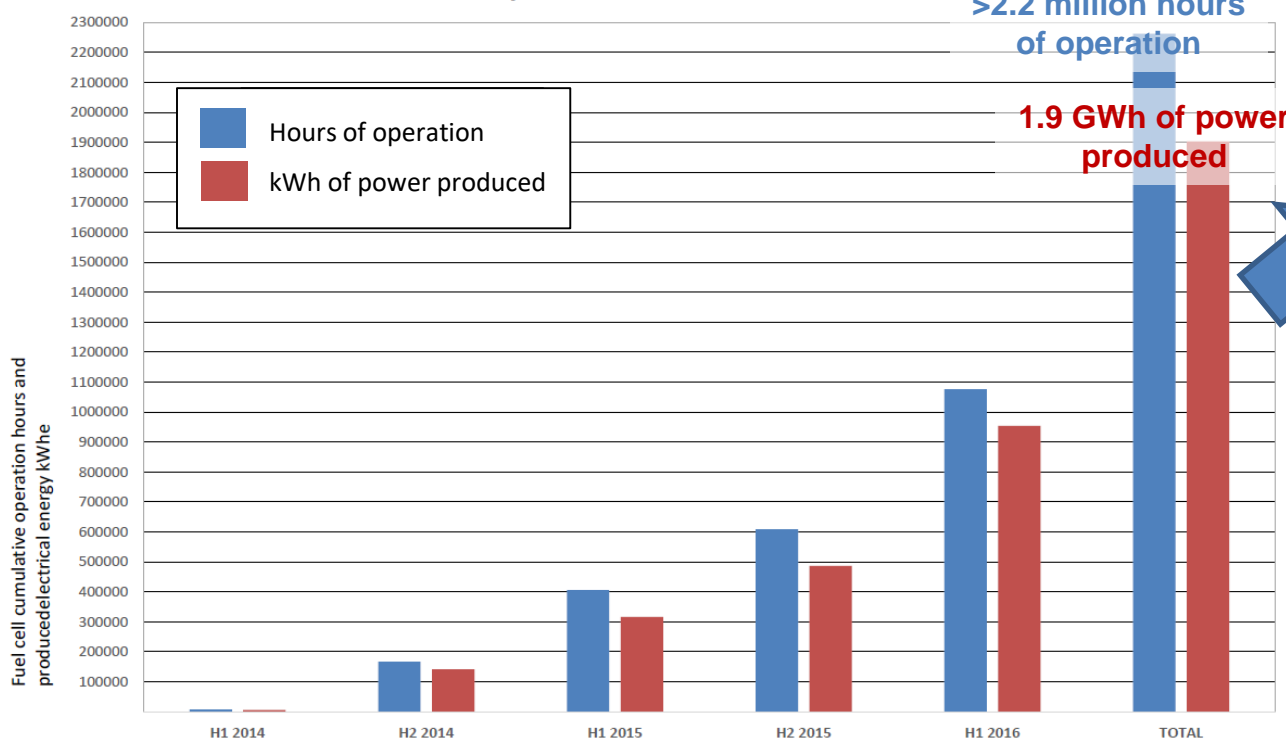
Status as of November 2016, additional systems to be deployed



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

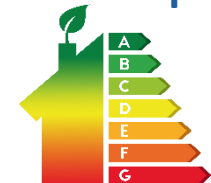
Cumulative operational hours fuel cell in total



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

Enough electricity to cover the yearly consumption of

500 X



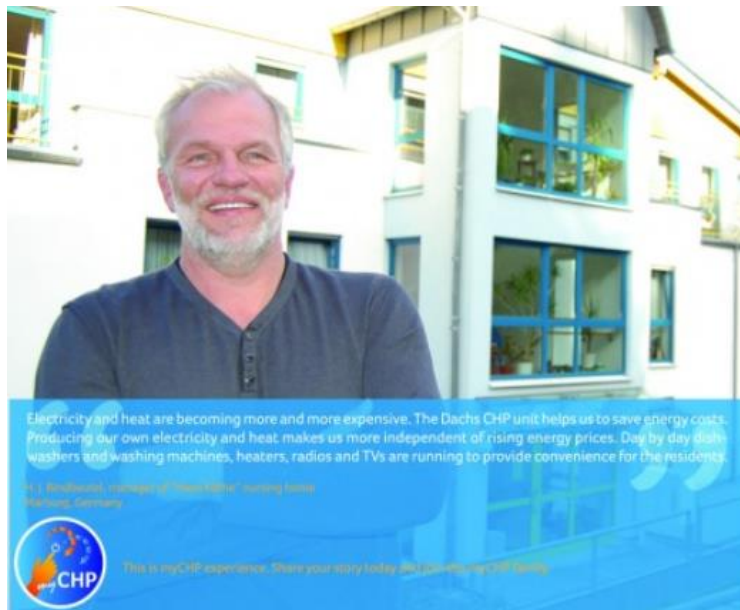
600 X Heat Pumps

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

Property Type

- Customers taking part in the trial are most likely to be dependent on gas for heating and hot water (~70% of those surveyed were previously relying on a natural gas boilers) and live in detached homes built during the period 1976 – 2000

Customer profile



- Overall **customers were satisfied with their current energy system** (ease of use, speed of performance and ability to provide comfort and warmth) but **concerned by their CO2 emissions** and were noted for taking an active role in energy conservation measures
- Participants reflected both an **eagerness to engage with renewable energy technologies (63%)**, with a further 71% stating that they consider renewable energy to be an important part of future energy infrastructure
- **Running costs as of today and in the future as well as security of energy supply were also noted as being of particular concern**

Putting citizens at the centre of energy transition

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

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

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



ene.field unit installed at Family Aberl's home



Historical Logherberhaus Hotel equipped with an ene.field fuel cell



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

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

Early results and status of analysis conducted (February 2016)

- The ene.field project is in the final project phase
- A number of reports and deliverables have also been completed for the project and are available on the website (see list on the right)

ene.field Public Deliverables

- **Field Support Report** - evaluation of the current state of the art for field support arrangements, training and certification
- **Position Paper on RCS (regulations, codes and standards)** overview of the current European framework for installation aspects
- **European Supply Chain Analysis Report** - evaluation of the maturity, competition and standardisation levels
- **Position Paper on Smart Grid Capabilities** – analysis of potential for FC-micro-CHP to positively contribute to grid stability in the context of the emerging smart grid model
- **Report on the Grid Connection of fuel cell based micro-CHPs: Standards, legislations, issues and lessons learned** - insight in the current status of grid connections (incl. standards, legislations, connection guidelines and issues)
- **Non-economic barriers: preliminary report** - identifies product perception by consumers or installers, policy and political environment
- **Field Support Reports: Review of lessons learnt** - analysis of the lessons learnt and of future needs for installation and field support
- **See full reports here:** <http://enefield.eu/category/news/reports/>

- **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

The main drivers of cost reduction identified in the ene.field supply chain study are:

- Reduce system complexity and component count
- Standardisation of component lines
- Automation of manufacturing
- Increasing volumes
- Greater supply chain competition

Developments in the European supply chain:

- Partnerships between Asian OEMs of ene-farm and European manufacturers, introducing learnings and cost-savings to European markets
- Consolidation between European OEMS –e.g. Viessmann have become full owner of Hexis and SOLIDpower have bought out Ceramic Fuel Cells Ltd IP and manufacturing capacity

Supply chain report – Recommendations

- On-going field trial collaboration and standardisation efforts are appropriate
- Define level and nature of subsidies required for successful roll-out (1)
- Form European industry group to support collaboration and advocacy, to secure additional funding
- Develop strategic partnerships – component suppliers, utilities etc.

A good training process reduces installation time and avoids installation related errors. Areas for training were identified :

- To ensure a better understanding of both the Fuel Cell and the CHP technologies
- The content of the courses should have a general common core with additional modules addressing specific topic and needs: safety, RCS, operation and maintenance, mCHP operation and maintenance

A number of aspects related to the installations process were highlighted as requiring streamlining:

- System size and weight should be carefully included in site selection process to avoid complications on site during installation e.g. transport of components inside the house can sometimes be problematic
- Varying standards for grid and gas connections as well as non-transparent installation requirements across European countries (e.g. chimney connection specifications) increases complexity
- Formalities for the customer can be daunting. OEMs have resorted to supplying sales packages including as much help with paperwork as possible to relieve customers from this burden

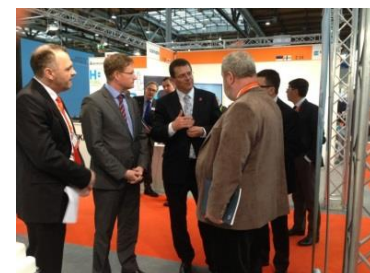
Field supports – Recommendations

- E-learning platform seems to be the best way to provide widely accessible training, at least in a first stage. Practical courses are also recommended for specific topics e.g. maintenance
- Training courses and training done internally by OEMs are covering the present needs
- Offering the customer a complete package, including handling of all paperwork for connection, installation and subsidies applications, among others, is strongly suggested

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 also 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!!



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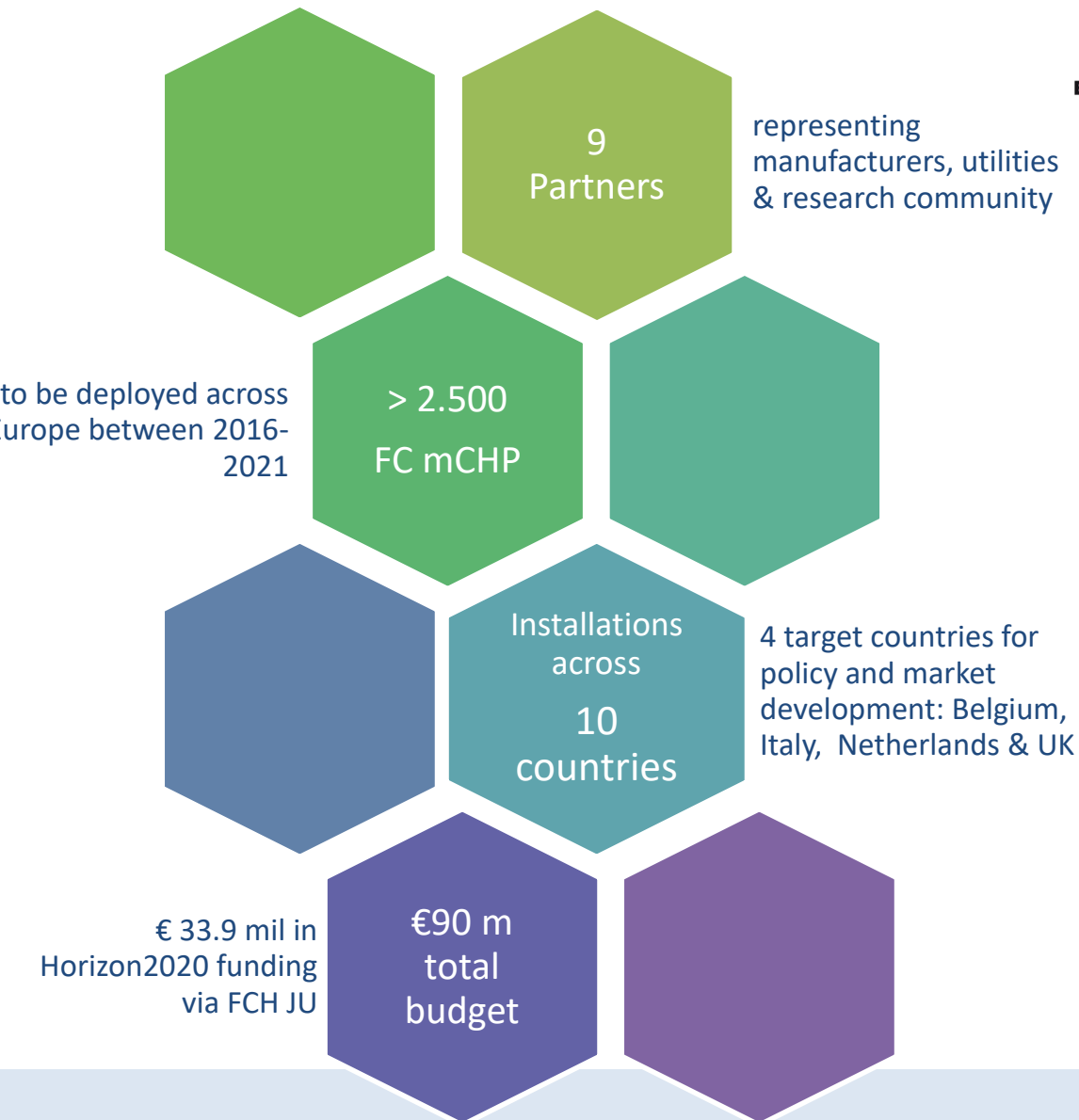
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PACE – Pathway to a Competitive European FC mCHP Market

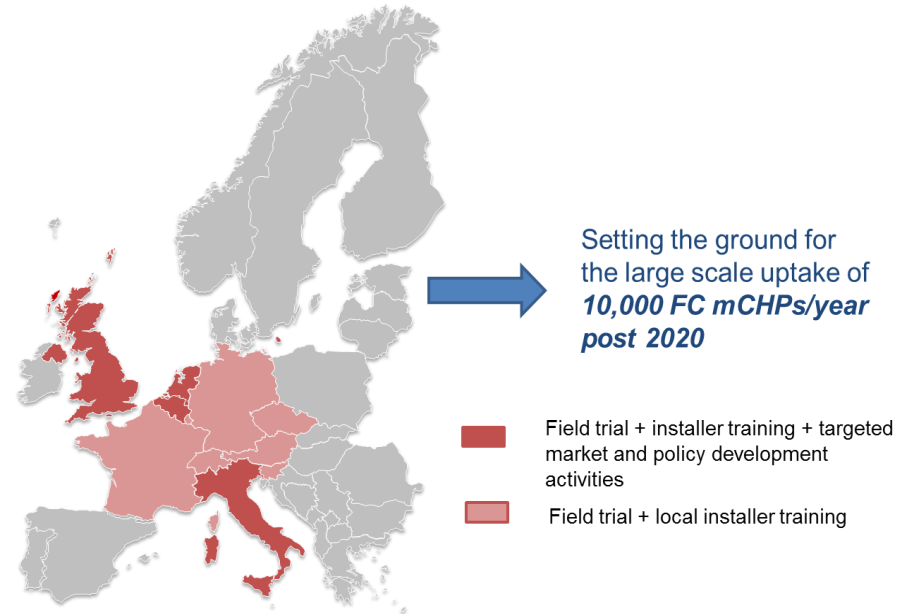


Objectives:

- **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.

PACE – Pathway to a Competitive European FC mCHP 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 supportive** 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)

- 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** → Analysis conducted in the context of the project showed 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!

BALLARD

BAXI **INNOTECH**
fuel cell heating

BOSCH
Invented for life

British Gas
Looking after your world

CeresPower

COGEN
EUROPE

Danmarks Tekniske Universitet

DTU

DBI GTI
Gastechnologisches Institut

Development Centre
for Hydrogen Technologies

Dolomiti
energia

DONG
energy

EIFER
EUROPEAN INSTITUTE FOR ENERGY RESEARCH

elcore

elementenergy

ENGIE

ENVIRONMENT
PARK

energy
saving
trust

gwi
Gas- und Wärme
Institut Essen e.V.

HEXIS

HyER Imperial College
London



RBZ
Brennstoffzellentechnik GmbH

SOLID
POWER

SENERTEC
KRAFT · WÄRME · ENERGIESYSTEME

Vaillant

VIESSMANN

www.enefield.eu



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- While **FCmCHP are already competitive with regards to OPEX and GHG emissions compared to other heating technologies**, CAPEX needs to be reduced consistently for the technology to be attractive to a wider group of customers. **Financial supports are key during this transitional period as shown by the Japanese experience and determine where systems are being installed today in Europe**
- **Consolidations of activities between European and Asian OEMs is expected to contribute to accelerate costs reduction and tackle some key challenges around supply chain development.** However, not all learnings obtained from the Asian market demo trials can be systematically transferred to EU markets
- The **market uptake of FC micro-CHPs requires a coherent, steady and predictable policy framework – Analysis conducted in the context of the project showed that these conditions are not in place today**
- The **changing landscape of funding programmes and subsidies** is also hard to manage for FC mCHP suppliers as they lead to unforeseen challenges and often require changes to their sales strategies
- The **lack of a common framework of European standards** is seen as a great hindrance to market uptake with stakeholders pointing at the need to update, improve and revise a large amount of the current standards for more consistent and better suited standards
- **In the current market phase customers are facing a number of subsidies with varying requirements for a number of competing technologies.** Suppliers have assumed a role closer to the one of energy providers, supporting customers beyond the supply of equipment in the early phase of the market preparation