Fuel Cell technology in the European Energy market

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Energy Union

(European Commission Communication Feb.2015)

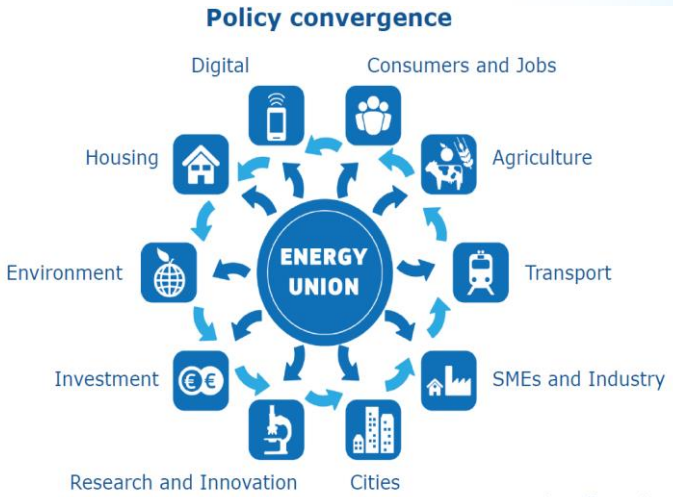
"I want to reform and reorganise Europe's energy policy in a new European Energy Union."
Jean-Claude Juncker (President of the European Commission)

The vision of the Energy Union:

- a sustainable, low-carbon and climate-friendly economy that is designed to last;
- strong, innovative and competitive European companies that develop the industrial products and technology needed to deliver energy efficiency and low carbon technologies inside and outside Europe;
- with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected.

The Energy Union strategy has five mutually-reinforcing and closely interrelated dimensions:

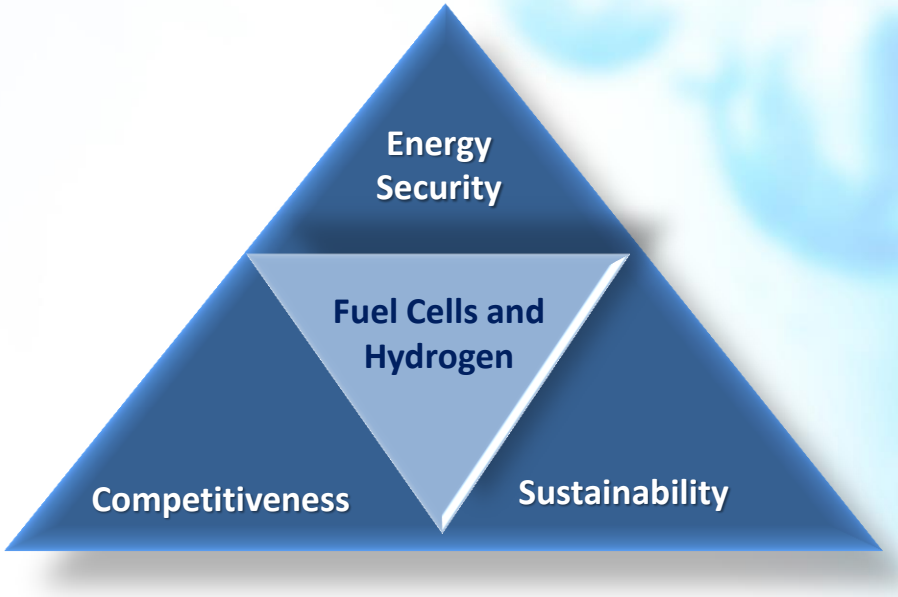
- Energy security, solidarity and trust;
- A fully integrated European energy market;
- Energy efficiency contributing to moderation of demand;
- Decarbonising the economy, and
- Research, Innovation and Competitiveness.



Fuel Cells & Hydrogen technologies in the context of the European Energy policy

Sustainability

- H_2 is a clean energy carrier
- Transport and Energy applications, generate electricity and heat with very high efficiency
- Possibility for storage of renewable energy sources
- Reduction of CO_2 emissions



Energy Security

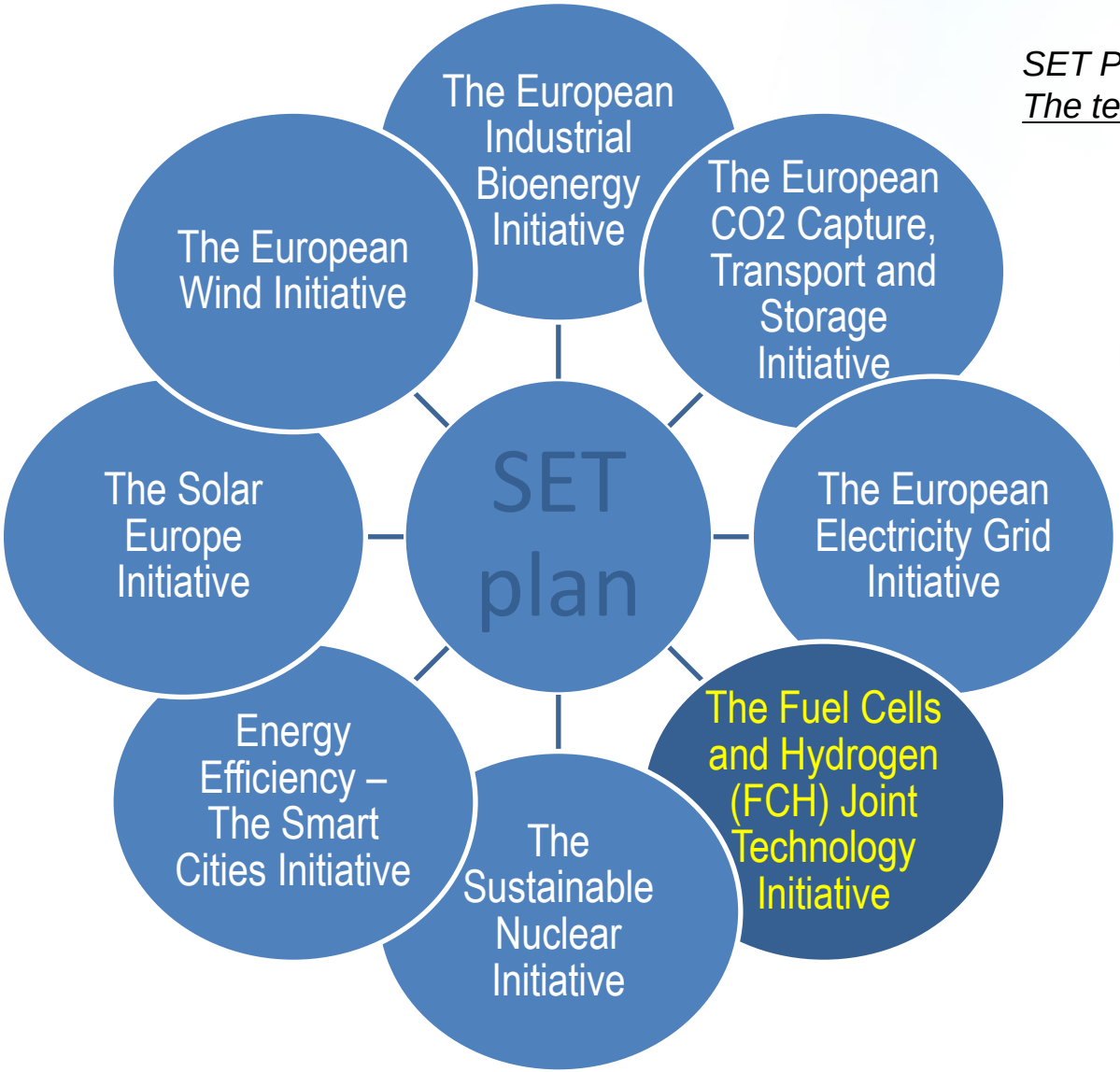
- Increase independence from unstable outside regions

Competitiveness

- research excellence leading to industry innovation and growth

From 80% dependency on fossil fuels to
80% reduction in GHG emissions in 40 years !
→ A reinvention of our energy system…

The FCH JU/JTI in the SET plan



SET Plan = Strategic Energy Technology Plan
The technology pillar of the Energy Union !

EU 2030 targets*:

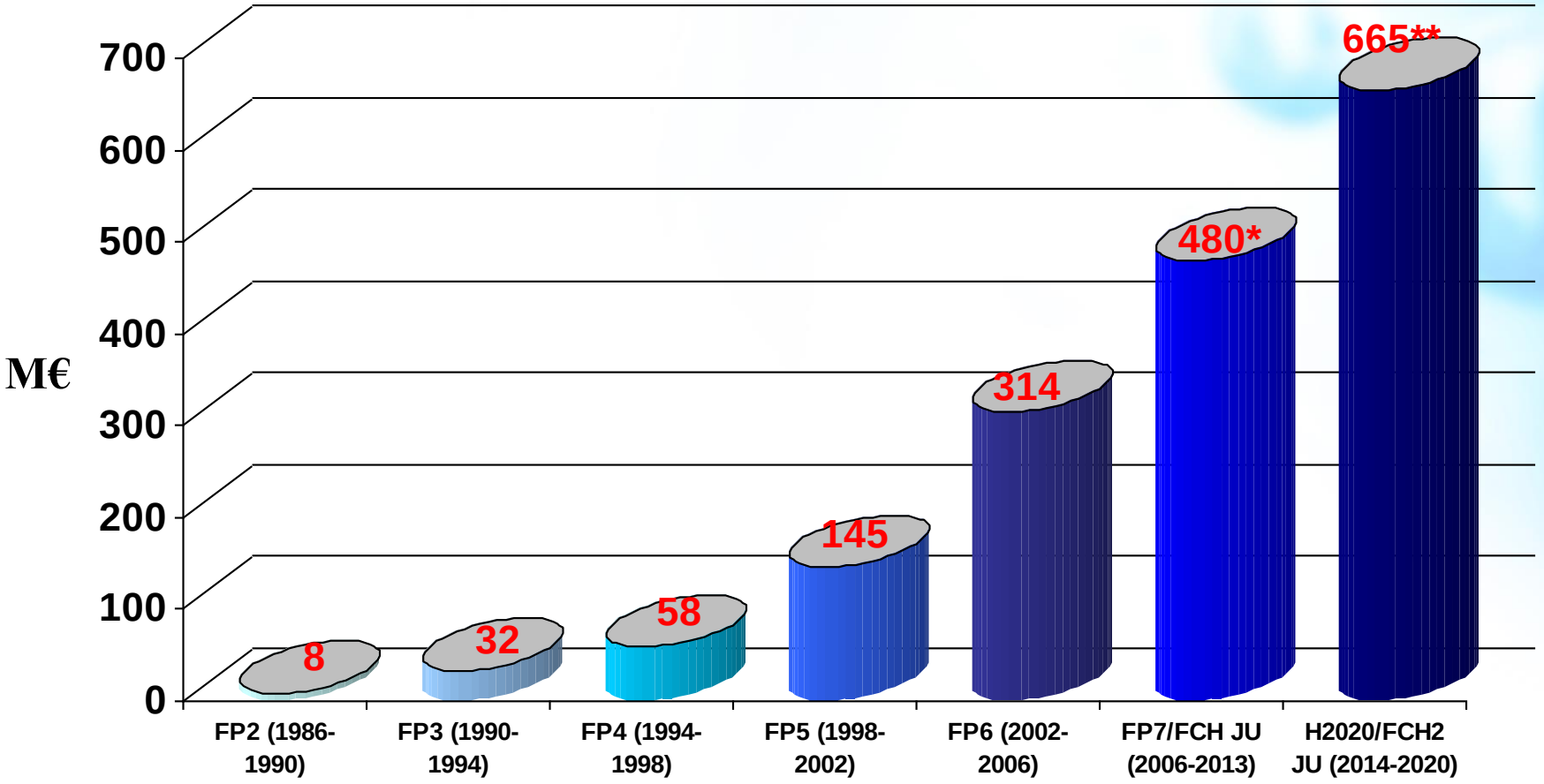
27 % increase in renewables
27 % increase in efficiency
40 % decrease in emissions

Fuel Cells and Hydrogen Joint Undertaking

- FCH JU - EU body
- Budget: 1.4 bill.€ (2014-2020)**
- FCH JU Programme Office

*European Council, October 2014
** continuation of previous exercise for 2008-2013 with a budget of approx. 1 bill.€

Continuous Support in the EU Framework Programmes



** 470 mill EUR implemented by FCH JU + about 10 mill EUR already spent from EU 2007 budget, before FCH JU in place*
*** 665 mill EUR only to be implemented by the FCH2 JU + additional budget from EU programmes for low TRL (basic research) and structural funds/smart specialisation*

Strong Public-Private Partnership with a focused objective

Fuel Cells & Hydrogen Joint Undertaking (FCH JU)

Hydrogen Europe

Industry Grouping
Close to 100 members
~ 50% SME

European Commission

ON.ERGHY
RESEARCH ON FUEL CELLS & HYDROGEN

Research Grouping
Over 60 members

The Joint Undertaking is managed by a Governing Board composed of representatives of all three partners and lead by Industry.

To accelerate the development of technology base towards **market deployment of FCH technologies** from 2015 onwards

Fuel Cell and Hydrogen community in Europe

+10%

average increase of annual **turnover** (on a 2012 total of €0.5 billion)

+8%

average increase of **R&D expenditures** (2012 total €1.8 billion)

+6%

average increase of **market deployment expenditures** (2012 total €0.6 billon)

+6%

growth in **jobs** per year (~4,000 FTE in 2012) while average EU job market has contracted

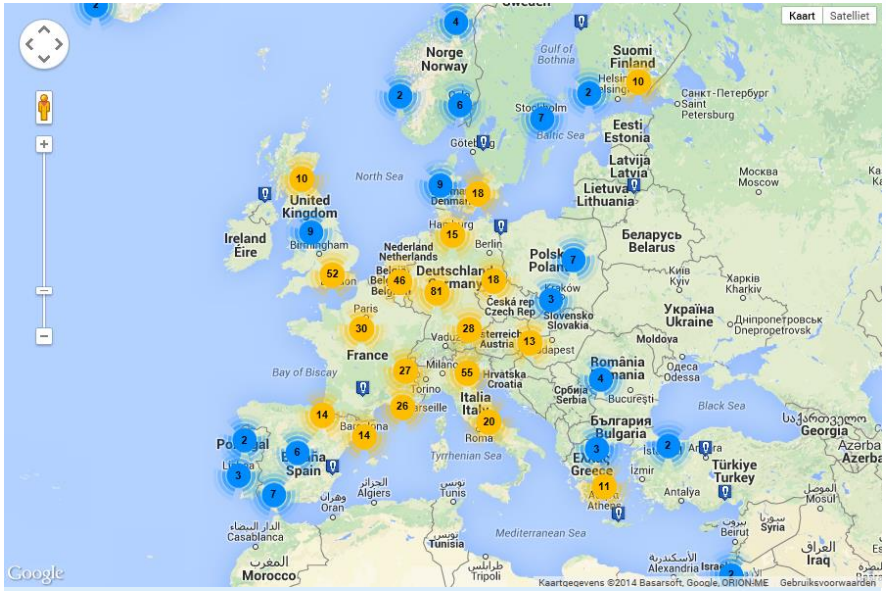
+16%

annual increase in **patents** granted in the EU to European companies (average 1.5% for all European industries)

Source: Trends in investments, jobs and turnover in the Fuel cells and Hydrogen sector, 2012

Strong FCH community in Europe

Projects involving 22 EU Member States (under FP7)



1266 Participations

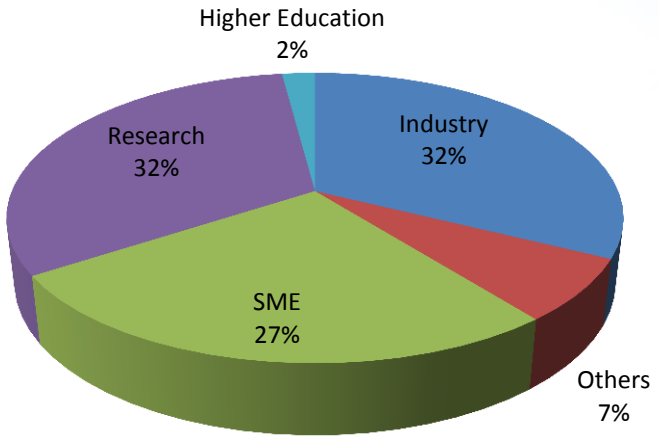
545 Beneficiaries:

- 192 Industries (35%)
- 154 SMEs (28%)
- 149 Research Organizations (27%)
- 20 High Education Institutions (4%)
- 30 Others (6%)

Incl international cooperation outside EU

(Additional non-EU countries: CH, NO, IL, TR, IS, RS, CN, RU & US)

Funding of beneficiaries categories

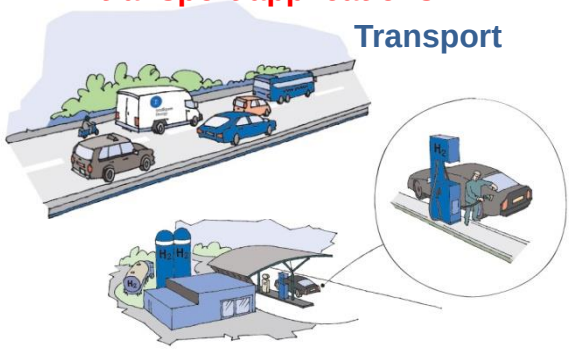


FCH 2 JU objectives

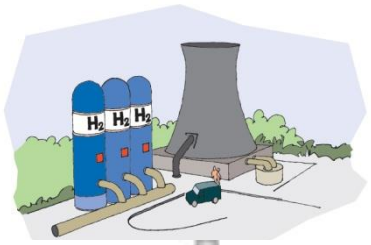
Reduction of production costs of long lifetime FC systems to be used in transport applications

Increase of the electrical efficiency and durability of low cost FCs used for power production

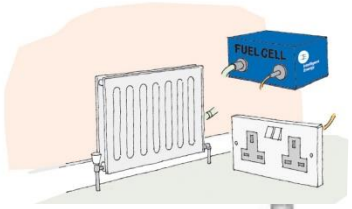
Transport



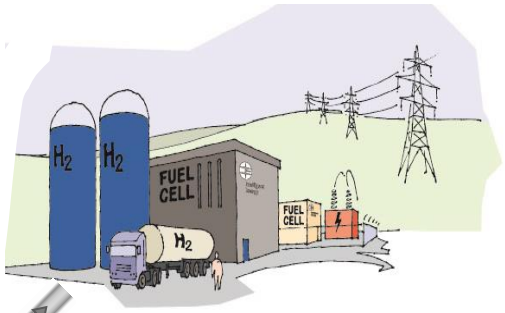
Industrial applications



Residential CHP



Feed to electricity grid

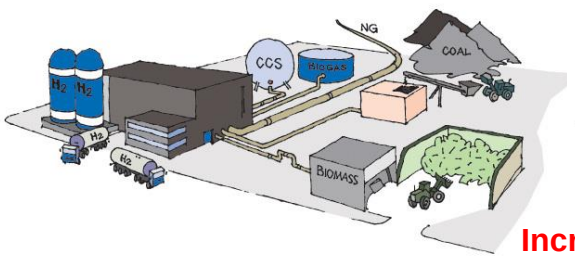


Reduce the use of critical raw materials

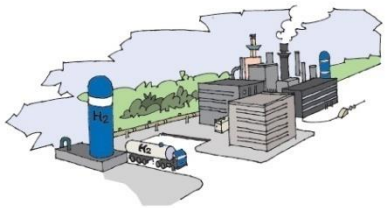
Existing natural gas, electricity and transport infrastructures

Methanisation feed to natural gas grid

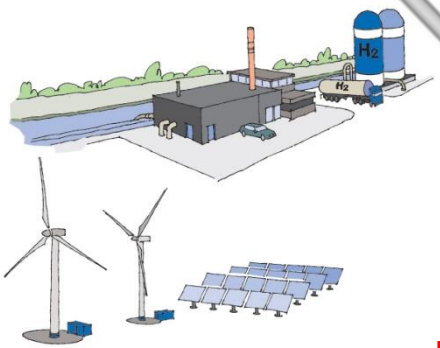
By-product from Chemical Industry



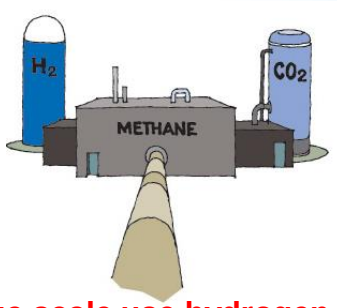
Natural gas, biogas, coal, biomass



Increase the energy efficiency of low cost production of hydrogen from water electrolysis and renewable sources



Renewable generation, storage and 'buffering'



Large scale use hydrogen to support integration of renewable energy sources into the energy systems

2030 Energy Goals and FC potential contribution

Energy Goals by 2030:*

27 % energy savings
40 % less greenhouse gas
27 % renewable energy

Strong European economy
Energy security
Lower energy cost

Stationary Fuel Cells:

~25 % less primary energy
Up to 80 % less CO_2, no NO_x, SO_x etc.
Storage (H_2), grid support (flex base load)

Technology driver, job creator
Decentralized, grid support, lower import
Up to 60 % el. efficiency, lower grid loss

Higher chance to reach goals with Stationary Fuel Cells

**European Council, October 2014*

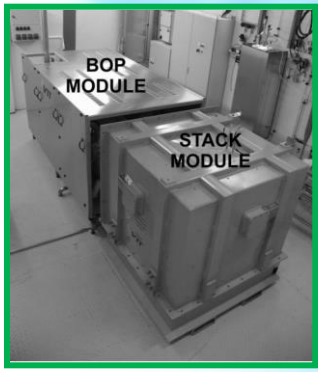
FCH JU Goals and Objectives
on Stationary Fuel cells

By 2015, demonstrate at least 1,000 m-CHP units and 5 MW large CHP

By 2020, decrease the CAPEX to 12,000 €/kWe (micro-CHP), respectively 3,000-4,000 €/kWe (large CHP)

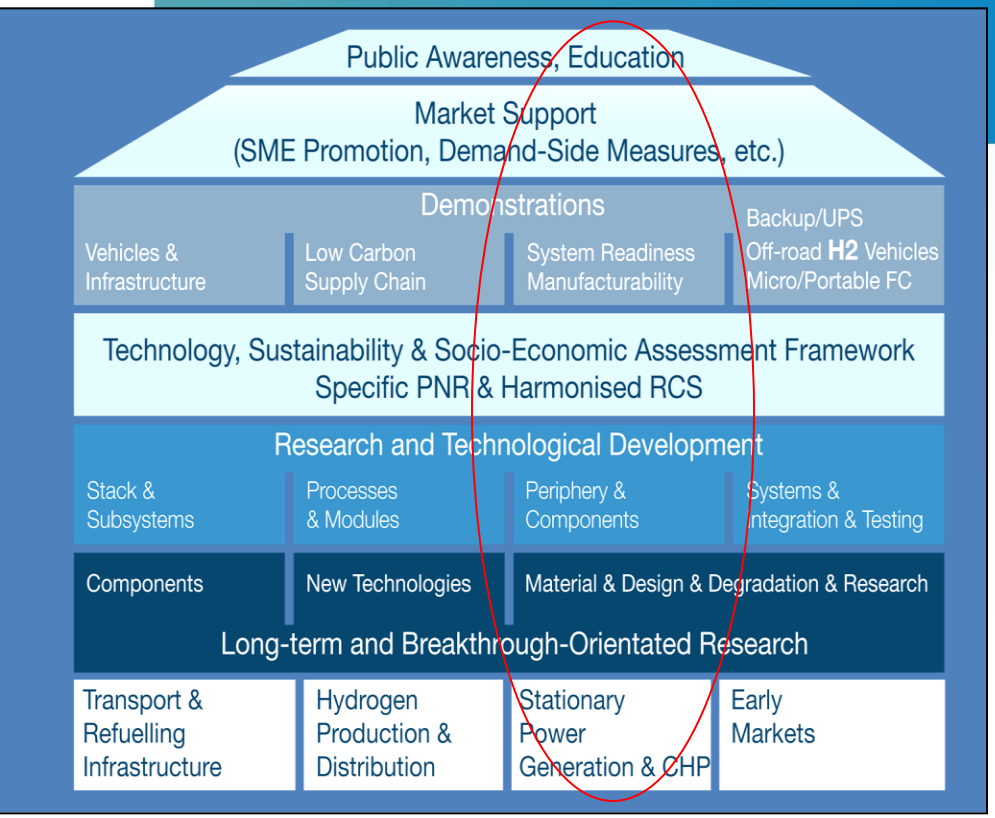
By 2020, increase durability to 40,000 h (12 years of operation for micro-CHP or even 20 years for large CHP), at 97% availability

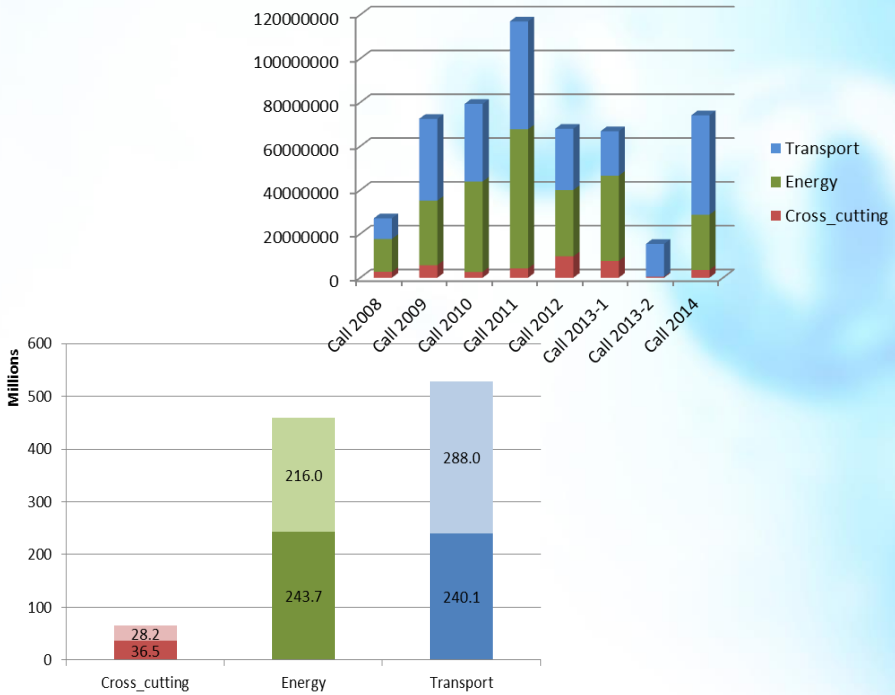
Electrical efficiencies >45% for power only units (towards 60% for SOFC systems), while Total efficiency > 80



Improve the technology for fuel cell stack and balance of plant components by bridging the gap between laboratory prototypes and pre-commercial systems

Multi-Annual Implementation Plan 2008-2013

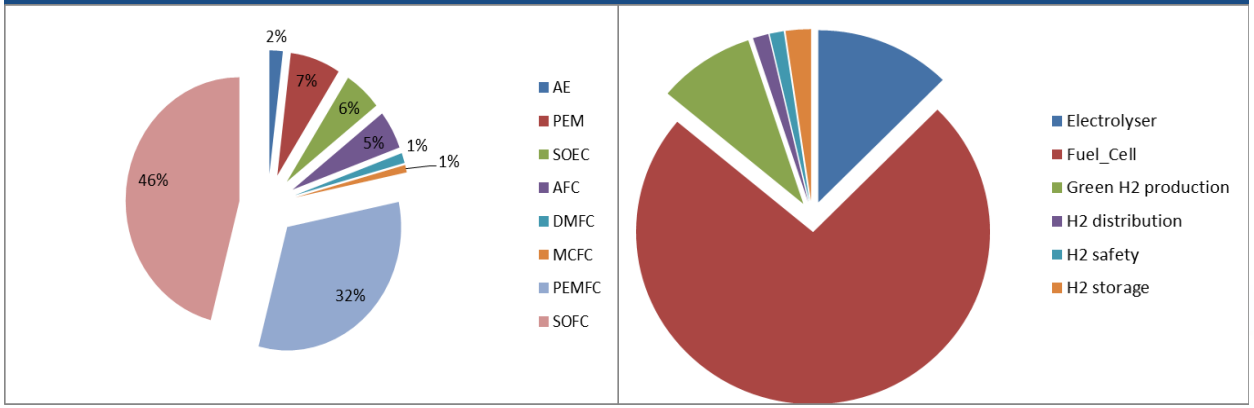


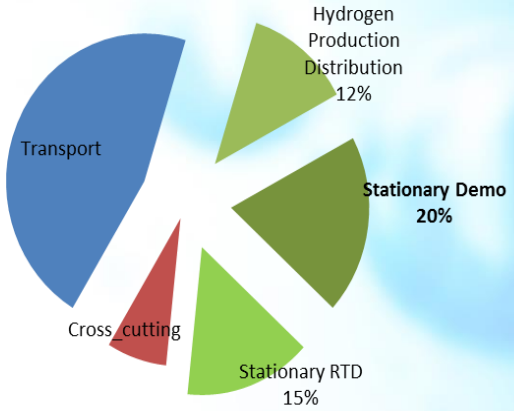


		Volume & cost		
Application Area	Market application	2010 baseline	2015 mid-term	2020 long-term
AA3 – Stationary	Micro-CHP (residential), natural gas based		1,000 units / 10,000 € per system (1kWe + household heat) Assuming supported deployment from 2013+	50,000 units / 5,000 € per system (1kWe + household heat) Anticipating commercial introduction beyond 2020
	Industrial/commercial, H2 based	1 MW / 4,500 €/kW	>5 MW / 3,000 €/kW Assuming supported deployment from 2013+	>50 MW / 1,500 €/kW Anticipating commercial introduction beyond 2018
	Industrial/commercial, natural gas based		>5 MW / 4,000 €/kW Assuming supported deployment from 2013+	>100 MW / 2,000 €/kW Anticipating commercial introduction beyond 2018

ENERGY portfolio

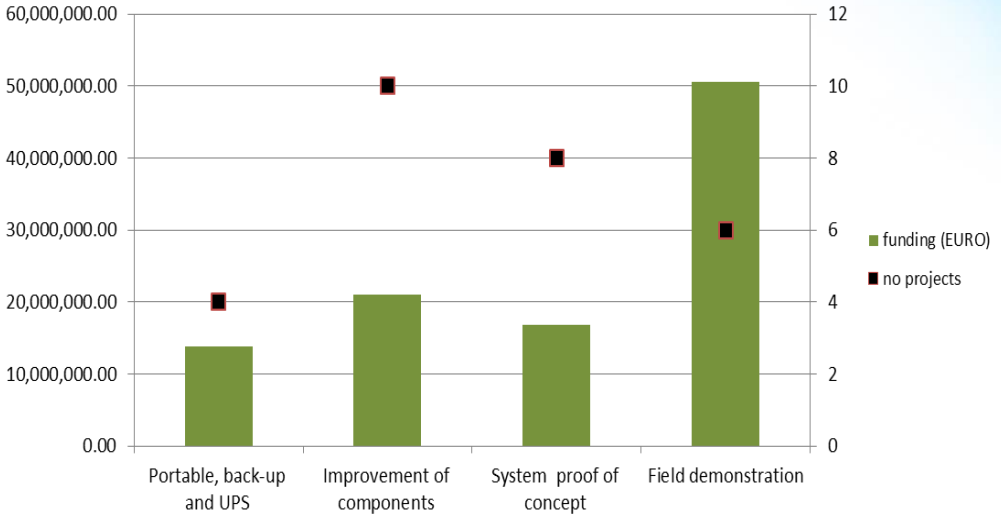
96 projects under Energy pillar, for more than 240 mill €





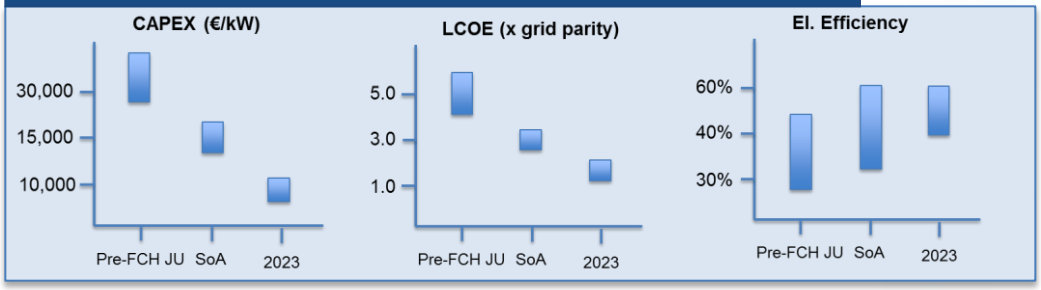
Technology neutral approach, however most support to Solide Oxide and PEM for both fuel cells and electrolyser applications

28 projects at TRL ≥ 3 for about 100 mill € ('Stationary Demo' type), mainly focusing on system integration and field demonstration (e.g. components development, including control systems; proof-of-concept; field demonstration of CHP and back-up power units)



Accomplishments
(examples of projects achievements)

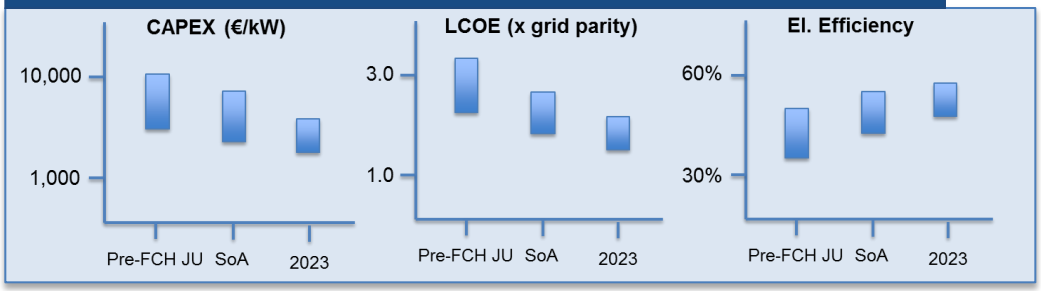
Residential Market Segment (< 5 kW)



ene.field project: more than 300 units installed in 10 countries of Europe, reliabilities confirmed, very good customer satisfaction (70% positive feedback),

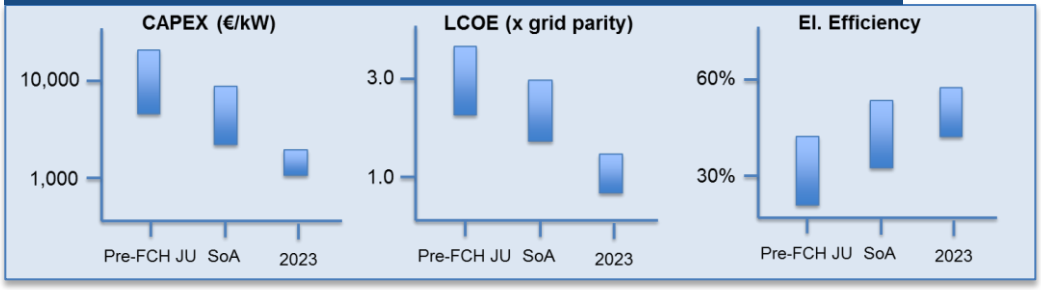
SOFT-PACT project: 65 fuel cell systems, electrical efficiency higher than 42 % over lifetime (total efficency higher than 78%), 25% cost reduction

Commercial Market Segment (5-400 kW)



SOFCOM project: proof-of-concept poly-generation SOFC systems fed by biogenous primary fuels (biogas and bio-syngas, locally produced), modular concept, cost driver identified → next step: upscaling to hundreds kW size (DEMOSOFC project)

Industrial Market Segment (0.3-XX MW)



POWER-UP project: first module of 40kW (out of 240 kW) in the field, 61% electrical efficiency (started Oct2015)

ClearGenDemo project: 1 MW PEM to be installed near Bordeaux, FR on by-product H2 from clori-alkali plant

DEMCOPEM-2MW project: 2 MW PEM (European technology) to be demonstrated in China

Sources: MAWP, Roland Berger Study, IBZ/Callux

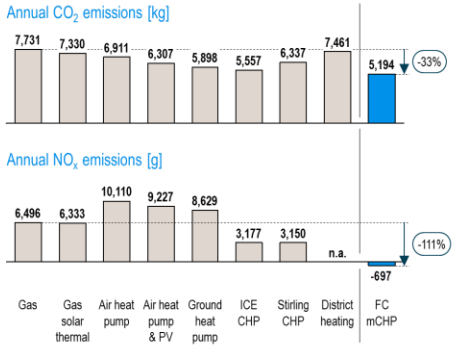
Developing targets/Studies

Roland Berger Study: ***Advancing Europe's energy systems: Stationary fuel cells in distributed generation***

- Industry coalition composed of more than 30 stakeholders – Results reflect common understanding
- The most comprehensive assessment of the commercialisation potential of stationary fuel cells in Europe (4 focus markets, 6 generic fuel cells, 35 years time horizon, 45 different use cases, >30 benchmark technologies, >3 energy scenarios, >34,000 resulting data points)

MUNICH

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



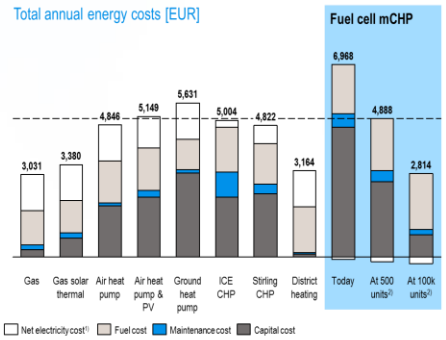
1) Considering the total annual balance of emissions attributable to the building, i.e. for power and heat consumption. Any power feed-in is thus credited with the primary energy equivalent.

Source: FCH JU Coalition, Roland Berger

MUNICH

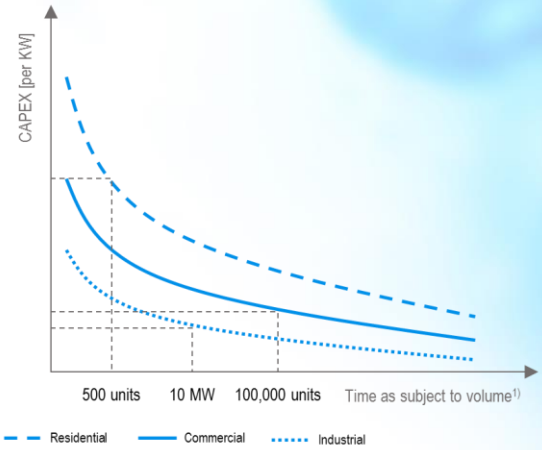
Fuel cell micro-CHP system

Electric capacity	1 kW_{el}
Thermal capacity	1.45 kW_{th}
Electric efficiency	36%
Thermal efficiency	52%
System lifetime	15 years
Required stack replacements	2



1) Negative electricity cost reflect higher earnings from power feed-in than residual purchase of grid power. 2) Cumulative production volume per company.

Source: FCH JU Coalition, Roland Berger



1) Cumulative production volume per company

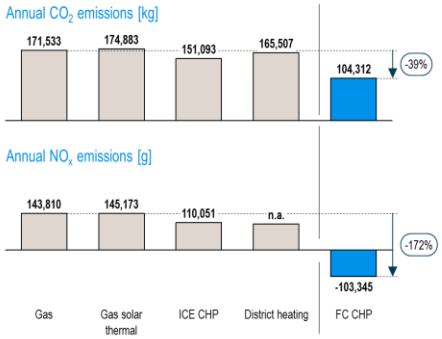
Source: FCH JU Coalition, Roland Berger

Today FC can reduce CO_2 emissions by more than 30%, while No_x emissions can be eliminated entirely; however, to become economically competitive, capital costs must be reduced substantially by increasing production volumes

Use-case specific environmental benchmarking¹⁾

MILAN

Heated space	6000 m²
Construction	1970
Total heat demand	477,000 kWh
Electricity demand	159,000 kWh
Central heating	yes



1) Considering the total annual balance of emissions attributable to the building, i.e. for power and heat consumption. Any power feed-in is thus credited with the primary energy equivalent.

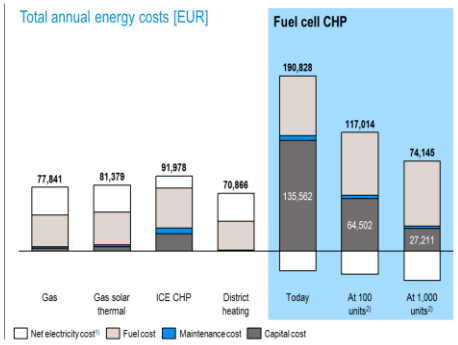
Source: FCH JU Coalition, Roland Berger

Use-case specific economic benchmarking¹⁾

MILAN

Fuel cell CHP system

Electric capacity	50 kW_{el}
Thermal capacity	40 kW_{th}
Electric efficiency	53%
Thermal efficiency	32%
System lifetime	10 years
Required stack replacements	2



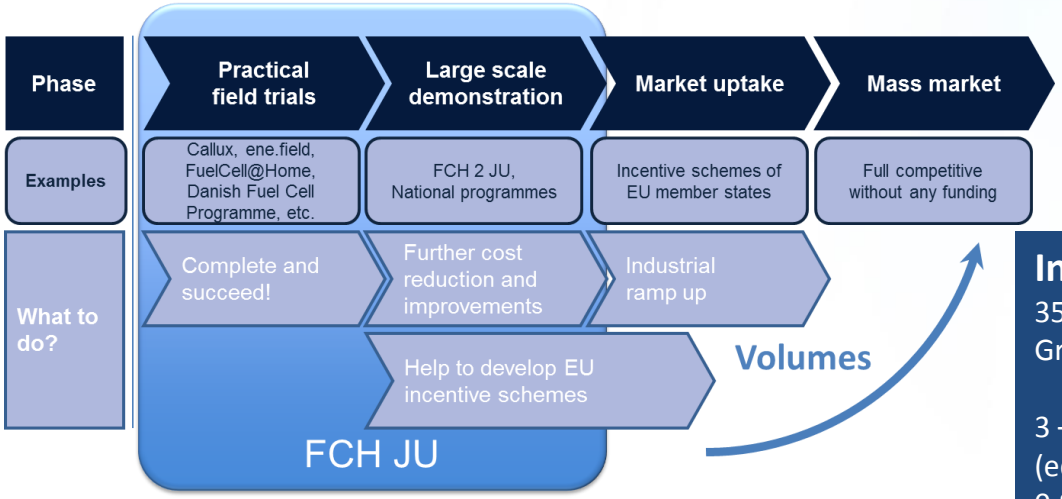
1) Negative electricity cost reflects higher earnings from feed-in than purchase of grid power. 2) Cumulative production per company.

Source: FCH JU Coalition, Roland Berger

Industry sees ambitious potential
(larger volumes allow for automation and bundled sourcing strategies, standardisation must increase within and across technology lines)

Industry is fully committed to decreasing cost with sufficient installation volumes !

Road-Map for 2020/2023



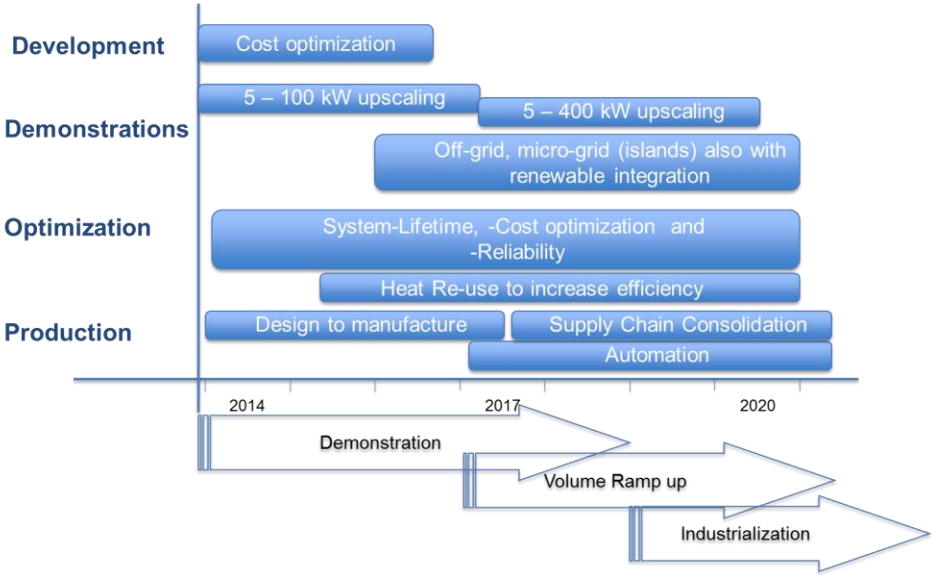
Market uptake needs to develop incentive schemes in parallel to large scale demonstration. This ensures a final and sustained take-up of initial funding.

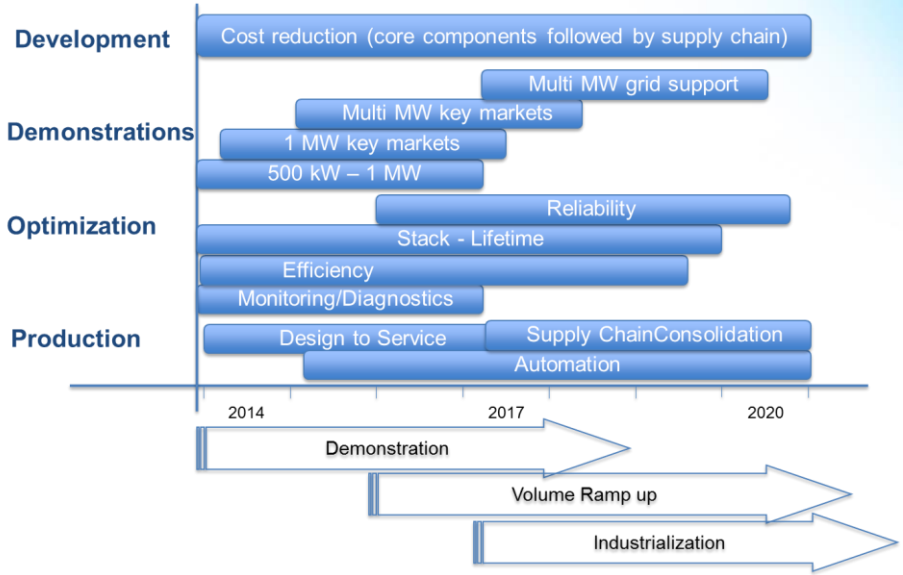
Industry Vision for Stationary Fuel Cells in 2023

350 MW – 2 GW installed capacity
Grid parity price of generated electricity

3 – 17 Mt/a less CO2 emissions
(equal to 1.6 - 8 million avoided car emissions)
0.8 – 4.6 Mt/a NOx emissions nearly eliminated

10,000 sustainable, green jobs created





Fuel Cells and Hydrogen Joint Undertaking Achievements

Hydrogen Packard car (1927) - Woikoski

Hybrid FC Buses

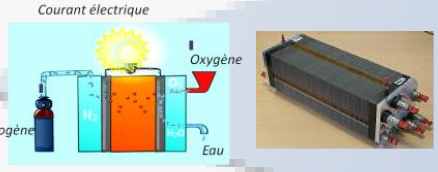
FCEV

FC in commercial planes

Marine & aerospace

Forklifts

FCEV RE



1995 2000 2005 2010 2015 2020

Backup power

Large scale stationary applications

Energy storage

CHP Systems

Portable applications

The scope of applications is widening with time

Thank you for your attention !

Further info :

- **FCH2 JU : http://www.fch.europa.eu/**
- **HYDROGEN EUROPE : www.hydrogeneurope.eu**
- **N.ERGHY : http://www.nerghy.eu**