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RESEARCH DAYS

15-16 NOVEMBER



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End-uses: Clean Heat & Power

Eleni Kontonasiou

Nikolaos Lymperopoulos, Antonio Aguilo Rullan, Dionisis Tsimis

Project Officers



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Parallel session

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15th Nov. 15:45 -17:15



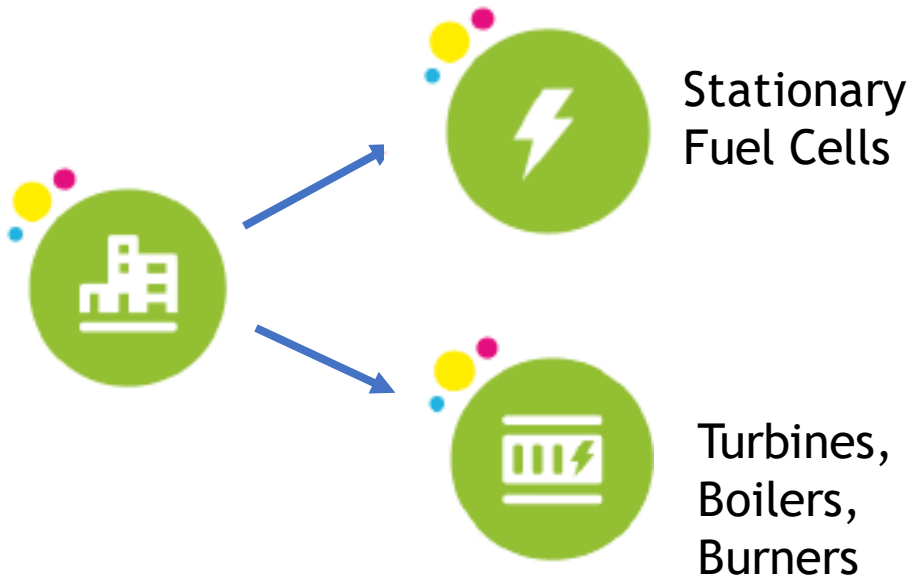
End-Uses: Clean Heat & Power
Eleni Kontonasiou



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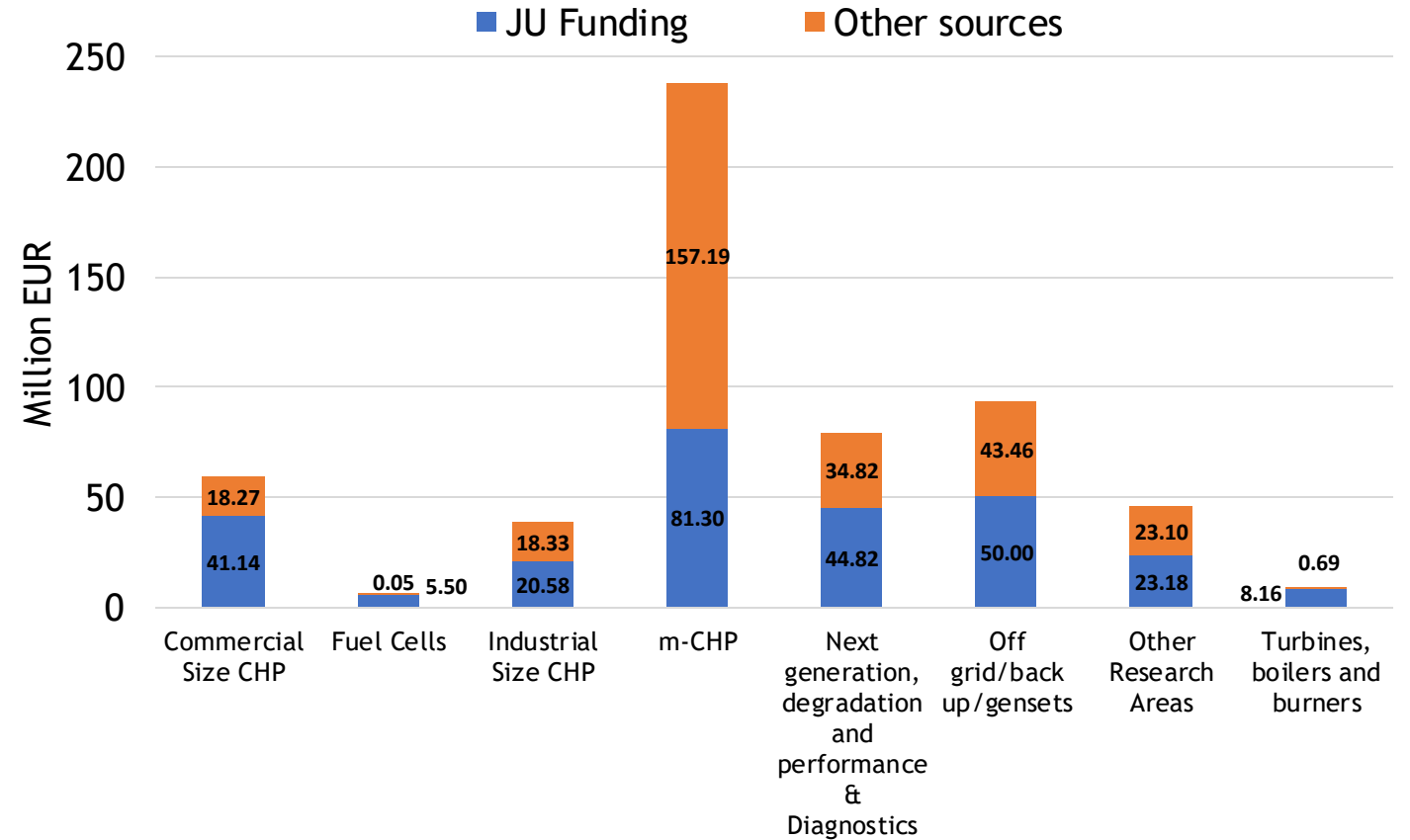
End uses: Clean Heat and Power



81 projects

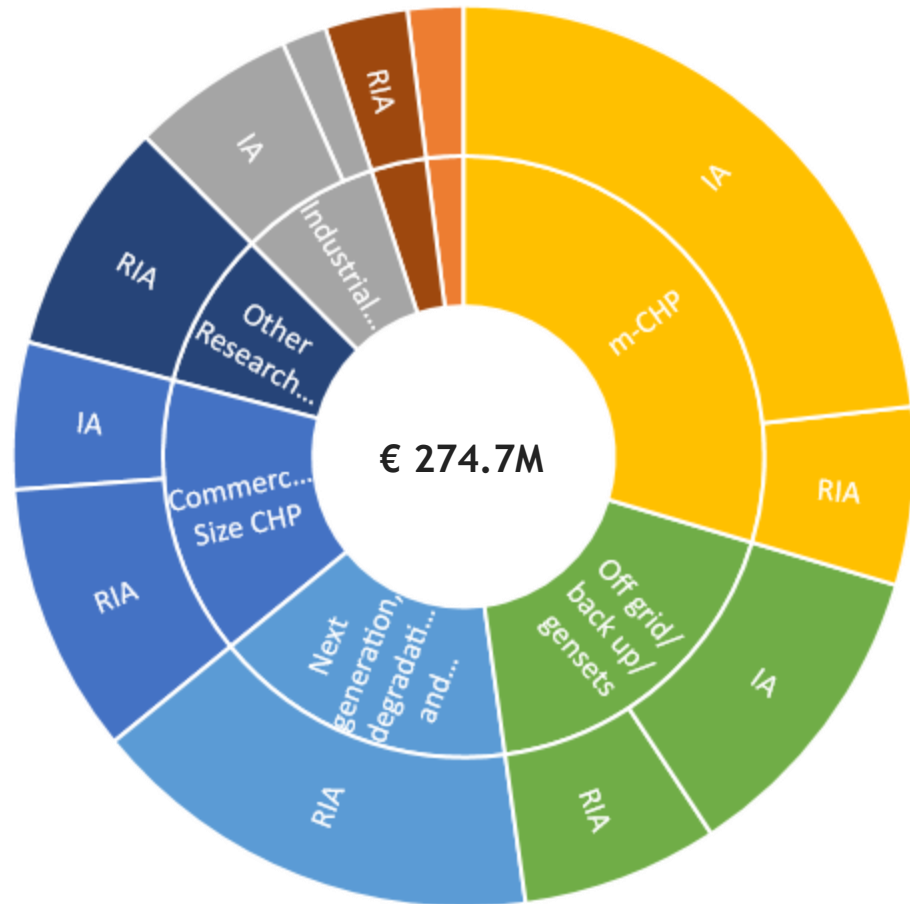
EUR 274.7 million

23% of the total JU funding

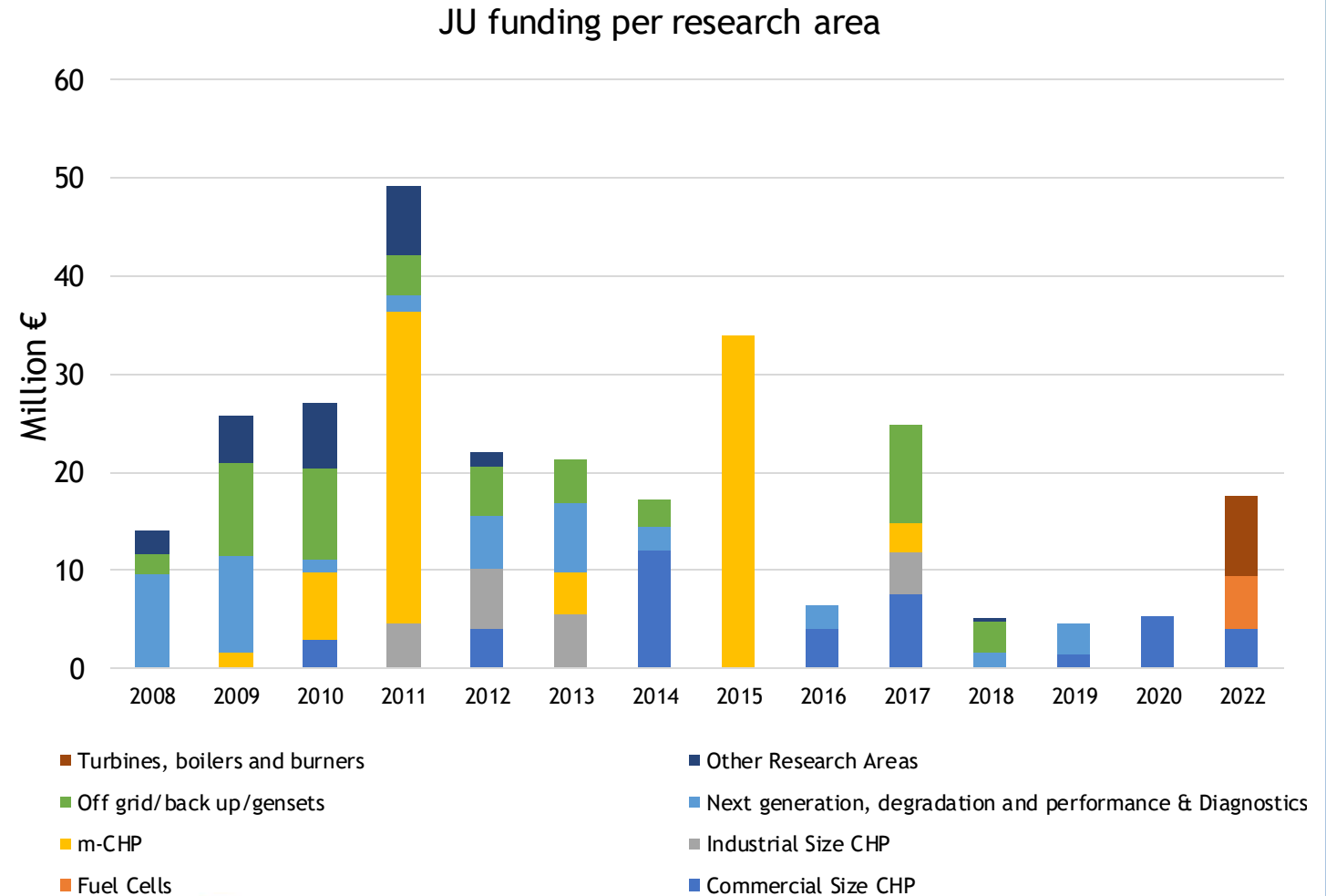


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End uses: Clean Heat and Power

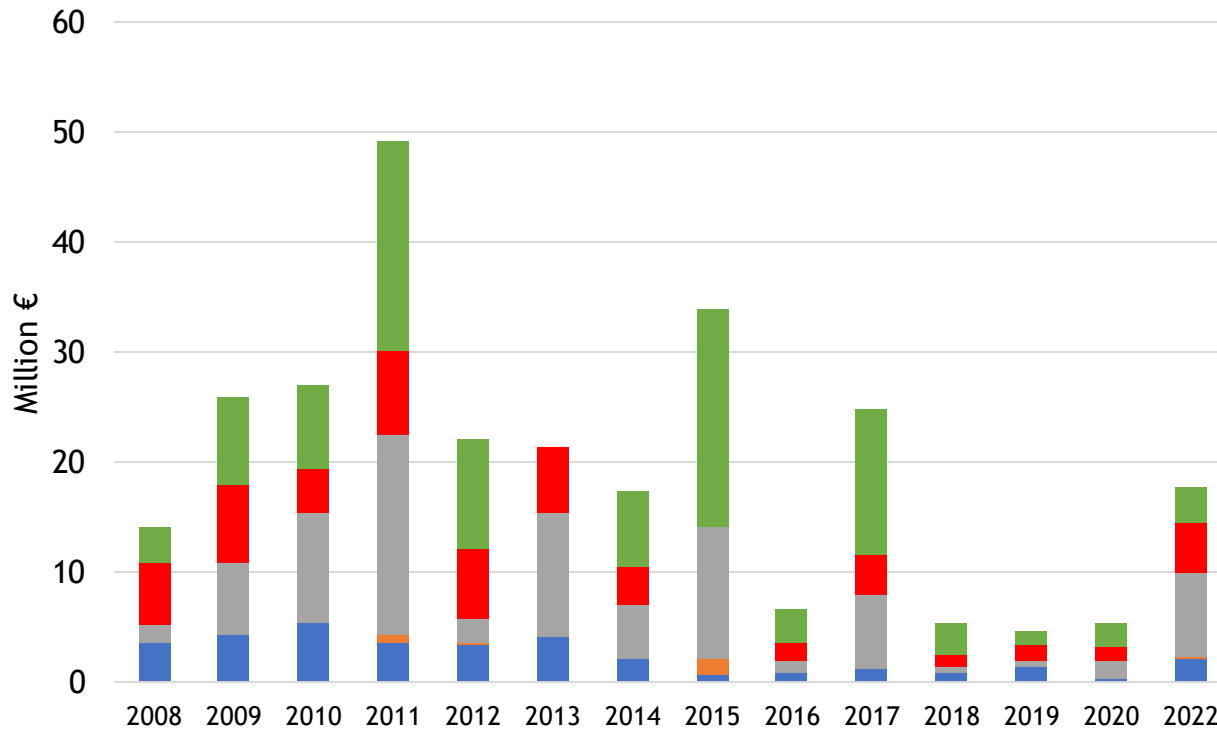


RIA: Research & Innovations Actions
IA: Innovation Actions

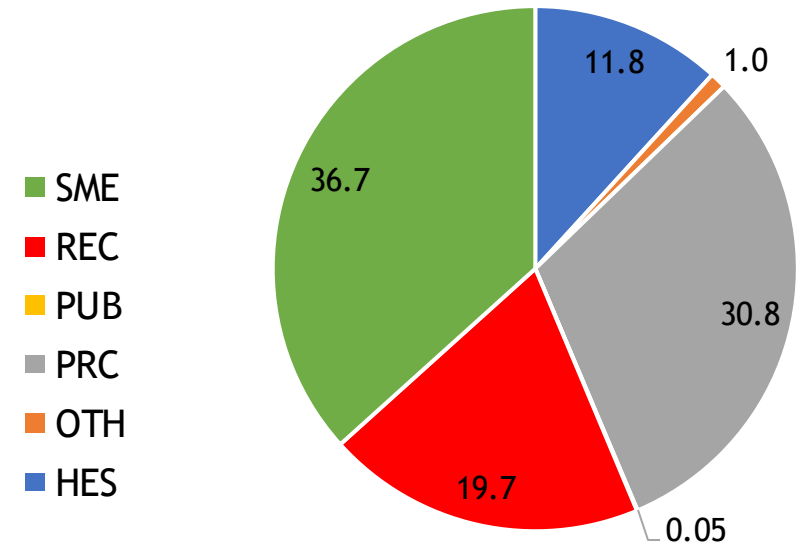


End uses: Clean Heat and Power

JU funding per type of Beneficiary



% of JU funding per type of beneficiary

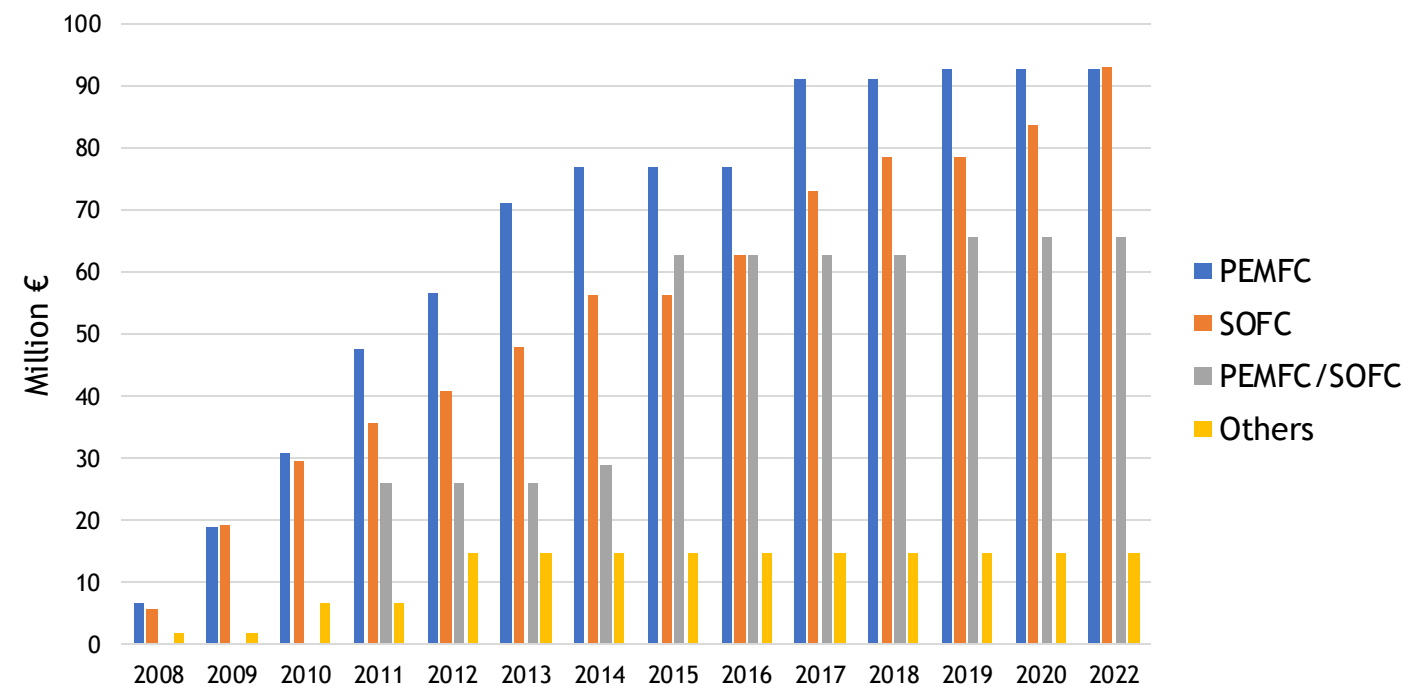


PRC: Private Companies
REC: Research Centres
PUB: Public Bodies
SME: Small Medium Enterprises
OTH: Others
HES: Higher Education Schools

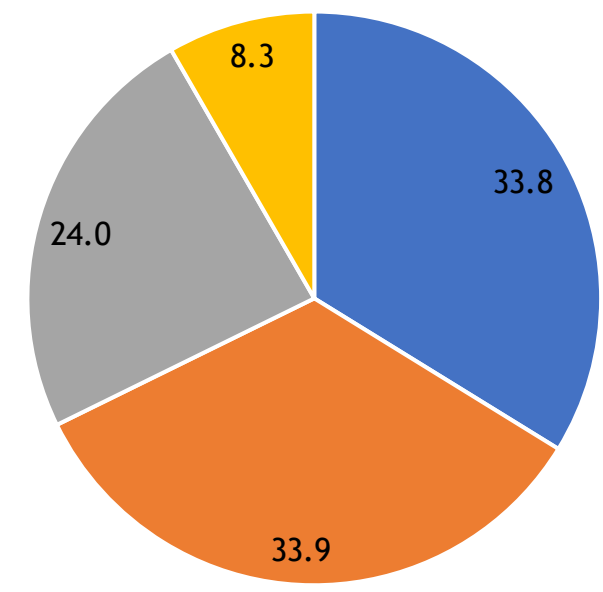
End uses: Clean Heat and Power

Focusing on SOFC and PEMFC

Cumulative JU funding per FC type



% of the JU funding per FC type



End uses: Clean Heat and Power

SOFC

CAPEX

- μ -SOFC
 - 10k €/kW (2020 target) achieved in the best cases
 - ⚠ 6k€/kW (2024 target) work needed
- Mid- and large-size SOFC
 - 10k €/kW (2020 target) achieved on project average
 - 5k€/kW (2024 target) is feasible

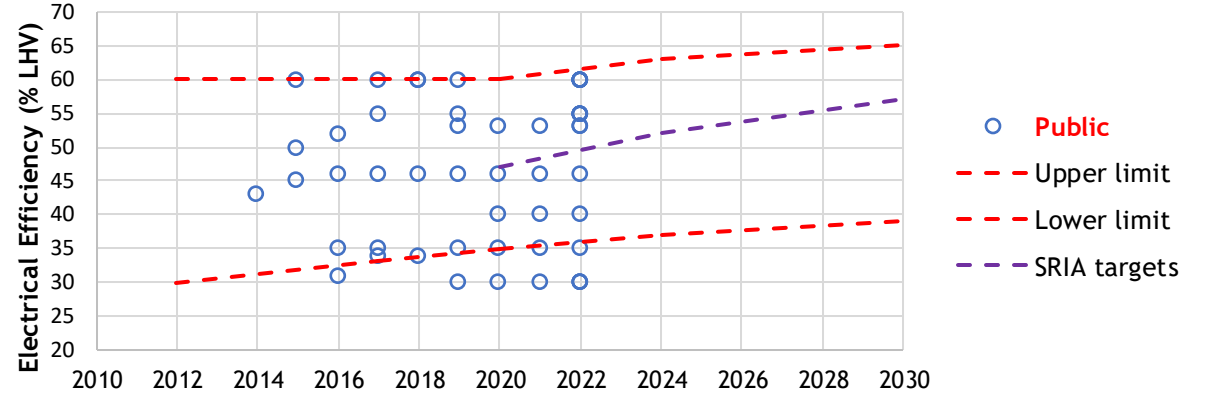
Electrical Efficiency

- 52 % (2024 target) already achieved in best cases

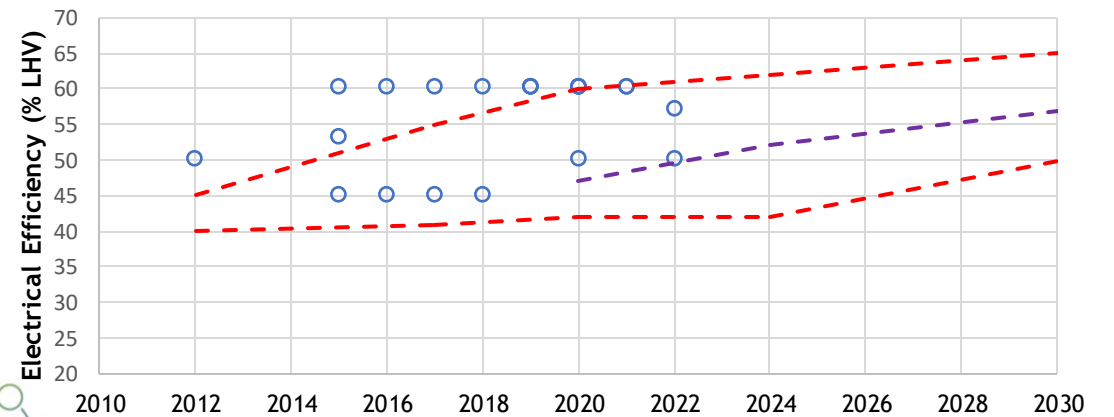
Availability

- 97% (2020 target)
- 99% (2024 target) achieved in the best cases

Electrical Efficiency - μ -SOFC



Electrical Efficiency - Mid-size SOFC



End uses: Clean Heat and Power

PEMFC

CAPEX

- μ -PEMFC
 - 7,5k €/kW (2020 target) achieved on project average
 - ⚠ 5k€/kW (2024 target) is feasible - work needed
- Mid- and large-size PEMFC
 - 7,5 k €/kW (2020 target) achieved on project average
 - ⚠ 1,8-1,2 k€/kW (2024 target) work needed

Electrical Efficiency

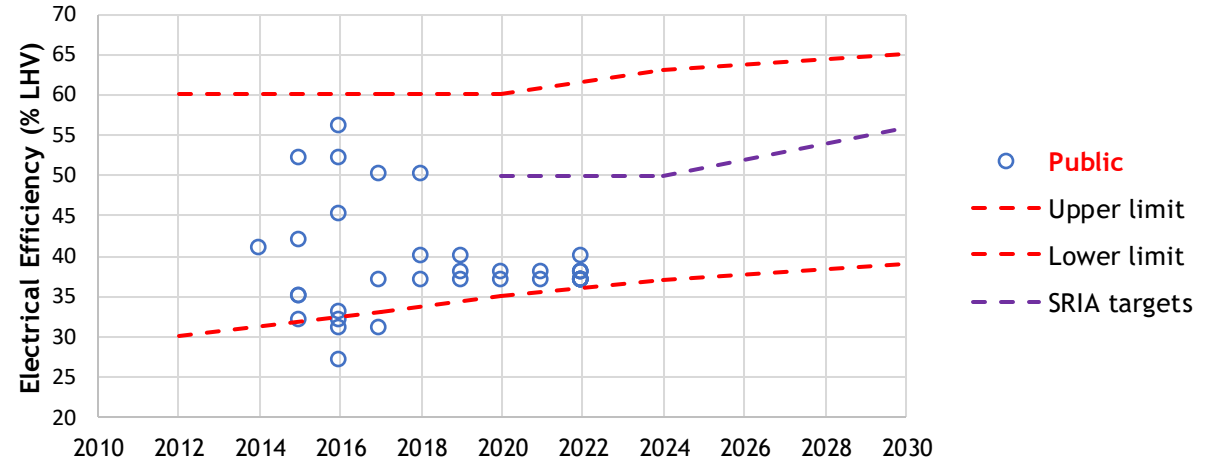
- 50% (2024 target) achieved on project average

Availability

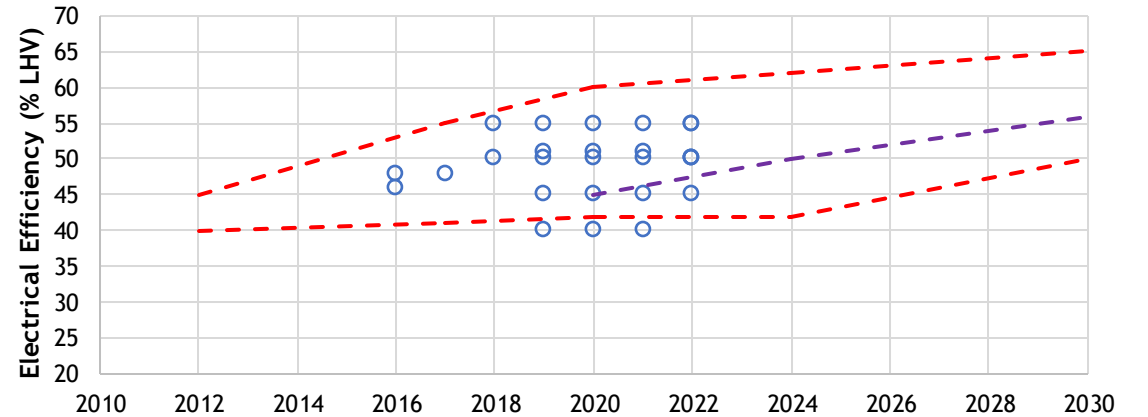
- 97% (2020 target) achieved
- 97-98% (2024 target) achieved



Electrical Efficiency - μ -PEM



Electrical Efficiency - Mid-size PEM



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Fuel cells for domestic heat and power

Europe market is in the order of 25,000s systems



Vitovvalor 300-
P,PA2 and SAZ

Sunfire-Home
750



>750	500
PEM & SOFC	SOFC
0.75kW	0.75kW
VIESSMANN	sunfire

Dachs 0.8 eLecta



200	300
PEM	PEM
0.75kW	0.75kW
BENTHERMA GROUP	SENERTEC
remeha	

BlueGEN

BlueGEN
BG15



750	
SOFC	SOFC
1.5kW	1.5kW
SOLID POWER	SOLID POWER

Buderus
Logapower
FC10.2

Buderus System
Logaplus



100	200
SOFC	SOFC
0.7kW	1.5kW
Buderus	Buderus

Complementary to heating system

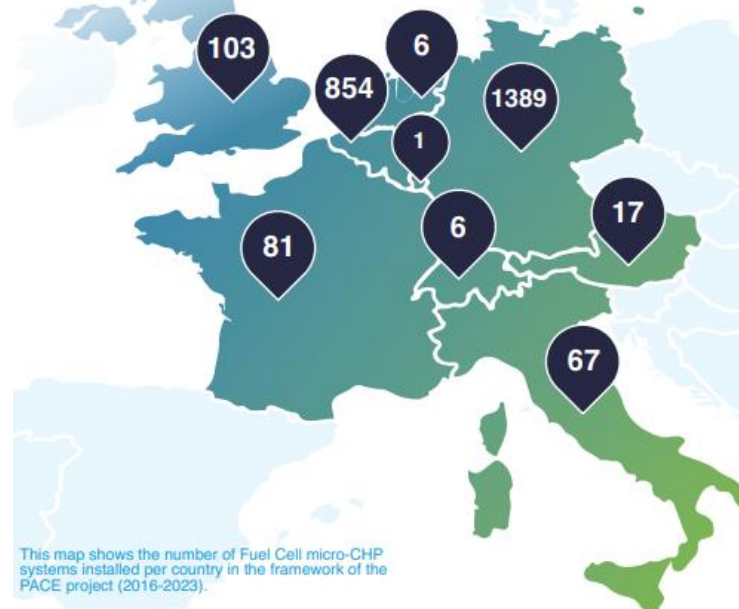
Replaces heating system

Clean Hydrogen
Partnership

PACE installations

2016-2023 | €90m | €34m | €56m
Project Duration | Total Budget | EU Funding | Industry Investment

2600 Fuel Cell Micro-CHP Units Installed | 3400 Installers Trained | 23m hours of operation | 24m kWh of electricity produced



This map shows the number of Fuel Cell micro-CHP systems installed per country in the framework of the PACE project (2016-2023).



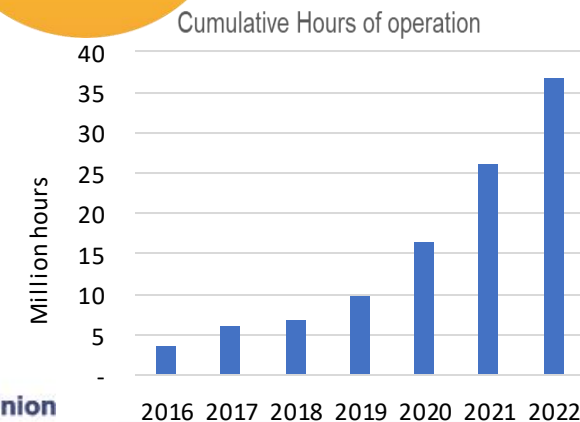
24 million kWh of electricity

SOFC
Av. El. Ef. ~53%
Av. Ther. Ef. ~35%

>3,400 installers trained

90% Customers satisfaction

97-99% availability



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Remote power with solid oxide fuel cells

Demo campaign: remote gas/oil infrastructure, telecom towers
Exporting European solutions abroad (North America)



RoRePower (2019-2023)



Remote power generation in harsh climate conditions (-40 to +50°C)

PROGRESS



✓ 36 units (400W - 1.5 kW) installed until 2022 (out of the 50)

✓ Electrical efficiency up to 53% η_e

✓ 5-10 years durability -> improvement expected

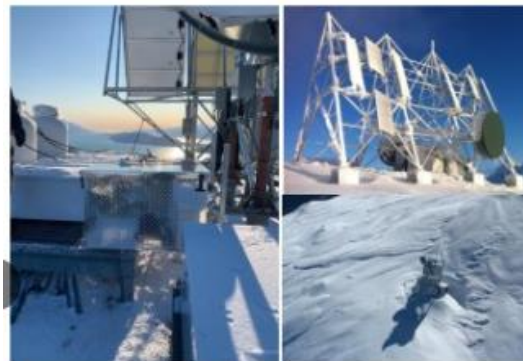
✓ Availability >97.5%

⚠ Maintenance frequency: 15 months

⚠ CAPEX reduction



Monitoring systems at German railway company



Telecommunications in Alaska

Autonomous

- 10,000 hours without proactive maintenance

Durable

- Runtime of up to 30,000 hours. The system only needs to be changed every 3 to 5 years.

Robust

- Operates at temperatures between -40 and +55°C

Easy

- Plug-and-play solution

Clean Hydrogen Partnership



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rorepower.com

Sunfire: 1st price in the Network Sustainability Award 2021



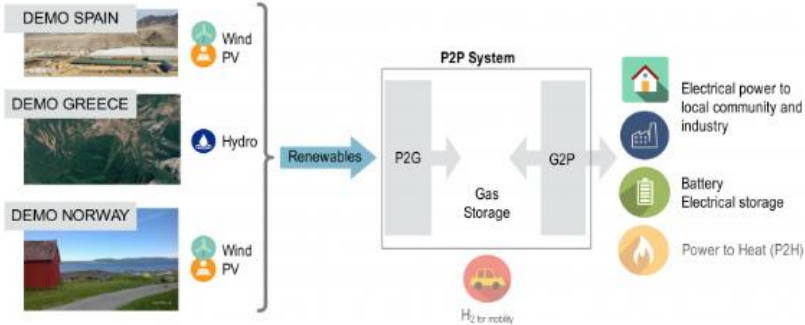
Power to Power for isolated micro-grid or off-grid remote areas

Fuel cells-based H₂ energy storage solutions

Renewable electricity either isolated micro-grids or off-grid remote areas



REMOTE (2018-2023)



Higher CAPEX, lower OPEX

Zero local air emissions

Alternative to diesel generation

Basis for next-generation P2P systems

✓ Agkistro, Greece (50 kW PEM FC, 25 kW ALK EL)

- Fuel cell: 181 hours, 45% system η_e
- H₂ production: 152 hrs, 10.8kg H₂/day @ 58% system η
- Availability: 99 % FC / 100% Electrolyser

✓ Rye, Norway (100 kW PEM FC, 50 kW PEM EL)

- Fuel Cell: 270 hrs., 61% system η
- H₂ production: 1206 hrs, 6.4kg H₂/day @ 44.% system η
- Availability: 98 % FC / 97 % Electrolyser

✓ Gran Canaria, Spain (100 kW PEM FC, 80 kW ALK EL)

- Wind & solar P2P (fuel cell + electrolyser + H₂ storage)
- Electricity supply for a milking facility, replacing diesel generation
- Grid extension restrictions, surrounded protected area



Agri-food processing plant, avoiding new transmission line



Supporting loads for a fish farm by integrating RES



Milking facilities

FC-based containerized transportable gensets in operation

Clean power generation for temporary events, demonstration activities have started (Festivals, construction sites, urban events, shore power)

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EVERYWH2ERE (2018-2023)



OBJECTIVES

4 x 25kW_e and 3 x 100 kW_e

5500 €/kW_e (CAPEX)

1.1 €/kWh (LCOE)

PROGRESS

6 gensets completed

100 kW_e Construction site in Spain, Moto GP Aragon Motorland, Port of Tenerife (next stop)

✓ 690h of operation; 89% availability; 55% electrical efficiency

25 kW_e: Hydrogen Energy Summit, Piramide of Cestius

✓ 67h of operation; 92.4% availability; 55% electrical efficiency

5500 €/kW_e (CAPEX), work in progress

Remote monitoring and control enabled

Noise emission <65dB

CONSTRUCTION SITE
DEMO, 100 kW_e



122 days demo period
86 site working days in such period
67 days genset available for operation
533 hours of effective operation
935 kWh supplied to construction site
247 kg of H₂ consumed



Clean
Partners

Euro
Hydrogen
Week

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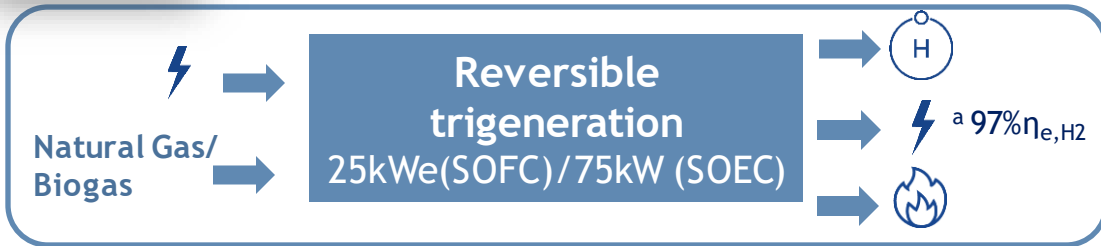
Offering flexibility to the energy system with Solid Oxide Cells

One of the objectives of the Clean Hydrogen partnership SRIA



SWITCH

SWITCH (2018-2024)



- +2100h tests
- Pilot testing phase
- 5 €/kg H₂ cost target
- 40 kg H₂/day (SOE)

^a H₂ production efficiency, SOEC mode, LSM using waste steam

Scalable and modular solution

Industrial, residential and grid services

Operation of SOFC at partial fuel conversion allowing the simultaneous production of hydrogen and electricity

- OBJECTIVES**
- Sustainability: 65% CO₂ reduction (vs conventional steam methane reforming)
 - Flexibility: multiple input, 2 operation modes
 - Efficiency: optimization of H₂ production
 - Security: H₂ supply in all operating and demand conditions

SRIA 03 - Improve flexibility with rFCS

AWP2022- rSOC system



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Towards next generation of fuel flexible, high performance and cost-effective fuel cells

Supporting European industry to keep leadership

Flexi-fuel stationary FC



- SOFC-based system for CHP production running on any mixture of natural gas, biogas and hydrogen
- Commercial kW_e SOFC on agro-biogas is prepared, as well as novel cryo-cleaning of biogas at 100m³/h scale
- 5 kW_e High-temperature methanol PEMFC built > 85% fuel processing efficiency achieved , prototype evaluation to start in Autumn 2023 / scale up 50-100 kW_e

Improving cost competitiveness of SOCs

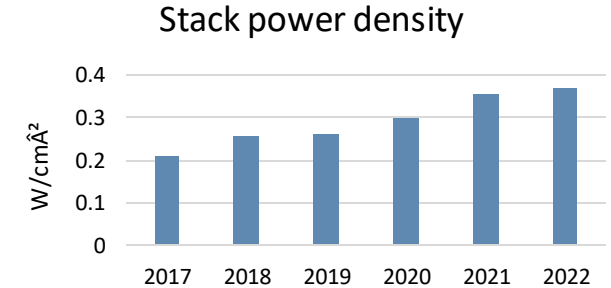
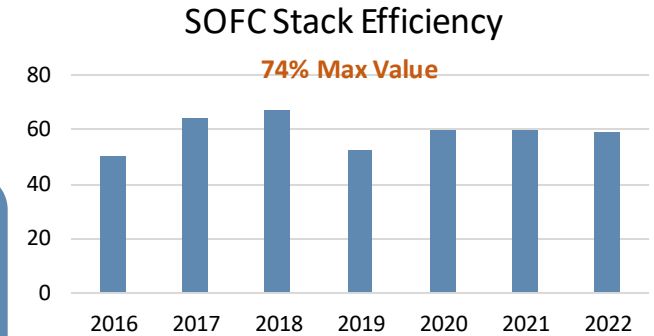


- Improved performance, durability, and cost competitiveness of SOCs
- Validation of large cells and short-stacks
 - Gathers EU Solid Oxide industry and research community

Advanced monitoring and control of FCs



- A new way to monitor and control fuel cell technologies by integrating hardware, stack diagnosis, control algorithms and fault detection algorithms
- Lifetime: 12 yrs (SOFC) and 15 yrs (PEMFC)



SRIA 02 - Next generation 0-100% H2 and H2-rich fuels

AWP 2022 - Ammonia Fuel Cells



HORIZON EUROPE

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AMPS - Automated Mass Production of SOC Stacks

- Automated high-speed cell and interconnect plate production with integrated quality control
- Assessment and demonstration of target stack manufacturing cost of <math><800 \text{ €}/\text{kW}</math> at production volume of 100 MW/year

AMON - Ammonia to Power

- A novel system for the utilization and conversion of ammonia into electric power at high efficiency using a solid oxide fuel cell system

24/7/ZEN

- Design and develop a high performing 33/100 kW scale rSOC power balancing plant and demonstrate its compatibility with the electricity and gas grids

Flex4H2 - Flexibility for Hydrogen

- Fuel-flexible combustion system capable of operation with any hydrogen concentration in natural gas, up to 100% H₂

Helios - Stable high hydrogen low NOx combustion in full scale gas turbine combustor at high firing temperatures

- Retrofit solution for hydrogen combustion in gas turbines

Clean Hydrogen
Partnership

European
Hydrogen
Week



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Conclusions

Supporting European actors to develop clean, renewable and flexible hydrogen-based heat and power generation solutions



Long term operation of units , +40,000 hrs. confirms performance of fuel cells for domestic applications, volume manufacturing needed to decrease costs further



SOFC generate power at 60% electrical efficiency, exporting EU technology abroad

Flexi-fuel fuel cell systems being developed (biogas, H₂, biofuels)

Reversible operation of Solid Oxide Cell tested



100 kW prototype representative of MW scale FCs have shown sound performances including at partial load, volume manufacturing ready



H₂ gensets being demonstrated across Europe

SOFC for remote power in harsh conditions proven, exporting EU technology abroad



Support in the period 2021-2027 extended to gas turbines and H₂ for heat

Preparing 0-100% H₂ gas turbines whilst keeping low emission, high efficiencies and flexible operation



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