DEMOSOFC

FCH2-JU PROJECT

high efficiency
electrochemical system
for energy

BIOGAS FED FUEL CELL SYSTEMS FOR INDUSTRIAL APPLICATIONS

DEMOSOFC: presentation of the project

Prof. Massimo Santarelli, Politecnico di Torino
Project Manager

Torino, September 24th, 2015

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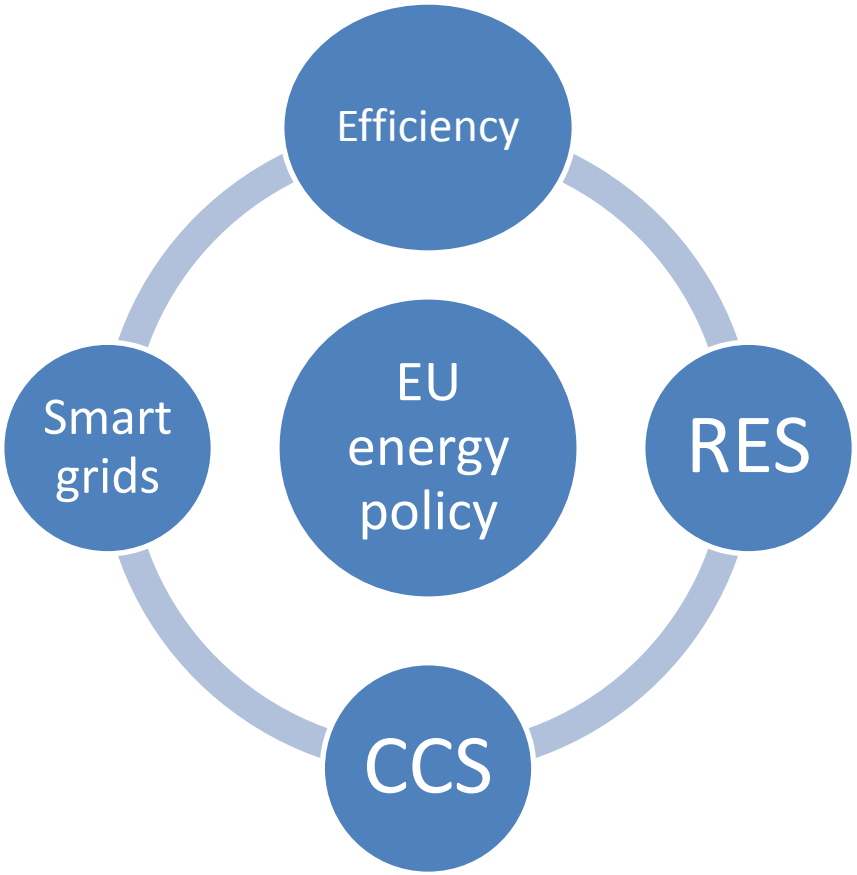
Energy Context: EU

From the point of view of energy policy, the **European Strategic Energy Technology (SET) Plan for 2020** identifies Strategic Technologies Focus on the following priorities:

- **Energy Efficiency**: **high efficiency conversion devices** represent elements of a higher efficiency portfolio
- **Renewable Energy**: traditional RES (solar, wind, hydro) but also biogenous fuels (**biogas**, bio-syngas, bio-fuels) and new synthetic vectors (H2, synthetic NG,….)
- **Carbon capture and storage**: mitigation of CO2 emissions (related to **efficient energy conversion devices**, and improved adoption of **RES fuels**) and CO2 recovery and re-use
- **Smart Grid**: wide topic, in which several technologies are included (energy storage, ICT intelligence, prosumer, **distributed CHP plants**, …)

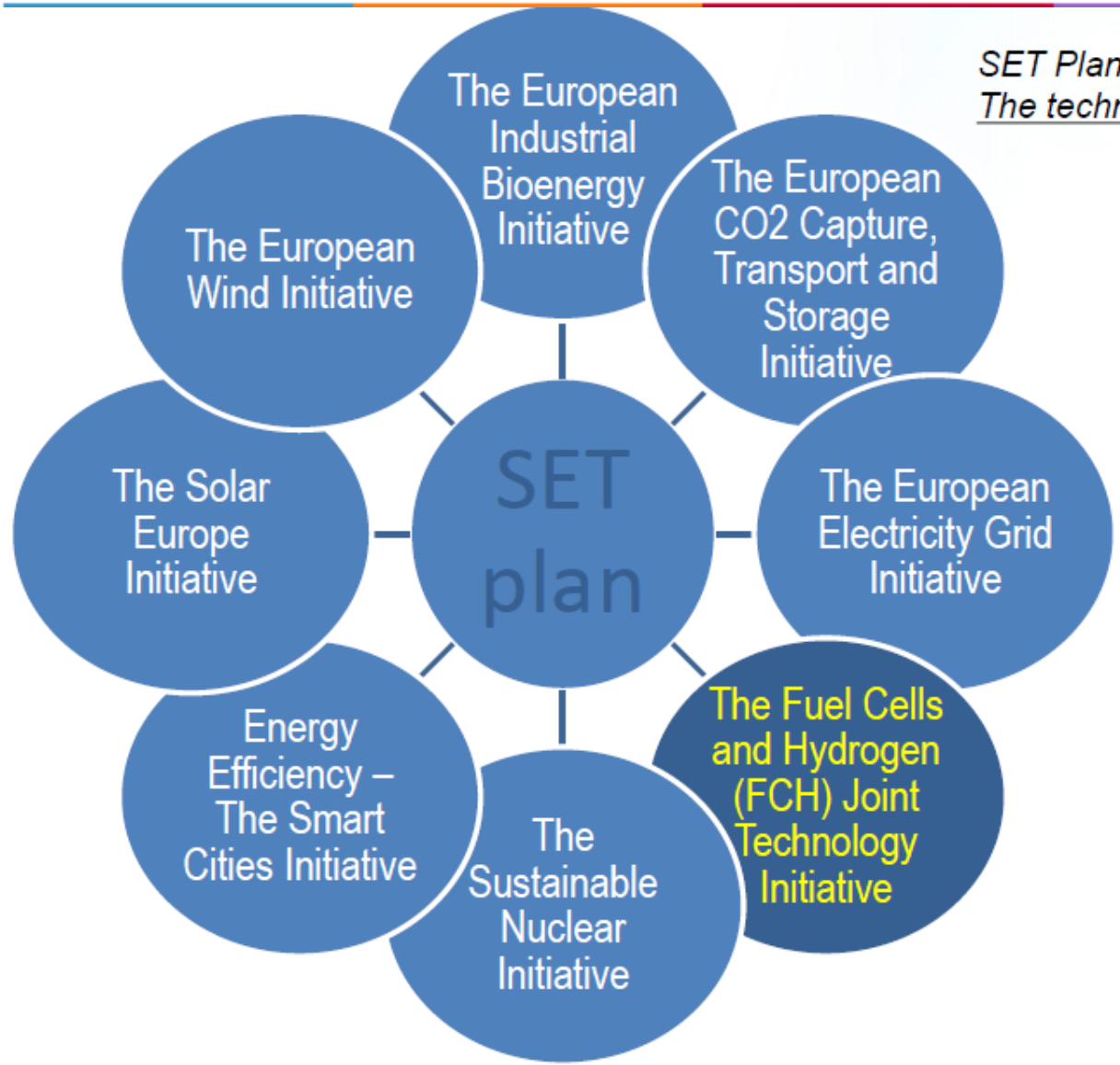


European Commission Communication (2010) "EUROPE 2020 A strategy for smart, sustainable and inclusive growth".
European Commission Communication (2011) "Energy Roadmap 2050".

Introduction: needs and innovation

- **Distributed CHP** with **high energy efficiency** exploiting **CO2 neutral fuels** for industrial and commercial applications.
- In this context: urgency for the adoption of **innovative energy systems** with significantly **higher efficiency** and **lower emissions**: **electrochemical systems** – in particular high temperature fuel cell systems (e.g., **SOFC**) – represent the **best option especially at the sub-MW scale**.
- Then: **need for increasing market opportunities for the SOFC** leading toward final market acceptance. This can be accomplished through **field demonstration that aims to show the high energy and environmental advantages of the SOFC** to both the broader energy community as well as decision makers who are willing to support sustainable technologies.

Introduction: the EU strategy



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.€

DEMOSOFC: some figures

Proposal full title:	**DEMOnstration of large SOFC system fed with biogas from WWTP**
Proposal acronym:	DEMOSOFC
Call:	FCH2 JU CALL FOR PROPOSALS 2014
Topic:	FCH-02.11-2014: Large scale fuel cell power plant demonstration in industrial/commercial market segments

Grant agreement no: 671470

Project Coordinator: Prof. Massimo SANTARELLI (Energy Department, Politecnico di Torino)

Start 01/09/2015 **End** 31/08/2020

Total Budget: 5'905'336 € **EU Contribution**: 4'492'562 €

DEMOSOFC: Consortium

Participant No *	Participant organisation name	Country
1 (Coordinator)	POLITO	Italy
2	CONVION	Finland
3	SMAT (+ linked Third Party RISORSE IDRICHE spa)	Italy
4	VTT	Finland
5	IMPERIAL COLLEGE	United Kingdom

DEMOSOFC: Energy Concept

Collegno city

Waste Water

SMAT Collegno Waste Water Treatment Plant

- Service for the municipality: waste water treatment
- Residual sludges from water treament are converted in biogas (sub-product)

Clean Water

Biogas

Electricity

Heat

3 Convion SOFC modules

- High efficiency electricity production (> 53%)
- Heat recovery, required for the anaerobic digestion
- Zero emissions to atmosphere (no NOx, SOx, VOC...)
- 100% modular system

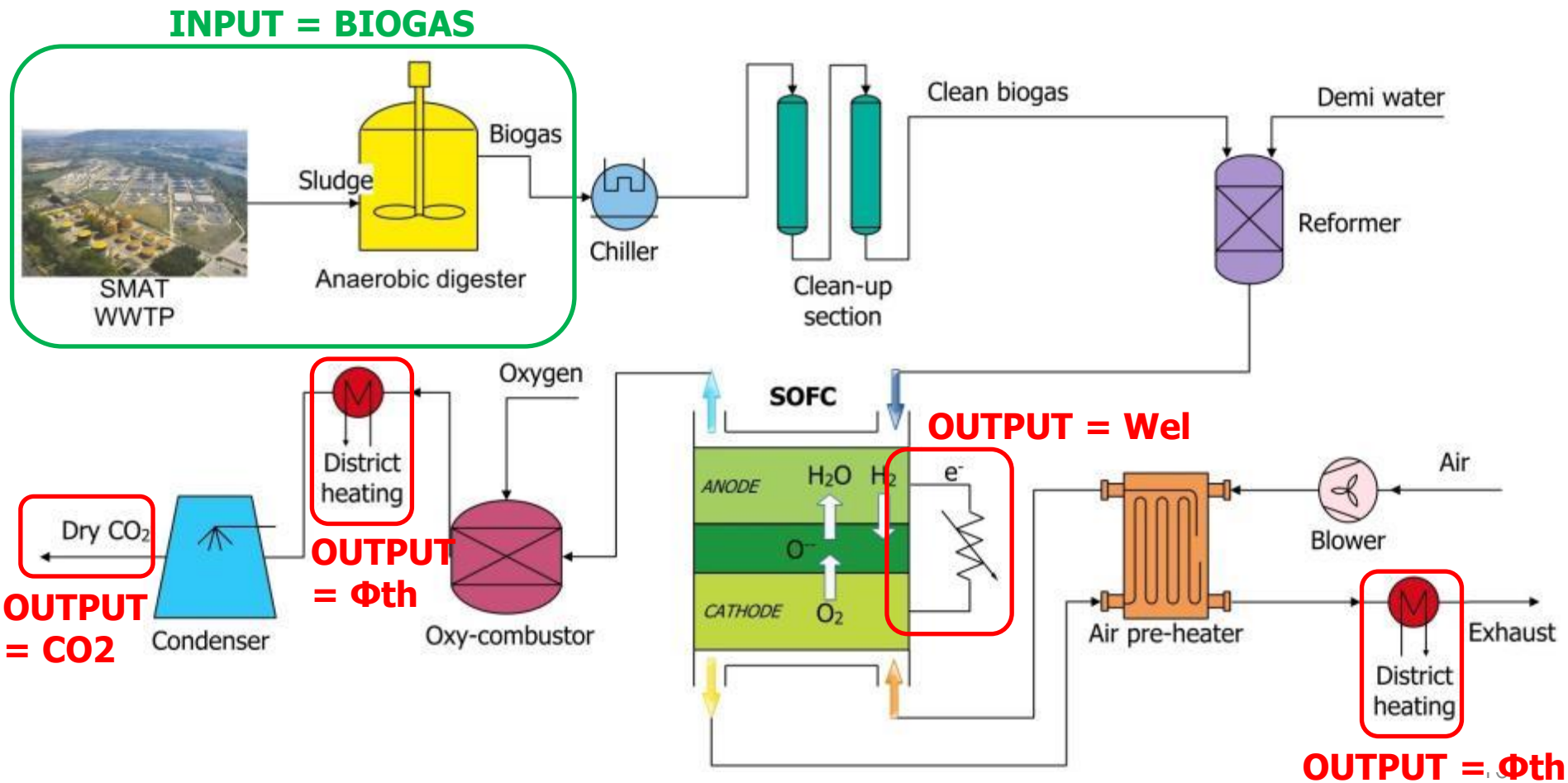
DEMOSOFC: Objectives

- **DEMO**: design, engineering, installation of a medium-scale (**174 kW_e**) distributed CHP system based on SOFC and fed with locally available biogas produced in an industrial-scale waste water treatment plant (WWTP).
- **DEMO**: self-consumption in the WWTP of the electric power produced by the SOFC system (distributed power generation with local use of power); full thermal recovery from the SOFC system (**89 kW_{th}**) to serve the thermal loads of the WWTP (optimization of CHP concept).
- **DEMO**: management on the long run, maintenance experience: all in a real industrial context.
- **ANALYSIS**: energy and environmental analysis: high interest for the society in terms of resources and emissions.
- **EXPLOITATION**: exploitation and business analysis – high economic interest for the energy market.
- **DISSEMINATION**: strong dissemination for public awareness.

DEMOSOFC: SMAT WWTP in Collegno (Torino, IT)

DEMOSOFC: follow-up of positive experience

Proof-of-Concept: SOFCOM Demo Layout - 1

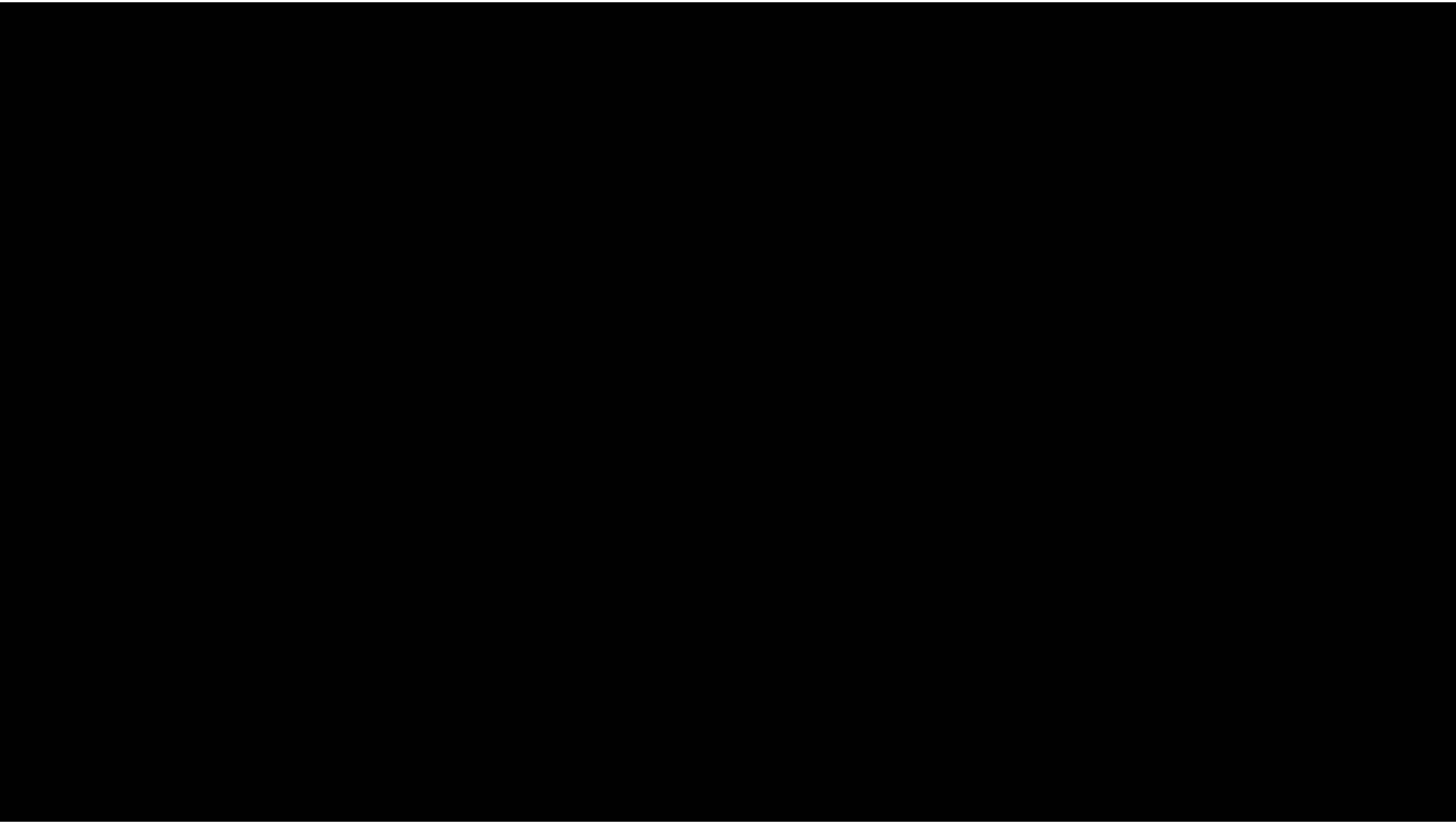


DEMOSOFC: follow-up of positive experience

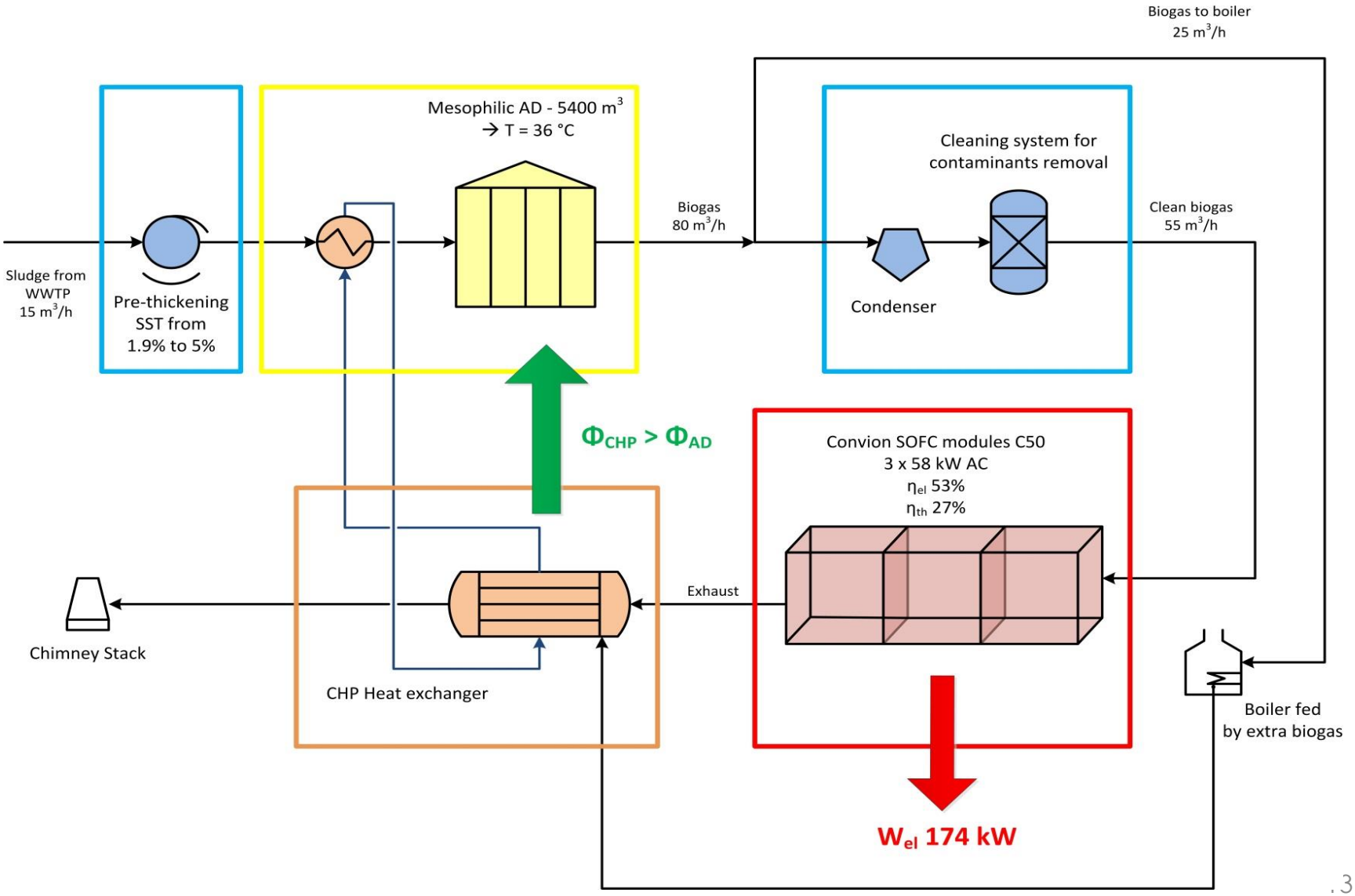
SOFCOM Demonstration Plant

SOFCOM Demonstration plant

DEMOSOFC: follow-up of positive experience



DEMOSOFC: complete plant



DEMOSOFC: advantages of SOFC plants: efficiency

Sub-MW size (distributed CHP)

	Micro Gas Turbine	Internal Combustion Engine	Solid Oxide Fuel Cell
Electrical efficiency	28.0%	38.5%	53%
Thermal efficiency	45.9%	23.3%	27% (37% with further cooling)
Total efficiency	74%	62%	80% (90% with further cooling)
CO_2 emission [gCO_2/kWh_e] with the system fed by NG	798	580	422

DEMOSOFC: advantages of SOFC plants: emissions

Sub-MW size (distributed CHP)

Contaminant	Emissions with ICE fed by biogas	Emissions with SOFC fed by biogas
Total PM	2.31 mg/Nm^3	-
NO_x	443 mg/Nm^3	< 1.23 mg/Nm^3
SO_x	25.8 mg/Nm^3	negligible
CO	353 mg/Nm^3	< 12.31 mg/Nm^3
H_2S	< 0.2 mg/Nm^3	-
VOC	659 mg/Nm^3	< 2.46 mg/Nm^3
HCl	0.38 mg/Nm^3	-
HF	< 0.2 mg/Nm^3	-

DEMOSOFC: Impacts

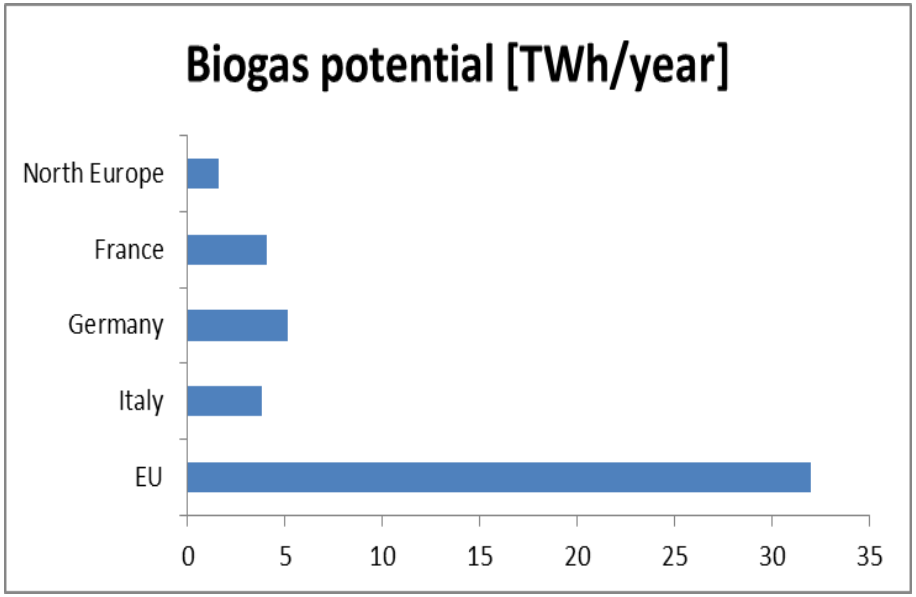
Reduction of the use of primary energy by (a) Electrical efficiency > 45% ; (b) Total efficiency > 70% (heat cycle: 45°C/30°C)

Supplier and user experience of design, engineering, installation/commissioning and operation of distributed power generation

Building and validating references to build trust among the stakeholders

Enable active participation of consumers in order to bring the fuel cells technology closer to their daily business

DEMOSOFC: Business Perspective



WASTEWATER	Electrical potential [TWh/year]	Thermal potential [TWh/year]
EU	16.933	10.224
North Europe	0.854	0.516
Germany	2.736	1.652
France	2.140	1.292
Italy	2.022	1.221

Reduction of cost of SOFC technology

		SoA	KPI	KPI	KPI
		2014	2017	2020	2023
CAPEX	€/kW	6’000 – 10’000	5’000 – 8’500	4’500 – 7’000	3’500 – 6’500

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Thanks a lot! Questions?

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