SOFCOM
(278798)

Massimo Santarelli
Politecnico di Torino (Italy)
http://areeweb.polito.it/ricerca/sofcom/en/

PROJECT OVERVIEW

- SOFC CCHP with poly-fuel: operation and management
- SP1-JTI-FCH.2010.3.4 - Proof-of-concept and validation of integrated fuel cell systems
- START 01/11/2011 – END 30/04/2015 (6 months extension)
- Total Budget: **€ 6,261,369.84** Project funding: **€ 2,937,758.10**

- SOFCOM: demonstration project devoted to **poly-generation systems** based on SOFC fed by biogenous primary fuels (biogas and bio-syngas, locally produced) integrated with a process for the CO2 separation and Carbon reutilization.
- Stage of implementation: 100% project duration passed, but 6 months extension for full demonstration

PROJECT TARGETS AND ACHIEVEMENTS

PROOF-OF-CONCEPT OF FC-BASED POLY-GENERATION SYSTEM

Two **CLEANING VESSELS**:
- H_2S removal
  => ZnO
- Siloxanes removal
  => Activared Carbon
- 14 SLPM biogas

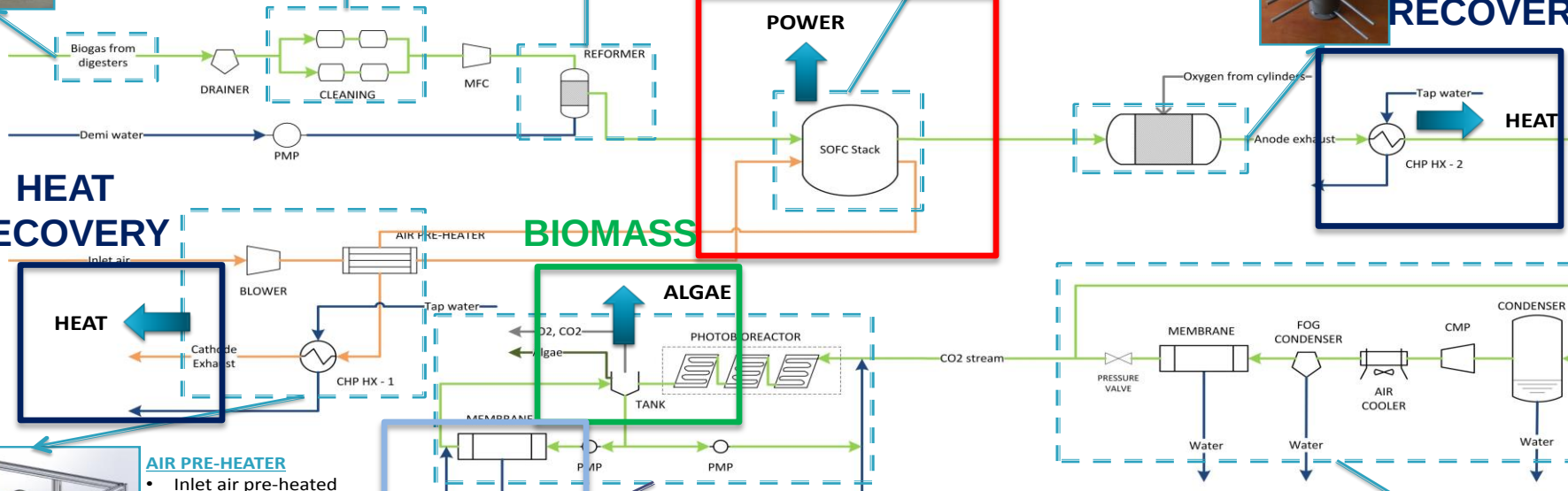
FUEL PROCESSING UNIT
- Steam reforming (demi water from demineralizer)
- Evaporator Mixer
- Reformer (S/C = 2)
- Reformer Temp. = 750 °C

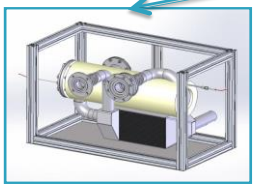
SOFC Stack
- 2 kWe
- 90 cells, 3YSZ
- SOFC Temp = 800 °C.
- Inlet fuel Temp = 750 °C.
- Inlet air Temp = 650 °C.

BIOGAS from SMAT digesters fed by secondary treatment sludges of the WWTP.
Biogas:
60% CH_4 – 40% CO_2

ELECTRIC POWER

HEAT RECOVERY





AIR PRE-HEATER
- Inlet air pre-heated through a mixed exhaust recuperator/electrical heater.
- Cathode exhaust used for CHP (water heating).

WASTE WATER TREATMENT VIA ALGAE GROWTH
3 PBR modules (9 m²)
Algae production 8 g_{dry}/h
Outlet streams:
- Treated water (reduced N/P compounds)
- Algae (to digesters)

CO_2 SEPARATION UNIT
- Water condenser
- Compressor up to 5 bar
- Pressurized membrane stage => H_2O < 500 ppm

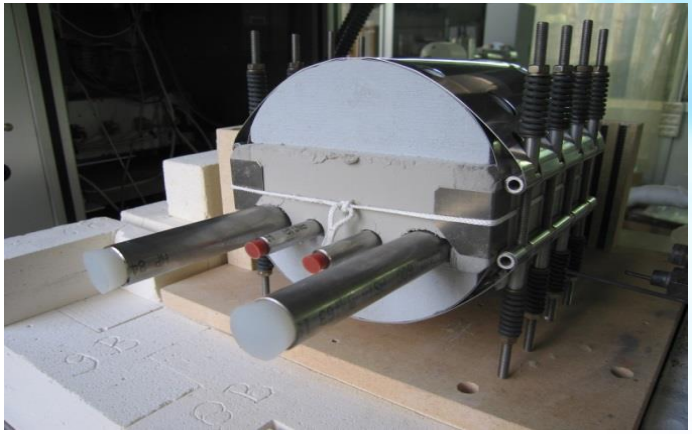
PROJECT TARGETS AND ACHIEVEMENTS

Proof-of-concept SOFC-based poly-generation system (biogas - SOFC CHP – C recovery – waste water cleaning): designed, built, tested indoor

DEMO in real WWTP industrial site for 6 months: end @ April 30th, 2015

SOFCOM - The movie

PROJECT TARGETS AND ACHIEVEMENTS



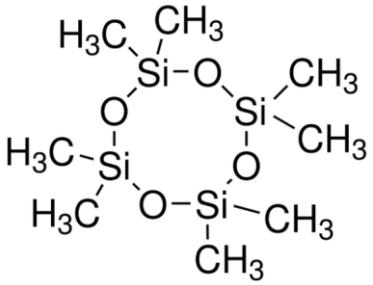
- SOFC stack fed with lean fuel (syngas simulating biomass gasification): complete characterization
- Analysis of halogens (HCl, C2CL4), siloxanes (D4, L4) and combined effects

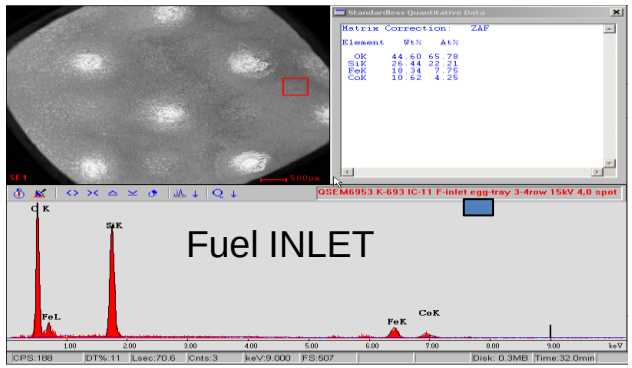
PROJECT TARGETS AND ACHIEVEMENTS

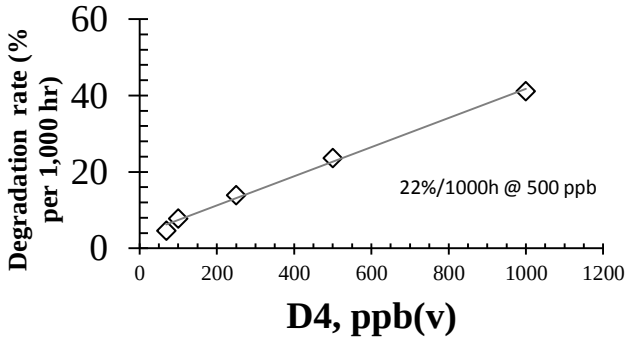
Status before project	AIP target	Project Target	Current status/achievements	Expected final achievement
Few proof-of-concept installations in real industrial context with EU technology. No poly-generation concepts and demo based on fuel cells.	Proof of concept prototypes that combine fuel cell units into complete systems	SOFCOM develops two proof-of-concept demonstration plants: Torino (SOFC+biogas+ CO2 recovery+H2O cleaning) Helsinki (SOFC+syngas)	DEMO 2 Helsinki (FI): done. DEMO 1 Torino (IT): in-house testing done; in-field activity from October 2014.	Complete demo of FC-based poly.generation system (SOFC+biogas+ CO2 recovery+H2O cleaning) by April 2015.

PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target	Project Target	Current status/achievements	Expected final achievement
No full analysis of biogas behaviour in SOFC stack and BoP	Identification of technical requirements	Preliminary lab-scale experimental analysis, fuel production; fuel cleaning; fuel processing; SOFC; carbon capturing modules	Analysis of biogas contaminants (siloxanes, halogens, VOC, sulphur) Analysis of CO2 recovery steps	Technical needs for biogas-to-SOFC real plants. Technical needs for CO2 recovery from SOFC-based plants





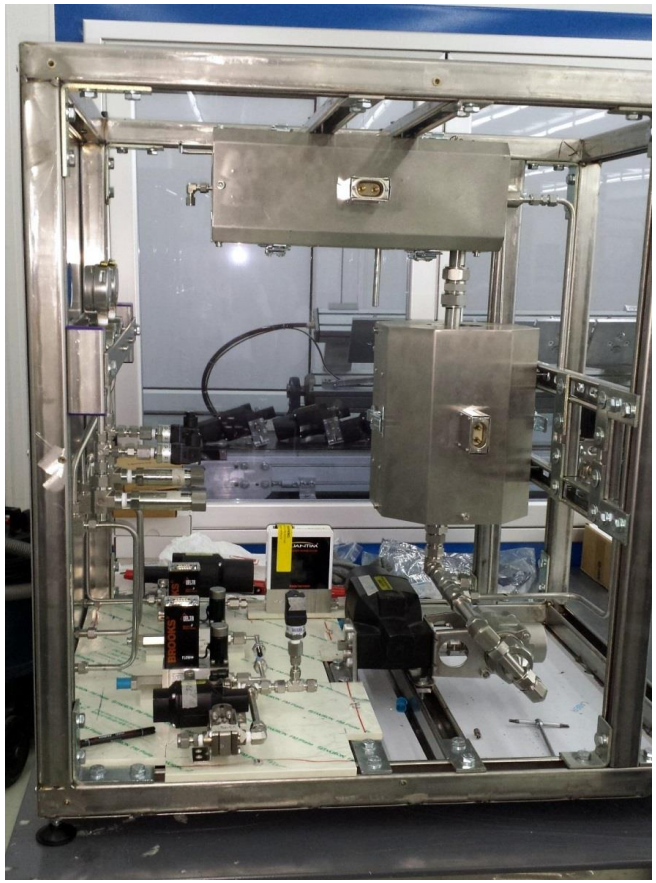


PROJECT TARGETS AND ACHIEVEMENTS

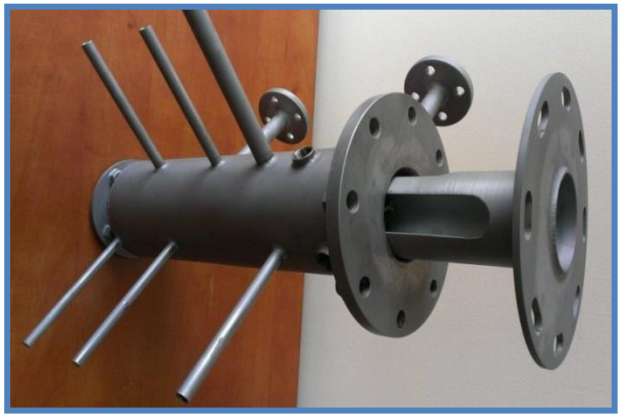
Status before project	AIP target	Project Target	Current status/achievements	Expected final achievement
No complete technical and economic analysis of installation of a siginficant FC-based CHP plant in real industrial context	Validation of the whole system built, costs targets, including life-cycle considerations and integration into power plants and networks	Validation achieved through scale-up design, life-cycle and economic assessments	Complete scale-up analysis. Complete scale-up design. Complete life-cycle analysis. Complete analysis of business case.	Scale-up FC-based CHP plant in a real industrial context.

RISKS AND MITIGATION

- DEMO of proof-of-concept SOFC-based poly-generation system (biogas - SOFC CHP – C recovery – waste water cleaning)



  - Real demo
  - Design and control of hot components: biogas reformer and anode exhaust oxy-combustor



RISKS AND MITIGATION

- DEMO of proof-of-concept SOFC-based poly-generation system (biogas - SOFC CHP – C recovery – waste water cleaning)
  - New design of reforming section; adoption of lean auto-thermal reforming solution (lean O2 injection)
  - Improved control of oxy-combustion operation (O2 injection, procedure of spark ignition, exhaust control)

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

FCH and FP projects	Description of complementarity, nature of interaction and/or joint activities (if any)
ENEFIELD "European-wide field trials for residential fuel cell micro-CHP" (FCH JU 2011)	Data on SOFC performances and reliability, installation requirements. Collaboration in the RC&S topics
BIOALMA "Biofuels from Algae" (National Italian, 2011)	Algae and photo-bio-reactors (DEMO 1 Torino)
PRIN 2009 "Experimental use of syngas from coal and biomass to feed SOFC systems integrated with CO2 separation processes" (National Italian, 2011)	Biogenous gas-fed SOFC: cleaning, processing, degradation issues. Technologies and processes for CO2 separation from anode exhausts
OZ-BOX "Design of Balance of Plant of an integrated SOFC stack" (National Italian, 2011)	All issues connected to requirements of real installation of a SOFC system with related BoP

Name of programme and/or projects	Countries involved	Description of complementarity, nature of interaction and/or joint activities (if any)
NFCRC (Irvine, US) for Orange County Sanitation District	Italy, US	Collaboration with National Fuel Cell Research Center (NFCRC) and Advanced Power and Energy Program (APEP) in the University of California, Irvine, CA (US): analysis of the poly-generation plants (SOFCOM in EU, Orange County Sanitation District in USA): exchange of post-doc and PhD students.

HORIZONTAL ACTIVITIES

Horizontal activities	
Training and education	Erasmus Mundus II Master Environomical Pathways for Sustainable Energy Systems (SELECT): KTH (Sweden), **POLITO (Italy)**, Aalto University (Finland), TU/e (The Netherlands), UPC (Spain), AGH (Poland), IST (Portugal).
Safety, Regulations, codes and standards	Some activities of connection with RC&S Bodies have already been performed: 1. Prof. Santarelli (Politecnico di Torino, SOFCOM Coordinator) is the representative for Italy in ISO/TC 197 "Hydrogen Technologies". 2. Prof. Santarelli is one of the representatives for Italy appointed at the IEC/TC 105 Fuel Cells (WG 11 on "Single Cell/Stack Test Methods for SOFC"). 3. Prof. Santarelli is appointed Italian member of IPHE: he presented SOFCOM activities in the Plenary Meeting in Seville (Spain) in November 15-16 2012. The DEMO will be presented also in the coming IPHE Plenary Meeting in Rome (IT) in early December 2014.
Public awareness	The website (www.polito.it/sofcom) is active since the beginning of the Project (December 2011). Public visits in the DEMO site of Torino have started in November 2014 (media will visit and describe the DEMO on regular journals)

DISSEMINATION ACTIVITIES

- Around 15 conference presentations (EU, US, China, Japan, South America)
- Around 10 paper publications so far (same number under revision or in preparation)

In the framework of the SOFCOM Kick-Off Meeting held in **Torino (Italy)** on **December 1-2, 2011**, an **Open Workshop** on "**SOFCOM Activities and Energy Context**": Invited Lecture given by **Prof. Thomas G. Kreutz**, Senior Research Scientist at the Energy Systems Analysis Group of the Princeton Environmental Institute (PEI, **Princeton University, US**), about "A Role for Systems Analysis in Developing Future Energy Systems".

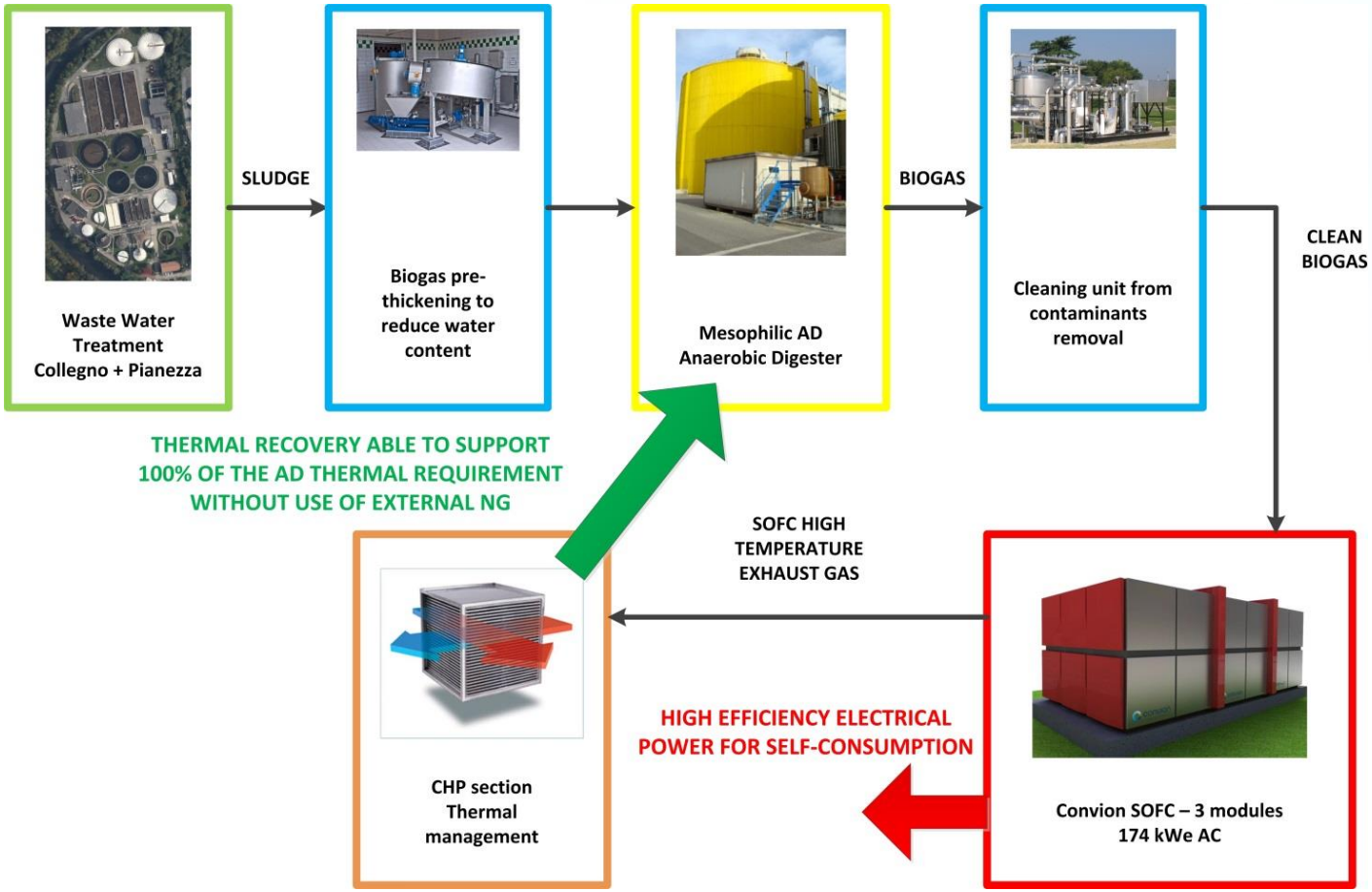
In the framework of **the SOFCOM M24 Meeting** held in **Barcelona (Spain)** on **October 24-25, 2013**, a **Seminar** has been given in MATGAS: **Prof. Fausto Massardo**, Dean of Engineering School, **Università di Genova (IT)** "**Pressurised SOFC hybrid systems: near term or long term solution?**"

In the framework of the SOFCOM M30 Meeting held in **Espoo (Finland)** on **May 7-9, 2014**, a **Open Workshop** has been given: "**FC systems fed by biogenous fuels: biogas and syngas**", with Invited Speakers: "Experience with Bio-Gas Fed High Temperature Fuel Cells" **Jack Brouwer, University of California, Irvine (US)** - "Conversion of wood derived syngas in SOFC systems", **Jürgen Karl, University of Erlangen-Nuremberg (DE)**

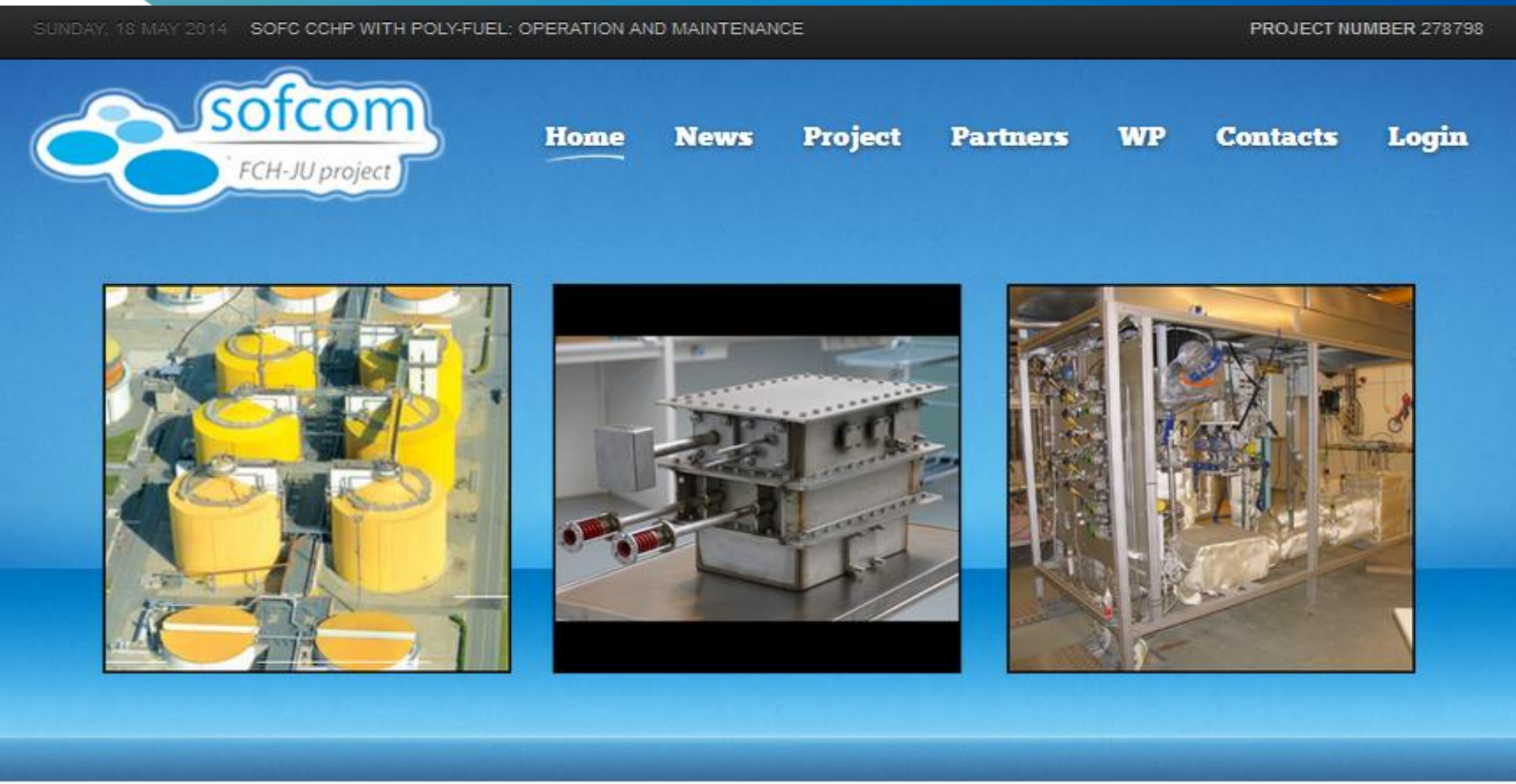
Final Workshop in Torino (IT): March 2015

EXPLOITATION PLAN/EXPECTED IMPACT

Medium scale biogas-SOFC CHP plant (174 kW_e + 89 kW_{th}) in real industrial context



THANKS


SUNDAY, 18 MAY 2014 SOFC CCHP WITH POLY-FUEL: OPERATION AND MAINTENANCE PROJECT NUMBER 278798
sofcom
FCH-JU project
Home News Project Partners WP Contacts Login
SOFCOM is an applied research project devoted to demonstrate the technical feasibility, the efficiency and environmental advantages of CCHP plants based on SOFC fed by different typologies of biogenous primary fuels (locally produced), also integrated by a process for the CO2 separation from the anode exhaust gases. The research activity will be devoted to the scientific, technical and economical management of two proof-of-concepts of complete energy systems based on SOFCs. Several issues