POLITECNICO DI TORINO

PRESS RELEASE

HARVESTING ENERGY FROM WASTEWATER TREATMENT PLANTS

The EU project SOFCOM is coordinated by Politecnico di Torino. The project developed a break-through solution to transform the organic waste collected in wastewater treatment plants into valuable energy products through the use of high-efficiency fuel cell technology.

Torino - March 25, 2015 | Matching environmental sustainability to energy efficiency through poly-generation: this is the focus of **SOFCOM**, a project financed by the EU Commission through a dedicated technological platform that goes under the name of the Fuel Cell and Hydrogen Joint Undertaking (**FCH-JU**), an initiative under the VII Framework Programme.
The project coordinator is Politecnico di Torino along with other 10 partners spread across 7 countries both from the academy and the industry[1]. The rationale behind the project (with an overall budget of 6.2 million euro) is to make energy efficient wastewater treatment plants (WWTPs) where biologically active wastewater from urban and industrial users is converted to clean water and energy. A novel process has been designed, built and tested to produce electricity and heat from the biogas generated from the sludge that is fed to anaerobic digesters within the WWTP. Along with combined electricity and heat production (CHP), two additional *products* are generated: filtered water and clean CO_2 that is recycled to grow algae so that the carbon that is originally contained in biogas is made available again as a fuel.

The prototype plant that demonstrates the feasibility of the SOFCOM concept has been presented today during the conference *"Patrimonio idrico, risorse rinnovabili e ambiente. Il presente e il futuro della depurazione in Europa"*, an event held in Torino and organized by **SMAT** Spa, which is partner of SOFCOM.

The prototype plant – **Massimo Santarelli** explains, Professor at the Department of Energy of Politecnico di Torino and project coordinator – *"foresees an integrated poly-generating energy system that uses renewable fuels (digester gas from WWPT and bio-syngas from wood gasification) in high-efficiency fuel cell electrochemical generators that allows for the complete recovery and re-use of CO_2 so to close the carbon cycle of the plant"*.

The term **SOFC (Solid Oxide Fuel Cell)** refers to the specific fuel cell technology exploited in the project. SOFC generators operate at around 800 °C and are in fact the most efficient fuel cell devices that can be directly fed with methane fuel, syngas or biogas (as in the case of SOFCOM).

The core component of the SOFCOM plant is the fuel cell stack reactor where biogas is transformed to electricity through efficient electrochemical reactions instead of combustion reactions that take place in less efficient internal combustion engines (ICEs). **The overall fuel cell electrical efficiency is >50%** when running on biogas and the only exhausts of the plant are pure CO_2 and water. Compared to ICEs, the efficiency is 10-20 percentage points higher and with virtually zero emissions.

From an energy strategy point of view, the demo plant aims at demonstrating how Smart Fuel Cell based systems are key-enabling technologies that run on renewable fuels with best-in-class electric conversion efficiency and the potential for a closed-loop cycle on C-H-O atoms (carbon,

[1]Politecnico di Torino (coordinator), SMAT Spa, Università degli Studi di Torino and CNR-ITAE are the Italian partners within the consortium. Other partners are the Finnish Teknologian Tutkimuskeskus VTT, Topsoe Fuel Cells A/S from Denmark, Matgas 2000 A.I.E from Spain, the Institut Enegetyki (IEn) from Poland, the Swiss Ecole Polytechnique Federale de Lausanne (EPFL) and the Technische Universitaet of Munich (TUM), Germany.

hydrogen and oxygen). Such paradigm is that of **new poly-generating systems** for co-production of electricity, heat, fuels and chemicals.

In a conventional gas engine, the exhaust gas is heavily diluted in nitrogen so that is both energy and economic intensive to capture CO_2 for subsequent sequestration or re-use. In the SOFC, the fuel exhaust is instead N_2-free so that is relatively easy to capture pure CO_2 for further use. This is right what happens inside the SOFCOM plant.

The SOFCOM plant is now installed in one of the largest EU **wastewater treatment plant** that is located nearby Torino (ITALY) . The fuel cell plant with carbon capture is followed by a photobioreactor (PBR) plant where water still rich in micro-nutrients (phosphates and nitrates) is purified by growing micro-algae. The carbon source for algae comes from the SOFC plant that makes available pure dry CO2 to the PBR.

Started in 2011, the SOFCOM project in now approaching its conclusion. Levering from the promising results achieved during the project, Politecnico di Torino has been awarded **a new FCH-JU project called DEMOSOFC**. The project foresees the installation of a 175 kWe SOFC plant that will run on sewage biogas. SMAT is also partner of the project and will host the installation. The plant will be largest EU SOFC plant running on biogas. At the moment, the SOFC technology has manufacturers in Germany, UK, Italy , USA and Japan. WWTPs are among the most interested end-users of the SOFC technology as electricity is consumed on-site and biogas fuel is locally produced. Investment costs are still quite high for the technology, but competitive costs are reachable as new installations are issued. Compared to ICEs, SOFC promise higher revenues due to the higher electrical conversion and lower maintenance costs.

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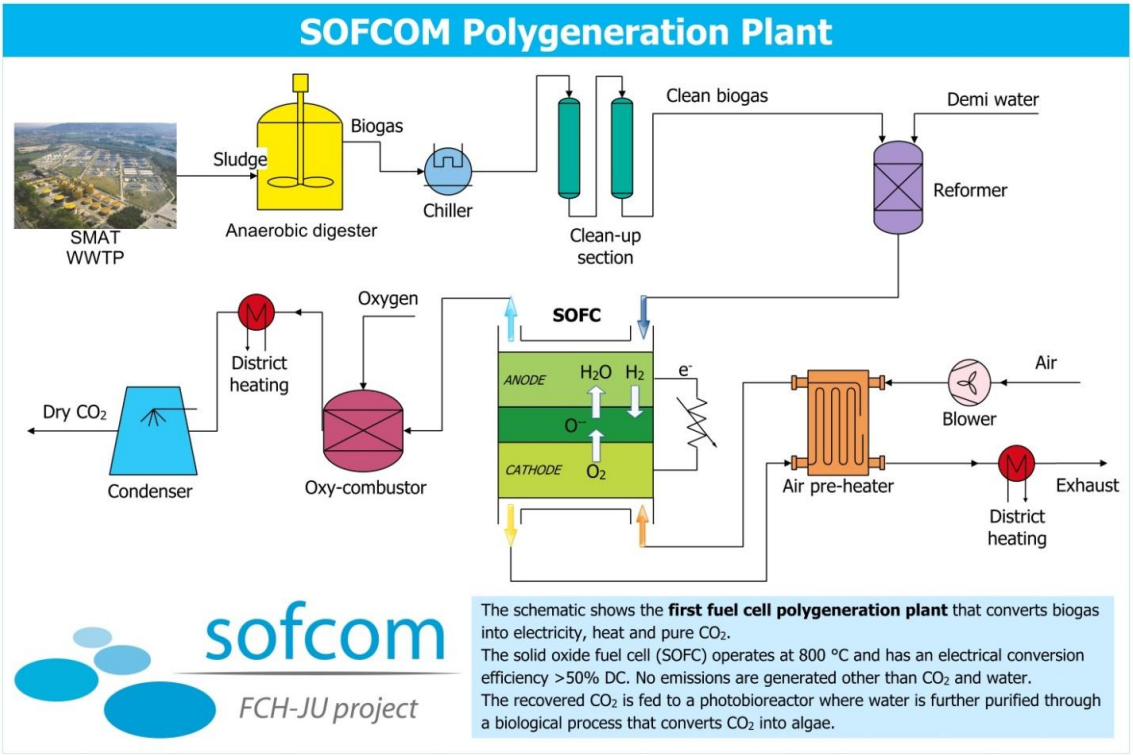
THE SOFCOM DEMO PLANT

The SOFCOM demo plant – shown in the figure below – has the objective to demonstrate the feasibility of biogas as a fuel for fuel cell electrochemical generators with high combined electrical and thermal power production efficiency.

Fuel cell plants will be a reliable competitor for internal combustion engines in the next decades, currently the leading choice for biogas energy conversion.

The main advantages of fuel cell systems are:

1. High electrical efficiency compared to internal combustion engines, with electrical efficiency on biogas up to 60%.
2. Nearly zero NOx, SOx and (VOC) Volatile Organic Compounds emissions.
3. High modularity of the technology, a key factor for satisfying different biogas availabilities.

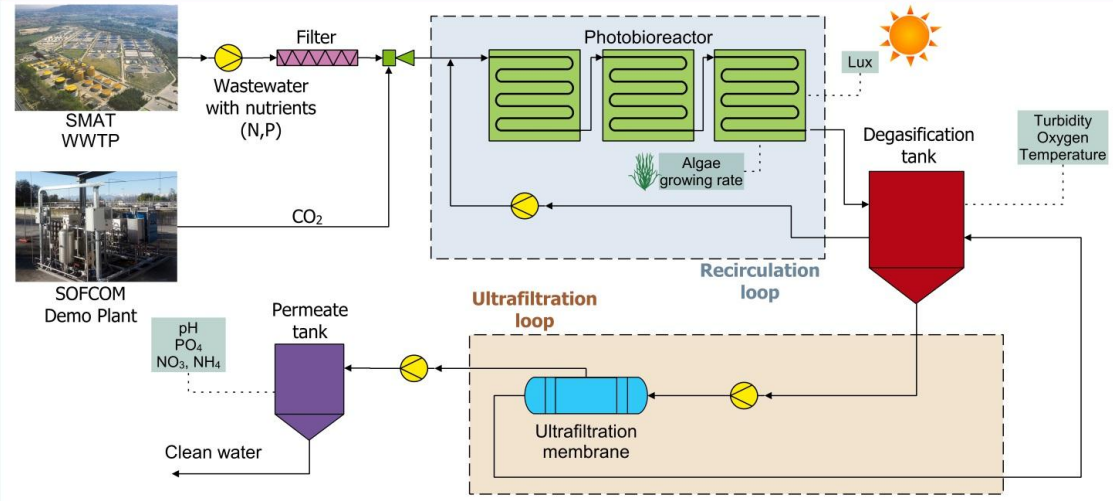


Furthermore, the SOFCOM demo is a poly-generating plant, first of its type.

The exhaust gases from the SOFC are just water (H_2O) and carbon dioxide (CO_2). The CO_2 can thus be easily recovered and converted into a fuel stream through a photosynthetic process, which occurs in a tubular photobioreactor (see figure below).

The photobioreactor converts CO_2 into algae biomass through solar radiation and nutrients (nitrates and phosphates) found in the SMAT filtered water. The algae production leads to a high nutrients removal from filtered water generating two products: a potential fuel (algae) and a purified water stream.

SOFCOM Photobioreactor Plant



sofcom

FCH-JU project

The schematic shows the photobioreactor plant that converts wastewater flow into clean water by fixing the CO_2 exhaust from the SOFC system into algae through the photosynthesis process.

THE DEMOSOFC PROJECT (2015 - 2020)

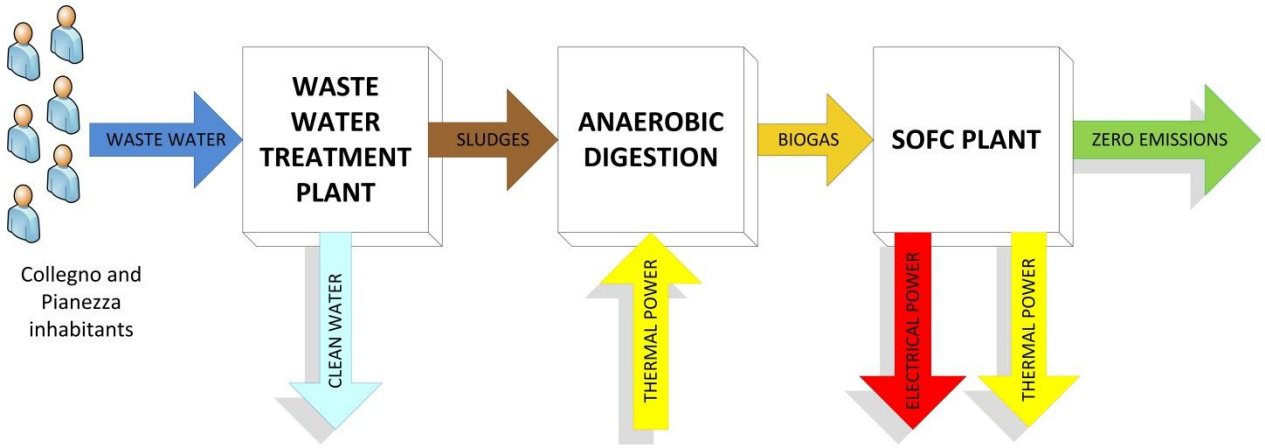
DEMOSOFC is a new project devoted to the design and installation of an SOFC (Solid Oxide Fuel Cell) plant that will generate around 175 kW electric.

The SOFC plant will be installed in the SMAT Collegno WWTP (Waste Water Treatment Plant), in the Turin area, and will guarantee the supply of around 30% of the site electrical consumption, and almost 100% of the thermal requirement.

The DEMOSOFC plant will be the first example in Europe of high efficiency cogeneration plant with a medium size fuel cell fed by biogas.

DEMOSOFC partnership includes, besides SMAT and Politecnico di Torino, the Finnish fuel cell manufacturing company Convion Oy and the Finnish research center Teknologian Tutkimuskeskus VTT, together with the Imperial College of Science, Technology and Medicine (UK).

The project, whose budget is about 5.9 million euro, is funded by EU with 4.2 million euro, in the framework of the Horizon 2020 program.



Service for the municipality:

- Cleaning of the waste water from Collegno and Pianezza inhabitants

Anaerobic digestion process:

- Conversion of organic matter contained in sludges into biogas → **Biogas is a by-product of the process**

Advantages with the SOFC choice:

- **High efficiency electrical power** → Reduction of electrical energy bought from the grid
- **Thermal power 100% recovered for AD heating** → Elimination of NG consumption from the grid
- **Zero emission system** --> No NOx, SOx, PM and VOC
- **Reliability of the system**
- **Distributed generation** → Lower grid impact
- **Sustainability** → Biogenous fuel
- **Energy security** → Local fuel