# Opportunities development for micro-cogeneration in France - the point of view of GDF SUEZ

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Micro-cogeneration, or micro combined heat and power (mCHP), is recognized for its benefit with respect to the increase in peak electricity phenomenon, increased by a strong deployment of electric heating systems in France. Moreover, the new thermal regulation for the residential market starting from 2012 will set strong requirements in terms of primary energy consumption of the buildings (between 45 and 60kWh of primary energy/m²/year according to the climatic zone in France). Micro-cogeneration is clearly mentioned in this new regulation, as an alternative to renewable energy.
Micro-cogeneration is one of essential bricks for development of Smart Grids, regarding the flexibility to the electric network. Moreover, local generation of electricity from natural gas will in particular allow to relieve the electric infrastructure in the case of the deployment of electric vehicles.
GDF SUEZ, as a gas and electricity utility, strongly established on the residential and tertiary market of gas in France, has accompanied the development of micro-cogeneration for more than 10 years.
The paper presents the recent highlights of this activity, and in particular those of its Research and Innovation Centre on Gas and New Energies (CRIGEN) on two main technologies which are Stirling-based mCHP boiler, with two waves of field tests, and fuel cells, with laboratory tests on systems, in partnership with manufacturers.

## The first demonstration of 40 Stirling mCHP boilers in France at residential individual customers from 2007 to 2010.

After having tested several generations of products integrating the Stirling technology of WhisperGen, GDF SUEZ launched in 2007 the first demonstration operation of 40 mCHP boilers among particular customers in the Rhone-Alpes, a cold region of the south-east of France around Lyon.
Between 2007 and 2010, more than 100 000 kWh of electricity were produced among 40 customers and nearly 600 million data have been collected by CRIGEN.
Performed by SAVELYS, a subsidiary of the group GDF SUEZ, and number one in France in the field of maintenance in heating in dwellings, the installation phase proceeded very well and showed that the French sector of fitters is ready to accommodate this new technology.
In spite of some expected troubles of reliability on such a technology at the end of the development, the customers showed themselves very satisfied with their new installation. Indeed over the season 2009-2010, one notes an average decrease by 120€ on their gas

and electricity invoice compared to the former installation. Moreover, more than 18% savings on primary energy consumption of these dwellings was measured.
CRIGEN in particular undertook important works on the regulation of the system in order to find the best trade-off between comfort, performance and reliability.

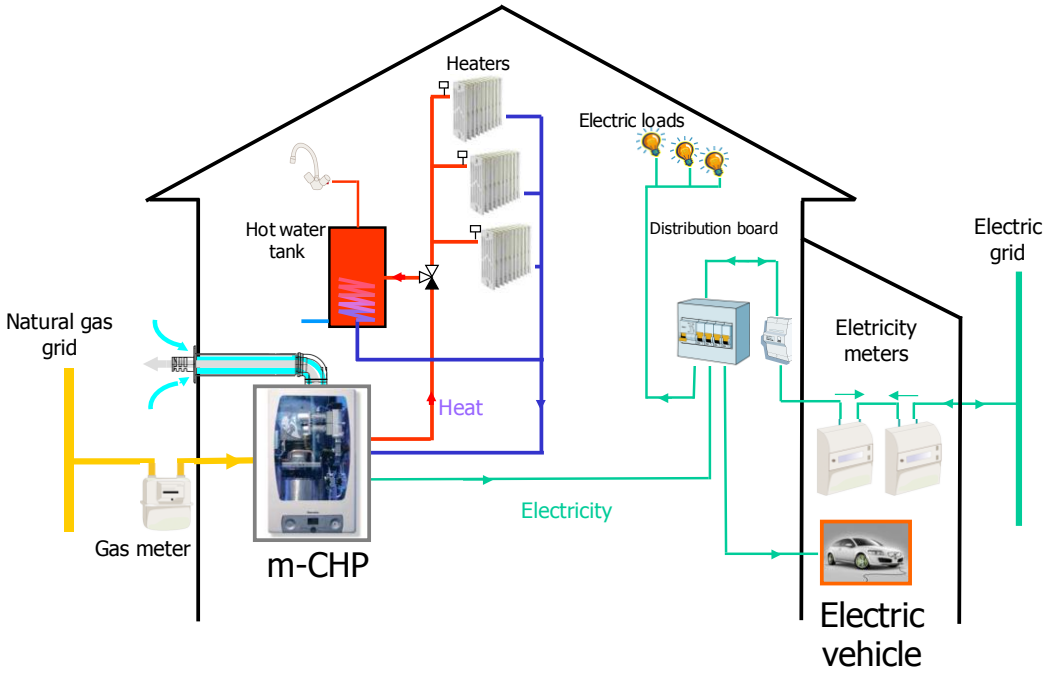
## Pre-commercial deployment of 250 last generation Stirling mCHP boilers (Baxi and De Dietrich Thermique) since 2010

*Installation of a mCHP for field test*

Based on its experience with the WhisperGen field-test, CRIGEN tested in laboratory better integrated and more efficient products as those developed by Baxi or De Dietrich Thermique boiler manufacturers. Following that, a pre-commercial deployment phase started in 2010 whether with GrDF (French company in charge of the natural gas distribution network, and affiliated to GDF SUEZ) or with "Branche Energie France", the commercial division of GDF SUEZ in France. The objective is to install up to 250 last generation micro-cogeneration boilers by 2011. Customers are ready today to invest in this new product which offers primary energy savings of approximately 45% compared to a standard installation.

## A demonstration of the coupling between mCHP boiler and electric vehicles charging device at home.

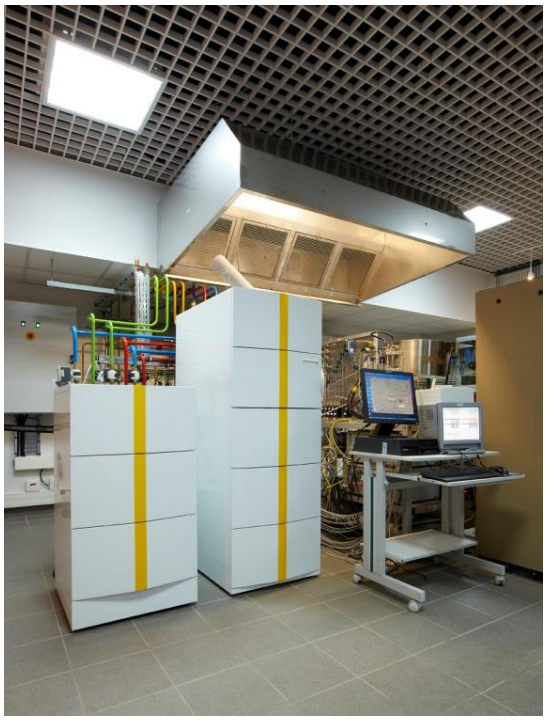
In order to test their synergy, we associated within the same house an electric vehicle and a Stirling mCHP boiler. This coupling enables on one hand to increase the share of self-consumed electricity produced within the house, and on the other hand, to decrease the impact of the charge of the vehicle on the electric grid. Based on two sites, the micro-cogeneration boiler can produce up to 30% of the electric need to charge the electric vehicle.




*Integration of a micro-CHP and an electric vehicle at home*

## Looking for the second generation of micro-cogeneration boilers: fuel cells.

France defined as an objective to gradually reinforce the thermal regulation by 2020 horizon, to reach a "positive energy building" level. In this context, the share of thermal needs compared to electric needs will continue to decrease. It then becomes crucial to develop mCHP technologies which electricity to heat ratio is much higher than the actual products as Stirling. Indeed, fuel cell systems, operated on natural gas, can reach electric efficiencies varying between 30 and 60%, and electricity/heat ratio of almost 3, against 0.2 for Stirling.



GDF SUEZ collaborates with several manufacturers on systems, whether based on PEMFC (Proton Exchange Membrane Fuel Cell) technology, which is near to technological maturity and presents electric efficiency between 30 and 40%, or based on SOFC (Solid Oxide Fuel Cell) technology, which is more promising in term of electric efficiency but less technologically mature.

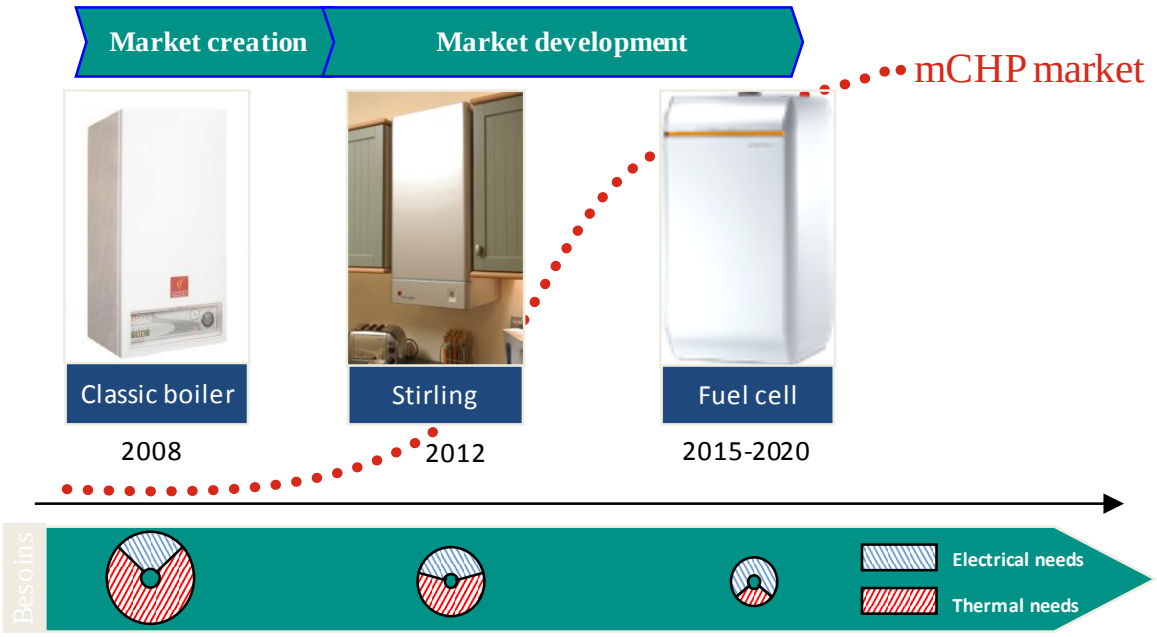
Over 2010 a new prototype co-developed together with De Dietrich Thermique and Ceramic Fuel Cells Ltd. was being tested at CRIGEN laboratory. This prototype named "Beta 0" showed unequalled performances by reaching an electric efficiency of 60% on natural gas.

*FC based mCHP system "Beta 0", co-developped by De Dietrich Thermique and CFCL, tested at GDF SUEZ CRIGEN fuel cell laboratory*

Such a system would ideally fit to "Positive Energy" buildings or to houses with coupling between the fuel cell and an electric vehicle charging device.
One has to note that other parallel solutions are possible, as an increase in the electric efficiency of Stirling technology by coupling two engines in opposition (project CETI, sponsored by the French Research Agency –ANR-), or with breakthrough solutions as thermo-acoustic generators.

## Conclusions and prospects

As a facilitator, CRIGEN also works on transverse subjects like the integration of the mCHP boiler to the statutory texts (Thermal Regulation, grid connection, electric safety, EuP European directive, white certificates…)
The whole of work at CRIGEN enables to refine a technological road-map with micro-cogeneration systems. Stirling technology, very near to a commercial deployment, will meet the needs of the customers, in particular in residences for which thermal needs are dominating on electric needs. Fuel cell based solutions will take over in the long term, in residences with lower thermal consumption, but also together with the deployment of electric vehicles.
Finally, the development of Smart Grids should enable to improve the benefits from mCHP systems by optimizing their operation thanks to remote control.




*Road map of mCHP market*