

**NEW GAS SOLUTIONS AND RENEWABLE ENERGIES COUPLING
FOR SUSTAINABLE RESIDENTIAL BUILDINGS IN FRANCE**

Main author

F. Piètre-Cambacédès (GDF SUEZ)

Co-authors

Juliette Promelle, Cristian Muresan, Romain Ruillard (GDF SUEZ)

ABSTRACT

A new thermal regulation for new residential buildings (RT 2012) has been enacted in 2012 in France, resulting from the “Grenelle Environment”, a round table for civilians and public services representatives to discuss environmental concerns. This new standard sets a low yearly energy consumption target of 50 kWh/m² of primary energy (for heating, cooling, DHW, lighting, auxiliaries for ventilation). It also makes mandatory a renewable energy requirement of 5 kWh/m² in new houses. Consequently, heating and water heating equipments are deeply affected by the RT 2012.

In order to reach the objective to offer a gas technology perfectly suitable of the new residential buildings, GDF SUEZ Group works with European manufacturers to develop new technologies.

The development of a condensing boiler with a high modulation rate (minimum power of 0,8 kW and a maximum power of 28 kW for the hot water needs) is a first answer to these new residential buildings with a low value of maximum heat loss (around 2 to 3 kW for 7°C). Under development is the ability of the boilers to be installed and operated automatically in a high range of pressure of combustion products will contribute also to the competitiveness of the gas boiler.

The development of more efficient and cheaper solar thermal panels, coupled with gas condensing boilers, is also another way to respect new requirements and keep competitiveness. But geographical or architectural constraints for example do not allow these solutions as the most relevant in all cases. A small capacity electrical heat pump can provide the required amount of renewable. Therefore several associations with condensing boilers have been designed for heating or domestic hot water production : “mono-bloc” or “split” hybrid boilers, domestic hot water heat pump and boilers. Various control strategies are possible : minimize primary energy consumption, minimize operating cost, minimize CO₂ emissions.

The high level of requirements of this new thermal regulation induced new improvements and innovative solutions, encouraged and promoted by GDF SUEZ, but also more choices and more complexity for the French customers and installers. It is essential to bring a critical look on these new technologies in technical, economical and regulation terms in a comparative approach, and for each kind of residential building.

TABLE OF CONTENT

ABSTRACT

TABLE OF CONTENT

1 ENERGY TRANSITION AND FRENCH THERMAL REGULATION : A NEW CONTEXT TO ASSOCIATE NATURAL GAS AND RENEWABLES ENERGIES

2 A ROADMAP FOR THE DEVELOPMENT OF PRODUCTS

3 BOILERS WITH HIGH MODULATION RATE : ADAPT THE BOILERS TO THE LOW HEATING NEEDS

3.1 Lower heat loads for low energy buildings

3.2 The GDF SUEZ / VERGNE Innovation partnership

4 SOLAR AND BOILER : OPTIMIZE THE ASSOCIATION

4.1 A new answer to a new thermal regulation

4.2 the Field-tests confirm the benefits

4.3 Conclusions

5 SOLAR, HIGH MODULATION BOILER AND BALANCED VENTILATION WITH HEAT RECOVERY, A PACKAGING SOLUTION TO DIVERSIFY INSTALLATION AND OPTIMIZE EFFICIENCY

6 HYBRID SYSTEMS : TAKE THE BEST FROM HEAT PUMPS AND BOILERS

7 NATURAL GAS HEAT PUMPS : IMPROVE THE BOILERS EFFICIENCY THANKS TO THE USE OF RENEWABLE ENERGY

8 CONCLUSIONS : A PANNEL OF PRODUCTS TO OBTAIN THE BEST ASSOCIATIONS OF NATURAL GAS AND RENEWABLE ENERGIES IN INDIVIDUAL HOUSING

1 ENERGY TRANSITION AND FRENCH THERMAL REGULATION : A NEW CONTEXT TO ASSOCIATE NATURAL GAS AND RENEWABLES ENERGIES

In Europe, new directives as the Energy Performance of Buildings Directive [1] and the Energy related Product Directive [2] push for energy efforts in the residential buildings sector, in order to achieve energy efficiency and renewable energy targets for 2020 and beyond. For new houses, each country adapt its regulation to apply the principle. In France, RT 2012 introduces a high level of requirements regarding new houses :

- An average level of energy consumption not exceeding 50 kWh/m²/year of primary energy (modulated depending on the geographic zone).
- A part of renewable energy of 5 kWh/m²/year or an equivalent. As equivalent, are accepted : thermodynamic domestic hot water production (with COP higher then 2 according to EN 16 147) and micro-cogeneration systems.

This is an important evolution for the buildings, so that heating and domestic hot water (DHW) products must be adapted.

2 A ROADMAP FOR THE DEVELOPMENT OF PRODUCTS

It is crucial to develop new gas systems as the boilers alone do not comply to the thermal regulation. GDF SUEZ follow a roadmap for the products development, which can be summarized in four main axes :

- the adaptation of the boilers to the little heating loads of the new houses,
- the association of the natural gas to renewable energies,
- the production of decentralized electricity combined with heat, the micro CHP (Combined Heat and Power),
- the development of smart controls.

The paper focus on the two first points.

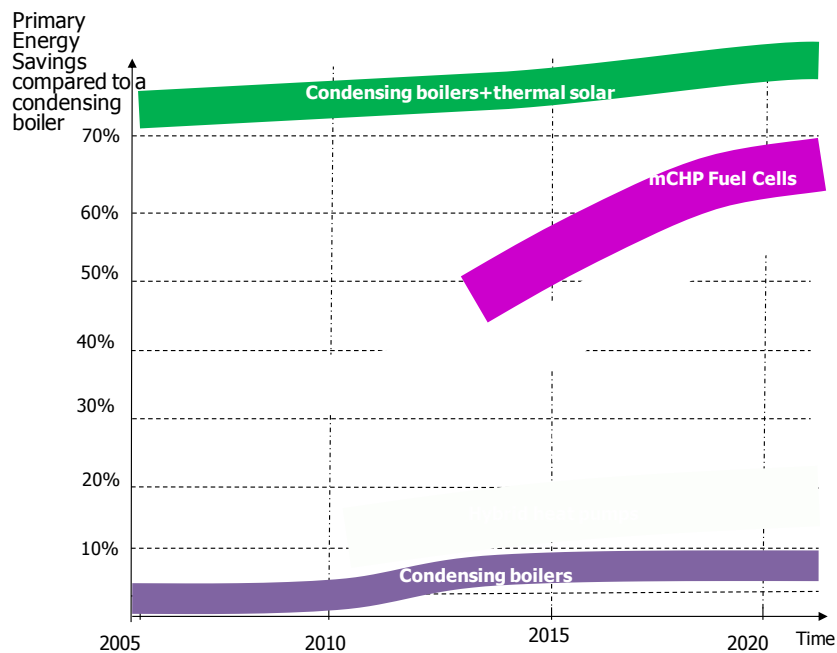


Figure 1: Among GDF SUEZ roadmap for products development, the association of natural gas with renewable energies is a pillar

3 BOILERS WITH HIGH MODULATION RATE : ADAPT THE BOILERS TO THE LOW HEATING NEEDS

Condensing boilers with high modulation rate are a first answer to these low energy residential buildings.

3.1 Lower heat loads for low energy buildings

We can consider for this kind of buildings a **low value of maximum heat loss (around 2 or 3 kW for -7°C)**. Indeed, Figure 2 shows that few hours (approximately 130 hours/year) are below 0°C in an average climate area in France, and that most of the time, the outside temperature is higher than 7°C.

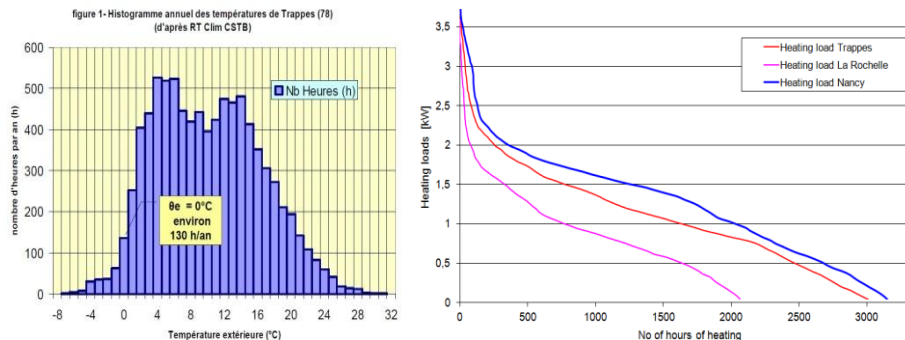


Figure 2: In France, the heating loads are very often between 0 and 3 kW during the year, for low energy residential buildings.

Whereas classical condensing boilers modulate their power from approximately 7 to 23, 28 or 35 kW, Therefore, it was necessary to work with manufacturers to develop and promote new generation of condensing boilers, more adapted to these heat needs, with a higher modulation rate.

Some manufacturers already sell models with a higher modulation rate and a minimum value of thermal power more suitable : 5 kW or even 3 kW, but Figure 2 show real interest to achieve a higher modulation rate, with a lower minimum value of thermal power.

This high modulation rate would bring:

- ✓ an energy efficiency optimized (start/stop losses reduced),
- ✓ but also a lifetime improved.

3.2 The GDF SUEZ / VERGNE Innovation partnership

The GDF SUEZ collaboration with the French manufacturer VERGNE Innovation succeeded in developing high modulation rate condensing boilers: a first one with a thermal power range from 0.8 kW to 12 kW, available on the French market since the beginning of 2013.

The second one, with a thermal power range from 0.8 to 28 kW, available since the beginning of 2014.



Figure 3: the VERGNE innovation “MC3 model” Condensing boiler with the gas valve patented.

Tests done in CRIGEN (The Research and Innovation Center of GDF SUEZ related to gas and new energies) show that this decreasing of the minimal power optimizes the global efficiency of the installation. Thus, the gas consumption reduction is around 5 to 10%.

4 SOLAR AND BOILER : OPTIMIZE THE ASSOCIATION

4.1 A new answer to a new thermal regulation

In 2010 and 2011, GrDF and the CRIGEN developed the idea of an optimized thermal solar heater, built with an unique solar panel, a domestic hot water tank with a reduced volume (150 L), and condensing boiler with micro-tank, a new solution really adapted to small and middle houses (up to 120 m² of area). See Figure 5.



Figure 5: The optimized solar thermal heater, compared to a classical one.

This new concept leads to reduce the costs of the system in an significative way (30% cheaper than classical solar heaters), optimize their performances, and in the same time, answer to the new requirements of the French thermal regulation 2012 for new houses.

The optimization reduced also the time necessary to install the product: one day is enough to install all the system.

4.2 the Field-tests confirm the benefits

Manufacturers, interested in this concept, decided to develop their own “optimized” solar thermal heaters. In order to validate performances of these new systems in real conditions, GrDF and

CRIGEN decided with the help of INES to equip and follow 4 sites with these new innovations from De Dietrich and Saunier Duval, the two first manufacturers involved.



Figure 7: One of the field-test of an optimized solar thermal heater, with the monitoring system

These four sites are located in Nantes and Metz areas in France, and have been followed since the end of 2012. The solar contribution, solar diffusion, gas consumption, and energy and financial savings are measured and calculated. These results open new potential improvements.

The analysis results show good results, similar to the simulations trends.

		Jan	Fév	Mars	Avril	Mai	Juin	Juil	Août	Sept	Oct	Nov	Dec
Ensoleillement mesuré	kWh	70	118	153	250	259	263	370	369	259	164	91	109
Consommation moyenne journalière d'ECS	l/j	151	155	164	155	150	124	96	64	128	141	146	157
Taux de couverture solaire mesuré	-	19%	33%	36%	60%	61%	73%	92%	81%	67%	46%	24%	25%
Taux de couverture solaire théorique (Solo 2000)	-	13%	35%	31%	60%	64%	78%	99%	99%	60%	43%	24%	16%

Figure 8: Results of one field-test for a complete year

Ratio of solar covering are around 70% for three equipped sites, and all temperature profiles let confirm a good behavior and operation of these installations. One site chosen for extreme conditions (bad oriented-roof, cold climate, high surface) give also good result: 44% of covering.

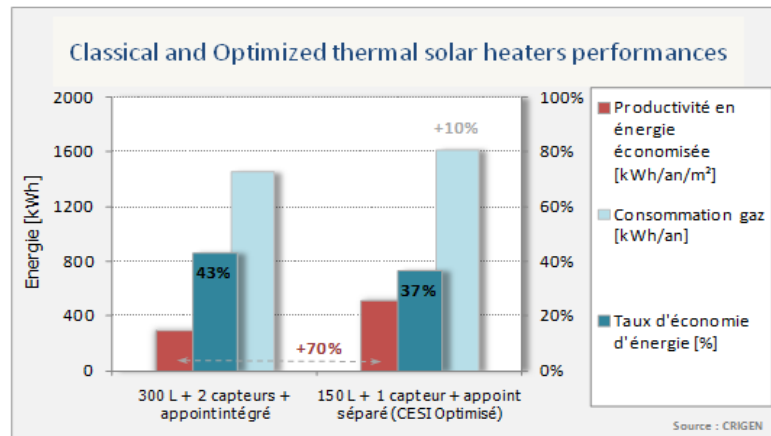
4.3 Conclusions

CRIGEN and GrDF go on following the field tests up to the end of 2014 in order to get a complete overview of these systems and their performances on more than one year.

Today, more than 10 manufacturers propose in France their model of “optimized” solar heater.

The benefits are really important:

- 30% cheaper than classical ones + reduced installation costs.
- 5 more heat storage losses for classical thermal solar heaters. In a classical thermal solar heaters, 70% of the production of the second collector equals the heat storage losses of the storage tank.
- A gain of 40% to 70% in the DHW bill for the consumer, with a comfort level guaranteed.

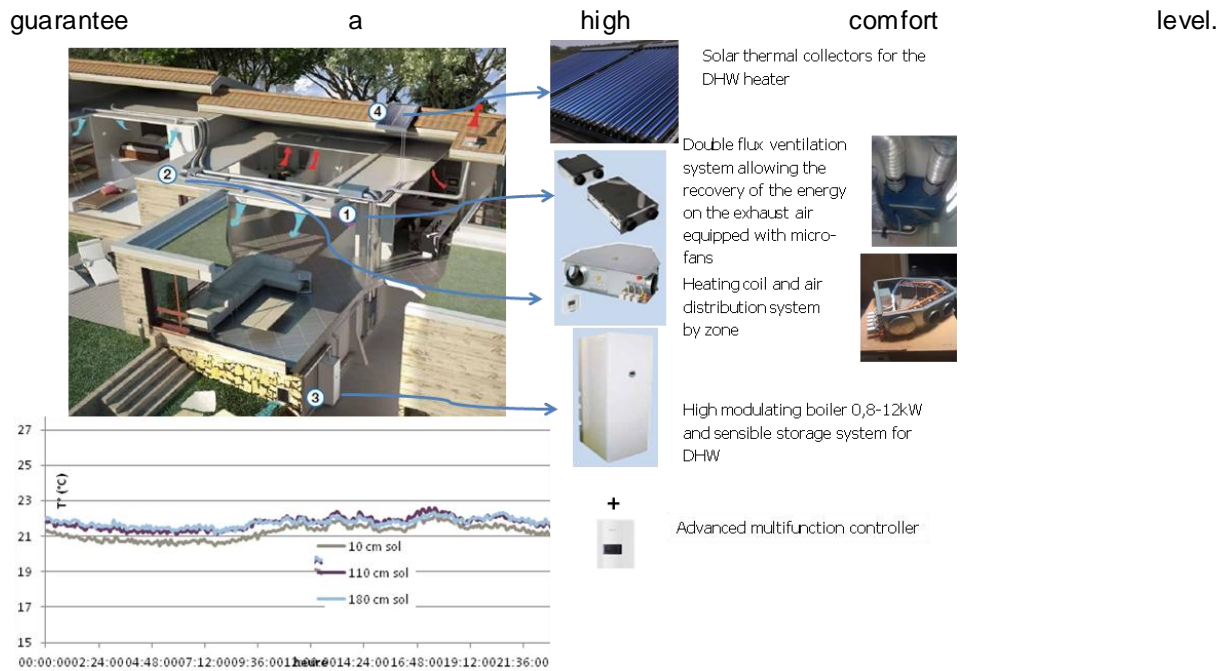


5 SOLAR, HIGH MODULATION BOILER AND BALANCED VENTILATION WITH HEAT RECOVERY, A PACKAGING SOLUTION TO DIVERSIFY INSTALLATION AND OPTIMIZE EFFICIENCY

The development of a high modulation boiler gave GDF SUEZ the opportunity to propose an innovative air heating system for low energy house.

The EQUATHERMIE product, result of a partnership with ALDES (ventilation manufacturer), TESCOL (solar manufacturer), VERGNE (boiler manufacturer), is a innovative solution to optimize efficiencies and address different kind of customers but new efficient buildings.

The principle of this product is to heat up the supply air by an water/air heat exchanger connected to a condensing boiler. The energy is distributed by a balanced ventilation system (with heat recovery) in each room excepted the wet rooms. Wet rooms can be heated by the transfer of the air flow from the living rooms. Solar panels lower the gas consumption for DHW production, Individual room controls



6 HYBRID SYSTEMS : TAKE THE BEST FROM HEAT PUMPS AND BOILERS

Hybrid boilers combine :

- a low power electric heat pump
- a gas condensing boiler
- a controller on primary energy

Depending of the efficiency of each system and of the power needs, the controller will start the low power electric heat pump (up to 5 kW of thermal power) and/or the gas condensing boilers, in order to optimize the overall energy efficiency and guarantee a high comfort level in heating and domestic hot water production.



Figure 10: Monobloc and bi-bloc wall-hung hybrid boilers.

Lot of boiler manufacturers developed hybrid boilers, which are ideally installed in new houses with low-energy consumptions.

The field-tests organized by CRIGEN confirmed the efficiencies of the hybrid boilers. The energy consumption reduced from 10% to 20% compared to a condensing boiler, and these products are cheaper than electrical heat pumps for heating and DHW.

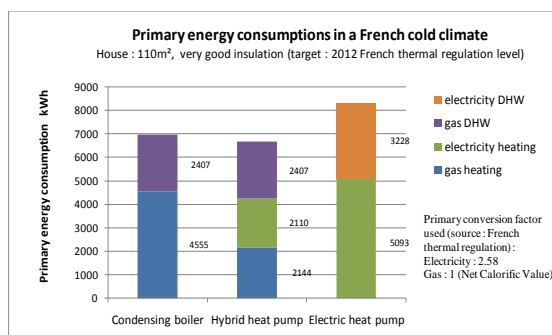


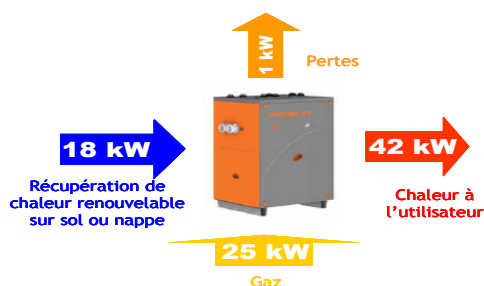
Figure 11: Energy consumption benefits of an hybrid boiler.

This product is a very good answer to the thermal regulation 2012 requirement : it have a good efficiency on primary energy, and it uses a part of renewable energy. Furthermore, it has a smart control, able to choose the energy. In the future, it could be connected to the grid and be piloted depending on the energy price, or the heat pump could putted on in case of renewable electricity available.

7 NATURAL GAS HEAT PUMPS : IMPROVE THE BOILERS EFFICIENCY THANKS TO THE USE OF RENEWABLE ENERGY

For collective residential buildings, the absorption heat pump is an available technology with several advantages :

- The refrigerant is without environmental impact.
- The efficiency is high, up to 170% on primary energy for geothermal version, and 165% for aerothermal version.
- It produces high temperature for Domestic Hot Water.



GDF SUEZ - CRIGEN made several field tests proving the good efficiency of the products.

If product are available for collective and light commercial building, developments are ongoing to extend the range of product, **particularly for individual houses** :



- GDF SUEZ-CRIGEN in the European Project HEAT4U for a 18 kW gas heat pump development and French R&D projects.
- European Manufacturers announced future products (with CO₂ or ammonia/water fluids)

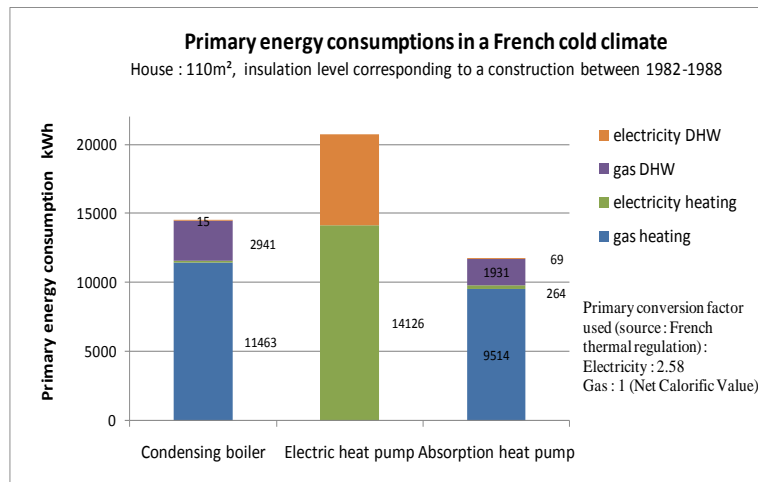


Figure 12 : absorption heat pumps have a very good efficiency in retrofitted houses compared to boiler or electric heat pumps

The economical study, the simulations and the first results from field tests confirm that absorption heat pump has an good efficiency in retrofit applications.

8 CONCLUSIONS : A PANNEL OF PRODUCTS TO OBTAIN THE BEST ASSOCIATIONS OF NATURAL GAS AND RENEWABLE ENERGIES IN INDIVIDUAL HOUSING

The traditional gas technologies for buildings are far from their maximum progress,

but also the technology innovation must be directed towards :

- Decrease Capital Costs (improve efficiency to maximize pay-back time),
- Improve installation (plug & heat) (for installers, for maintenance, for customers ...),
- Improve Building integration (coupling with renewable energies).

Some ways of progress :

- More compact and efficient products,
- Simple & Reliable & Proven heat exchanger ("heart" of many products),
- Quick-time pre-installation sets ("plug & heat"),
- Improved the coupling with others energies,
- Electrically autonomous technologies (from the electric grid).