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my SMART Life

Deliverable due date : November 2019

D2.3 HIGH LEVEL ENERGY RETROFITTING OF MULTI OWNER PRIVATE BUILDINGS

WP2, Task 2.2 (Subtask 2.2.1)

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife	
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**	
Project Duration	1st December 2016 – 30th November 2021 (60 Months)	
Deliverable	D2.3 High level energy retrofitting of multi owner private buildings	
Diss. Level	PU	
Status		Working
		Verified by other WPs
	■	Final version
Due date	30/11/2019	
Work Package	WP2 Demonstration in Nantes	
Lead beneficiary	Cerema	
Contributing beneficiary(ies)	Engie, Nantes Metropole	
Task description	Task 2.2: Building/District Renovation and Smart Homes Deployment – SMART DISTRICT [NAN] (CAR, ENG, NBK, CER) This task focuses on extensive retrofitting of the existing building stock as well as the construction of a highly energy efficient buildings that will create a new high-performance district. Led by NAN and ENG, the deployment of smart home solutions will create a highly energy efficient urban district. - Subtask 2.2.1: Retrofitting of 6 multi owner buildings, led by NAN, representing about 22,000 square meters and 270 dwellings by November 2019 with a high-level energy target below 80 kwh/m2. Monitoring and analysis of buildings energy performance.	

Date	Version	Author	Comment
12/11/2019	1.0	Coordination: Myriam Humbert (Cerema) Contribution: Natacha Javalet, Yassir Dkhissi, Thomas DUSSAUX (Engie), Marine Buron, Benoit Cuvelier, Guillaume Chanson (Nantes Métropole), Pierre Nouaille (Cerema)	Submitted to review
27/11/2019	1.1	Myriam Humbert (Cerema)	Final version

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Abbreviations and Acronyms

Acronym	Description
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
KPI	Key Performance Indicators
RES	Renewable Energy System
DHW	Domestic Hot Water
PV	Photovoltaic
BEST	Building energy specification table
BBC	Bâtiment Basse Consommation: French energy label for low consumption Building

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1. Executive Summary

This deliverable describes the action of high-level energy retrofitting of multi owner private buildings in Nantes. The original action of retrofitting private residential buildings was based on the retrofitting of one building with a third-party financing mechanism. Four third party financing plans were studied, but it could not be achieved within the project delay. Indeed, the decision process is complex in multi-owner residential buildings and the time between audit and completion of works lasts at least 4/5 years. Nantes Metropole then proposed to integrate the high-level energy retrofitting of five condominiums. The co-owner's associations of these buildings had accepted the retrofitting works to achieve the high-level energy retrofitting with a target below 80 kWh/m² gross area, after refurbishment. The works were finalized between 2017 and 2019. This five retrofittings aim at an energy consumption savings in comparison to regulation from 35 to 68%, based on the improvement of insulation and the use of RES. A least one year in depth monitoring is planned in the framework of the "Ville de Demain" program, and will be articulated and extended with the monitoring requested in the framework of mySMARTLife.

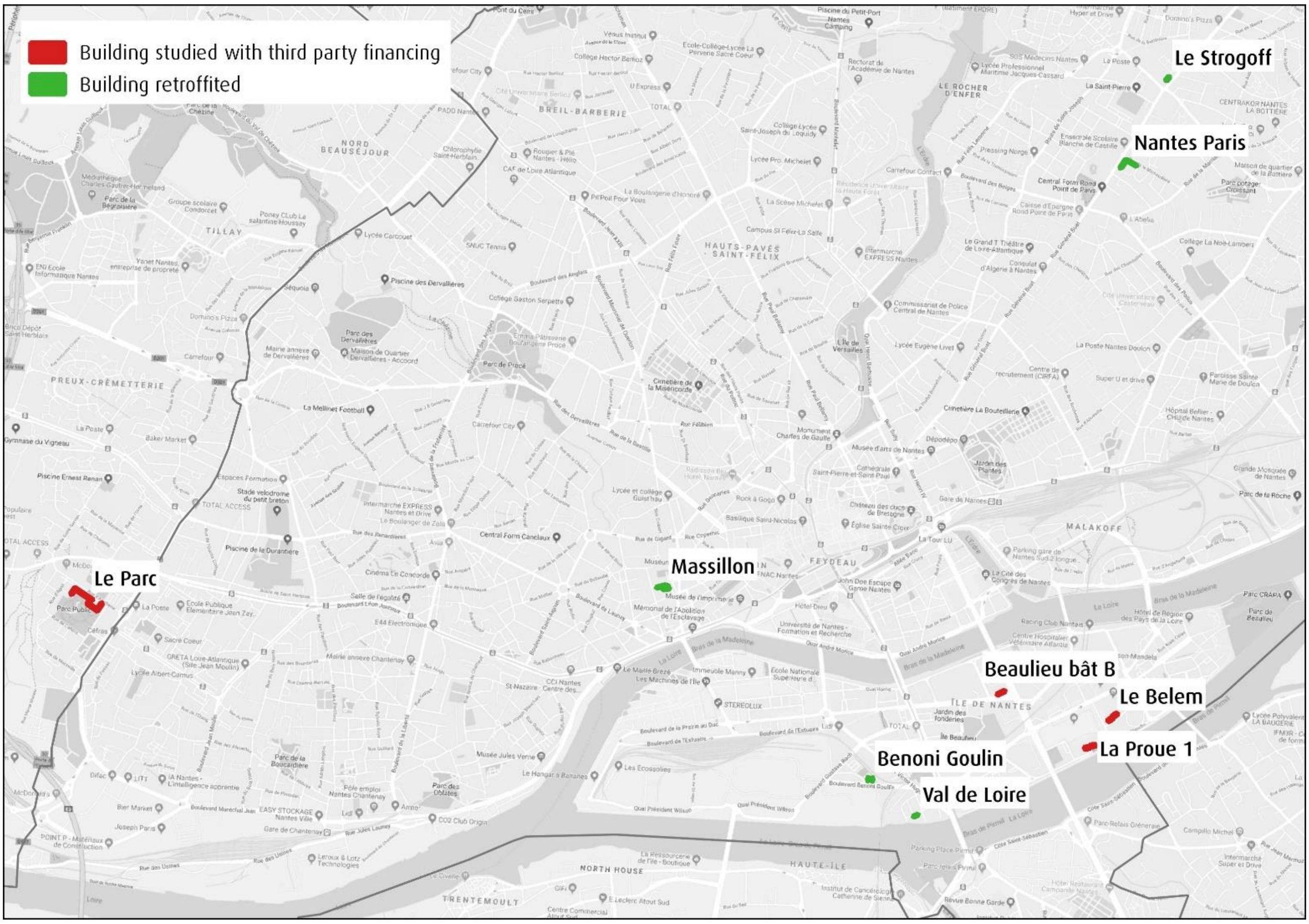

Figure 1: Location of the studied and renovated condominiums

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2. Introduction

2.1 Purpose and Target

This deliverable is intended to describe the specific process of refurbishment in co-ownership, the technical specifications and implementation plan of building retrofitted, and analyses the building expected performance.

The original action of retrofitting of one private residential building based on third-party financing could not be achieved within the project delay. Indeed, the decision process is complex in condominiums and the time between audit and completion of works lasts at least 4/5 years.

Therefore, high level energy retrofitting of five condominiums part of the “Ville de demain” program was integrated in this action. The co-owner’s associations of these buildings had accepted the retrofitting works to achieve the high-level scenario with an energy target below 80 kWh/m² gross area, after refurbishment. The works were finalized between 2017 and 2019. These buildings represent around 17 000 m2 and 200 dwellings. The monitoring will be done in 2019-2021. Two buildings are on Ile de Nantes demonstration district, others on Nantes metropole area.

These buildings received financial support from the French government and Nantes Metropole. One year in depth monitoring is already planned and will be articulated and extended with the monitoring requested in the framework of mySMARTLife project.

2.2 Contributions of partners

The following Table 1 depicts the main contributions from participating partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
ENG	Contributing partner (Natacha Javalet, Yassir Dkhissi, Thomas DUSSAUX)
CER	Main responsibility for deliverable (Myriam Humbert, Pierre Nouaille)
NAN	Contributing partner (Marine Buron, Guillaume Chanson, Benoît Cuvelier, Jonathan Lefebvre)

2.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

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Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D5.1 Interim version	This deliverable develops an integrated evaluation procedure to assess the success of the actions implemented in the three lighthouse cities which participate in mySMARTLife project from a holistic point of view
D2.1	Baseline report of Nantes demonstrator area [NAN] (M6,12)
D2.2	Simulation models of the building stock, energy system, transportation, urban infrastructures [NAN] (M24, M36)
D2.8	Urban Platform deliverable, describes a systemic KPI integration framework into Nantes' Urban Platform iin the "ontology" chapter.
D5.3 interim version	Definition of the monitoring program: the monitoring scheme defines the actions' impacts in the intervention's system and how data will be collected to ensure the calculation of the monitoring KPIs. KPI table described them thoroughly in D5.3.

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3. Functioning of co-ownership in France

All the co-owners of a building form the syndicate of co-ownership. This association has the same legal capacity as companies. The functioning of this association is regulated by laws (Law n° 65-557 of 10th July 1965) which determines the status of condominium ownership of housing and Decree n° 67-223 of 17th March 1967; modified by the law ELAN of 25th November 2019 and the law ALUR (law n° 2014-366 of 24th March 2014).

By law, the co-owner's association meets necessarily each year and this meeting is called the general meeting of the co-owners. Its purpose is to pronounce:

- on the accounts of the past year and on the estimated budget of the future year, i.e. the amount of the quarterly provision of expenses to pay by each,
- on the provision for construction funds since January 2017 (except for new buildings and condominiums of less than 10 lots),
- on the discharge to be given to the trustee,
- to renew the co-ownership trustee in his duties or to choose a new one,
- to elect the members of the trade union council,
- to set the threshold for consultation of the trade union council and to put companies in competition with each other,
- to vote for the work necessary for the maintenance of the common areas, etc...

During the general meeting, it is important to respect a formalism: only the items on the agenda are voted on and decided on.

Depending on the type of decision to be taken, the law imposes various kind of majority rules at the General Meeting and even unanimity for the most important decisions. In the case of works for energy efficient retrofitting, the majority is at least 50% of voters for the project.

By law, the co-owner's association is made up of two bodies:

- the co-ownership trustee (professional or voluntary),
- the co-owner's association, represented by the co-owner's association board (comprising elected co-owners) with a view to implementing decisions taken by a general meeting.

During a general meeting are present:

- the co-ownership trustee,
- the co-owner's association board,
- The owners.

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The co-owner's association board is responsible for assisting the property manager and overseeing its management, especially when the subjects concern important and expensive work.

The vote on the works is taken at this general meeting. Each co-owner owns one or more commonhold unit composed of a private portion and a share of the common portions. This proportion is expressed in « tantièmes » - thousandths or ten thousandths.

- Each co-owner participates in the vote at the general meeting in proportion to his commonhold unit. The more unit the co-owners has, the larger his share in the vote is.
- In return, each co-owner must pay the co-ownership fees in proportion of his commonhold unit.

4. Implementation plan of third-party financing for retrofitting private residential buildings

4.1 Third-party financing concept

As accessing to finance is a frequent barrier to renovation, Engie Cofely proposes to be the third-party funder in order to smooth out the cost of the work.

The principle of third-party financing is that the savings from retrofitting offset the investment (see Figure 2).

Before retrofitting, the owners or the tenants pay the expenses related to the operation of the co-ownership (cleaning, insurance, maintenance, etc.), and their part of energy for heating and domestic hot water.

After the retrofitting, the owners still pay the expenses for the operation of the co-ownership. The energy savings and the various financial support offset the monthly payment for the investment. In conclusion, for the owner or the tenant, the bill is the same or less expensive than with no other financial investment.

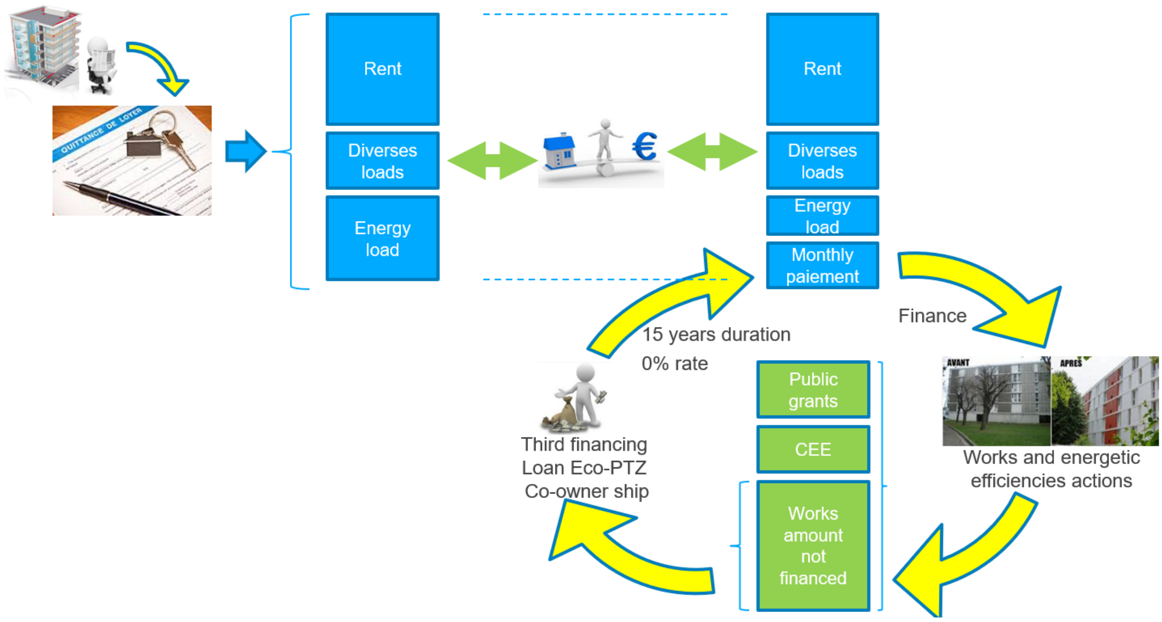

Figure 2: Principle of third-party financing

The contract proposed by Engie Cofely smoothes out the cost of the works during its duration, between 10 and 15 years. Engie Cofely is also committed by the Energy Performance Contract (EPC) to achieve a measurable objective in improving the energy efficiency of the condominium. The advantages for co-ownership are as follows:

- Guarantee of technical and financial savings,
- Guarantee of occupant comfort,
- Management of studies and work,
- Financing of the work.

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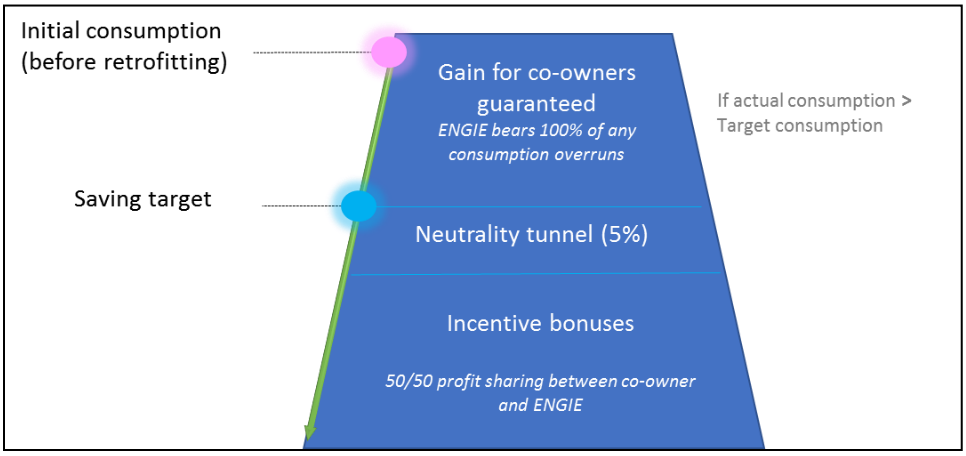

Figure 3: Principle of the energy performance contract

Besides, Engie Cofely takes over the entire project from design to retrofitting works and includes the following services and subsidies:

Services

- Financial engineering and partnership with a bank for Zero-Interest Eco-Loan
- Preventive and corrective Maintenance
- Small works (secondary heating network cleaning and balancing…)
- Total guarantee of equipment and energy saving results
- Action on behavioral, raising awareness on green gestures, owners' challenges (Positive energy family)
- Individual energy billing

Subsidies

- Low VAT rate (5.5%)
- Energy Efficiency Certificates (EEC)
- Zero-Interest Eco-Loan
- Governmental Energy transition Tax Credit « CITE »
- « Climate plan » local authorities' subsidies
- « Habiter mieux » programme from Anah[1] for low-income households.

[1] Anah: Agence Nationale de l'Habitat (French National Agency for Housing)

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4.2 Methodology for the definition of the technical specifications and implementation plan

Engie has developed a package to audit the buildings, called **EFFICLOUD:** Engie directly gathers information (Number of buildings, heating energy, building elements, boiler room information, type of ventilation, dimensions, temperatures…) on site with a mobile device in which data is entered. This methodology allows to support the design of the offer and makes it quicker. It communicates to the cloud with 3G. Through mySMARTLife, this technology did move from TRL 8 to TRL 9, now currently used for energy audit of builings.

Available information on the cloud is directly synchronized and processed in a SaaS (Software as a Service) to determine automatically:

- the reference situation with local climate
- the building refurbishment works to be planned
- the heat power resizing
- the boiler room refurbishment
- the energy savings
- the renovation scenarios
- the financial offer including subsidies

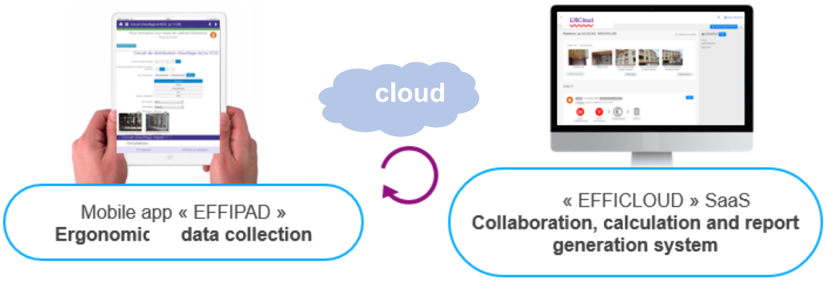

Figure 4: Efficloud and Effipad connexion

The pre-offer report is then presented to the co-ownership association to refine the assessment, chose the best scenario to reduce the CO_2 emissions, reach the best-performing labels, and finalize the documents that will be presented to the general meeting (cf. Example of the Belem rapport in Annex).

Convening all relevant participants in the renovation process from the first stages of developing a renovation scheme and then keeping them in the loop when deploying the scheme maximizes buy-in and the overall success of the initiative.

The technical specifications cover as well insulation as local and renewable energies system or energy managing systems (cf. Figure 5).

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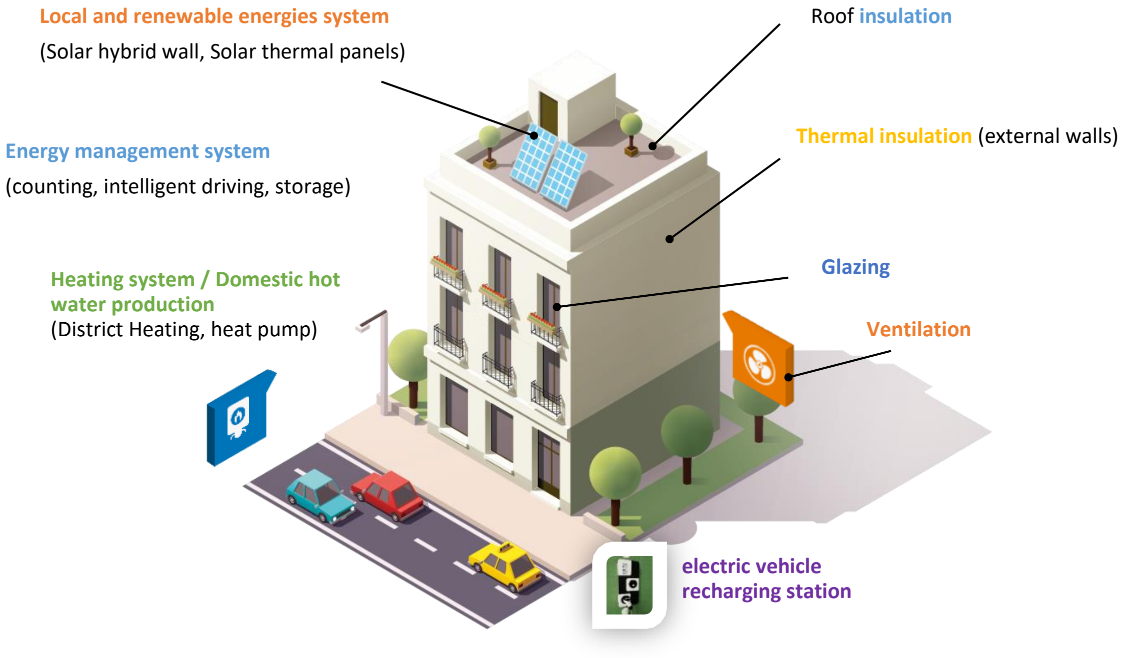

Figure 5: Refurbishment and RES actions

Especially hybrid PV and solar thermal panels were proposed, as this innovative RES is particularly well suited to collective heating. About 15 000m² of the solution DUALSUN are actually installed worldwide, and the solution is about to reach a TRL9.

In this system, a single panel gathers two technologies to garner the sun's energy: photovoltaics for electricity generation and solar thermal for hot water production.

A standard photovoltaic panel generates heat; this heat is not only wasted, but is averse to the panel's photovoltaic efficiency that decreases as temperature increases.

Figure 6: PV and solar thermal panel DUALSUN

Thanks to its heat exchanger and the water circulating behind the photovoltaic cells, the hybrid panel is constantly cooled which allows it to generate more electricity than a standard photovoltaic panel [3].

The system has to be coupled with the heating system of the building to afford hot water needs.

The heat generated by the hybrid panels will heat water that is stored in a hot water tank.

Heat recovery systems based on water are more suitable than heat recovery by air for a residential application, especially in the absence of dual flow ventilation.

The energy production (electricity and hot water) can reach 2,5 more than a classic PV panel.

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In Figure 7, the implementation in a residential building for hot water preparation is illustrated.

Figure 7: Implementation scheme in residential building for hot water preparation

This system has to be coupled with a battery to use the electricity in the common areas of the building. Selling the electricity is not interesting (circ. 110€ MWh) for the co-owner building.

It was also proposed to install charging stations for electric vehicles. However, as the installation of EV stations only benefits to co-owners using electric cars, which are seldom, this investment was considered unnecessary and was unlooked-at.

4.3 Detail of technical specification per building

35 condominiums distributed throughout the city of Nantes were pre-qualified according to the following criteria:

- Collective heating,
- Year of construction < 1970s,
- Co-ownership already aware of energy renovation, or having already taken steps,
- Energy label < D,
- At least, 80 flats

The result is 26 condominiums that have been the subject of a commercial approach to present mySMARTLife. The mySMARTLife project was presented to 10 of 26 condominiums to have the agreement to study the specific project for the building.

Four of the ten condominiums had finally given their authorization to study (cf. Table 3). The others did not follow up on the project.

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Table 3: The four buildings studied within MySMARTLife project

Name	Number of flats	Construction year	Heating source
Beaulieu bât B	480	1976	District heating
La Proue 1	156	1973	District heating
Le Belem	160	1975	District heating
Le Parc	206	1969	gas collective heating

For the four buildings that have been studied, the refurbishment works could have led to the energy performances that are presented in Table 4. The total heating and DHW demand, that would have been achieved with the refurbishment, is compared to the heating and DHW demand before work (first column) and to the heating and DHW demand for French normal refurbishment practice (second column). RES contribution comes mainly from the RES contribution to district heating. Finally, the net energy use (second to last column) is the energy demand minus RES contribution.

The technical specifications are detailed in the paragraphs below.

Table 4: Building expected performance (final energy)

Building	Heating and DHW energy demand (kWh/m²yr)			RES contribution (kWh/m²yr)	Building net energy use for Heating and DHW (kWh/m²yr)	
	Building before work	Normal practice	Refurbishment specification	Refurbishment specification	Refurbishment specification	Improvement / normal practice (%)
Beaulieu bât B	162	110	105	100	5	65%
La Proue 1	135	110	80	67	13	72%
Le Belem	151	110	115	98	17	61%
Le Parc	131	110	60	51	9	77%

4.3.1 Le Belem building

The LE BELEM building is located at 18 and 22 rue Paul Ramadier, in Nantes. The building consists of 160 dwellings and other tertiary or commercial units. It was built in 1975. 70% of the windows are simple glazing and the façades are poorly insulated. The flat roof has recently been redone with waterproofing and thermal insulation. The ERENA Urban Heating Network provides heating and domestic hot water production.

The planning of the project was:

- Presentation to the co-ownership trustee: 16/03/2017
- Presentation to the co-owner's association board: 11/05/2017
- Presentation to the general meeting: 13/06/2017

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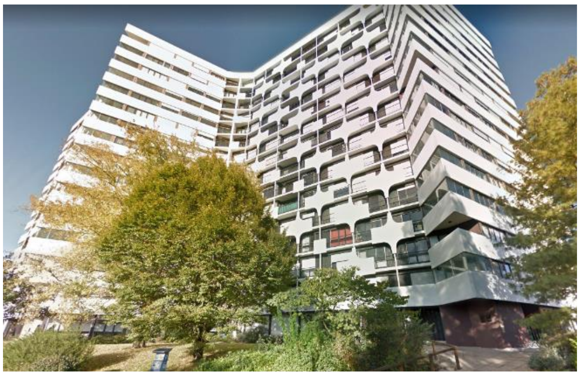

Figure 8: LE BELEM building

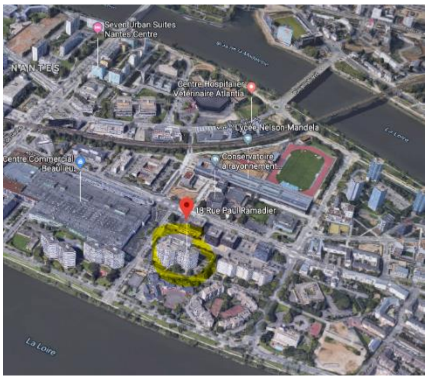

Figure 9: LE BELEM location

Finally, the General meeting has chosen not to participate to mySMARTLife project.

The works planned was as follows:

- **Renewable energy production systems:**
    - 18 kWp PV plant in self-consumption with heat recovery
    - Batteries Storage
    - Micro-wind turbine
- **Energy management system**
    - Regulation between local and renewable production and the electricity grid.
- **Building:**
    - Renovation and thermal insulation of facades (excluding balconies),
- **Charging station for Electric Vehicles**
    - 1 double EV station 2 x 3 kW for 2 places or 6 kW
- **Individualization of heating costs** with the installation of heat flux meters

With this work, the energy savings would have been of 25%. With a 15-year financing of 50 k€/year, the investment by housing type would have been of 62 € to 155 € incl. VAT/year (additional budget compared to the budget before retrofitting) cf. Table 5.

Table 5: BELEM Building: the financial impact according dwelling type

Dwelling type	Condominium unit (tantième)	Annual condominium charges before retrofitting (€ incl. VAT)	Annual condominium charges after (€ incl. VAT)	Additional annual budget (€ incl. VAT)
5 rooms	720	751	906	155
4 rooms	650	678	818	140
3 rooms	570	595	717	122
2 rooms	470	490	591	101
2 rooms	430	449	541	92
Studio	290	303	356	62

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4.3.2 Beaulieu Bat B

All the Beaulieu buildings were built in 1975, 25% of the windows are made of single glazing. There is no insulation of the exterior walls, and 12cm of roof insulation. The ERENA Urban Heating Network provides the heating and domestic hot water production

Finally, the project was not presented in a general meeting because of the too short timing, the co-owner's association wanted more time for think about the project and its important budget. Besides, the retrofitting project was conditioned on the sale of a plot of land for financing.

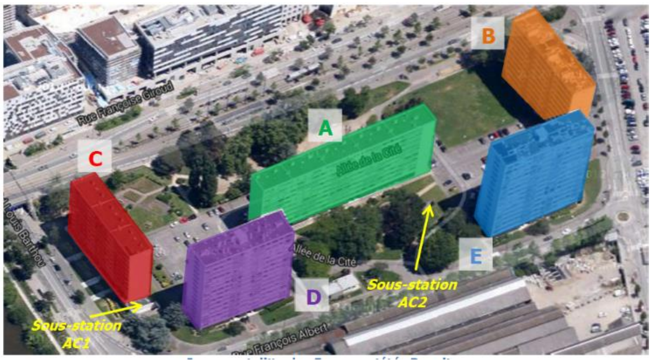

Figure 10: Beaulieu B building

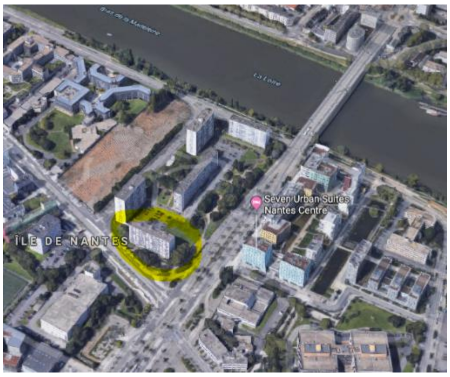

Figure 11: Beaulieu B location

The work planned were as follows:

1. External thermal insulation of the building,
2. Installation of double-glazed windows
3. Installation of hygrometric adjustable ventilation,
4. Installation Thermostatic valves,
5. Network balancing,
6. Photovoltaic power plant + storage battery
7. Wind turbine

Electric vehicles charging station.

The total work budget was 1 157 k€, with a return on investment time of 6 years (cf. Table 6).

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Table 6: Financial simulation for Beaulieu building

	Before retrofitting	After retrofitting with financing (15 years)
Baseline consumption	722 MWh	306 MWh (42% saving)
Heating budget	37 000€ TTC	22 000€ TTC
15-year work annuity		84 305 € TTC
Maintenance	5 860 € TTC	5 860 € TTC*
Total (retrofitting work not included)	42 860 € TTC	27 860 € TTC

*contract with performance commitment and profit-sharing

15 000€ TTC

ENGIE Cofely Contractual engagement

4.3.3 Le Parc

All the buildings of Le Parc were built in 1969, 85% of the windows are double-glazed and low thickness insulation of exterior walls and roof is installed. Heating production is provided by a collective gas boiler and the production of domestic hot water is individual. The ventilation is natural.

Planning:

- Meeting in the building: 14/11/2017 and 12/10/2017
- Presentation to the co-owner's association board: 10/02/2018
- General meeting: 12/02/2018
- Information meeting: 13/03/2018
- Meeting in the building: 20/03/2018

Figure 12: Le Parc building

Figure 13: Le Parc location

Because of structural disorders, the condominium for security reasons had to renovate its facades. Therefore, alternative scenarios were considered:

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1. Simple insulation works and renovation of the boiler room: target consumption after works 1493 MWh PCS
2. Low consumption renovation (“BBC”): Complete insulation work, renovation of the boiler room, replacement of windows, installation of a new ventilation system, installation of photovoltaic panels to reach the French “BBC” level: target consumption after works 896 MWh

Despite an equivalent average cost €/accommodation between the 2 scenarios, the co-owners chose Scenario 1 with the lowest investment. ENGIE Cofely carried out the renovation of the heating system. The retrofitting of the building was done by another actor. ENGIE Cofely is committed to the energy saving after the retrofitting work to guarantee energetic performance and savings on energy bills to co-owners.

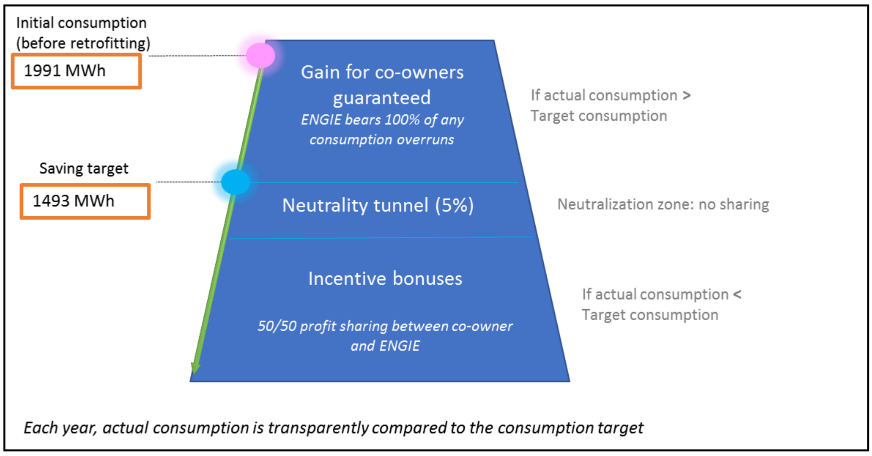

Figure 14: Le Parc, Performance commitment scenario 1

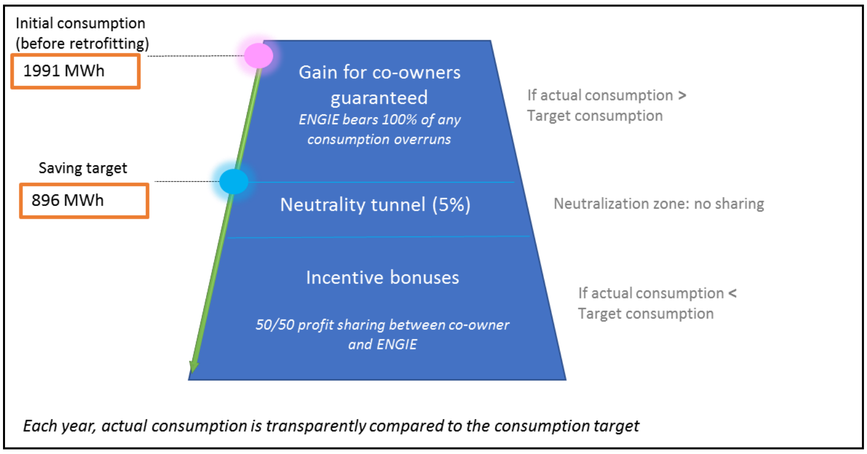

Figure 15: Le Parc, Performance commitment scenario 2 ("BBC")

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Table 7: Le Parc: Budgetary impacts and savings for co-owners

		Scenario BBC	Scenario -25%
	Price of work	**4 437 098,19 €**	**3 145 917,54 €**
	Project price (work suprvision included - 15%)	5 102 662,92 €	3 617 805,17 €
	Nantes Metropole subsidies	1 000 000,00 €	
	Other subsitdies : certificats économie energie (CEE) + subsidies MSL (mysmartlife)	180 000,00 €	37 000,00 €
	Cost to be financed (CEE + MSL included) excluding energy savings	**3 922 662,92 €**	**3 580 805,17 €**
	Photovoltaic revenue donated to the co-ownership	10 000,00 €	
	ENGIE: Engagement of gas saving	1 095 MWH PCS	498 MWH PCS
	Financial valuation of energy savings (gas price february 2018)	53 750,46 €	24 432,03 €
Example of financing (managed by the trustee)	Global annuity for codemonium with loan 2,43% over 15 years, **energy saving excluded**	315 190,44 € TTC/an	287 721,78 € TTC/an
	ENGIE : commitment consumption saving	53 750,46 € TTC/an	24 432,03 € TTC/an
Example of financing (managed by the trustee)	Global annuity for codemonium with loan 2,43% over 15 years, included **energy saving**	261 439,99 € TTC/an	263 289,76 € TTC/an
	per thousandth (based on 40000eme)	**0,545 € TTC/MILLIEME/MOIS**	**0,549 € TTC/MILLIEME/MOIS**
	€/apartment (average apartment)	105,76 € TTC/LOGEMENT	106,51 € TTC/LOGEMENT

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4.3.4 Proue 1

The audited Proue 1 building was built in 1973, and is composed of 156 dwellings. Heating and Domestic Hot Water are provided by a district heating substation. The ventilation is a single flow controlled mechanical ventilation.

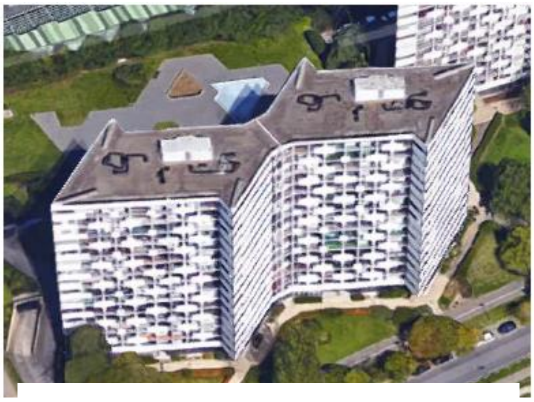

Figure 16: Proue 1 building

The 29th may 2018, the co-owner's association gave its authorization to study the project on Proue 1 building after 2 meetings (on the 9th and 16th of April). Finally, the decision planning was postponed following a complaint from the neighboring condominium (Proue 2), and the new timing no longer corresponded to mySMARTLife schedule.

The planned works for a budget of 3 650 000 € inclusive taxes was as follows:

- Optimization of the electricity contracts for the common areas,
- Replacement of the 6 controlled mechanical ventilation boxes by 2 high-performance boxes and installation of humidity sensitive ventilation units,

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- Insulation of the 1st floor overlooking the exterior,
- Insulation of the flat roof terrace,
- replacement of the windows of the dwellings and common areas in single glazing by double glazing,
- closing of the loggias by a full height curtain wall,
- thermal insulation from the outside of the walls overlooking the balconies and loggias.

4.4 Difficulties in retrofitting buildings in co-ownership

- **Cost and decision process**

The cost or refurbishment work and the decision process lead to long delay in refurbishment work in multi-owner buildings.

Indeed, each co-owner votes for the work in general meeting, and it is necessary to have at least 50% of voters in favor of the project for the resolution to be validated. The divergence of co-owners makes the outcome of the vote even more uncertain.

The major work deteriorates the business plan of non-occupied owner and the major investment does not increase the amount of rent collected.

Actually, each project represented an investment between 1 million and 3 million euros. These are exceptional important amounts for a condominium in terms of voting. The co-owners need time and several information meetings to fully understand and join the project.

Therefore, retrofitting a building takes on average between 3 and 5 years from the « sketch phase » to the approval phase.

In addition, even if the general meeting votes for the work, a co-owner who disagrees with the decision could bring this decision to court and made an appeal to the decision. In fact, the project is uncertain to succeed.

Despite the energy efficiency certificates (EEC), national subsidies and financing schemes, the rest of the costs were on average €15 to €20k per dwelling. The disparity of owners in terms of age, income, landlord/occupant leads to divergent opinions. Even if the project is viable (investment in terms of savings), the cost retains the co-owners.

In each proposal of third financing, the situation before and after the work was highlighted and compared with the rest of the charge to be borne by the co-owners. However, as the price of energy is low, the estimated saving was not high enough to justify an investment, even if the investment is spread out during the duration of the contract.

Other resistance to retrofitting work were also encountered:

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- **Intrusion feeling**

Retrofitting often concerns the replacement of windows. It also requires installation of CMVs for air quality reasons. These works lead to intervention in private dwellings. Thus, a feeling of intrusion is often highlighted during meetings.

- **Installation of individual meters**

The installation of individual meters is changing the way to invoice the consumption of heating. Before, the distribution of heating costs depends on the size of the dwelling (calculated according to the « tantieme ») whatever the level of insulation or temperature level in the dwelling. Yet, this way of invoice does not make possible to enhance the value of individual energy improvement works (e. g. replacement of windows), or to decrease the heating set point temperature. The only solution to correlate energy consumed by dwelling with the bill is to install individual meters. Many co-owners with misdirected dwellings (or poorer insulation) fear a significant increase in their energy bills.

4.5 Opportunities in retrofitting building in co-ownership

At the various meetings, in addition to third financing, and national and local subsidies, the following opportunities were presented to explain why to invest in energy saving.

- **Green label**

The green value defines the increase in value generated by a better energy and environmental performance of one dwelling compared to another, all other things being equal and according to notarial bases. According the study made by Notaire de France [4] older A-B energy labelled apartments sold in 2017 were in average 6% to 22% more expensive than D labelled. Considering that dwellings are sold in average every ten years, it could be an important future opportunity.

- **National regulations on on-board thermal insulation work**

The French government has chosen to act with a new measure: the obligation to carry out "on-board" thermal insulation work. They are called "on-board" because they concern buildings that are already undergoing renovation works on their exterior walls. This decree, effective since 1 January 2017, aims to remedy the poor energy performance of many homes.

More specifically, insulation works will be mandatory when:

- The building undergoes a façade renovation: the restoration or replacement of the plaster, the installation of a new facing on at least 50% of the façade
- A major renovation of the roof is carried out: for a roof repair of 50% or more of the roof covering.

On-board thermal insulation works will not be mandatory if:

- The intervention would deteriorate the appearance of the building or impact the preservation of heritage,

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- Financial problems arise. If the addition of external insulation works implies a return on investment of more than 10 years,

Many other derogations are provided for in the decree and allow many buildings to avoid additional work.

- **Local support**

Nantes Metropole has chosen to support retrofitting through financial and technical actions. This local mobilization leads to effective high-level retrofitting of condominiums in Nantes Metropole area. The actions of Nantes Metropole regarding energy retrofitting, are explained more in-depth next part.

5. Nantes Metropole implementation plan of energy retrofitting

5.1 Nantes Metropole's policy on energy retrofitting

5.1.1 The Great Debate for energy transition

Nantes Metropole has been involved in several actions regarding energy retrofitting. It appeared as one of the big challenges during the Great Debate on energy transition organized by the Metropolis in 2016 and 2017. Citizens and stakeholders of the area were asked to participate to help to build the territorial objectives on energy transition. Several modes of participation were possible: workshops, stakeholder seminars, the share of feedbacks, or a website where anyone could contribute. The diversity of subjects covered by the Great Debate was quite wide: development of renewables, energy retrofitting, mobility, energy savings, teleworking and co-working places, vegetation in the city, reducing waste, developing sustainable and local agriculture.

Figure 17: The Great Debate for energy transition

This led to the construction of a framework document in 2018: Nantes Metropole's roadmap for energy transition. The latter gathers the different objectives on the subjects mentioned above. In the roadmap for energy transition, quantified targets to reduce energy consumption are set and in particular for the private sector, allowing the energy renovation of 10 000 housings by 2030.

Three of the objectives are directly related to energy retrofitting:

- Invest 100 million euros from the metropolis by 2030 for the energy renovation of buildings; it includes a long-term investment program for the retrofitting of public buildings, a new financial aid package or the development of a web platform aiming at providing information on retrofitting and financial aids to private.
- Double the number of ambitious renovation projects in the area to reduce the energy vulnerability of low-income households

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- A new support for individual situations of energy vulnerability

Now focusing on the housing field and more precisely on the co-ownership cases, other financial aids are provided to undertake energy retrofitting works.

5.1.2 Nantes Metropole actions for residential energy retrofitting

Several initiatives are emerging on Nantes Metropole area to support the energy retrofitting, especially in the residential field.

One of these initiatives is the MonProjetRenov web platform that is also part of mySMARTLife project through action 32. It simplifies the energy retrofitting process for owners by improving its readability and providing owners with information on the financial aids they can ask for. It is also a way for owners to have general information on energy retrofitting works and to have a list of professionals of the area.

For condominium, specific financial aids are available through the “Ville de Demain” program in which Nantes Metropole takes part. The latter answered to a call for proposals named “Energy Retrofitting” launched by the “Ville de Demain” program (“City of tomorrow” program) in 2015. This call for proposals aimed at obtaining funds to set up a new grant for exemplary retrofitting on multi-owner buildings. These funds come from the French public financial institution “Caisse des Dépôts”. To get a grant, the retrofitting works must reach a specific energy efficiency: the “Low-consumption Level” (BBC level in French, which leads to a certification) defined by a maximum consumption for heating, DHW production, lighting, ventilation, air conditioning, and the auxiliaries. This value is adjusted according to the region of France in which the building is located; for Nantes area, it amounts to 80 kWhep/m²/year.

A thermal study modelling the building before and after works must be carried out by an engineering consultancy. If the energy work package allows the building to remain below this target value, the different grants may be awarded to the condominium. To do so, the latter needs to go through the application process of the BBC certification. If a certifying body approves the BBC level, the co-owners’ may be entitled to the following various grants:

- Financial support for an energy audit, if it has not been already carried out
- Financial support for the energy retrofitting works
- Assistance to fund the project management tasks
- Financing of 50% of the energy assessment after works, with a maximum cost of 5€/m².

Regarding this last point, when a heating season has passed following the renovation work, the condominium must start an assessment of the energy performance of the building(s). This energy assessment follows a technical specification, which defines the measurements and analysis to be made, such as:

- Operating measurements (temperatures), energy and water consumption for heating and DHW,
- Electricity consumptions,
- Air quality measurements (ventilation flows, CO2, radon) and temperatures in the dwellings

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- Occupant survey
- Infrared camera analysis
- Airtightness test

This data will be analyzed to gather feedbacks on energy renovations. In this analysis, the main objectives will be to determine the proper functioning of the system, to assess the actions implemented during the retrofitting work, which one are positive and useful, and those who did not work out as expected. This is therefore in line with the monitoring planned as part of mySMARTLife project. Indeed, in the latter, the objectives of the monitoring are to analyze if the energy targets are reached, and the evolution of the latter compared to the initial state.

5.1.3 Support by Nantes Metropole energy transition project manager

On Nantes Metropole area, 18 condominiums in total have engaged worked within the "Ville de Demain" program, but, as said previously, the condominiums system is quite specific and therefore it needs a dedicated support. It is the role of the "energy transition project managers" at Nantes Metropole.

Each of them has a defined intervention zone in Nantes Metropole area, and is in charge of supporting the condominiums of the area. The energy transition project managers provide them with several information and advice:

- General information on energy retrofitting, associated regulations and the challenges of renovation,
- Detailed information on the available financial aids and the associated bodies,
- Tools and advices all along a renovation project, for example with informative sheet on energy assessment, or speaking during the general meeting, presenting financial aids and their conditions.

To sum up, the energy transition project managers allow the co-owners to obtain free and neutral advice and support condominium on energy retrofitting and the associated tasks.

They have an important role to play with condominiums in the "Ville de Demain" program. They first introduced the program and its requirements to them and offered to participate in it. They are the link between the co-owners and Nantes Metropole, in particular to deal with the different grants of the program (for the energy assessment, the work and the monitoring) and oversee the smooth running of the program.

5.2 Selected Buildings for mySMARTLife

The five buildings selected for mySMARTLife have conducted high level energy retrofitting that represent around 17000 m2 and 200 dwellings (see Table 8). The co-owners of these buildings had accepted the works to achieve this high-level scenario, the works will all be achieved by the end 2019 (see Table 9).

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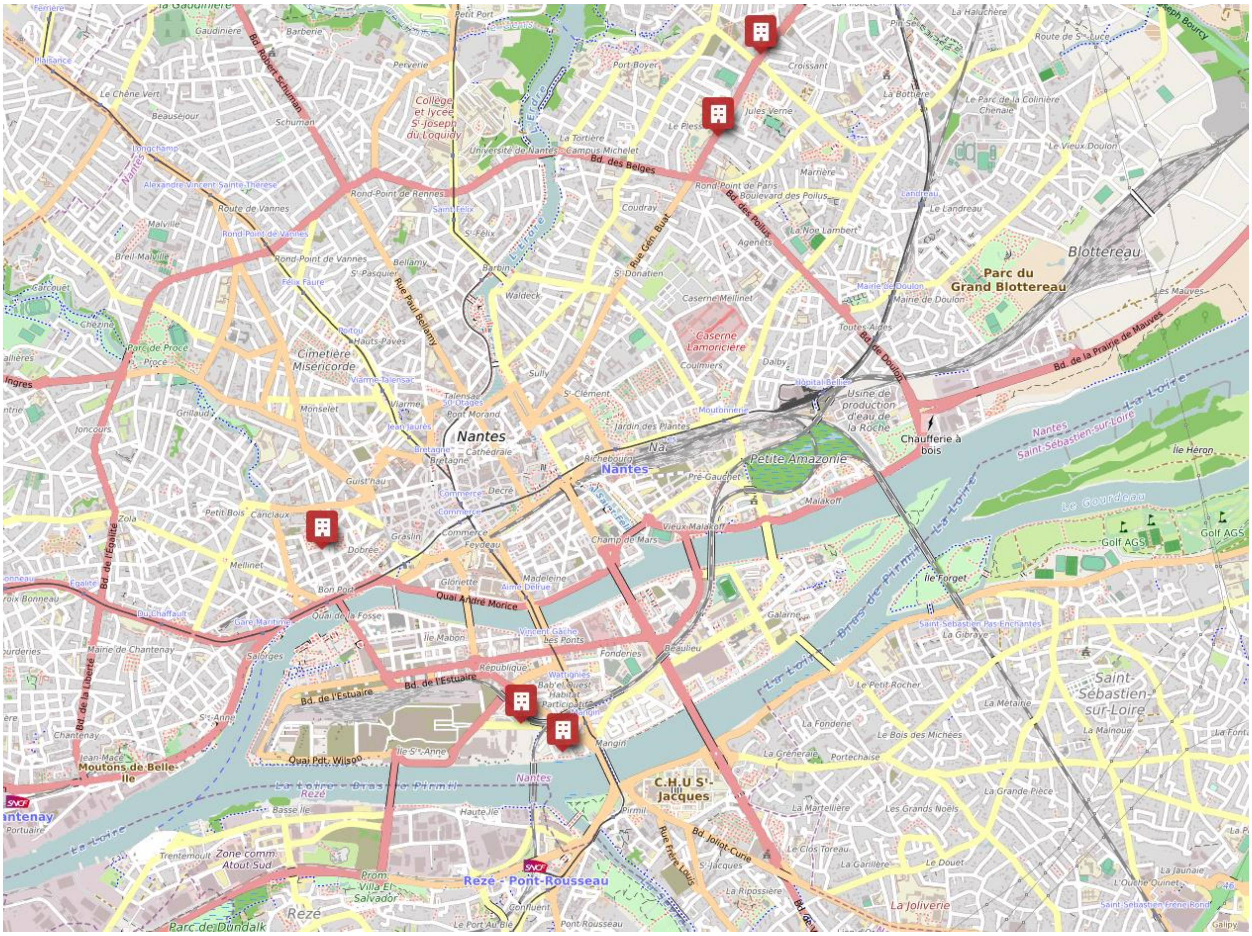

Figure 18: Location of the 5 retrofitted condominiums

Table 8: Selected buildings for mySMARTLife

Name of the co-ownership	Number of flats	Gross area	Initial construction year	Heating source
Nantes-Paris	A: 71 B: 39	A: 6 550m² B: 3 198m²	1962	Gas (collective)
Benoni Goullin	76	5 693 m²	1958	Gas (collective)
Le Strogoff	36	2 225 m²	1971	Gas (collective)
Val de Loire	20	1 441m²	1976	Gas (individual)
Massillon	34	2 889 m²	1972	Gas (collective)

The works were different for each building (see 5.4.2), so were the costs (see Table 9).

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Table 9: General information on the work

Name of the co-ownership	Date of the vote in General meeting for the work	Beginning of the work	End of the work	Cost of the work
Nantes-Paris	07/2015	11/2015	05/2018	2 239949 €
Benoni Goullin	12/2017	10/2018	12/2019	1 580 306 €
Le Strogoff	11/2015	11/2016	03/2018	468 795 €
Val de Loire	01/2017	10/2017	10/2018	983 000 €
Massillon	06/2017	01/2018	06/2019	1 166 259 €

5.2.1 Nantes-Paris

Nantes Paris was built in 1962 in concrete and is composed of two buildings placed in right-angle (see **Figure 19**). Building A is directed NW/SE, as building B is directed NE/SW. Building A (building basement + 10 floors) is higher than building B (building basement + 5 floors). Works lasted between November 2015 and May 2018.

Figure 19: Nantes-Paris

Figure 20: Building B before retrofitting

Figure 21: Building B during retrofitting work

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Figure 22: Nantes Paris after retrofitting works

Architect: SoléCité, Scop d'architecture, Laurent Raimbault & associés

5.2.2 Benoni-Goullin

Benoni-Goulin was built in 1958 in concrete. Because of the specific architecture of the building, there is no main orientation (see Figure 23). The building is high of 13 floors + building basement. Works will end between October 2018 and December 2019.

Figure 23: Location of Benoni Goulin

Figure 24: Benoni-Goulin during retrofitting // Architect: Mervane architectes

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5.2.3 Le Strogoff

Le Strogoff was built in 1971 in concrete. Its main orientation is NW/SE (see Figure 25). The building is high of 6 floors + building basement. Works have lasted between November 2016 and mars 2018 (see Figure 26).

Figure 25: Location of Le Strogoff

Figure 27: Le Strogoff before retrofitting work

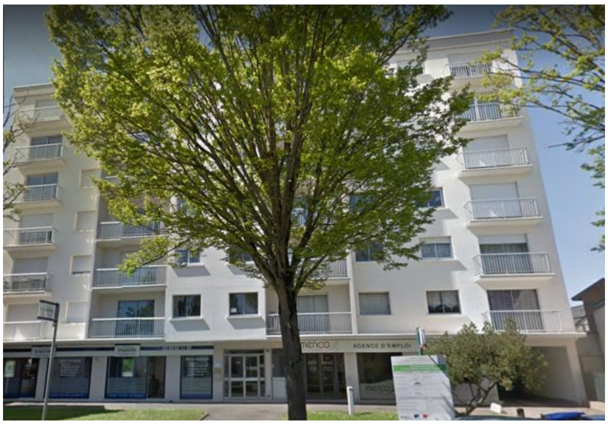

Figure 26: Le Strogoff after retrofitting work

Architect: CHANTIERS INGENIERIE

5.2.4 Val de Loire

Val de Loire was built in 1976 in concrete. Its main orientation is South-East (see Figure 29). The building is high of 5 floors + building basement. Works has lasted between October 2017 and October 2018.

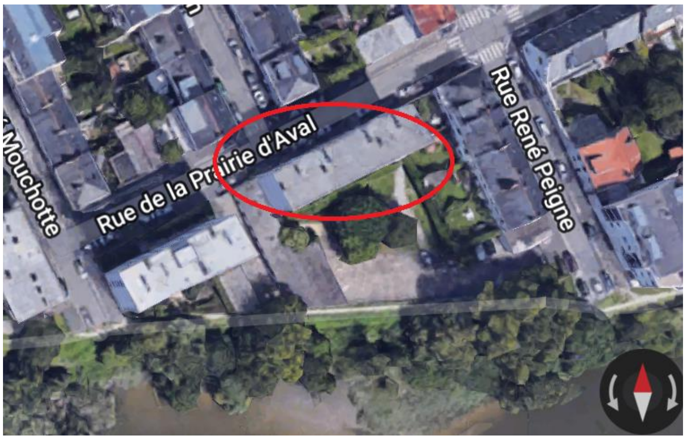

Figure 29: Location of Val de Loire

Figure 28: North West Facade of Val de Loire after retrofitting

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Figure 30: South East Facade of Val de Loire after retrofitting Works

Architect: Frédéric MAURET, Architecte du Patrimoine

5.2.5 Massillon

The Building was built in 1972 in concrete. It has two façades on the street, north and East. Its main orientation is East/West (see Figure 32). It is a seven-floor building and it includes basement, with some part lower. Works has lasted between January 2018 and June 2019.

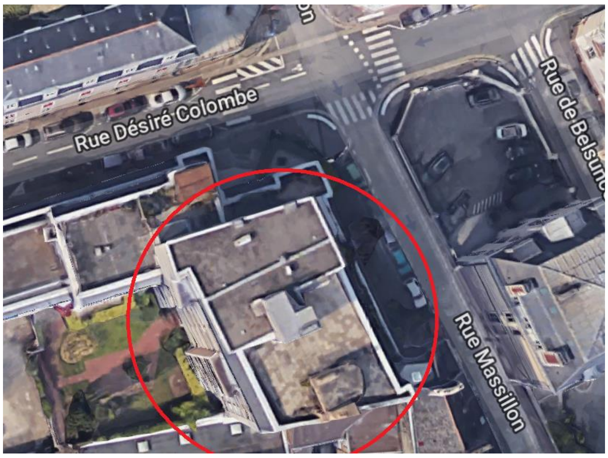

Figure 32: Location of Massillon

Figure 31: Massillon facade before retrofitting works

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Figure 33: Massillon facade during retrofitting works

Architect: AXENS Architectes

5.3 Building expected performances

For a relevant refurbishment design, it is important to assess accurately the impact of various energy reduction initiatives. In France, the choice of the refurbishment and RES actions is usually based on an energy simulation with Th-CE-ex calculation code of French energy saving regulation RT-ex "globale" for existing buildings [6]. The aim is to divide by 3 to 4 the initial building consumption and by 2 in comparison to normal practise.

The calculation algorithm Th-CE-ex concerns the global energy consumption of the building (heating, hot water production, electricity consumption due to ventilation and heating systems such as pumps, lighting or cooling). This procedure in particular, contains the calculation of the energy demand (that includes the loss due to the distribution, regulation, stocking of hot water and the loss due to the heat emission). As the software containing the Th-CE ex code is available among all French energy consultants, it was used for the energy calculation for the expected performance of Nantes' buildings.

The inputs of the code are the following:

- the geometrical data of the building and site topology;
- the thermal characteristics of the building and equipment's;
- the conventional meteorological data of standard year, based on the statistical data from 1970 to 2000;
- the conventional occupancy scheme and needs: occupancy hour, internal gain and set point temperature according to the destination of the building as defined in the French regulation;

The French regulation code is used only for labelling "BBC" low energy building (consumption of 80kWh/m². year of primary energy).

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The goal given in "Ville de Demain" experimentation was not expressed in % but in absolute value of a total consumption less than 80kWhep/m².year.

In Table 10 are presented the expected energy demand results for the retrofitting specification in comparison to the initial energy demand of each building. The data is derived from the Best Tables of each building, and the energy demand covers heating, ventilation, DHW and Lighting.

Table 10: Building expected energy demand (final energy)

Building		Energy demand (KWh/m²yr)				RES contribution (KWh/m²yr)		Total Building net energy use (KWh/m²yr)	
		Building before works	Normal practice	Refurbishment specification	Improvement	Refurbishment specification	Improvement	Refurbishment specification	Improvement / normal practice (%)
1A	Nantes Paris Bât A	110	125	57	68	17	17	40	68%
1B	Nantes Paris Bât B	158	125	62	63	18	18	44	65%
1C	Nantes Benoni Goulin	232	121	58	63	0	0	58	52%
1D	Nantes Le strogoff	230	124	83	41	10	10	73	40%
1E	Nantes Val de Loire	164	124	73	49	0	0	73	41%
1F	Nantes Massillon	178	123	80	43	0	0	80	35%

The retrofitting works mainly targeted the reduction of heating demand (insulation work) and secondly the development of RES with the connection to green district heating or installation of thermal solar panels for hot water production. Concerning the replacement of windows, most of them are voluntary – depending of each co-owner decision.

All the buildings did change the ventilation system.

As these buildings are residential buildings, most of the lighting depend on the choice of each dwelling owner, and often, no action is undertaken on the lighting on common spaces. Therefore, there is no improvement in lighting consumption taken into account.

In Table 10 the expected energy demand results for the retrofitting specifications is also compared to normal practices and French regulation energy demand. Indeed, for the renovation of buildings, there is no compulsory minimum energy demand: the French regulation requires only minimum performances for each renovated

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building fabric element. But we used the reference building specification defined in the French regulation of deep energy retrofitting of existing buildings, and the consumptions for the reference building were calculated thanks to the Th-CE ex code.

We obtained for normal practice/national regulation a heating and DHW consumption each of 50 KWh/m²yr, for lighting consumption 10 KWh/m²yr.

The improvement in comparison to normal practice/regulation varies from 35% to 68% depending on the building, its insulation level and its use of RES. The technical specifications are detailed in paragraph 5.4.

You can notice that Nantes A and Nantes B buildings have not the same consumption: it comes only from the difference in compactness and orientation, the technical specification for refurbishment are the same.

5.4 Technical specifications of retrofitting

5.4.1 Existing building

The buildings did not have the same consumption before retrofitting works: energy demand varies between 110 and 232 kWh/m²/year (see Table 10). Indeed, the five buildings did not have the same technical performance before retrofitting, due to difference in the insulation of the buildings, or heating systems efficiency.

Concerning initial insulation level, the buildings Benoni-Goulin, Le Strogoff, -and Massillon to a lesser extent- were all less renovated, with some original walls and/or single glazed Windows (cf. Table 11). However, for all buildings, the initial heating system was gas boilers.

Table 11: Existing building fabric characteristics of mySMARTLife Buildings

Maximum requirements of building fabric	National regulation / normal practice	Nantes Paris A	Nantes Paris B	Benoni Goullin	Le Strogoff	Val de Loire	Massillon projet
Façade/wall U-value (W/m².K)	0,97	0,97	2,71	1,90	1,14	1,85	0,97
Roof U-value (W/m².K)	2,05	2,05	2,11	4,10	0,18	1,35	2,05
Ground floor U-value (W/m².K)	1,56	1,56	2,33	3,20	1,64	1,96	1,56
Glazing Uw (W/m².K)	1,80	1,90	4,20	2,40	1,85	3,18	1,80
Average U-value (W/m².K)	1,51	1,56	3,03	3,45	1,26	2,30	1,51
Shading correction factor Fs	0,40	0,40	0,60	0,60	0,51	0,40	0,40
Ventilation rate (air change rate per hour)	0,77	0,77	0,80	0,84	0,80	0,76	0,77

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5.4.2 Retrofitting projects

After retrofitting, the five buildings obtained different net energy consumption from 40 to 80kWh/m²/year (see Table 10). It comes from the use (or not) of RES and from the different insulation level of the buildings.

Table 12: Energy efficiency and RES actions of mySMARTLife buildings

Building	Building fabric	heating	ventilation	DHW	RES
Nantes Paris Bât A	insulation of walls, ground floor, windows	district heating	hybrid mechanical ventilation	None: existing individual boiler	District heating - renewable part (84%)
Nantes Paris Bât B	insulation of walls, ground floor, windows	district heating	hybrid mechanical ventilation	None: existing individual boiler	District heating - renewable part (84%)
Nantes Benoni Goulin	insulation of walls, roof, ground floor, windows,	sensitive thermostatically controlled valve	hybrid mechanical ventilation	None: existing individual boiler	-
Nantes Le strogoff	insulation of roof, ground floor, partial insulation of walls and windows	Gas condensing boiler	low consumption hygrometric ventilation	Thermal solar panels	22 m² of thermal solar panels for DHW
Nantes Val de Loire	insulation (walls, ground floor)	replacement of 2/3 of the individual boiler with highly modulating and connected condensing gas boiler	hybrid mechanical ventilation	Replacement of 2/3 of the individual boiler with highly modulating and connected condensing gas boiler.	-
Nantes Massillon	insulation of walls, roof, ground floor, windows,	sensitive thermostatically controlled valve	low consumption hygrometric ventilation	None: existing condensing gas boiler for heating and hot water	-

5.4.2.1 Insulation specifications

Table 13 shows the insulation requirements for the five buildings after retrofitting.

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Table 13: Building fabric requirements of mySMARTLife buildings

Maximum requirements of building fabric	National regulation / normal practice	Nantes Paris A	Nantes Paris B	Benoni Goulin	Le Strogoff	Val de Loire	Massillon projet
Façade/wall U-value (W/m².K)	0,36	0,22	0,22	0,24	0,23	0,32	0,44
Roof U-value (W/m².K)	0,27	0,19	0,19	0,18	0,14	0,18	0,80
Ground floor U-value (W/m².K)	0,27	0,28	0,28	0,29	0,32	0,69	0,29
Glazing (W/m².K)	1,80	1,40	1,40	1,40	1,40	1,45	1,38
Average U-value (W/m².K)	1,20	0,73	0,63	0,86	1,34	0,53	0,75
Shading correction factor Fs	-	0,40	0,40	0,60	0,40	0,51	0,40
Ventilation rate (air change rate per hour)	0,58	0,37	0,37	0,40	0,52	0,4	0,51

The insulation levels are average level, as walls, parts of roof or ground floor can be insulated differently in a same building due to architectural constraint.

The insulation level required for Val de Loire (Ground Floor and Wall) and Massillon (Wall and Roof) are not so high as for the other 3 buildings. For Massillon, it is due to architectural constraint, (see Figure 31). Val de Loire has nevertheless the best average U-level due to its compactness and avoidance of thermal bridges by disconnecting the balconies (see Figure 34).

Figure 34: Disconnected balconies of Val de Loire after retrofitting

Figure 35: Nantes-Paris - external insulation during works

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5.4.2.2 Renewable sources

Nantes-Paris buildings are connected to the green district heating of the metropolis, called “Centre Loire” for its heating. The latter is supplied by 84% by renewable energies: waste and biomass recovery that allows the reduction of CO2 emissions.

It is fitted with two different biomass-heating plants named Malakoff and Californie that are located on Nantes Metropole area, and represent 208 MW of installed capacity.

The network represents 85-kilometers of insulated pipes.

Figure 36: Map of the "Centre Loire" district heating network

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This district heating, including the biomass power plants, is operated by ERENA, a subsidiary of ENGIE Réseaux.

For the Building Le Strogoff, ten solar panels (22,6m² effective area) were installed on the roof for the DHW production (see Figure 37). The productivity of the solar panels prescribed is of 0,793 with the certification Solar Keymark N°011-7S1603 F (EKLOR CSOL423 EKS). The solar panels are connected to a solar tank of 1250l (EKLOR BSOL ECS).

Figure 37: Le Strogoff solar panel

A controller regulates the collection of solar heat based on the sensor's information for three hot water temperatures: solar panel temperature (Tc), heat exchanger return temperature (submerged at the bottom of the solar tank), exchanger inlet temperature submerged in the tank. It also collects data as solar operating time, cumulative kWh production and the three additional energy meters of the DHW installation (pulsed output).

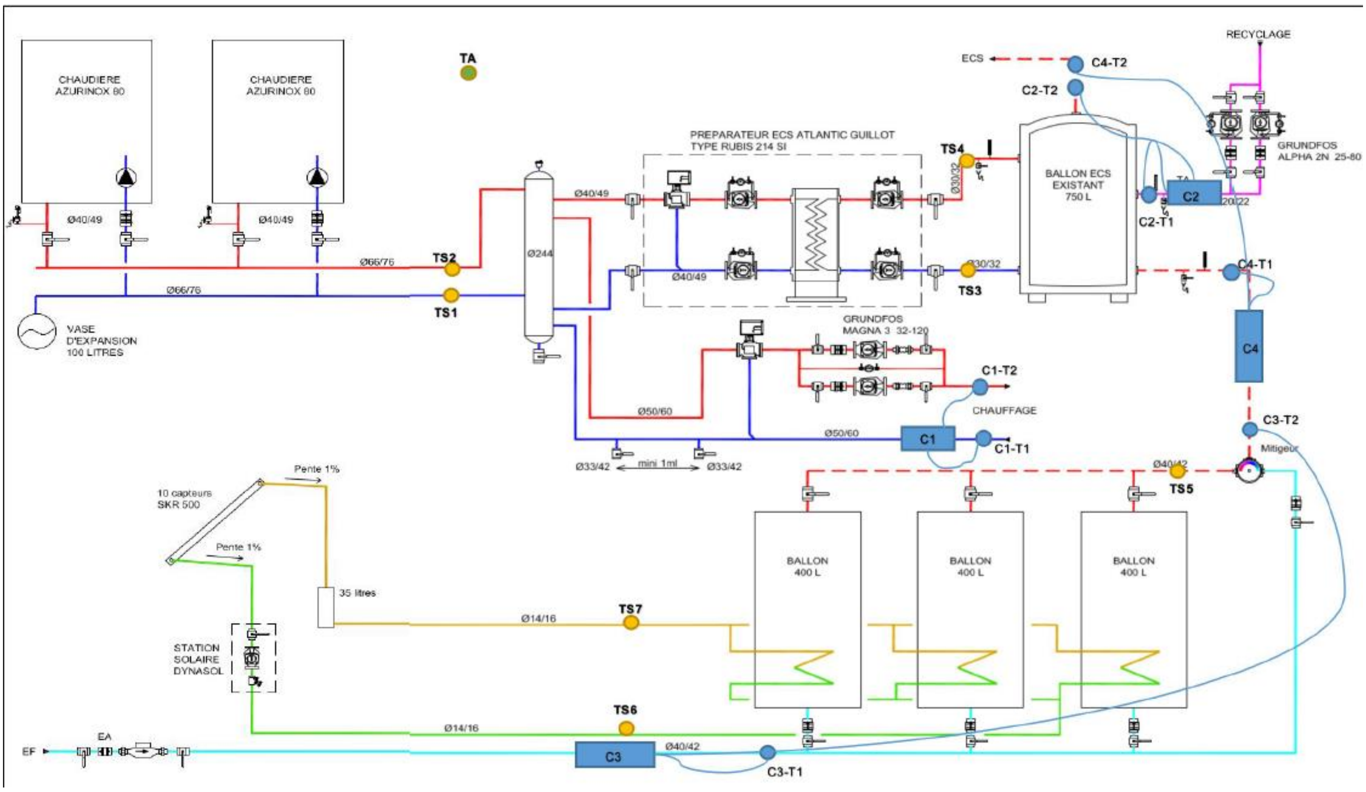

Figure 38: solar installation and regulation

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5.4.2.3 Ventilation systems

Hybrid mechanical ventilation is installed for four buildings out of six (cf. Figure 40 and Figure 41). For the other two buildings, low consumption hygrometric mechanical ventilation was installed.

Hybrid ventilation systems can be described as systems providing a comfortable internal environment using different features of both natural ventilation and mechanical systems at different times of the day or season of the year. It is a ventilation system where mechanical and natural forces are combined in a two-mode system. The main difference between conventional ventilation systems and hybrid systems is the fact that the latter are smart systems with control systems that automatically can switch between natural and mechanical mode in order to minimize energy consumption and maintain a satisfactory indoor environment. [IEA project HybVent].

In our case, the hybrid ventilation is a fan assisted natural ventilation. The system works under most weather conditions with natural forces, but in case the wind and buoyancy forces do not fulfil, the required ventilation level, the special developed fan starts to run (cf. Figure 39). The air enters through inlet in the windows, and is extracted in the WC, Bathroom and kitchen in each apartment trough existing natural ventilation concrete duct, with so-called shunt. A fan can support the flow of the duct. These systems are now proven to be operational in existing building with existing natural ventilation duct and are about to be currently installed in this case (TRL 9).

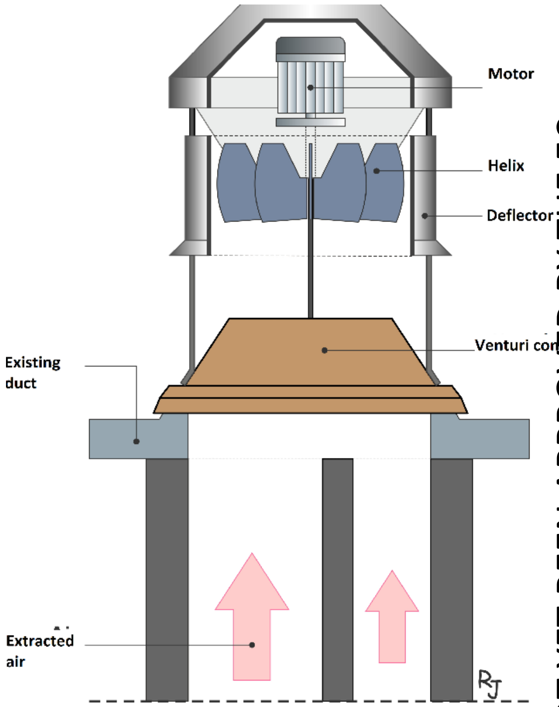

Figure 39: fan assisted natural ventilation principle

Figure 40: Fan support of Val de Loire hybrid ventilation

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Figure 41: Fan support of Nantes-Paris hybrid ventilation using existing duct

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6. Monitoring

The monitoring process is an essential part of the project. It provides the necessary raw material for carrying a precise evaluation of this project, keeping track of performance, further helping to understand the impacts one intervention can bring; also, to relate to the city scale.

As part of WP5 dedicated to the monitoring, a lot of work has already been done and preparation was undertaken to be ready for M36, and to prepare for the monitoring.

The WP5 work is still ongoing, and projections are subject to change; but first milestones have undoubtedly been reached upon the common work of WP5 T5.1, T5.2 and T5.3, such as the set of monitoring KPIs, shared between the three lighthouse cities and based upon reference sources (“SCIS” or “CITYKEYS” to name a few).

As for this deliverable and at times of writing, a monitoring schema and a refined set of KPIs have been consolidated to prepare the monitoring implementation. These documents are developed as part of the WP5 T5.3 for which an interim version of the deliverable D5.3 is due by M36, and the final one by M48; it is likely, therefore, that they could be updated with a few changes.

The monitoring scheme concerning the actions A2: Retrofitting of multi-owner buildings and A17: Connection to the district heating is presented in Figure 42.

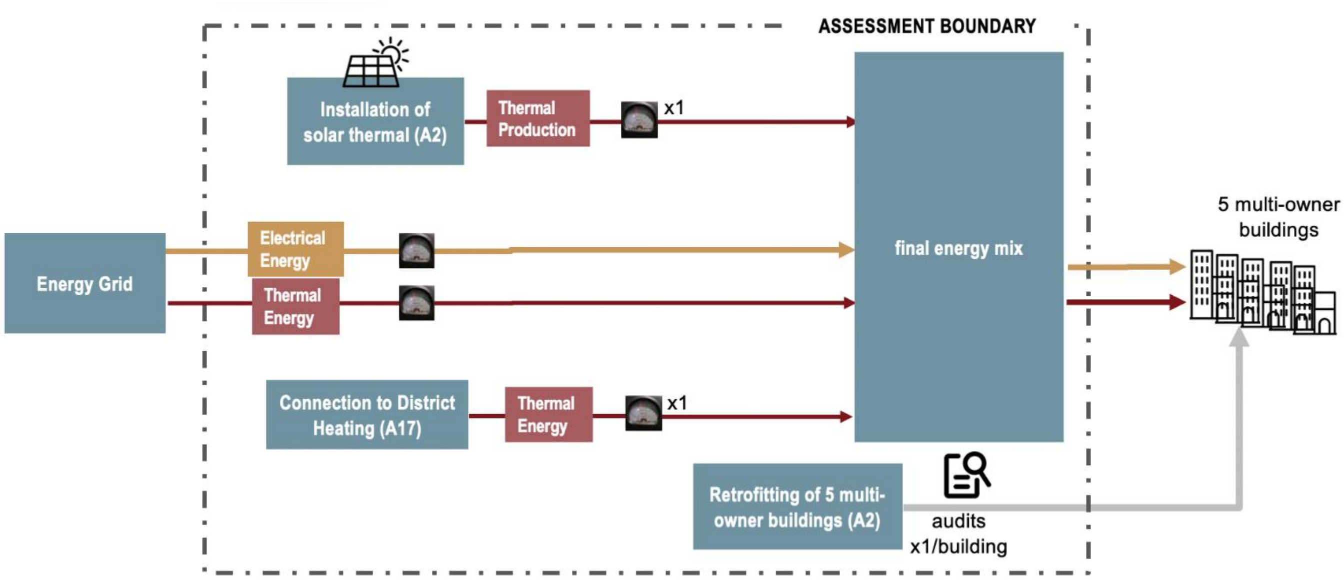

Figure 42: Monitoring scheme

In the framework of the program “Ville de Demain” the monitoring of the refurbished building is compulsory. We will especially have access to the consumptions and temperatures listed in Table 14. The temperature, hygrometry and electric consumption will be monitored in at least 15% of the flats of each building, with a minimum of 5 flats. The consumption of heating, DHW, and RES production are monitored at the whole building

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level, expect for Val de Loire, where the boilers are individual. Electricity for ventilation, boiler room and common spaces is monitored also.

The data is available in cvs files at the frequency of one hour for one year. The monitoring duration will be extended to meet MySMARTLife requirements.

Table 14: Monitored data in the selected buildings

Outside	Meteorological station	Temperature, hygrometry, irradiation
Dwelling	Temperature	Living room optional: bedroom
	hygrometry	Living room optional: bedroom
	Electricity	Dwelling electric meter
Boiler room	Gas / district heating	Gas meter/ district heating meter
	Heating	Heat meter
	DHW heating	Heat meter
	RES production (solar panel)	Heat meter
	DHW volume	volumeter
	Temperature	Boiler room
		Cold water inlet
		Inlet/outlet primary loop
		Inlet/outlet heating
		Inlet/outlet production DHW
		Inlet/outlet distribution DHW
		Inlet/outlet solar loop
General services	Common spaces	electric meter
	Boiler room	electric meter
	Ventilation	electric meter

In mySMARTLife project, a list of shared indicators has been established so that the actions and their impacts may be compared from one city to another. These indicators will be centralized in the Urban Data Platform.

The monitoring

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Table 15 explains, for each chosen KPI, how they will be calculated, with formulas, units, KPI sources and more information on the integration with the mySMARTLife ICT ecosystem: yellow rows highlight primary indicators, which are based on the collected data, blue rows indicate the secondary indicators which can be calculated straight from the primary KPIs. The green rows, finally, highlight the secondary indicators for which a human evaluation is required (e.g. evaluation of Greenhouse Gas Emissions reduction if emissions prior to the intervention need to be simulated).

As mentioned above, this monitoring scheme can still be updated in the coming months, as it is part of WP5 T5.3 and for which the final version of the deliverable is due by M48.

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Table 15: mySMARTLife KPIs

KPI	Indicator	Type	Monitored ?	Formula	Unit	Source	Urban Platform		
							Service	Integration	Open Data
E1	Thermal energy consumption	Primary	Monitored	#	kWh/(m2.month); kWh/(m2.year)	Central heating system	No	Yes	Yes
E2	Electrical energy consumption	Primary	Mixed	#	kWh/(m2.month); kWh/(m2.year)	Energy bills + mesh address data	No	Yes	Yes
E4	Annual energy consumption	Secondary	Monitored	E1 + E2	kWh/(m2.month); kWh/(m2.year)	Calculation	No	Yes	Yes
E6	Energy use for heating	Primary	Monitored	#	kWh/(m2.year)	Central heating system heat-meter	No	Yes	Yes
E7	Energy use for DHW	Primary	Monitored	#	kWh/(m2.year)	Central heating system heat-meter	No	Yes	Yes
E19	Primary thermal energy consumption	Secondary	Monitored	E1 * primary thermal energy factor	kWh/(m2.year)	Calculation	No	Yes	Yes
E20	Primary electrical energy consumption	Secondary	Monitored	E2 * primary electrical energy factor	kWh/(m2.year)	Calculation	No	Yes	Yes
E21	Total primary energy consumption	Secondary	Monitored	E19 + E20	kWh/(m2.year)	Calculation	No	Yes	Yes
E28	Total greenhouse gas emissions (thermal)	Secondary	Monitored	E1 * thermal energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes
E29	Total greenhouse gas emissions (electrical)	Secondary	Monitored	E2 * electrical energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes
E31	Total greenhouse gas emissions	Secondary	Monitored	E28 + E29	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation	No	Yes	Yes
E25	Total heat supplied to the buildings connected to district heating network	Secondary	Monitored		kWh/year	Calculation	No	Yes	Yes
E26	Degree of heating supply by district heating	Secondary	Monitored	(E25 * 100) / E4	% of kWh/year	Calculation	No	Yes	Yes
E13	Total renewable thermal energy production	Primary	Monitored	#	kWh/year or kWh/(m2.year)	Sensors	No	Yes	Yes
E14	Total renewable electrical energy production	Primary	Monitored	#	kWh/year or kWh/(m2.year)	Sensors	No	Yes	Yes
E15	Total renewable energy production	Secondary	Monitored	E13 + E14	kWh/year or kWh/(m2.year)	Calculation	No	Yes	Yes

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KPI	Indicator	Type	Monitored ?	Formula	Unit	Source	Urban Platform		
							Service	Integration	Open Data
E17	Degree of energy self - supply by RES	Secondary	Monitored	(E15 * 100) / E4	% of kWh/year	Calculation	No	Yes	Yes
E5	Reduction in annual energy consumption	Secondary	Monitored	100 - [(E4 after) * 100 / (E4 before)]	% in kWh	Evaluation + energy bills	No	Yes	Yes
E10	Reduction in annual heating energy use ambitious compared to national regulation for new or retrofit building	Secondary	Monitored	100 - [(E6 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation	No	Yes	Yes
E11	Reduction in annual DHW energy use ambitious compared to national regulation of retrofitted building and/or normal practise	Secondary	Monitored	100 - [(E7 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation	No	Yes	Yes
E22	Reduction of total primary energy consumption	Secondary	Monitored	100 - [(E21 after * 100) / (E21 before)]	% change in kWh/(m2.year)	Evaluation	No	Yes	Yes
E32	Reduction of total greenhouse gas emissions	Secondary	Monitored	100 - [(E31 after * 100) / (E31 before)]	% change in kg CO2eq/(m2.year)	Evaluation	No	Yes	Yes
E16	Increase in local renewable energy production	Secondary	Monitored	[(E15 after * 100) / (E15 before)] - 100	% of kWh/year	Evaluation	No	Yes	Yes
E18	Increase of degree of energy self - supply by RES	Secondary	Monitored	[(E17 after * 100) / (E17 before)] - 100	% of kWh/year	Evaluation	No	Yes	Yes

NB : Responsible for the action is Nantes, and the monitoring Cerema

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Finally, from the common KPI list shared with the three cities, Nantes' stakeholders from monitoring & the Urban Platform have worked together to bring a systemic KPI integration framework into Nantes' Urban Platform. This is described more into details in the Urban Platform deliverable (D2.8) in the "ontology" chapter.

As said previously, the periods of the retrofitting projects are different, so will be the planning of the monitoring, as shown on the following table. For some buildings, it is necessary to stop the boiler to install the calorimeters, therefore some monitoring can only begin in spring 2020.

Table 16: Planning of monitoring

Name of the co-ownership	End of the work	Monitoring
Val de Loire	10/2018	11/2019-10/2021
Benoni Goullin	12/2019	03/2020- 10/2021
Nantes-Paris	05/2018	03/2020-10/2021
Le Strogoff	03/2018	03/2020 -10/2021
Massillon	06/2019	03/2020-10/2021

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7. Conclusion

The energy management, as well as the development of RES is one of the main stakes of the energy transition. Increasing the number of high energy retrofitting and integrating RES into buildings, must then be supported.

Nantes Metropole, through its roadmap for energy transition, has committed to support energy retrofitting in several ways. One of the targets is the condominiums, since an important share of the private residential buildings can be quite old, and sometimes no energy retrofitting works have been carried over the life of the building. Thus, this is a significant source of energy savings.

The condominium context is specific and requires special management. Several difficulties lead to longer and more complex work projects for co-ownerships. Energy renovation projects often involve heavy financial investments on a personal scale, and that is the reason why Nantes Metropole chooses to support retrofitting through various actions.

The main difficulties in retrofitting buildings in co-ownership comes from the governance and the disparity in owners (income, tenant or property owner) that leads to difficulties in decision—making. Combined with high cost of investment despite of subsidies, the process of decision making is very long from 3 to 5 year between energy audit of building and the decision to undertake the work. The duration of the project is also extended because the co-owners need time to familiarize themselves with the works and thus accept the project and the financial investment it represents.

One thing that can be underlined is the fact that including renewables in energy renovation projects for co-ownerships is not always easy. Indeed, renewable energy systems are often seen as an additional investment that is not profitable for the co-owners.

Nevertheless, the implication of Nantes Metropole in the “Ville de Demain” program, delivering financial and technical support, lead to five high-level retrofitting of multi-owner private buildings, with an improvement of 35% to 68% in comparison to national regulation. These buildings will be monitored through an energy assessment and KPIs imported in the Urban Platform.

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8. References

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