Ref. Ares(2019)7391310 - 01/12/2019

Deliverable due date: M36 – November 2019

D2.4 Concept of energy retrofitting in individual houses

WP2, Task 2.2

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	D2.4 Concept of energy retrofitting in individual houses
Diss. Level	PU
Status	☐ Working ☐ Verified by other WPs ☒ Final version
Due date	30/11/2019
Work Package	WP2
Lead beneficiary	Cerema
Contributing beneficiary(ies)	Engie
Task description	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 2.2.2: Energy retrofitting in individual houses. Engagement of citizens in renovation works, via communication events, press and municipal information tools and identification of "volunteer homes" to demonstrate the benefits of energy retrofitting. Renovation work up to 10 individual houses retrofitted on Ile de Nantes by ENG. Monitoring results of the uses of the new services to citizens and of the renovation work of houses.

Date	Version	Author	Comment
24/05/2019	0.1	ENG	First version – table of content
30/08/2019	0.2	CER	Drafting of chapters 3 and 4
09/09/2019	0.3	CER	First writing of chapter 5
26/09/2019	0.4	ENG	Review of the draft version
04/10/2019	0.5	CER	Complete version
11/10/2019	0.6	ENG	Last comments
14/10/2019	0.7	CER	Finalized version – to be sent for review
15/11/2019	0.8	CAR	Review of the document
18/11/2019	0.9	CER	Final version

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Table of Content

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

Table of Figures

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Table of Tables

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Abbreviations and Acronyms

Acronym	Description
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
BBC – label	Bâtiment Basse Consommation – label (Low Consumption Building – label)

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1. Introduction

1.1 Executive summary

The retrofitting and development of local renewable energy in individual houses are a key challenge for energy savings in the building sector and to meet the French national commitments to carbon neutrality by 2050.

The action described in this deliverable consisted in the project of ambitious energy retrofitting of individual houses in the Nantes metropolitan area, combining realizations of works to increase energy performance and installation of innovative hybrid solar panels.

This action has been carried out by Engie, that launched an important call of candidates to identify owners wishing to engage in the project. More than 15 000 mails have been distributed; 250 owners responded to this call, and Engie technicians realized around 150 technical audits.

Within this action, Engie aimed at achieving high-level energy retrofitting operations, that required important works for each home, and as a consequence, important financial investments from owners with long investment returns (more than 15 years).

In spite of the advantages of the Engie offer, many owners preferred to engage in partial renovation works, and only one owner implemented large energy retrofitting works, allowing significant increase of energy performance of his home.

This deliverable describes in detail the action carried out by Engie and analyses its results. It also draws some conclusions about the challenges of large-scale energy renovation of individual homes.

1.2 Contributions of partners

The following table depicts the main contributions from participant partners in the development of this deliverable.

Participant short name	Contributions
CER	Leader of the deliverable, drafting of the deliverable
ENG	Leader of the action ; Contribution to the deliverable : providing of technical information and data

Table 1: Contribution of partners

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1.3 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.

Deliverable Number	Contributions
D2.1	Nantes city audit and baseline assessment of the Nantes demonstration area
D2.3	High level energy retrofitting of multi-owners private buildings
D1.2	Key issues for social awareness and acceptance
D5.1	Integrated evaluation procedure
D5.2	Definition of the data sets and requirements
D5.3	Monitoring programs and deployment in the three lighthouse cities
D2.8	Development of improved services in Nantes Urban Platform

Table 2: Relation to other activities in the project

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2. The challenges of energy renovation in individual houses

2.1 Houses retrofitting in France and in Nantes Metropole

2.1.1 Energy retrofitting of individual homes in France: an important lever to reduce greenhouse gas emissions

In France, the residential sector represents 26% of the final energy consumption and more than 20% of the country's CO_2 emissions; this is approximately equivalent to the emissions from the industry sector, and twice those from the energy sector. To this end, residential buildings are an important source of energy savings and of reduction of greenhouse gases (GHG). That is especially the case for the oldest dwellings, built before the first thermal regulations resulting from the first oil shocks. Dwellings built before 1975 represent more than 20 million of housing units (more than 55% of the housing stock in France) and their energy consumption (per m²) is almost 50% higher than that of newer dwellings (more than 200 kWh / m² / year[1] for dwellings built before 1970, compared with 140 kWh/m² for dwellings built since 2006) [2].

Energy retrofitting of the oldest dwellings is therefore essential to enable France to achieve carbon neutrality by 2050 and thus to respect the commitments made at the international level with the signature in 2016 of the Paris Agreement on Climate.

That is the reason why France adopted in the spring of 2018 a National Plan for Buildings Energy Retrofitting, which defines the objectives of the new French low-carbon strategy for the building sector.

This plan identifies old buildings as a national priority and aims at the renovation of the total building stock at the BBC renovation level by 2050 (BBC : “Bâtiment Basse Consomattion – renovation”, or Low Consumption retrofitted Building label). To do this, the plan provides for the renovation of 500.000 dwellings each year, including 400.000 in the private building stock.

Individual homes (19,5 millions of dwellings) account for more than half of all French dwellings, and about 55% of the heat consumption of all buildings in the country (residential and tertiary ones) [3]: they are so a key target for energy renovation.

[1] Final energy.
[2] Ademe, 2015, Climat, air et énergie – chiffres clés, 214 p.
https://www.ademe.fr/sites/default/files/assets/documents/chiffres-cles-climat-air-energie-8705-bd.pdf
[3] Institut Négawatt, 2014, La transition énergétique du secteur du bâtiment – exploiter les gisements d’efficacité énergétique dans le secteur résidentiel : les actions à mener du point de vue de la demande, 86 p.
http://www.institut-negawatt.com/fichiers/etudes/2014_FFREE_Batiment.pdf

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BBC Rénovation Label (Low Consumption retrofitted Buildings label)

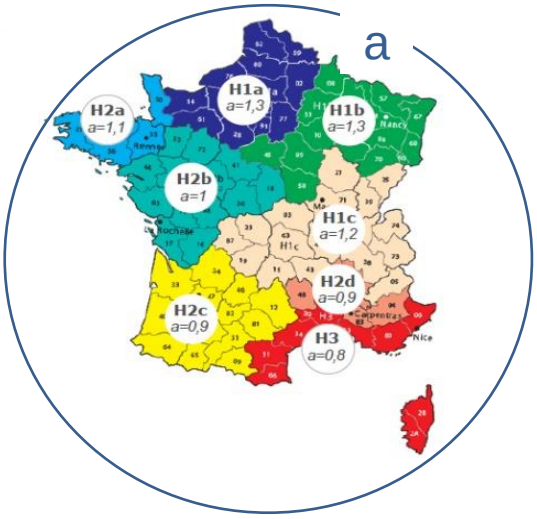
This BBC (Bâtiment Basse Consommation) - rénovation label has been introduced in France in 2009. It sets energy consumptions targets not to be exceeded after renovation of old dwellings.

Once the works are completed, the annual primary energy consumption of retrofitted buildings must be less than 80 kWh_{PE}/m^2.
Value of this threshold can be adapted according to the climate area of the building (a) and its altitude (b).
The annual primary energy consumption (Cep_{max}) not to be exceeded is calculated using the following formula:

$$Cep_{max} = 80\ kWh_{PE}/m^2 \times (a + b)$$

Values of the (a) and (b) coefficients to be taken into account in the calculation are given in the two figures below.

Value of the (a) factor according to the climatic zone



Value of the (b) factor according to the altitude

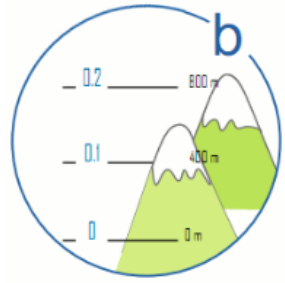


Figure 1: (a) and (b) coefficients BBC level

2.1.2 Energy retrofitting of old buildings and individual houses in Nantes Métropole

At the Nantes Métropole level, challenges are quite similar. Dwellings account for 25% of the energy consumption of the territory and 20% of the greenhouse gases (GHG) emissions. The residential sector is the second largest sector of emissions of the metropolitan area, after the transport sector (42% of the total GHG emissions).

Until now, Nantes Métropole's action in favor of energy retrofitting of buildings focused on multi-family buildings, whether private condominium buildings or collective dwellings in the social housing stock, and

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between 2015 and 2018, 67 condominiums representing 4,920 dwellings were involved in energy retrofitting initiatives in the Nantes Métropole area.

In its new Climate Plan, adopted in February of 2018, Nantes Métropole confirmed the importance of public action in favor of energy retrofitting of buildings, in order to reduce emissions per capita. The new Climate Plan sets up the objective to engage, by 2030, the renovation of 10.000 private housings units at the BBC-renovation level.

To this end, financial aids and communication tools, centralized in the platform « MonProjetRénov » (managed by Nantes Métropole), that targeted only private condominium buildings, are now also aimed at owners of individual homes[4].

In parallel, Nantes Métropole aims at eliminating high-energy consumption buildings and aims at reducing individual situations of energy insecurity. In this perspective, different actions have been launched, in collaboration with associations, energy companies, and housing stakeholders, in order to deploy specific initiatives towards modest households in favor of energy retrofitting.

It is in that context and to face these different challenges that Engie[5], in collaboration with Nantes Métropole, has decided to commit, within mySMARTLife Project, into the “energy retrofitting in individual houses” initiative.

2.2 Regulation applicable to building energy retrofitting

In France, every thermal renovation of residential building is regulated by regulatory standards, defined by law (articles L 111-10 and R.131-25 to R.131-28-11 of the French housing and building code):

- If the building was constructed before 1948, there is no specific normative requirement regarding its renovation.
- If the renovation is related to a building of more than 1,000m² and costs more than 25% of the price of the building, a regulated model has to be done to calculate conventional gains. The consumption calculated after the renovation has to be lower than the regulatory consumption (from 80 to 165 $kWh_{PE}/m^2/an$, depending on the cases). The energy retrofitting of the building must be an “overall renovation”, and regulation sets a normative level of performance to achieve.
- If the building does not fit any of the criteria above, the regulation sets target value for each element of the building that is part of the renovation. For example, if the external walls are insulated, the thermal resistance of the wall has to be higher than 2.9 m².K/W; if the heating system is replaced by a gas condensation boiler, performance of the system has to be higher than 90.9%, etc All the required

[4] In 2016, there were 325.000 dwellings in Nantes Métropole area, including 133.000 individual houses (40% of the dwellings stock) and 192.000 multi-family buildings (60%) (reference : INSEE)
[5] Engie is a French industrial group in the energy sector. It is one of the biggest company of the energy sector in the world ; French State is ist main shareholder.

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conditions can be found in “Arrêté du 3 mai 2007 relatif aux caractéristiques thermiques et à la performance énergétique des bâtiments existants”.[6] In this case, the building energy retrofitting is said to be “element by element”.

For individual houses, regulation to be applied is “element by element”, that is quite easy to achieve regarding to the equipment and materials available on the market. The law is not incentive to achieve very high performances after a renovation.

It is possible for owners to go further than the regulatory prescriptions or to highlight the performances through different labels such as BBC Effinergie Rénovation or HQE Rénovation. International labels like BREEAM or Passivhaus can also be applied to any French renovation.

2.3 Energy retrofitting works in houses

2.3.1 Kinds of work realized for energy retrofitting of individual houses

The different kinds of works that can be made for the energy retrofitting of individual houses are:

- Insulation of roofs and attics
- Insulation of exterior walls and floors
- Installation of new windows and doors
- Installation of new heating system
- Installation of new domestic hot water system
- Installation of a new ventilation system

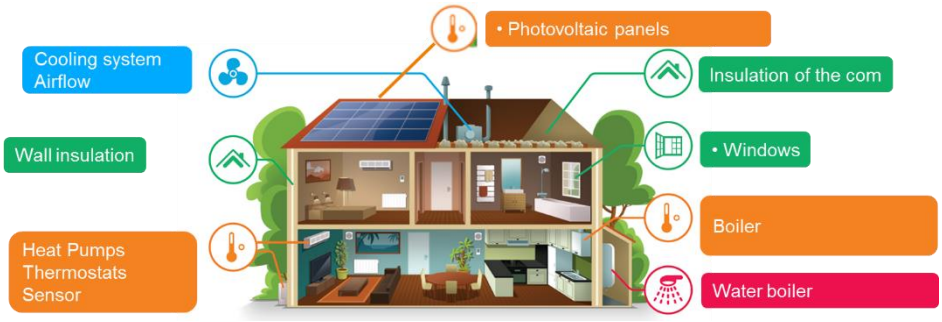

Figure 2: Drawing of retrofitting in individual houses

Some of these works can be coupled or completed with installation of renewable energy production systems (solar water heater, PV panels…).

[6] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000822199

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2.3.2 Encouraging complete renovations for effective renovations

Energy renovation of old dwellings and especially individual houses is a real challenge in order to manage to reduce energy consumption and GHG emissions. However, surveys realized in France towards owners of individual houses who engaged energy retrofitting operations of their houses underlines that results are not very good in terms of energy savings.

Indeed, if more than 5 million of individual houses (approximately 1/3 of the stock) have been subject of energy retrofitting works between 2014 and 2016, only 25% of these renovation operations enable to increase significantly the energy performances of houses[7]. One of the reasons is that an effective retrofitting operation (that achieve to reach the BBC-renovation level) often requires an overall renovation of the building and a good level of performance for each works package engaged.

However, even if the majority of households that have undertaken energy renovation works have realized works packages (*.i.e* they have realized at least two kinds of works at the same time), operations are often insufficient to lead to significant gains.

In addition, French regulations for energy retrofitting of old buildings require minimum levels of performance for each kind of works. However, thresholds of performance are currently insufficient to achieve effective renovations; the mere respect of the thresholds imposed by the regulation during partial renovation does not therefore make it possible today to realize effective renovations in terms of energy gains.

The 10 most frequent works packages completed by houses owners	Part (%)
Windows / doors + Heating system	4,4%
Roof / attics + Windows / doors	4,3%
Walls + Windows / doors	3,5%
Roof / attics + Walls + low floors + Windows / doors + Heating system	3,3%
Roof / attics+ Walls	3,1%
Roof / attics + Heating system	2,7%
Roof / attics + Heating system + Windows / doors	2,5%
Roof / attics + Walls + Windows / doors	2,4%
Roof / attics + Walls + Heating system + Windows / doors	2,2%
Walls + Heating system	1,8%

Table 3: The most frequently works packages realized (source: Tremi survey, 2017)

[7] Ademe, 2018, Enquête Tremi – travaux de rénovation énergétique des maisons individuelles – campagne 2017, 32 p. https://www.ademe.fr/sites/default/files/assets/documents/enquete-tremi-2017-010422.pdf

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It is therefore necessary to encourage homeowners even more to include their work approach in a complete and coherent renovation process, able to achieve the BBC-renovation level. Until now, these more complete and ambitious renovation approaches, which must become the norm, remain marginal: to date, they account only for 10% of individual home renovations.

Obviously, overall renovations are often more expensive than partial renovations. And even if many financial aids and public grants exist (both at national and local levels) for owners wishing to complete energy renovation works, mobilization of these financings is often complex, and that severely limits access for a number of eligible owners.

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3. The call for applications

3.1 Objectives of the project carried out by Engie

The project of "energy retrofitting in individual houses" carried out by Engie Home Services[8] tries to answer some of the observations and issues mentioned above.

Targeting owners of individual houses in the Nantes area, the project aims at testing a complete approach for energy retrofitting that makes it possible to transform very energy intensive houses to effective houses, at the BBC-level standard.

To do this, the project consists on completing works packages among the classical ones realized for energy retrofitting of buildings (insulation of walls and roofs, installation of new windows or new heating systems…) on 10 individual houses.

In addition to these works, it was initially planned to install innovative and smart equipments, produced by 2 companies of the Nantes region:

- Hybrid solar panels from the Systovi company, to produce both electricity (for self-consumption) and to blow hot air in houses (aero-voltaic system) (see technical description below)
- Intelligent and connected Qivivo thermostats, optimizing triggering of the heating system (air and domestic water) according to occupants habits and weather forecasts. But due to the acquisition of the Qivivo company by the Aalberts group in 2018, Qivivo thermostats are not commercialized anymore. Thus, they will not be installed within the framework of the project.

In this way, the project carried out by Engie will try to demonstrate the relevance of complete energy renovation operations on individual houses, combining works for energy retrofitting and installation of renewable energy production systems (unfortunately, the energy regulation of heating has been abandoned because of the end of the Qivivo thermostats commercialization).

The Engie project, however, goes beyond the mere implementation of technical solutions for the energy renovation of housing. By leading the preliminary thermal studies, ensuring the realization and coordination of the works, and accompanying owners in the whole of their approach of renovation (constitution of documents to get building permits, help for fundings search), the project brings to owners an "integrated offer".

This helps to remove the main obstacles and difficulties usually encountered by owners wishing to undertake a major renovation of their home. Moreover, the financing of this action in the framework of the mySMARTlife project also makes it possible to award a grant of € 15,000 per renovated house (additional to national or

[8] Engie Home Service is a subsidiary of Engie, specialized in the maintenance of heating systems for individuals.

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local financial aids). That allows to cover a large part of the cost of the works and reduce the remainder amount to be paid by owners.

Technical description of the R-Volt system by Systovi

Systovi is a French company that develops innovative systems for photovoltaic panels, and multi-energies solutions for housing. Its headquarters is located in the municipality of Carquefou and its main factory in the municipality of Saint-Herblain, both located in the Nantes metropolitan area.

Systovi developed recently an aerovoltaic system, called R-Volt. The R-Volt system is a hybrid solution, allowing both electricity production and heat production. It is composed with a special photovoltaic panel under which the air, naturally heated by the sun, can be recovered and blown into the house. Thus, the system contributes to reduce heating needs. The system allows insufflating healthy air inside, but does not replace a ventilation system. The flow rate is from 70 to 400 m^3/h.

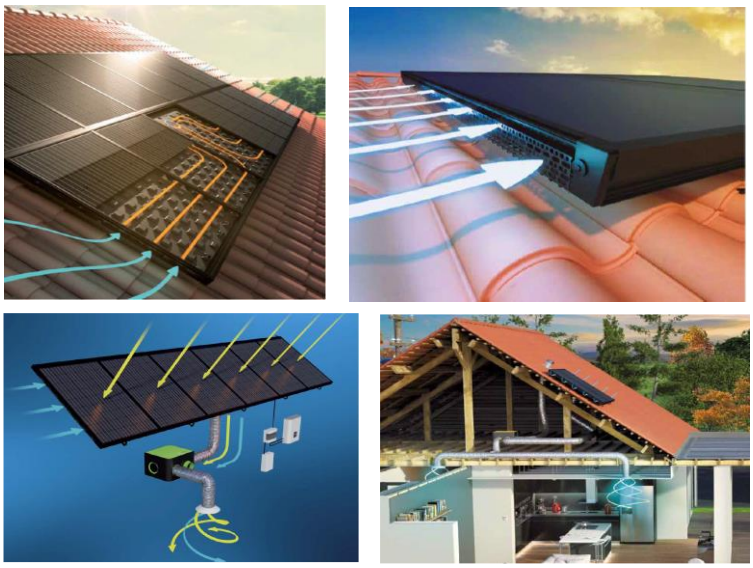

Figure 3: Illustrations of the R-Volt system (reference: Systovi)

The electricity produced by the PV panels is self-consumed to meet household needs.

The hybrid panels can be installed with “boosters” ie panels, which are dedicated to produce heated air (no photovoltaic cells).

There is a specific thermostat in the blow box to deal with the air flow and ensure the comfort inside the house. The specific thermostat can be connected or replaced by the thermostat inside the house to prevent any disturbances with the heating system.

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There can also be a benefit during the summer as the temperature under the panels can be lower than the temperature inside the house and outside (diffuse radiation from the sky vault)

Like any other PV panels, the R-Volt system has to be installed on a roof oriented West to East and with an angle around 30° with no shadows to work as its best level. It requires also some space inside the house to install the mechanical ventilation.

Each unit has a surface area of 1.55 m² (1.52x1.01 m) and can provide up to 900 W (electric 250 Wc with an efficiency of 16.5% and thermic 650 W).

The table in the following page shows the annual performances (thermal and electric productions) for different kinds of roof slopes and according to different climatic areas in France (calculation hypothesis: South orientation, external temperature: 16°C, air flow: 200 m³ / h)

Climatic zone (see map p. 9)		H1a	H1b	H1c	H2a	H2b	H2c	H2d	H3
roof slope : 17°	Annual solar energy (kWh / m²)	1209	1169	1231	1252	1421	1378	1624	1635
	Maximal annual heating production potential (kWh / m²)	116	104	114	134	143	114	114	148
	Annual electric production (kWh / m²)	148	143	151	154	174	169	199	200
roof slope : 30°	Annual solar energy (kWh / m²)	1234	1191	1250	1279	1446	1402	1671	1684
	Maximal annual heating production potential (kWh / m²)	125	110	122	144	152	121	128	163
	Annual electric production (kWh / m²)	151	146	153	157	177	172	205	206
roof slope : 45°	Annual solar energy (kWh / m²)	1207	1162	1215	1251	1406	1363	1642	1656
	Maximal annual heating production potential (kWh / m²)	129	113	125	148	155	124	137	171
	Annual electric production (kWh / m²)	148	142	149	153	172	167	201	203

Table 4: Performance levels of the R-Volt system (reference: Systovi)

The system has been certified with a technical advice delivered by the Centre Scientifique et Technique du Bâtiment[9] (CSTB). This technical advice[10] describes the system and the conditions to install this equipment and its thermal and electrical results obtained in a lab.

[9] Scientific and Technical Center for Building: it is a French public institution whose main mission is to ensure the quality and safety of buildings. CSTB is an accredited certification organisation that is a key player in the certification of construction products and services. Certifications activities of CSTB are accredited by the French accreditation committee (COFRAC). http://www.cstb.fr/en/

[10] http://www.systovi.com/wp-content/uploads/2018/02/Atech-R-Volt-On-Top-14.4-172241_V1.pdf

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3.2 Area of the project

In order to identify the voluntary owners to deploy its project, Engie, launched a call for applications, in collaboration with Nantes Métropole. The call for applications targeted a precise perimeter of the agglomeration Nantes:

- the district of Ile de Nantes (18,251 inhabitants in 2015), main area for the deployment of mySMARTlife actions and center of the Nantes urban demo-site
- the districts of Nantes located in the South of the Loire (11,897 inhabitants)
- the municipality of Rezé (39,649 inhabitants)
- the municipality of Saint-Sébastien-sur-Loire (26,371 inhabitants)

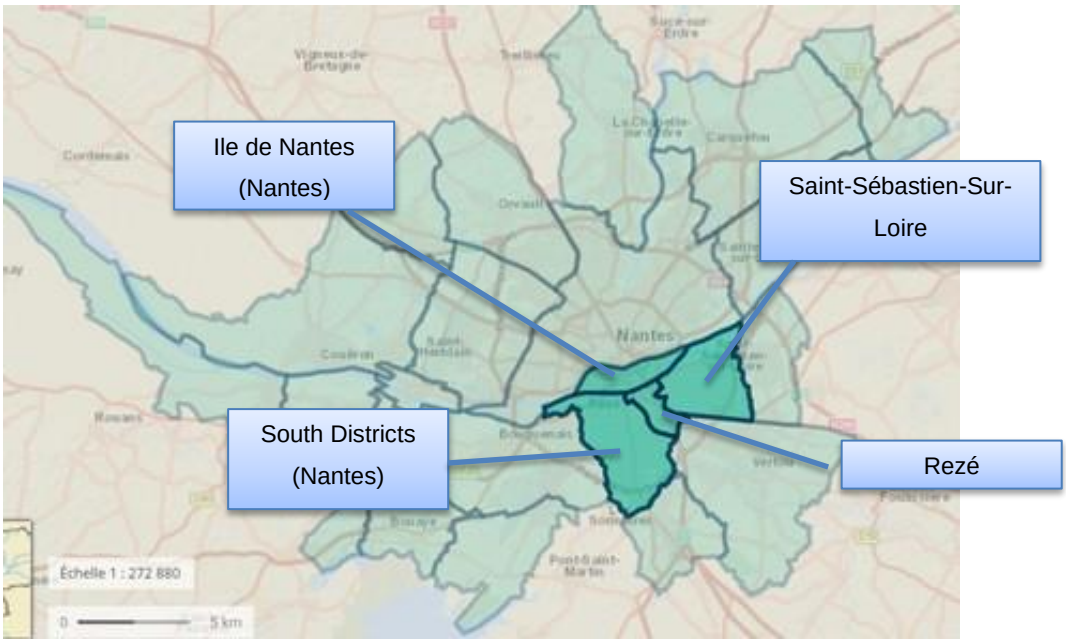

Figure 4: Area of the project

These four zones, located in the heart of the Nantes agglomeration, account for nearly 51,000 dwellings, including almost 20,000 individual houses. Most of these 20,000 houses are located in the two municipalities of Rezé and Saint-Sébastien-sur-Loire (Table 5).

	Housing units	Houses		Apartments	
		Number	%	Number	%
Ile de Nantes	12 337	208	2%	11 898	96%
Quartiers Sud (Nantes)	6 274	1 838	29%	4 401	70%
Rezé	19 457	9 918	51%	9 471	49%
Saint-Sébastien-sur-Loire	12 884	7 656	59%	5 211	40%
Total	**50 952**	**19 620**	**39%**	**30 980**	**61%**

Table 5: Number and types of housing units in the area of the call for candidates

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Among these 20,000 houses, 8,750 (or 47%) were built before 1970 (Figure 5). This kind of houses, built before the first French thermal regulation (introduced in 1975), have in fact energy consumption 20 to 50% higher than that of the most recent housing. As a result, they are the main source of energy savings in the building sector. They also have quite similar constructive characteristics allowing the development of homogeneous solutions for renovation. For all these reasons, selected neighborhoods for the project constitutes interesting sites to test an energy retrofitting process at a large scale.

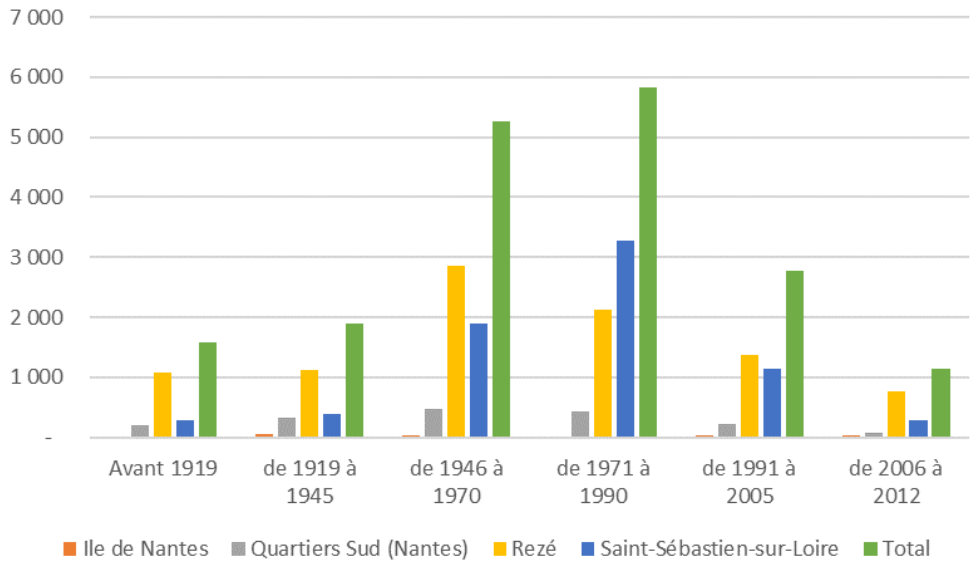

Figure 5: Distribution of houses by construction period (reference: INSEE)

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3.3 Method and tools used

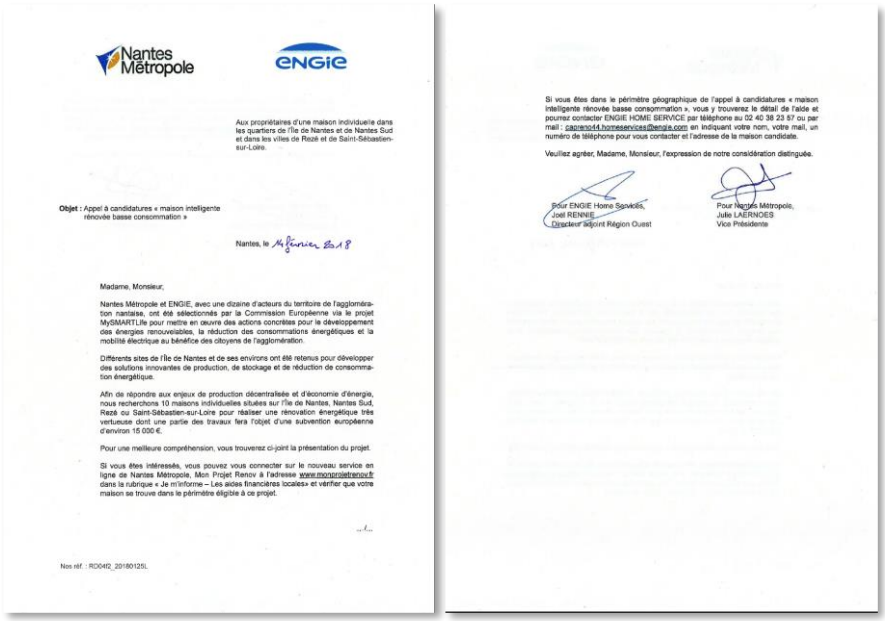
Engie launched its call for applications to find 10 owners of individual houses and volunteer to engage the thermal renovation of their home in mid-2017.

Engie started by sending 2,000 mails to owners of individual houses in the Ile de Nantes and South districts of Nantes.

From February 2018, Engie decided to widen the perimeter to owners in the municipalities of Rezé and Saint-Sébastien-sur-Loire, in order to reach a larger panel of potentially interested owners.

The mail included a letter co-signed by the President of Nantes Métropole (Johanna Rolland[11]) and Engie Home Service Deputy Director for the West Region. The letter informed owners of the projects and invited them to contact Engie Home service if they were interested to commit or get more information.

The mail was completed with a 2 pages explanatory note. This note was detailing the project more precisely and was detailing the eligibility criteria for houses (houses built for more than 15 years and not having been renovated). The note was also indicating the conditions of the commitment in the project (signature


Nantes Métropole

ENGIE

Aux propriétaires d'une maison individuelle dans les quartiers de l'île de Nantes et de Nantes Sud et dans les villes de Rezé et de Saint-Sébastien-sur-Loire.

Objet : Appel à candidatures « maison intelligente rénovée basse consommation »

Nantes, le 14 février 2018

Madame, Monsieur,

Nantes Métropole et ENGIE, avec une dizaine d'acteurs du territoire de l'agglomération nantaise, ont été sélectionnés par la Commission Européenne via le projet MySMARTLife pour mettre en œuvre des actions concrètes pour le développement des énergies renouvelables, la réduction des consommations énergétiques et la mobilité électrique au bénéfice des citoyens de l'agglomération.

Différents sites de l'île de Nantes et de ses environs ont été retenus pour développer des solutions innovantes de production, de stockage et de réduction de consommation énergétique.

Afin de répondre aux enjeux de production décentralisée et d'économie d'énergie, nous recherchons 10 maisons individuelles situées sur l'île de Nantes, Nantes Sud, Rezé ou Saint-Sébastien-sur-Loire pour réaliser une rénovation énergétique très vertueuse dont une partie des travaux fera l'objet d'une subvention européenne d'environ 15 000 €.

Pour une meilleure compréhension, vous trouverez ci-joint la présentation du projet.

Si vous êtes intéressés, vous pouvez vous connecter sur le nouveau service en ligne de Nantes Métropole, Mon Projet Renov à l'adresse www.monprojetrenov.fr dans la rubrique « Je m'informe – Les aides financières locales» et vérifier que votre maison se trouve dans le périmètre éligible à ce projet.

Nos réf. : RD0412_20180125L

Si vous êtes dans le périmètre géographique de l'appel à candidatures « maison intelligente rénovée basse consommation », vous y trouverez le détail de l'aide et pourrez contacter ENGIE HOME SERVICE par téléphone au 02 40 38 23 57 ou par mail : capreno44.homeservices@engie.com en indiquant votre nom, votre mail, un numéro de téléphone pour vous contacter et l'adresse de la maison candidate.

Veuillez agréer, Madame, Monsieur, l'expression de notre considération distinguée.

Pour ENGIE Home Services,
Joël RENNIE
Directeur Adjoint Région Ouest

Pour Nantes Métropole,
Julie LAERNOES
Vice Présidente

Figure 6: Copy of the official letter sent to houses owners for the call for candidates


ENGIE

MySMARTLife

Nantes Métropole

Appel à candidatures « maison intelligente rénovée basse consommation »

De quoi s'agit-il ?

Nantes Métropole et ENGIE, avec une dizaine d'acteurs du territoire de l'agglomération nantaise, ont été sélectionnés par la Commission Européenne via le projet mySMARTLife pour mettre en œuvre des actions concrètes pour le développement des énergies renouvelables, la réduction des consommations énergétiques et la mobilité électrique au bénéfice des citoyens de l'agglomération.

Une action de ce projet consiste à démontrer la performance d'une rénovation qui combine travaux de rénovation énergétique, production locale d'énergie et régulation intelligente du chauffage et de l'eau chaude sanitaire. Ainsi ENGIE, responsable de cette action, en partenariat avec Nantes Métropole, lance un appel à candidature et propose d'accompagner 10 propriétaires dans la rénovation de leur logement en « maison intelligente rénovée basse consommation ». Les propriétaires retenus bénéficieront d'un accompagnement technique sous la forme d'une étude de rénovation énergétique qui identifiera les scénarios de rénovation possibles et d'une subvention importante des travaux sur des fonds européens (à hauteur de 15 000 € environ, cumulable avec les autres aides à la rénovation telles que crédit d'impôt, éco-prêt à taux zéro, ...).

Les travaux consistent en une rénovation énergétique très performante des maisons qui passeront d'une classe minimum E à une classe B ou A. Ils comprennent notamment :

- Une isolation performante du logement : isolation des murs périphériques, des combles, changement des menuiseries
- L'installation de panneaux hybrides (PV et thermiques) sur le toit qui produiront de l'énergie électrique et contribueront au chauffage et/ou à la production d'eau chaude sanitaire
- L'installation de thermostats intelligents permettant d'optimiser le déclenchement du chauffage en fonction des habitudes des occupants et des prévisions météo

Des travaux complémentaires pourront être réalisés en fonction des besoins et de l'intérêt des propriétaires (rénovation de la ventilation, du système de chauffage, ...)

Qui peut y prétendre ?

Cette offre s'adresse aux propriétaires de maisons individuelles situées sur l'île de Nantes et dans le quartier Nantes Sud, dans les villes de Rezé et Saint Sébastien. Les maisons doivent avoir été construites il y a plus de 15 ans, pas ou faiblement rénovées, quels que soient l'énergie et le système de chauffage installé.

Tous les propriétaires (occupant ou bailleurs) sont éligibles, quels que soit leur niveau de ressources.

Comment bénéficier de cette opportunité ?

Si vous êtes intéressé ou que vous souhaitez des informations complémentaires, vous pouvez contacter ENGIE HOME SERVICE

- Par téléphone au 02 40 38 23 57
- Par mail : capreno44.homeservices@engie.com

Ce projet a reçu un financement du programme de recherche et d'innovation Horizon 2020 de l'Union européenne en vertu de l'accord de subvention n° 731297.

- En indiquant votre nom, votre mail, un numéro de téléphone pour vous contacter et l'adresse de la maison candidate.

Vous pouvez vérifier que votre maison se trouve dans le périmètre éligible à ce projet en regardant la carte sur https://monprojetrenov.nantesmetropole.fr/

Suite à ce premier contact, ENGIE proposera qu'un expert vienne réaliser gratuitement une étude de rénovation énergétique du logement. Après l'analyse complète, l'expert proposera plusieurs scénarios de travaux avec des montants d'investissements associés. Il présentera la solution éligible aux subventions du projet MySmartLife.

Le choix des maisons retenues pour bénéficier de l'étude puis de l'aide aux travaux sera fait en fonction des critères suivants :

1. Respects des critères de l'appel à candidature (localisation, délai de réalisation compatibles avec le calendrier (voir ci-dessous), compatibilité des travaux avec les objectifs d'économies d'énergie ...),
2. Ordre d'arrivée des dossiers

Si vous êtes intéressé par la solution éligible aux subventions du projet MySmartLife et que votre projet est retenu par ENGIE, un contrat sera signé avec ENGIE Home Service qui réalisera le chantier, en direct ou avec ses partenaires.

Les chantiers retenus bénéficieront d'une subvention d'environ 15 000€ directement déduite de la facture des travaux.

En contrepartie de cette subvention, le propriétaire s'engage à communiquer ses consommations énergétiques et sa production d'énergie pendant 4 ans. De plus, le propriétaire accepte (i) de mettre un élément de communication (autocollant sur sa boite aux lettres, ou autre moyen de communication...) indiquant que l'Union Européenne a participé à la rénovation et que Nantes Métropole, ENGIE et l'Union Européenne communique sur l'opération afin de faire profiter les autres professionnels et particuliers des retours d'expérience obtenus.

Si vous n'êtes pas intéressé par cette opportunité ou que votre projet n'est finalement pas retenu dans le cadre de cette opération, vous pouvez poursuivre votre réflexion sur un autre scénario de rénovation en vous connectant sur https://monprojetrenov.nantesmetropole.fr/

Calendrier

Les candidatures sont acceptées jusqu'au 15 mars 2018, elles seront traitées par ordre d'arrivée.

L'audit des maisons devra être réalisé d'ici au 1er juin 2018. Il permettra de définir les travaux à réaliser. Les travaux seront réalisés par ENGIE HOME SERVICES en 2018.

Ce projet a reçu un financement du programme de recherche et d'innovation Horizon 2020 de l'Union européenne en vertu de l'accord de subvention n° 731297.

Figure 7: Copy of the technical notice describing the project

[11] From February 2018, letters were signed by Julie Laernos, Vice-Présidente of Nantes Métropole in charge of climate and energy.

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

of a contract between the owner and Engie Home Service, amount of the subsidy paid, counterparties requested from the owner), as well as the different stages and the schedule.

Communication on the project has also been set up on the Nantes Métropole web site dedicated to energy renovation (https://monprojetrenov.nantesmetropole.fr/), as well as on the Engie web site (www.engie.com).

3.4 Steps of the call for applications

3.4.1 First customer contact and control of eligibility of houses

Once the letters sent, Engie Home Service began collecting (by email or telephone) the first calls and applications from the owners targeted

This first customer contact allowed Engie to explain more in detail the objectives and the content of the project to owners. This preliminary discussion allowed Engie to collect technical information on houses, in order to start checking their eligibility for the project (houses of more than 15 years old, no thermal renovation works done, localization into the perimeter of the project, orientation compatible with installation of solar panels…).

3.4.2 Realization of thermal audits on site, and identification of works to be done

For potential eligible houses, an appointment is scheduled on site in order to realize a complete thermal diagnosis of the housing.

Audits are realized by a technician of Engie Home Service. They are based on technical information regarding each house: age, surface area and volume, windows, walls and roof characteristics (material, insulation level…), number of rooms. Realization of audits also requires collection of information on the heating and hot water production systems (type of equipment, age…), ventilation systems, and on the household habits (living temperature, heating planning, number of people in the houses…).

Data collected from each house is then filled in the “bati-cube” software (www.bati-cube.fr) that is a thermal evaluation tool used for retrofitting operations. It makes it possible:

- to establish a first estimation of the energy performance of each house; this first estimation can also be compared with the amount of energy bills of the household (heating, gas, electricity…).
- to identify works to realize to achieve a level of performance equivalent to the BBC-renovation level (80 kWh_{EP}/m^2/year for dwellings located in the Nantes area).

As outputs of the calculation, the bati-cube software provides an estimation of the total energy consumption in kWh and in euros (€), so that values can be compared to real bills. The model can be adjusted to be as representative of the reality as possible. The software also specifies the energy class of the house (classification from A to G, A rating being attributed to the most energy-efficient buildings) [12].

[12] Thermal audits realized with bati-cubre do not take into account energy gains obtained thanks to installation of the Systovi panels. These gains are estimated separatly, using the Systovi software.

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

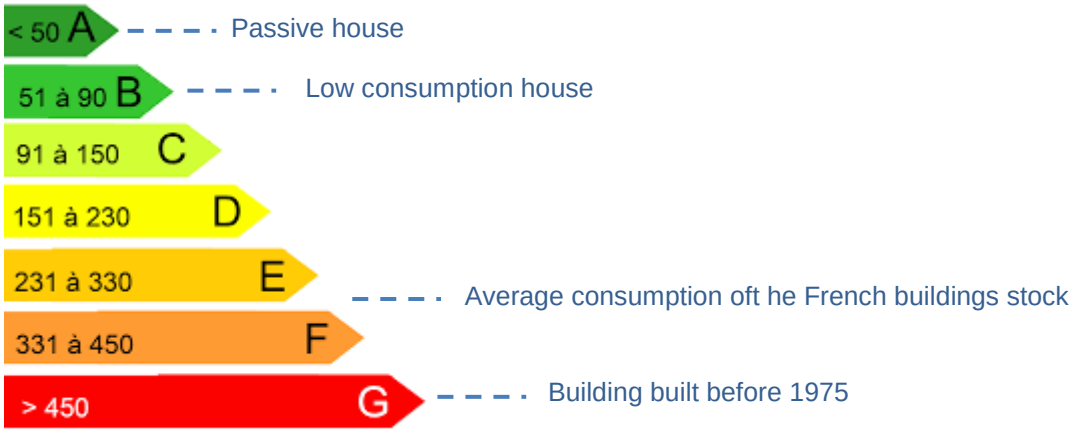


Figure 8: Energy classes (consumption in kWh / m² / year)

Then, different renovation solutions can be simulated (outside surfaces, heating system, renewable energy production), so that the software can estimate new consumptions and bills after realization of works.

As the objective of the project is to achieve a BBC-renovation level, only houses increasing from an energy class E to B are eligible to the project.

Note: the idea is that the evolution from the initial level (E, F or G) to a B level is achieved in two steps: first, works to be realized are defined to reach a C level, and then, installation of the Systovi system has to provide the additional gains to reach the B level.

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

ETAT EXISTANT

INTRODUCTION

La présente évaluation thermique a pour objectif de sensibiliser l'utilisateur sur les axes d'amélioration énergétique de son logement. Cette évaluation thermique a été effectuée à partir des informations recueillies auprès de l'occupant ainsi que des caractéristiques apparentes de l'habitation et des constatations faites lors de la visite, voire certaines mesures relevées sur plan.

Cette étude ne peut se substituer à une étude thermique faite par un bureau d'étude telle que l'impose la réglementation thermique, ni au diagnostic de performance énergétique (DPE) établi par un professionnel certifié. Le maître de l'ouvrage est invité à s'adresser à des entreprises spécialisées s'il souhaite compléter et préciser la présente évaluation thermique par des études ou des devis spécifiques à chaque corps de métier.

Les estimations de consommation n'ont qu'une valeur indicative. Elles dépendent d'éléments variables, tels que la précision des données renseignées, le comportement de l'habitant, les conditions météorologiques, le rendement et l'entretien des équipements...

DESCRIPTIF DU BATI

TYPE DE BATIMENT & SITUATION

- Maison individuelle situé(e) dans le département 44 (Loire Atlantique).
- 100 m² de surface chauffée sur 2 niveau(x) avec 5 pièce(s) principale(s).

OCCUPATION & CONFORT

- Occupation par 3 personne(s) en permanence pendant 12 mois.
- Chauffage à 19 °C avec une température constante et permanente.

ISOLATION

- Construction du 01/02/1900 avec une isolation répartie.
- Plancher bas
- Plancher haut ★★★★★
- Murs ★★★★★
- Vitrages ★★★★

APPORTS SOLAIRES

- Présence d'occultations.
- Pas de présence de masques proches.
- Pas de présence de masques lointains.

DESCRIPTIF DES SYSTEMES

VENTILATION

- Bâtiment avec : 1 cuisine(s), 1 salle(s) de bain sans WC, 1 WC.
- Ventilation simple flux non modulée 1983.

ETAT EXISTANT

SYSTEME DE CHAUFFAGE PRINCIPAL

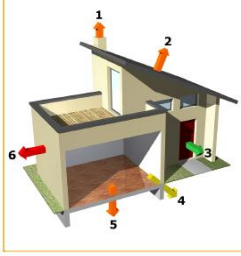
- Habitation chauffée 12 heures par jour.
- Chaudière basse température ancienne de 24 kW au gaz naturel (rendement à 100% de charge de 90.50 %).
- Emission par radiateurs haute température (80/60) couvrant 100% de la surface de la zone.

EAU CHAUDE SANITAIRE

- Production instantanée assurée par le générateur principal de chauffage.

DEPERDITIONS

REPARTITIONS DES DEPERDITIONS



1 - Renouvellement d'air : déperditions = 138 W/K
2 - Toiture : déperditions = 113 W/K U = 2.5 W/m².K
3 - Baies vitrées et portes : déperditions = 25 W/K U baies vitrées = 1.55 W/m².K U portes = 4 W/m².K
4 - Ponts thermiques : déperditions = 65 W/K
5 - Plancher bas : déperditions = 100 W/K U = 2 W/m².K
6 - Murs : déperditions = 160 W/K U = 2.5 W/m².K

Coefficients de déperditions	
H Enveloppe	462 W/K
H Ventilation	138 W/K
H Total	601 W/K
Déperditions	
T° ext de base	-5°C
T° de consigne	19°C
Déperditions	17.3kW

ETAT FUTUR

PROJET 1 : H20_20
AMELIORATIONS DE L'EXISTANT

DESCRIPTIF DU BATI

EXTENSION

- Pas de présence d'une extension.

OCCUPATION & CONFORT

- Chauffage à 19 °C avec une température réduite de 2°C durant 8h la nuit.

ISOLATION

- Isolation extérieure.
- Plancher haut ★★★★★
- Murs ★★★★★
- Vitrages ★★★★★

DESCRIPTIF DES SYSTEMES

VENTILATION

- Ventilation simple flux hygroréglable B.

SYSTEME DE CHAUFFAGE PRINCIPAL

- Chaudière condensation récente de 24 kW au gaz naturel (rendement à 100% de charge de 97.80 %).

EAU CHAUDE SANITAIRE

- Production semi-accumulée assurée par le générateur principal de chauffage.

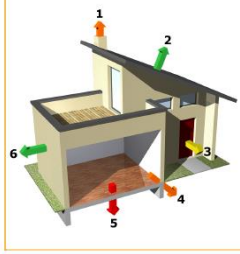
ETAT FUTUR

PHOTOVOLTAIQUE

- 2 m² de panneau(x) multi cristallin, orienté(s) sud à 30°.

DEPERDITIONS

REPARTITIONS DES DEPERDITIONS



1 - Renouvellement d'air : déperditions = 63 W/K
2 - Toiture : déperditions = 6 W/K U = 0.13 W/m².K
3 - Baies vitrées et portes : déperditions = 20 W/K U baies vitrées = 1.21 W/m².K U portes = 3.3 W/m².K
4 - Ponts thermiques : déperditions = 65 W/K
5 - Plancher bas : déperditions = 100 W/K U = 2 W/m².K
6 - Murs : déperditions = 15 W/K U = 0.24 W/m².K

Coefficients de déperditions	
H Enveloppe	206 W/K
H Ventilation	63 W/K
H Total	269 W/K
Déperditions	
T° ext de base	-5°C
T° de consigne	19°C
Déperditions	7.5kW

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

COMPARATIF

CONSOMMATIONS

	EXISTANT kWh/an	PROJET 1 kWh/an
Chauffage	21960	6950
Eau chaude sanitaire	3980	3170
Refroidissement	0	0
Autres usages domestiques	2770	2770
Auxiliaires	1760	590
Production d'électricité	0	-281
TOTAL	**30470**	**13199**
GAIN		**57%**

COUTS PAR POSTES

	EXISTANT € / an	PROJET 1 € / an
Chauffage	1546	489
Eau chaude sanitaire	280	223
Refroidissement	0	0
Autres usages domestiques	389	389
Auxiliaires	280	94
Abonnements	207	207
Montant de revente d'électricité	0	-66
TOTAL	**2702**	**1336**
GAIN		**51%**

DONNEES PUREMENT INDICATIVES SANS ENGAGEMENT CONTRACTUEL ET SOUS RESERVES DE MODIFICATIONS EVENTUELLES. Bati-Cube® de CARDONNEL Ingénierie ne peut être tenu pour responsable sur un manque de fiabilité des résultats édités.
Version de l'interface : V1.836 - Version du moteur : V1.83 - Version de la base de données : V1.83

- Page 6/9 - 11/01/2018

COMPARATIF

COUTS PAR ENERGIES

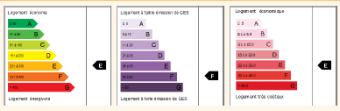
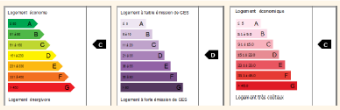
	Abt € / an	Ch € / an	ECS € / an	Froid € / an	Autres € / an	Aux. € / an	Total hors abt € / an	Total € / an
ETAT EXISTANT								
Electricité Abonnement Electricité Bleu option Heures Creuses 6kVa Coût unitaire 0.1593 € le kWh Coût unitaire heures creuses 0.1252 € le kWh	114	0	0	0	348	280	628	742
Gaz naturel Abonnement Gaz naturel tarif B0 Coût unitaire 0.7746 € le m³	93	1546	280	0	41	-	1867	1960
PROJET H20_20								
Electricité Abonnement Electricité Bleu option Heures Creuses 6kVa Coût unitaire 0.1593 € le kWh Coût unitaire heures creuses 0.1252 € le kWh	114	0	0	0	348	94	442	556
Gaz naturel Abonnement Gaz naturel tarif B0 Coût unitaire 0.7746 € le m³	93	489	223	0	41	-	753	846

DONNEES PUREMENT INDICATIVES SANS ENGAGEMENT CONTRACTUEL ET SOUS RESERVES DE MODIFICATIONS EVENTUELLES. Bati-Cube® de CARDONNEL Ingénierie ne peut être tenu pour responsable sur un manque de fiabilité des résultats édités.
Version de l'interface : V1.836 - Version du moteur : V1.83 - Version de la base de données : V1.83

- Page 7/9 - 11/01/2018

COMPARATIF

COMPARATIFS ETIQUETTES

Scénario	Facture €	Etiquette énergie kWhep/m².an	Etiquette climat kg Co2/m².an	Etiquette coût €/m².an
ETAT EXISTANT				
	2702	305	61	27
PROJET H20_20				
	1402	116	24	14
GAIN	**1300**	**189**	**37**	**13**
	48%	**62%**	**61%**	**48%**

Les étiquettes sont un équivalent du DPE (Diagnostic de Performance Energétique) français. Celles-ci ne sont pas réglementaires.

DONNEES PUREMENT INDICATIVES SANS ENGAGEMENT CONTRACTUEL ET SOUS RESERVES DE MODIFICATIONS EVENTUELLES. Bati-Cube® de CARDONNEL Ingénierie ne peut être tenu pour responsable sur un manque de fiabilité des résultats édités.
Version de l'interface : V1.836 - Version du moteur : V1.83 - Version de la base de données : V1.83

- Page 8/9 - 11/01/2018

Figure 9: Example of thermal diagnosis realized

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

3.4.3 Works costs estimation, search for financial aids and requests for administrative authorizations

Once thermal audits have been completed, Engie technicians transmitted to each eligible house owner a quote detailing the type and costs of works to be done to achieve an energy retrofitting at the BBC-renovation standard.

Engie also suggested that each owner contact the Solhia Association. This association aims at improving housing conditions of low-income families, and has thus been able to support homeowners in seeking financial aids and subsidies for the thermal renovation of their home.

Once contents of works have been approved and the financing obtained by owners, Engie took the responsibility of the administrative processes, by ensuring constitution of building permits files when necessary (in case of modification of the external appearance of façade when outside insulation for example).

3.4.4 Realization of works

Engie Home Service technicians have carried out all the heating, ventilation, and windows works. On the other hand, all insulation works (thermal insulations of walls, attics insulation), and installation of Systovi panels have been sub-contracted to specialized local companies.

For each dwelling, works were to last about 3 months.

3.4.5 Initial planned schedule

- July 15, 2017: sending the first wave of letters to home owners living in Ile de Nantes and South Nantes Districts.
- Februray 15, 2018: sending the second wave of letters to home owners living in a wider area, including Rezé and Saint-Sébastien-sur-Loire municipalities
- March 15, 2018: end of the call for applications
- June 1st, 2018: end of thermal audits
- June – September 2018: drafting of quotes, request for administrative procedures, search for financing
- September – November 2019: achievement of works

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

3.5 Results of the call for applications

Results of the call for applications are detailed in the table below:

	1st wave	2nde wave	Total
Number of letters sent	2 000	13 000	15 000
Number of candidates	44	175	219
Number of technical appointments on site	37	47	84
Number of thermal audits realized	20	36	56
Number of admissible applications	5	15	20
Number of quotes sent to owners	3	5	8

Table 6: Results of the call for applications

These figures underline that of the 15,000 letters sent, 213 homes owners have answered and expressed interest in the project and have contacted Engie. In terms of localization, 43 applications come from owners living in Nantes districts (Ile de Nantes or South Nantes Districts), 111 in Rezé municipality, and 59 in Saint-Sébastien-sur-Loire Municipality.

Of the 219 applications received by Engie, 84 resulted in a technical visit on site, and 56 led to realization of thermal audits. In the end, 20 homes, or 10% of the total initial applications have been considered admissible to take part in the project (localization in the perimeter of the project, house over 15 years old, no thermal renovation achieved, direction compatible with installation of solar panels…). Finally, Engie has submitted an offer of works (quote) to 8 owners. To date, only one complete renovation offer has been accepted (and signed) by an owner and led to works.

However, communication on this call for applications has aroused interest from owners beyond the eligible perimeter. Several tens of owners from all the Nantes area, having been informed of the Engie initiative, have asked Engie Home Service for advices in order to engage renovation works.

Thus, Engie carried out audits and works on 32 additional houses located outside the project perimeter. Because of their localization, these 32 additional houses did not have to respect technical requirements imposed by the project in terms of energy gains for example. Their owners could not claim the European subsidy either.

Most of the works done resulted in partial renovations. The works achieved in this context are not sufficient to reach the BBC-renovation level; however, these partial renovations improve the energy performances of the considered dwellings.

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

4. Main results of the action

4.1 Results of technical audits realized with bati-cube software

Engie realized 84 thermal audits on houses with Bati-cube software: 52 in the project's perimeter and 32 additional audits for houses located outside the project's perimeter.

For the 52 audits realized within the mySMARTlife project, the initial energy consumption rates are depicted in the table below:

Energy class	Number of houses
C	5
D	25
E	9
F	8
G	5

Table 7: Number of houses by energy class (before retrofitting works)

For the record, in order to carry out complete renovations and achieve truly significant performance gains, only houses with an E or less mark could be eligible within the mySMARTlife project: 22 houses fulfilled this condition at this step of the research.

For those 22 houses, first the surface of the eligible roof was calculated to ensure that the Systovi system could be installed. For that criteria, 3 houses did not have enough space on the roof.

Moreover, 7 owners did not want to proceed with the estimation of the renovation costs.

For the 12 other houses, the renovation to obtain a C mark has been modeled and the cost for the works has been estimated. Only one owner agreed to go into the renovation process. For the other 11 owners, the costs for the renovation were too high.

The paragraph 4.2 describes the results of the audit and the works in progress for the house whose owner decided to commit in an ambitious renovation process.

For the other 32 houses, audits and modelling for the renovation have been realized. It should be remembered that because these houses were outside the perimeter project, they did not have to comply with the objective to reach a C mark after the renovation (and owners could not benefit from the Engie's grant obtained within the

Energy class E	
Number of houses	**9**
Owners who did not want to proceed with the renovation	6
Houses with too smal available area on the roof	1
Owners who di not have the budget to proceed with all the works	1
Owners who retained Engie proposal	1
Energy class F	
Number of houses	**8**
Owners who did not want to proceed with the estimation of the renovation costs	6
Houses with too smal available area on the roof	2
Energy class G	
Number of houses	**5**
Owners who did not want to proceed with the estimation of the renovation costs	1
Owners who did not want to proceed with the renovation	2
Owners no compliant with the project rules	1
Houses with too smal available area on the roof	1

Table 8: Thermal audits results and decisions of houses owners

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mySMARTlife project). That explains why owners often chose to carry out small and partial renovations. The next table shows the marks before and after energy renovation works, and the works that will be or have been done:

House N°	Renovation works done or to be done	Number of types of works	Energy level		Energy gains			GHG savings
			Before works	After works	kWhep/year	%	Average	kg Co2/an
1	Heating	1	E		8 100	27%		600
2	Heating	1	D	C	3 060	19%		450
3	Heating	1	D	C	3 240	17%		720
4	Heating	1	D	C	1 568	10%		448
5	Heating	1	D	D	2 800	13%		400
6	Heating	1	F	E	6 720	17%		120
7	Heating	1	D	D	1 170	9%		810
8	Heating	1	D	D	4 140	12%		1 800
9	Heating (gas condensing boiler)	1	C	B	12 250	36%		2 000
10	Heating (heat pump)	1	F	E	6 300	27%	14%	490
11	Hot domestic water	1	E	E	1 825	10%		438
12	Roff insulation	1	D	D	960	6%		240
13	Roof insulation	1	D	D	300	2%		100
14	Roof insulation	1	C	C	500	4%		200
15	Ventilation	1	D	C	3 300	22%		800
16	Windows	1	D	D	1 320	6%		330
17	Windows	1	D	D	1 440	7%		240
18	Windows	1	D	D	1 260	6%		360
19	Windows	1	D	D	2 700	14%		400
20	Ventilation + windows	2	D	D	2 080	13%		240
21	Heating + hot domestic water	2	C	B	6 440	38%		280
22	Wall insulation + windows	2	D	D	3 100	16%	28%	400
23	Windows + roof insulation	2	F	D	14 040	48%		624
24	Wall insulation + ventilation	2	D	C	5 472	27%		576
25	Heating + roof and floor insultation + windows	3	C	B	5 760	33%		1 296
26	Floor insulation + windows + insulation of one wall	3	C	B	6 726	46%		1 482
27	heating + ventilation + florr insulation	3	E	D	8 352	29%		1 856
28	Wall insulation + ventilation + windows	3	E	C	8 308	50%	41%	1 922
29	Wall insulation + heating + ventilation	3	E	C	14 500	57%		2 500
30	Heating + roof and wall insulation + ventilation	3	C	B	6 795	35%		1 661
31	Heating + roof insulaiton + ventilation	3	E	D	8 004	29%		5 980
32	Heating + insulation + windows + ventilation	4	G	D	32 078	71%	71%	2 322
TOTAL					**184 608**	**24%**		**32 085**

Table 9: Types of works realized on the 32 additional houses, evolution of the energy performances and CO_2 savings (reference: Engie)

This table shows that the 32 renovations combined together reduce the energy consumption by 184,000 kWh per year (-24%), that corresponds to a CO_2 emissions reduction of 32 tons per year.

Otherwise, the table underlines that a majority of owners (19 out 32, or 60%) decided to engage partial renovations with only one type of works, 5 decided to realize 2 types of works (15%), 7 realized 3 types of works (22%) and one owner engaged a more complete renovation with 4 types of works at the same time.

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The results also confirm that the number of completed work packages has a strong impact on energy savings, since on average, consumption gains (in kWh primary energy / year) are:

- 14% for 1 lot of works
- 28% for 2 lots of works
- 40% for 3 lots of works
- and 71% for 4 lots of works.

As a conclusion, it can be mentioned that regarding to the cost of a complete renovation and the disturbance while the renovation is in progress, owners often prefer to do small renovations and operate on one or two elements at the same time. These kinds of small renovations can achieve reduction of energy consumption. However, some precautions have to be taken into account to avoid desorders in houses in the future. For example, the ventilation system has to be re-evaluated, when the windows are changed in order to guaranty the regeneration of indoor air and protect the house from mould due to humidity.

4.2 Example of one complete realization

As mentioned before, only one house fills in all the conditions to get into the mySMARTlife project:

- The owner answered positively to the call for candidates launched by Engie
- The audit shows that the consumption level of the house is E before the renovation, and will be B after
- The house is well situated and oriented to install the R-Volt system
- The cost of the renovation is reduced by 90% with the financial support. It is reasonable regarding the owner financial capacities (the owner is a low-income household, and benefits of financial aids from local and national funds).

The house is a 100m² house built in 1900 in the Nantes South district. It has a little bit of insulation inside the walls. There was a ventilation system installed in 1983. The heat and the domestic hot water were provided by an old gas boiler.

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Figure 10: Picture of the house before works

Before works, the heat loss was estimated to be distributed as shown in the figure below:

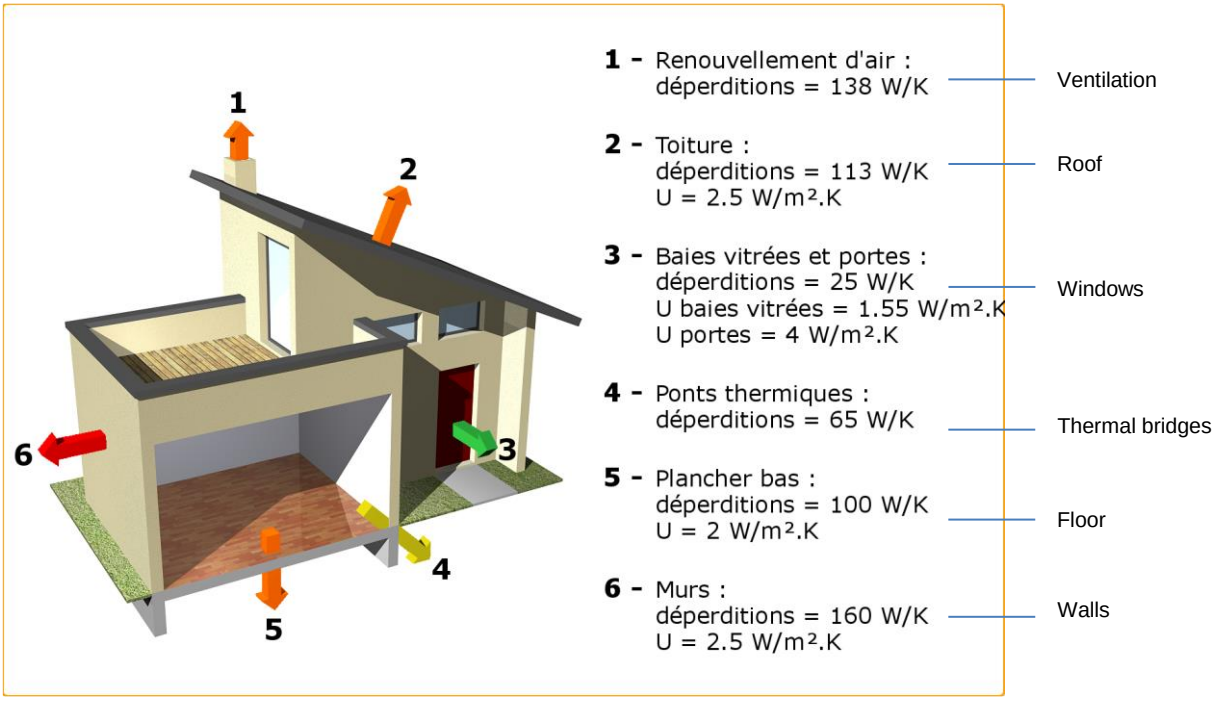

Figure 11: Heat loss distribution before works

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Engie Home services visited the house in 2017. Then, a technician from Engie realized the thermal audit showing that after the refurbishment works the house will have a C mark. The mark got to a B with the energy saving thanks to the R-Volt system.

The audit prescribes the following works (the prices mentioned below come from quotes and are with taxes):

- Insulation from the outside with expanded polystyrene (140 mm and sealant) : 14 700 €
- Insulation in the attic with insufflated glass wool (315 mm) : 1 200 €
- Change all the windows by PVC double glazing windows (U_w = 1,4 W/m².K) : 10 200 €
- Installation of a centralized mechanic ventilation : 3 000 €
- Installation of a new heating system (condensing gas boiler) : 3 8000 €
- R-Volt system (26 m² of aerovoltaic panels : 10 hybrid panels and 4 boosters, 2 points of insufflation): 21 600 €

Figure 12: Pictures of the house during works (installation or R-Volt panels)

Before changing the outside of the house (insulation, panels and windows), the urbanism services had to issue administrative authorizations and that postponed the works by one month. Finally, the works will be over by the end of November 2019 in the house.

The total for the works was estimated to around 54 400 €. The owner has been accompanied by Soliha association to find financial help : 33 000€ from national and local financial programs and 16 500 € subvention according within the mySMARTlife project. This part is the longest in the project as there were many different financial grants files to establish (national, regional, local) and then the owner had to subscribe a credit with a bank.

The energy consumption should be reduced by 57% after works: from 305 kWh_{EP}/m²/year to 116 kWh_{EP}/m²/year (without the airvoltaic panels). The airvoltaic system should provide 2 881 kWh of electricity and 5 163 kWh of thermal energy every year (70% of the heat needs after the retrofitting).

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After the works, the heat losses are estimated to be distributed as shown in the figure below:

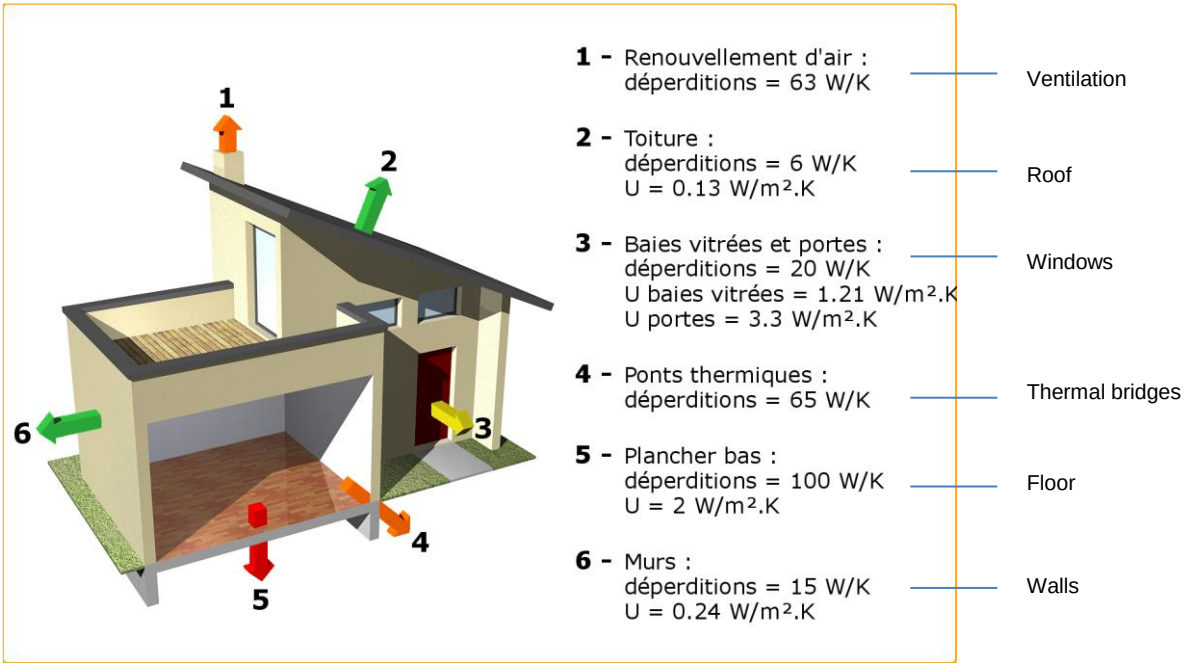

Figure 13: Heat loss distribution after works

Figure 14: The house after the renovation works

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5. Monitoring and evaluation

5.1 Evaluation and monitoring presentation

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, some 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 subjected 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 key performance indicators (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 key performance indicators 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, they could be updated with a few changes.

5.2 List of KPIs

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 centralised in the Urban Data Platform. Below is the monitoring table which explains, for each KPI defined to evaluate the individual houses retrofitting action, how they will be calculated, with formulas, units, KPI sources and more information on the integration with the mySMARTLife ICT ecosystem.

As mentioned above, this table 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.

In this table, yellow rows highlight primary indicators, which are based on the collected data; while blue rows show the secondary indicators which can be calculated straight from the primary KPIs; the green rows colour, finally, the secondary indicators for which a human evaluation is required (eg. evaluation of Greenhouse Gas Emissions reduction if emissions prior to the intervention need to be simulated).

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

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Platform. This is described more into details in the Urban Platform deliverable (D2.8) in the “ontology” chapter. A KPI column has finally been added to assess of this strong link.

KPI	Indicator	Type	Monitored?	Formula	Unit	Source
E1	Thermal energy consumption	Primary	Monitored	raw data	kWh/(m2.month); kWh/(m2.year)	Energy bills
E2	Electrical energy consumption	Primary	Monitored	raw data	kWh/(m2.month); kWh/(m2.year)	Energy bills
E4	Annual energy consumption	Secondary	Monitored	E1 + E2	kWh/(m2.month); kWh/(m2.year)	Calculation
E6	Energy use for heating	Secondary	Simulated	raw data	kWh/(m2.year)	
E7	Energy use for DHW	Primary	Simulated	raw data	kWh/(m2.year)	
E13	Total renewable thermal energy production	Primary	Monitored	raw data	kWh/year or kWh/(m2.year)	Sensors
E14	Total renewable electrical energy production	Primary	Monitored	raw data	kWh/year or kWh/(m2.year)	Sensors
E15	Total renewable energy production	Secondary	Monitored	E13 + E14	kWh/year or kWh/(m2.year)	Calculation
E19	Primary thermal energy consumption	Secondary	Monitored	E1 * primary thermal energy factor	kWh/(m2.year)	Calculation
E20	Primary electrical energy consumption	Secondary	Monitored	E2 * primary electrical energy factor	kWh/(m2.year)	Calculation
E21	Total primary energy consumption	Secondary	Monitored	E19 + E20	kWh/(m2.year)	Calculation
E28	Total thermal greenhouse gas emissions	Secondary	Monitored	E1 * thermal energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation
E29	Total electrical greenhouse gas emissions	Secondary	Monitored	E2 * electrical energy emission factor	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation
E31	Total greenhouse gas emissions	Secondary	Monitored	E28 + E29	kg CO2eq/(m2.month); kg CO2eq/(m2.year)	Calculation
E5	Reduction in annual energy consumption	Secondary	Monitored	100 - [(EN04 after) * 100 / (EN04 before)]	% in kWh	Evaluation
E10	Reduction in annual heating energy use ambitious compared to initial situation	Secondary	Simulated	100 - [(EN06 * 100) / (national regulation)]	kWh/(m2.year)	Evaluation
E22	Reduction of total primary energy consumption	Secondary	Monitored	100 - [(E21 after * 100) / (E21 before)]	% change in kWh/(m2.year)	Evaluation
E32	Reduction of total greenhouse gas emissions	Secondary	Monitored	100 - [(E31 after * 100) / (E31 before)]	% change in kg CO2eq/(m2.year)	Evaluation

Table 10: List of evaluation indicators

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5.3 Monitoring scheme

For this action the monitoring part consists more specifically in gathering the consumption and production data, and being able to see the evolution of the production over the weeks / months / year. The monitoring process is quite simple and is described in the scheme below.

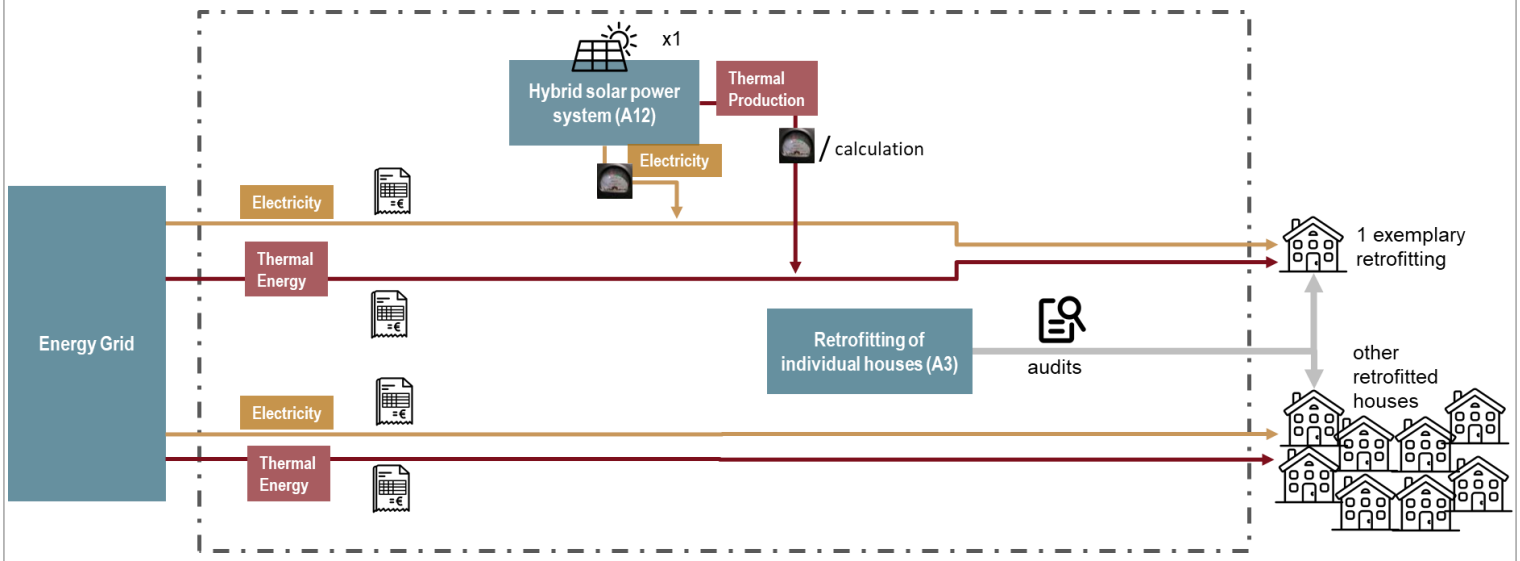

Figure 15: Monitoring scheme for this Action in mySMARTLife Nantes monitoring programme

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6. Conclusions

Engie's approach as part of the mySMARTlife project is an experiment with an innovative model, which aimed at the complete renovation of individual homes across several neighborhoods in the Nantes agglomeration.

By offering owners of individual houses an integrated offer, combining diagnosis, technical advice on the work to be done, implementation and monitoring of works, assistance in finding aid and financing, and taking in charge administrative procedures (authorizations and building permits), the approach carried out by Engie tried to remove most of the difficulties that today are holding back homeowners from embarking on ambitious renovation of their homes.

This approach attempts to provide an answer to the main challenge that the building sector has to face today in France in the context of energy transition: the renovation of the old housing stock, especially individual houses, to a high level of performance (which, it should be remembered, accounts for more than half of the country's housing units and account for more than 55% of the energy consumption of French buildings).

The resources deployed by Engie to carry out this project were important: letters have been sent to more than 15.000 owners of individual homes in 3 municipalities in the Nantes agglomeration. Technical visits have been conducted in more than 80 houses, and Engie technicians have realized 52 thermal audits.

On house has been subject to works to achieve the expected level of performance, even if the goal was to achieve the complete renovation of 10 houses. It will now be necessary to wait for the monitoring of the performance of this house to have a more precise idea of the energy gains and CO_2 emissions savings obtained within this action, but it is obvious that this situation constitutes a mixed result.

It shows the persisting difficulties in finding techno-economic models for efficient and large-scale renovation of the individual housing stock in France, and probably also in Europe. This action also shows that despite the many financial assistance (and advice) that households can benefit from to renovate their homes, the cost of a successful renovation is still too high for many households, who prefer to engage in partial renovations. While these small renovations provide an improvement in the thermal performance of dwellings, the improvements are modest and will not be sufficient to meet national targets for energy saving and CO_2 emissions.

For that reason, it remains to invent new solutions, to further reduce the cost of work, but also to limit the constraints for households that represent heavy renovation work (inconvenience, dust, temporary unavailability of rooms ...) to enable the building sector to meet the challenge of carbon neutrality.

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7. References

Ademe (2015), *Climat, air et énergie – edition 2015, chiffres clés*, 214 p., available at : https://www.ademe.fr/sites/default/files/assets/documents/chiffres-cles-climat-air-energie-8705-bd.pdf (accessed 12/09/2019)

Ademe (2017), *Enquête Tremi : Travaux de Rénovation Energétique des Maisons Individuelles – Campagne 2017*, 32 p. available at : https://www.ademe.fr/sites/default/files/assets/documents/enquete-tremi-2017-010422.pdf (accessed 12/09/2019)

Institut NégaWatt – Réseau Action Climat France (2014), La transition énergétique du secteur du bâtiment – exploiter les gisements d'efficacité énergétique dans le secteur résidentiel : les actions à mener du point de vue de la demande, 86 p, available at : http://www.institut-negawatt.com/fichiers/etudes/2014_FFREE_Batiment.pdf (accessed 12/09/2019)

Ministère de la Transition Ecologique et Solidaire, Ministère de la Cohésion des Territoire (2017), *Plan rénovation énergétique des bâtiments*, 56 p, available at : https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan%20de%20r%C3%A9novation%20%C3%A9nerg%C3%A9tique_0.pdf (accessed 12/09/2019)

Ministère de la Transition Ecologique et Solidaire (2018), *Projet de Stratégie Nationale Bas-Carbone – La Transition écologique et solidaire vers la neutralité carbone*, 151 p., available at : https://www.ecologique-solidaire.gouv.fr/sites/default/files/Projet%20strategie%20nationale%20bas%20carbone.pdf (accessed 12/09/2019)

Nantes Métropole (2018), *Plan Climat Air Energie Territorial – Arrêt du Projet*, 84 p., available at https://www.nantesmetropole.fr/deliberations/co_20180216/03_20180216_CNM_DELA1_projet_PCAET.pdf (accessed 12/09/2019)

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