

# E2ReBuild

Industrial Energy Efficient  
Retrofitting of Resident  
Buildings in Cold Climates



## D2.3 Demonstrator Voiron

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## Executive Summary

Stendhal is a multi-storey building located in Voiron, built in 1961. Voiron is a town located 25 km North-West of Grenoble, in the pre-Alps, at a height of around 300 m above sea level. The building has 72 dwellings (4 343 m<sup>2</sup> inhabited area) and is centrally located, close to the train station, the city hall and all services and shops. It's a typical construction using concrete from the 60's and 70's.

It belongs to the buildings France wants to improve (F class from the Energy Certificate) in order to reduce the consumptions of buildings of 38% by 2020.

The mixed heating systems, differing from a dwelling to another (boilers using, gas, fuel... or electrical heaters), the age of the building and tenants complains on heating and humidity oriented OPAC38 to carry out a deep retrofitting complying with E2ReBuild goals: installing a collective heating system while reducing heating demand by a 4 factor, and reducing energy consumption down to the limit for new buildings (60 kWh/m<sup>2</sup>/year). Also in line with E2ReBuild's vision on industrialisation, OPAC38 closed the balconies using prefabricated elements on the façade of the loggias [Figure 1].



Figure 1: Chronophotography of the building's south façade

Special attention was given to tenant's participation during the all process. This ensured a smooth although rather long project and they now benefit from a renewed building with energy consumptions reduced by 70%. Prefabrication was tested in accordance with the vision of E2ReBuild for industrialisation and means of improvement, also based on the experience of the other 6 demonstration projects, have been identified for further projects using prefabrication.

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# 1 Introduction

## 1.1 E2ReBuild Demonstrations

The demonstration projects in E2ReBuild are the core of the project. E2ReBuild is driven by the demonstration projects, whereas research activities feed into the demonstrations, and results of the demos feed into the evaluation and lessons learned in other work packages. The results and conclusions from the demonstrations will be gathered to produce an industrial platform for energy efficient retrofitting (work package 6).

The objective of the work package 2 projects is to demonstrate seven high energy efficient innovative retrofitting technologies and measures for low energy performing buildings with typologies representative for a large geographical area in Europe.

Each project establishes and demonstrates sustainable renovation solutions that will reduce the energy use to fulfill at least the national limit values for new buildings according to the applicable legislation based on the Energy Performance of Buildings Directives (for 2010) and to reduce the space heat use by about 75%.

Monitoring and follow-up: Based on recommendations given by work package 5, monitoring takes place during at least one year within this project, in some cases for a longer period (also continuing after the completion of this project).

One of the main issues in initial refurbishment discussions concerns costs. This has been treated in depth in deliverable D3.4 *Holistic Strategies for Retrofit* where costs from all demonstration projects are reported, analysed and discussed<sup>1</sup>.

The demonstrators are supported by work carried out in work packages 1, 3, 4 and 5.

This deliverable is defined as a “demonstrator”. This document is the written record of the achievement.

## 1.2 Demonstrator Stendhal in Voiron, France

Stendhal is a multi-storey building located in Voiron, built in 1961. Voiron is a town located 25 km North-West of Grenoble, in the pre-Alps, at a height of around 300 m above sea level. The building has 72 dwellings (4 343 m<sup>2</sup> inhabited area) and is centrally located, close to the train station, the city hall and all services and shops.

The building is made of concrete with no insulation. It's a typical construction from the 60's and 70's [Figure 2]. There were only minor works carried out before the deep retrofitting within E2ReBuild: recently (in 2000) the initial single glazed windows have been changed for PVC-framed double-glazing 4-10-4. Thus, thermal properties are rather poor:

- Wall: no insulation (20 cm concrete + 5 cm air + 5cm brick),  $U=1.75 \text{ W/m}^2\cdot\text{K}$ ;
- Roof: poor insulation (20 cm concrete + 4 cm cork),  $U=1.05$ ;
- Floor: no insulation (8 cm concrete + 15 cm brick),  $U=1.28$ ;

There is no ventilation system installed yet (natural ventilation), and all dwellings can be cross ventilated because of their double exposure. The dwellings have no common heating system: during construction, chimneys were installed, allowing tenants to install any kind of boilers (coal, fuel,

<sup>1</sup> As report D3.4 is restricted, public information can be found in GEIER, SONJA; EHRBAR, DORIS; SCHWEHR, PETER (2014); *Holistic Strategies for the Retrofit to Achieve Energy-efficient Residential Buildings*. In: *Proceedings 9th International Masonry Conference 2014*. Guimarães (P)

wood...). Before retrofitting, dwellings were mostly (around 2/3 of the dwellings) heated with gas boilers installed in the living rooms, the remaining third being heating with electrical heaters, installed when new tenants are moving in. Hot water is produced with individual gas boilers installed in the kitchen.

When asked, tenants pointed at their inefficient heating system, leading to high temperature differences from the living room to other places in the dwelling. It also has high costs. Furthermore, more than half of the tenants were complaining about moisture problems.



Figure 2: North façade before retrofitting

The mixed heating system, the age of the building and tenants complains on heating and humidity oriented OPAC38 to a deep retrofitting complying with E2ReBuild goals: creating a collective heating system while reducing heating consumptions by a 4 factor, and reducing energy consumptions down to the limit for new buildings (60 kWh/m<sup>2</sup>/year). In order to reduce energy needs and improve the comfort, an external insulation was added. The thermal bridges from the balconies' slab were corrected by closing. The new gas boiler combined with solar panels will reduce energy costs. Moisture problems were resolved with the creation of a mechanical ventilation system.

Based on the tenants needs some works were also carried out to improve comfort (ventilation, security access, free-barrier access, bathroom renewal...). Some other works were also driven by safety reasons: the electrical system, the water disposal...

Actions undertaken thus were [Figure 3]:

- Wall, roof and floor insulation;
- Closing of the balconies;
- Creation of a mechanical ventilation system;
- Creation of a collective gas heating system;
- Installation of solar thermal panels;
- Bathroom renewal (change of the former bath for showers);
- Change of the entrance doors;
- Renewal of the entrance hall with installation of an access phone;



- Renewal of the electrical system;
- Repair of the water disposal;
- Construction of an approach ramp to the hall already equipped with a lift (to eradicate the 3 existing stairs).



Figure 3: Layout of one dwelling with changes in red

The project will further benefit from the biomass district heating under construction (forecasted delivery in late 2015 or 2016). The creation of the collective heating system will allow an easy energy change with the connection to the district heating, reducing the primary energy consumptions and the greenhouse gases emissions (change from gas to wood).

## 2 Energy Efficient Retrofitting

### 2.1 Building Envelope

In order to reduce the needs for heating, the building envelop was improved:

- Wall insulation (20 cm polystyrene  $\lambda=0.039$ ), new  $U_{\text{wall}}=0.171 \text{ W/m}^2\cdot\text{K}$ ;
- Roof insulation (20 cm polyurethane  $\lambda=0.024$ ), new  $U_{\text{roof}}=0.117$ ;
- Floor insulation (10 cm mineral wool  $\lambda=0.046$ ), new  $U_{\text{floor}}=0.64$ ;
- Balconies closure using prefabricated elements.

It has to be noted that the windows were kept, although their actual position (on the inner part of the concrete wall) leads to thermal bridges [Figure 4]. Concerns were also raised about mould growth and moisture.

The choice was driven by economic reasons. Windows were replaced in 2000 and present no need for repair or replacement. They already are double-glazing 4/10/4 with  $U_g= 1.5 \text{ to } 1.8 \text{ W/m}^2\cdot\text{C}$ . Finally, most of the windows on the south façade will be enclosed in the new verandas.

Nevertheless, in order to estimate the thermal bridges and the risk for mould growth, NCC and SP studied within work package 5 on monitoring the impact of the position of the windows. Calculation confirmed that the actual and kept position was the worst in regard to thermal bridging. However this position has no impact on mould growth, especially when a mechanical ventilation system is installed.

Windows were thus kept. When replacement will be needed, they will be placed at the outer part of the concrete wall, partly covered with the insulation.

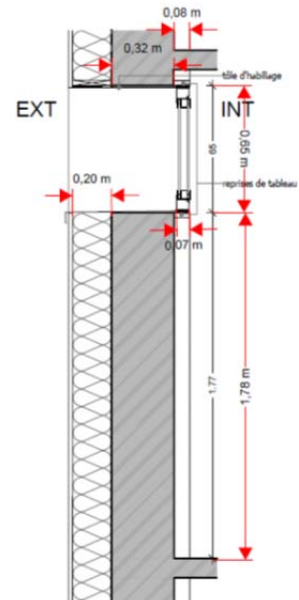


Figure 4: Wall detail

### 2.2 Focus on the Closing of the Balconies

In order to eradicate the thermal bridges caused by the balconies slabs, and create a new space for the tenants, balconies were integrated into the new insulation. E2ReBuild is focusing on industrialization: the closing of the balconies also gave the opportunity to test prefabrication. OPAC38 first had in mind to use prefabrication panels all along the balconies. However, due to fire and earthquake regulations, this would have meant to create new foundations to support the added structure, and these would have proven too expensive, especially regarding the size of the balconies (width=0.7 m): there is no social (balconies are not used as outer living spaces but rather for storage or drying clothes) and architectural justification to such costs regarding the use of the balconies..

That's why OPAC38 had to reduce the use of prefabrication to some elements of the façade of the loggias [Figure 5]. Those elements were prefabricated at the plant, and then transported and erected on site:

- a PVC frame over the all length and breadth for each loggia was mounted on the window back (part between the sill and the floor) that contains several windows (fixed or that can be opened), as well as a full and insulating over panel (part over the windows)
- the rest of the façade of the loggias is insulated with OSB (Oriented Strand Board) sandwich boards with 120 mm polyurethane





Figure 5: Detail and picture of the prefabricated elements for the balconies

## 2.3 Difficulties during Implementation

### 2.3.1 Supports of the Envelope to the Balconies

Unfortunately, after in deeper investigation, the balconies were proved not having enough load bearing capacity to support the additional weight of the metallic frame not correctly placed at the construction of the building.

To continue the work, OPAC38 had to recruit a company for the reinforcement of the balconies. The adapted solution consists of the injection of a resin into grooves to strengthen the support of the balconies by the façade.



Figure 6: Grooves with injected resin

### 2.3.2 Sink of the Structure Caused by Wet Soil

Some further adjustments were also needed. Specific measures had to be taken to prevent the cradle to sink into the very wet land, at the time work took place, and to be able to carry the heavy weight panels. Moreover, the building has moved since its construction and has sunk more and more unevenly than initially estimated. The ceiling of the balconies had thus to be levelled in the created loggias for a proper connection.

## 2.4 Technical Equipment

The existing individual gas boilers and electric heaters were replaced by a collective gas boiler (700 kW) [Figure 7] and solar thermal panels (91 m<sup>2</sup>) [Figure 8]. The boiler room is located in the basement (former cellars were used) and radiators have been installed in the dwellings. Solar panels are located at 4 different places on the roof: their expected production is 57 400 kWh/year, contributing to 51% of the needs.



Figure 7: Boiler room



Figure 8: Solar panels

Mechanical ventilation with hydrothermal air inlet was created. Fans are located on the roof [Figure 9], and the former chimneys, after their airproofing, have been used for extracting air in the dwellings.



Figure 9: Ventilation fans and ducts

## 2.5 Changes in the Dwellings

Part of the work program was not related to energy efficiency but rather to improve comfort. This was the case for the changes in the bathroom [Figure 10]: most of the tenants are rather old and had difficulties to use bath, this is why bathrooms were renewed. Side works in the kitchen [Figure 10] and rooms were also needed because of the heating system, and new equipment was installed [Figure 12]:

1. Accessible work: access ramp to one entrance, change of the baths for showers...
2. Security work: entry phone, new entrance door, renewal of the electric wiring...
3. Paintings in the hall and dwellings





Figure 10: Kitchen renewal



Figure 11 Bathroom renewal



Figure 12: Changes in the entrance

### 3 Retrofitting Process

#### 3.1 Main Organisation

This part is in deeper described within work package 3 of E2ReBuild, especially deliverable D3.1 on Collaboration Models.

OPAC38 has a so-called *Plan stratégique de patrimoine (Strategic Plan for Real-Estate)*. It lists and describes all buildings in the held portfolio due to their age, energy use, vacancies, realized measures, etc. It was up-dated in 2008 to better take into account energy challenges. The strategic planning is developed for 10 years in advance and is structured along short, mid and long-term plans. Still having no structured heating system, Stendhal in Voiron was of high priority in this plan, and was pointed at for a renovation in line with E2ReBuild time schedule:

	From	To
<b>Brief</b>	July 2010	December 2010
<b>Design</b>	January 2011	October 2011
<b>Construction</b>	January 2012	December 2013
<b>Monitoring</b>	July 2013	June 2015

Table 1 Time frame for demonstrator

The renovation for the project in Voiron proceeded as usual. The architect, all planners and consultants were commissioned directly by OPAC38. The project management was in the hands of OPAC38. There was only one contract for the design team that was headed by architect. The energy consultant, HVAC and electric planners were subcontractors of the architect. A draft of the work program was defined including goals such as the achievement of energy performance standards, the installation of a centralised heating system (in order to replace the single heating devices), and the compliance with further technical or structural requirements (e.g. to solve ventilation or noise problems). The architect was responsible for design, planning, building permission application and tender specification. All contractors were selected in the course of a tender process and resulted in the contracts with OPAC38. During renovation work the site management (coordination of contractors and work) was basically done by the architect, except HVAC and electric installations which were done by the technical planners. A “code inspector” and a “Health & Safety coordinator” were commissioned (from independent contractors) separately in order to supervise the construction works.

Role	Name	Brief	Design	Construction	Monitoring
<b>Building owner</b>	OPAC38	X	X	X	X
<b>Architect</b>	Cabinet Berne Architecte		X	X	
<b>Energy specialist</b>	BET Guillemard		X	X	X
<b>Structural engineer</b>	EA2C		X	X	
<b>Electric engineer</b>	ETEL		X	X	
<b>Contractors</b>	11 contractors			X	
<b>Local Energy Agency</b>	Ageden		X		X
<b>Maintenance company for heating</b>	Dalkia				X

Table 2 Key players involved in the retrofitting demonstrator

### 3.2 Specific Collaboration with the Tenants

Collaboration with the tenants is considered as an overall process during the all management of the refurbishment project, since it is a process mainly based on communication toward and participation of tenants during the project. Participation is contributing to minimize tenants' complaints, as further described in work package 5, deliverable D5.2 on Measured Data from Demonstration Buildings.

OPAC38 is thus setting a key focus on transparency. It starts with the participation of tenants during the brief and design phases of the project. Tenants are participating to the definition of the project objectives by using different means: questionnaires, meetings... in order to identify wishes and necessities. This is also a way to prevent future complaints by taking into account at this stage tenants expectations on the technical program and the rent increase and/or explain why some requests are difficult to meet. It also prepares the vote needed for the rent increase (17% in the Stendhal's case).

Based on the interviews, tenants were waiting works on safety (entry phone, new entrance door...) and heating (to improve comfort and reduce energy costs). Insulation is not expressed as such; tenants rather refer to humidity problems or cold feelings.

During the work phase, tenants concerns are the task of the site manager, also in charge of supervising the entire work together with the architect. At this stage, tenants usually only interfere with workers, and contact the site manager when they have to complain. In order to prevent this usual functioning, often leading to already rather long and difficult to solve complains, OPAC38 experimented an on-site "weekly-open desk". It is an open tenants meeting, held every Thursday evening, with presence of the architect and site manager of OPAC38. Within these meetings tenants can voice claims to the site manager and architect. It was seen that those meetings get more or less a favoured contact point for residents to talk and exchange. Questions can be answered at a very early stage sometimes directly by some other tenants having already experienced the retrofitting process. Furthermore, the "weekly open-desk" was held the day before the regularly construction meetings, giving the opportunities to immediately refer to the eventually involved companies for trying to reoriented their working habits (delay for appointments, cleaning procedures...).

### 3.3 Commissioning and Monitoring

OPAC38 has experienced that all programs need a close look at in order to reach initial goals. Furthermore, all stakeholders must be involved, all of them being contributors to the energy performance in some way. OPAC38 is thus using different means, implemented in Voiron.

Contractors have legal obligations: one year after completion they are fully liable ("well-done-work") and have to repair any defaults. OPAC38 has set up a procedure for the verification of work at this point, especially on energy relevant aspects. The architect and energy consultant have a contract including 2 years of full monitoring, which he can use to identify possible problems. OPAC38 also has an agreement with the local energy agency in order to have an independent view on monitoring. They also try to raise awareness of maintenance companies and tenants.

Results must be shared with all stakeholders, this is why OPAC38 created a "residence committee". This is a meeting held with tenants, designers (architect and energy consultancy), maintenance companies and OPAC38. It starts at the end of work and is meant to follow-up and to evaluate altogether the benefits of the project, on both social and technical aspects, as well as remembering all stakeholders of their actual role for reaching initial goals. The "residence committee" offers the opportunity for tenants to point at eventually mal-functioning aspects. Their remarks can be better understood and confronted to the perception of other tenants (example: cold is a feeling that will be perceived differently from one to another). They can then be treated before getting too annoying for



tenants, and explanations can be given to all present tenants. “Residence committee” are usually held on a biannual basis, depending of the actual needs of the project. An unexpected positive side effect of the “residence committee” is a better communication within OPAC38 between different departments.

## 4 Results

### 4.1 Conclusions and Experiences

Success of the demonstration can be evaluated through different means.

1. Regarding work, the participation of the tenants all along the process as well as the involvement of different stakeholders ensured a well-accepted and smooth project, even though tenants experienced real disturbance sometimes. On the other hand, the length of the all process has been raised by the tenants.
2. Furthermore it has already been pointed at within this report the difficulties encountered to implement prefabrication: regulations, problems discovered on site (need for balconies' reinforcement...)... This would suggest a better preparation during the design phase, possibly using BIM modelling as in some other demonstration projects. In Voiron, the use of prefabrication happened to be too limited to fully benefit from its added-values.
3. When regarding results, the main indicator for a social housing company could be the end-user satisfaction. Results from the questionnaire developed in Work Package 3 tend to highlight the tenants' satisfaction, with an overall increase in measured well-being and health: indoor temperature during winter, bathroom equipment standard and air quality had the strongest increase. Evaluation also shows an increase in the tenants' proudness and safeness. An exception still: although they are aware of the impact on thermal comfort of the closing of the balconies, tenants point at the light reduction they perceive after retrofitting.
4. Quality of the envelope and thermal bridging. Monitoring confirms the tenants 'view. Thermal images showed no defaults on the insulation, although you can clearly identify the thermal bridges around the windows [Figure 13], and a blowing door test gave an result of  $Q_{4Pa-surf} = 0,630 \text{ m}^3 / \text{h.m}^2$ , much lower than the requested value for new constructions ( $1 \text{ m}^3 / \text{h.m}^2$ ).

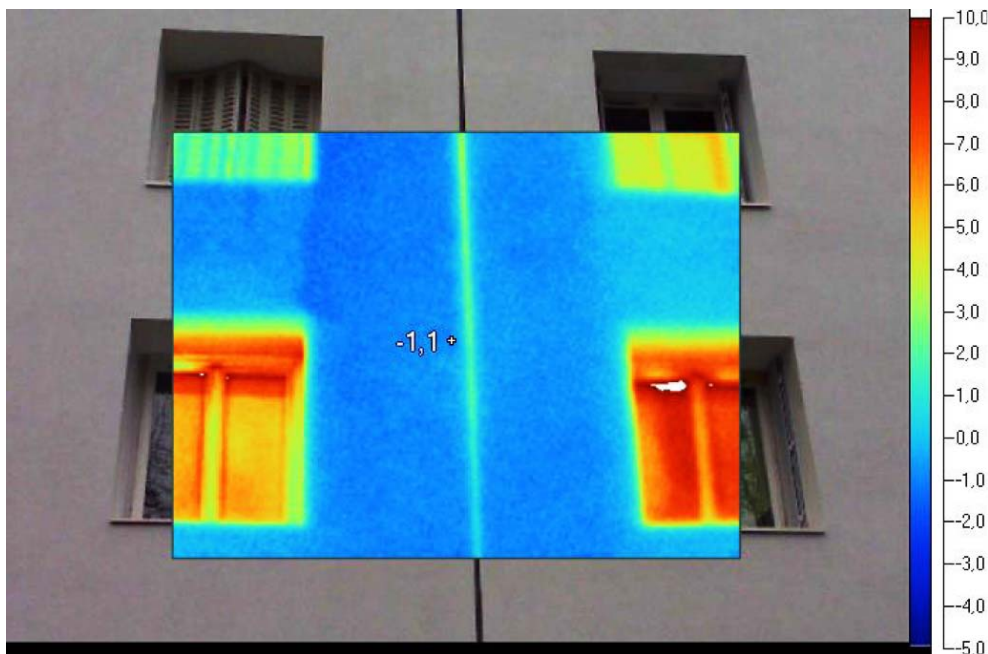


Figure 13: Thermal images after work

According to measured energy data, the project however still has possibilities for improvement [Figure 14]. Adjustments are still on going to improve the overall performance and reach the initial goals. Temperatures measured in the dwellings are still above 20°C, when calculation was based on 19°C. The reduced temperature over night was only recently applied. For DHW, temperature was once again

too high and was recently reduced by 5°C. This shows the importance of monitoring on reaching the initial goals.

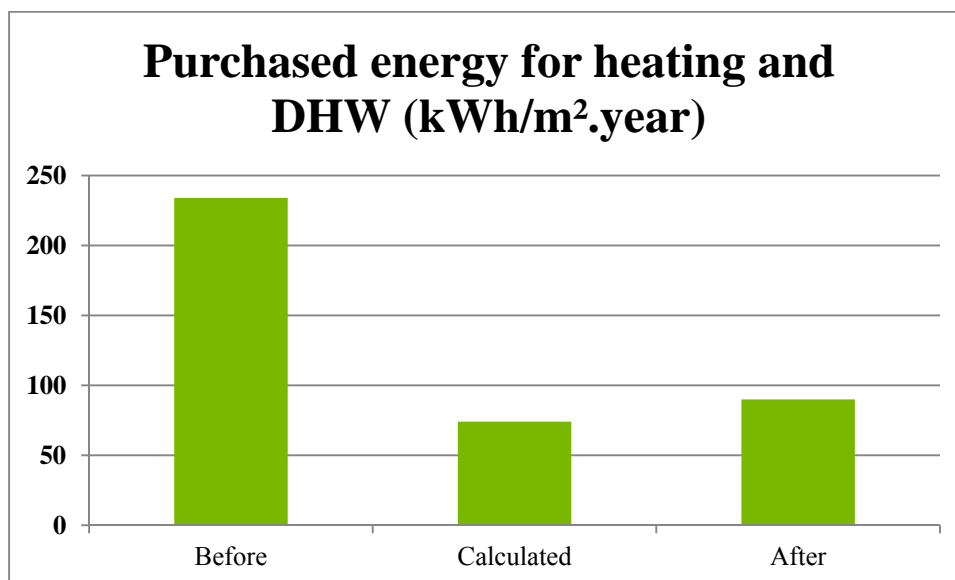


Figure 14: Energy needs before, expected and after

## 4.2 Replication Potential

This project has a high replication potential at different level, since the demonstration project in Voiron is typical from the 60s and 70s. When looking at OPAC38 portfolio in Isère (French department), 30% of the real estate (25 000 dwellings) was built at that period and only had minor repair programs: windows change, gables' insulation... The potential for energy savings is high. OPAC38 is refurbishing around 1000 dwellings every year. The recent programs have similar goals to E2ReBuild. Still adaptations are required, to take into account specificities of each building. It results in slightly changes from a project to another, but replication is already experienced.

At another scale, in the region Rhône-Alpes, it has been estimated in 2010 that 150 000 social dwellings (out of 435 000) have consumptions higher than 250 kWh/m².year. These buildings usually were built before 1976 and the first thermal regulation.

Finally in France, housings must reduce their consumption by 38% in 2020, in line with a 4 factor (to reduce energy demand down to 25%) in 2050. This means the refurbishment of around 10 million dwellings, once again mainly built before the first thermal regulation.

## Appendix A Original BEST Sheet

Building Energy Specification Table (BEST)				Community / site	Voiron	Stendhal	BEST no.	3
1.1	Building Category		residential retrofitted	total area / category / BEST sheet [2]		3674	m <sup>2</sup>	
1.2	Local Climate			January average outside temperature		°C	-11	
	Climatic Zone		H1C	August average outside temperature		°C	32	
	(national definition)		(RT2005)	Average global horizontal radiation		kWh/m <sup>2</sup> yr	1318	
				Annual heating degree days [3]		°Cd/yr	1850	
1.3	Maximum requirements of building fabric			Existing building [5]	National regulation for new built [6]	suggested specification [7]	Energy savings [%] [8]	
	Façade/wall	U	W / m <sup>2</sup> K	1,85	0,43	0,16	63%	
	Roof	U	W / m <sup>2</sup> K	1,00	0,40	0,15	63%	
	Ground floor	U	W / m <sup>2</sup> K	2,30	0,43	0,2	53%	
	Glazing	U <sub>g</sub>	W / m <sup>2</sup> K	1,9	2	1,1	45%	
	Average U-value	U <sub>av</sub>	W / m <sup>2</sup> K	1,8				
	Glazing	g	total solar energy transmittance of glazing [%]					
	Shading	F <sub>s</sub>	Shading correction factor					
	Ventilation rate [4]		air changes/hr	0,7	0,6	0,6		
2	Building Energy Performance							
2.1	Energy demand per m <sup>2</sup> of total used conditioned floor area (kWh / m <sup>2</sup> yr) incl. system losses							
	energy carrier existing building	suggested energy carrier	specify energy efficiency measures [13]	Existing building [5]	regulation / normal practice for new built	suggested specification [7]	% Energy savings [8]	
	Heating + ventilation							
	gas or electricity		kWh/m <sup>2</sup> yr	291		30		
	Cooling + ventilation							
			kWh/m <sup>2</sup> yr	0				
	Ventilation (if separate from heating/cooling)							
			kWh/m <sup>2</sup> yr	0				
	Lighting							
	electricity		kWh/m <sup>2</sup> yr					
	Domestic Hot Water (DHW)							
	gas		kWh/m <sup>2</sup> yr	45		30		
	Other energy demand							
			kWh/m <sup>2</sup> yr					
			kWh/m <sup>2</sup> yr	336	130	60	54%	
	Appliances (please indicate, but costs are not eligible)							
	electricity		kWh/m <sup>2</sup> yr					
2.2	RES contribution per m <sup>2</sup> of total used conditioned area (kWh / m <sup>2</sup> yr)							
	total production kWh/yr	m <sup>2</sup> installed	kW installed	specify RES measures	Existing building [5]	regulation / normal practice for new built	suggested specification [7]	RES contribution [%][8]
	55000	95	45	solar thermal panels	0	0	15	
			kWh/m <sup>2</sup> yr	Subtotal sum of RES contribution	0	0	15	
3	Building Energy Use			per m <sup>2</sup> of total used/heated floor area (kWh/m <sup>2</sup> yr)				
			kWh/m <sup>2</sup> yr	Subtotal sum of energy demand	336	130	60	
			kWh/m <sup>2</sup> yr	Subtotal sum of RES contribution	0	0	15	
			kWh/m <sup>2</sup> yr	Total Building Energy Use	336	130	45	65%
4	Other national overall energy performance targets or criteria (additional information, mandatory if existing)							
		Units [9]	explain content and scale [10]	Existing building	National regulation for new built (2006)*	suggested specification		

## Appendix B Energy Data

Voiron Before				Calculated TH-C-E-ex		
	Energy Demand Before [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on EN 15603 fp [kWh/m2 NFA]
Heating Source 1	126,0	Gas	1	126	1,36	171
Heating Source 2	84,0	Electricity	2,58	217	3,31	278
DHW Source 1	48,0	Gas	1	48	1,36	65
DHW Source 2				0		0
Auxiliary	0,0	Electricity	2,58	0	3,31	0
Losses Source 1				0		0
Losses Source 2				0		0
Total	258,0			391		515
Delivered to the grid	0			0		0

Voiron Afterwards				Calculated TH-C-E-ex		
	Energy Demand Afterwards [kWh/m2 NFA]	Source	PE conv. fact. fp [kWh PE / kWh S] national /local	PE national [kWh/m2 NFA]	PE conv. fact. fp [kWh PE / kWh S] acc. EN 15603	PE based on 15603 fp [kWh/m2 NFA]
Heating Source 1	59,0	Gas (intermed.)	1	59	1,36	80
Heating Source 2				0		0
DHW Source 1	32,0	Gas (intermed.)	1	32	1,36	44
DHW Source 2				0		0
Auxiliary	4,0	Electricity	2,58	10	3,31	13
Losses Source 1				0		0
Losses Source 2				0		0
Total	95,0			101		137
Delivered to the grid	0		0	0		0

Conversion factors fp (total) acc. EN 15603:2008\* Table E1 - Annex E

Electricity (UCTE Mix) 3,31 [kWh PE / kWh S]

Natural gas 1,36 [kWh PE / kWh S]

Reference national conversion factor: "Thermal regulation RT 2012"