UNIVERSIDADE DE LISBOA
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Energy component at the different stages of a building project in Switzerland

Internship at Putallaz Ingénieurs-Conseils

Maria Carolina Sollari Allegro Machado Lopes

Dissertação de Mestrado

Mestrado Integrado em Engenharia da Energia e do Ambiente

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Trabalho realizado sob a supervisão de

Marta Panão (FCUL)

2013

Abstract

The present document was developed in the context of an internship in a Swiss company active in the domain of consulting and engineering in the energy component of buildings. The aim of this study was to discriminate the different stages of a building project in terms of energy and to describe the process and the legal context in each of these stages.

In Switzerland the building sector has a strong role in the energy policies of the country, since it represents 46% of the national energy consumption. Therefore the energy component of a building project has to respect several legal requirements in order to ensure an efficient and rational use of energy. Concerning the canton of Geneva, where this study was focused, the energy demands in the building sector are one of the highest in Switzerland. For each stage of a building project there is a list of requirements to follow. These are mainly focus in the following aspects: i) Quality of the thermal envelope; ii) The obligation of using renewable energies; iii) The use of an air conditioning system only when justified; iv) Higher requirements for public buildings and large buildings; v) Correct sizing and installation of the heating, ventilation and air conditioning systems; vi) Energy consumption control.

As demonstrated, each of the different stages has its importance in the building project, and the correct performance of the building is dependent of each one of them.

Keywords: Building sector, Switzerland, energy efficiency.

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List of abbreviations and equivalents in French

HVAC - Heating, ventilation, and air conditioning **(*CVC* -** *Chauffage, ventilation et climatisation*)

MoPEC - List of energy limits to be applied in the cantons (**MoPEC -** *Modèle des Prescriptions Energétiques des Cantons*)

SIA - Swiss Society of Engineers and Architects (**SIA -** *Société suisse des ingénieurs et des architectes*)

DHW - Domestic Hot Water (***ECS*** - *Eau Chaud Sanitaire*)

IDC - Index that represents the quantity of final energy consumed for the production of heat for the heating system and for DHW (**IDC -** *Indice de Dépense de Chaleur*)

HPE - High Energy Performance as described in the Energy Law of the canton of Geneva (**HPE -** *Haute performance Energétique*)

$\mathbf{Q_{ww}}$ **-** Energy needs for production of DHW in units of MJ/m^2 of EBF

$\mathbf{Q_{h}}$ **-** Energy needs for the heating systems in units of MJ/m^2 of EBF

$\mathbf{Q_{h,li}}$ **-** Limit value for the energy needs for the heating systems in units of MJ/m^2 of EBF

$\mathbf{Q_{h,li,mi}}$ **-** Limit value Minergie for the energy needs for the heating systems in units of MJ/m^2 of EBF

EBF - Energy Reference Area: Total area of ground of the heated or acclimatized rooms, measured from the exterior of the building envelope (**SRE -** Surface *de Référence* Énergétique).

1. Introduction

1.1 Context

My internship took place in the Swiss company Putallaz Ingénieurs-Conseils SàRL, which is active in the domain of consulting and engineering in the energy component of buildings.

The company, established in Geneva, was founded by Jean Putallaz in 1987 [1].

Specialized in heating, ventilation, air conditioning (HVAC) and in building envelope, the company provides services that cover all the stages of a building construction and operation in terms of energy.

The services provided can be divided in three types:

i) Perform HVAC studies: Complete HVAC projects from preliminary studies to the building operation; energy audits; analyze of dysfunctional systems; operation monitoring of a HVAC system.

ii) Provide documents and filled out forms for energy-related authorization for construction and renovation of buildings: documents requested by law; documents needed for a building to be certified with the Suisse standard Minergie; financial support forms.

iii) Assist and advise project owners and architect in respect to energy and environmental aspects of a project.

Each of these services can be provided in separate or as part of the same project.

During this one-year internship I participated in all different stages of a project. However, rather than follow all stages in the same project, I have participated in the various stages in different projects. The reason for this is that from one stage of a project to the next, it can take months or even years.

1.2 Report structure

In this report, at first I am going to contextualize legal and policy aspects related to energy in Switzerland (Chapter 2). Then, I am going to describe the different stages of a building project in terms of energy in Switzerland (Chapter 3).

In Chapter 3, I am going first to briefly describe my participation in each of the projects I worked in, and then, in the following subsections, I am going to choose some of those projects to describe in detail each stage of a building project.

The projects I was involved in were mainly in the canton of Geneva, therefore this document will be focus on the legal aspects of this canton.

2. Energy legislation and policy in Switzerland

2.1 Swiss legal context

Switzerland is a federal state, in which power is shared among the Confederation (central state), the 26 cantons (federal states), and the 2408 communes (the smallest political units). The laws of the Confederation apply to the whole country, and the laws of the cantons apply to their communes [2, 3].

In terms of building legislation the Confederation established with the Energy Law – LEne 730.0 (art. 9) that the cantons must create their own laws regarding the efficient and rational use of energy in existing and new buildings. Therefore, the canton laws must refer to the following:

a. The maximum proportion of non-renewable energy sources intended to be used in heating systems and for domestic hot water production (DHW);

b. The conditions for the installation of electric heaters and the replacement of this kind of installations;

c. The setting of objectives agreed by the main consumers;

d. The deduction in the individual charges for heating and productions of hot water in the new constructions and major renovations.

Even though each canton has their own legislation, the Confederation gives financial support concerning the energy component of buildings. This was outlined in the Energy Law (art. 15) and defined more in detail in the CO2 Law – 641.71 (art.34). The CO2 Law defined that in order to reduce one third of the CO2 emissions of the buildings, the central state grants a maximum of 300 million swiss-francs (CHF) per year to the cantons until the year 2019. This amount, managed by the cantons, should be applied in giving financial support to:

a. Increase the energy efficiency of buildings;

b. Promote the renewable energy sources, the heat recovery systems and the improvement of the technical installations [4, 5, 6].

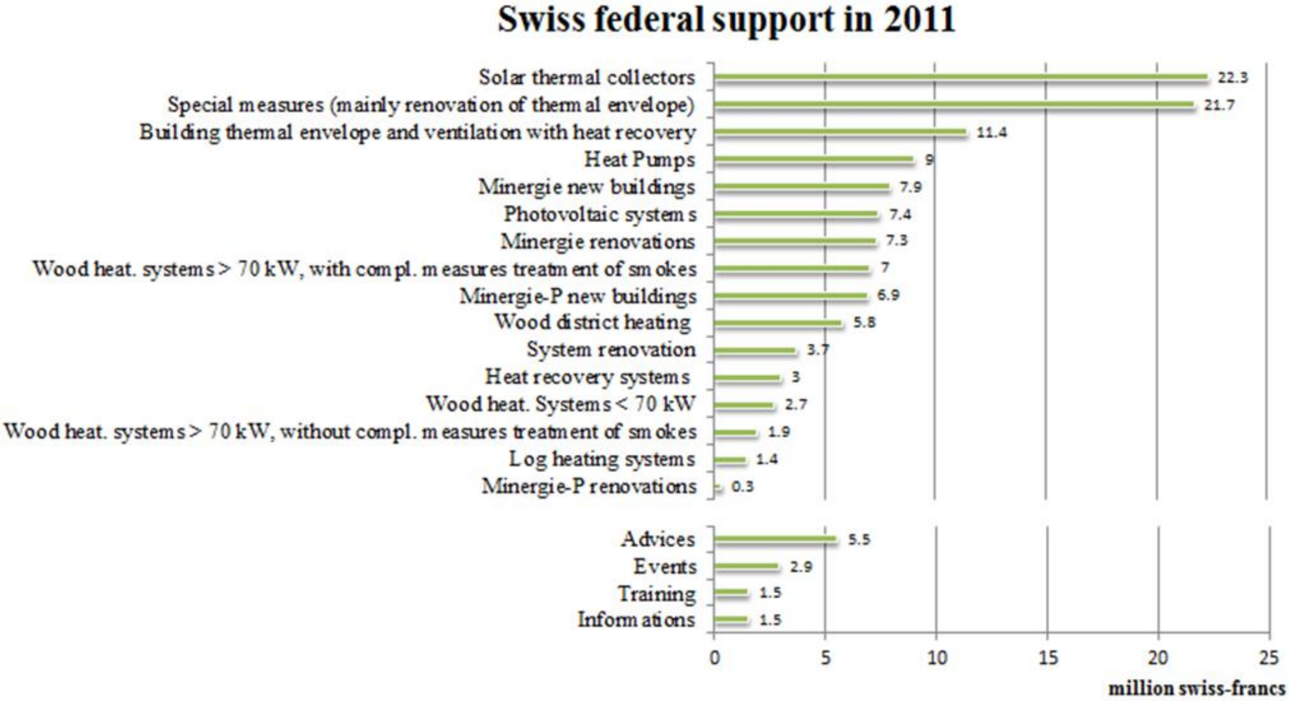


Fig. 1 - Swiss federal support in 2011 (adapted from [6])

In 2011, as shown in figure 1, an important part of the federal support was given to the improvement of buildings regarding thermal envelope, solar thermal collectors, automatic wood heating systems, heat pumps and photovoltaic systems.

2.2 Strategy 2050

The document *Stratégie Energétique 2050*, approved by the Swiss Federal Council in 2013, presents the energy goals for 2050 and a list of measures to adopt in order to change the Swiss energy system step by step until 2050.

This strategy aims the progressive shutting down of all the nuclear power plants in Switzerland, the reduction of final energy and electricity consumption, the promotion of renewable energy sources and the reduction of the CO2 emissions.

In this document the housing sector has an important role since nowadays it represents 46% of the national energy consumption (116TWh). The objective for 2050 is to reduce 34,9 TWh of the total energy consumption in buildings (including electricity) in relation to the tendency. This means a reduction of approximately 30% of the current consumption in buildings sector [7, 8, 9].

2.3 Canton's Energy Law

Each canton has their own Energy Law that is based in the document *Modèle des Prescriptions Energétiques des Cantons* (MoPEC) from 2008, which is a list of energy limits to be applied in the cantons. The MoPEC, jointly created by all the cantons, has some parts which are mandatory and other parts which are not, so that each canton can still decide what is best to apply in a region.

Both the Canton's Energy Law and the MoPEC often refers to the requirements described in the Swiss Society of Engineers and Architects (*Société suisse des ingénieurs et des architects*, SIA) norms, which is a group of norms devised to promote sustainable and high-quality design of the built environment in Switzerland [10,11,12].

2.3.1 Canton of Geneva: Energy Law and its Implementing Regulation

The Energy Law L 2 30 and its Implementing Regulation L 2 30.1 are the main legislation of the canton of Geneva concerning the new buildings and renovation projects. In these, they imposed rules in the territorial organization of energy, in the building construction and renovation as well as in the buildings operation.

Their principal goal is to reduce the energy consumption and to gradually replace all the energy from fossil fuels to renewable energy sources.

The Energy Law defines three different types of building construction procedures: New building; Extension of a building; Building renovation. All procedures have to respect a list of prescriptions and the new buildings and extensions must also be licensed with a High Energy Performance (HPE) certificate as well as install a thermal solar system covering a minimum of 30% of the energy needs for the production of DHW (Q_{ww}) [1] [13, 14, 15] (Annexes-I).

The prescriptions to comply are described in the Implementing Regulation. These are divided in the following articles: Thermal insulation and solar summer protection; Production of DHW; Ventilation; Luminosity; Heating system; Air conditioning; Energy consumption control; Cold rooms; Greenhouses and removable structure using a heating system; Electricity production.

[1] - The law describes some exceptions to the use of thermal solar systems, for example when other renewable energies are used or when the roof orientation is not favorable.

3. Stages of a building project in terms of energy

Concerning the energy component, a building project can be divided in six main stages:

1. Preliminary studies
2. Construction and renovation authorization
3. Sizing and design of HVAC systems
4. Description of installations and construction
5. Operation monitoring
6. Punctual studies

An explanation of what each of these stages is composed of is given in the following sections. For each stage, I provide an example of a project I have worked on, describing the procedure and the legal aspects related.

Table 1 summarizes the main projects on which I worked during the internship. For each project, I detail the stage of the project during my participation and I briefly describe what my work consisted of.

Table 1 - Projects in which I have participated

Project	Stage	Type of building procedure	Description of my participation
Caves de Mandemant	1	New building	Comparative study of four different types of heat production by solar panels using Polysun [a]
Beauregard 4	1	Extension	Calculation of different types of thermal bridges using Flixino [b]
Saconnex-Dessus	1	New building	Comparative study for three types of heat and DHW production: gas and solar panels; wood; wood and solar panels. Calculation of energy gains and losses using Lesosai [c] Comparative study between being granted HPE or Minergie.
La Renfile	2	Extension	Calculation of energy gains and losses using Lesosai. Study of thermal bridge using Flixino. Study of the risk of condensation in a wood slab with inside isolation. Preparation of documents and fill out forms for the construction authorization, canton of Geneva.
Chemin des manons	2	New building	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Geneva. Preparation of documents and fill out forms for the certification Minergie. Preparation of document with a presentation of installations to the project owner.
Route de la Capite	2	Renovation and extension	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Geneva.
Propriété Noble	2	Extension	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Geneva.
Haute-Belotte	2	Renovation and extension	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Geneva.
Moniaz	2	Extension	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Geneva. Preparation of documents and fill out forms for the certification Minergie
Villas Grob-Carbon	2	New building	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Vaud.
Villa Lens	2	New building	Calculation of energy gains and losses using Lesosai. Preparation of documents and fill out forms for the construction authorization, canton of Valais. Preparation of documents and fill out forms for the certification Minergie.

Chevillard	3 and 4	Renovation and Extension	Ventilation system: a) Calculation of air flow rate required for forced and return air for each room b) Sizing ducts of fresh air, exhaust air, forced air and return air Heating system and DHW production: a) Sizing the system of radiators b) Sizing the conduits of distribution c) Sizing boiler and water tank Design of the ventilation and heating systems using AutoCad [d] Measure the length of ventilation and heating system conduits and description of type of conduits used. Analyze of tenders from the installing enterprises.
Séracs	3 and 4	Renovation	Ventilation system: a) Calculation of air flow rate required for forced and return air for each room b) Sizing ducts of fresh air, exhaust air, forced air and return air c) Sizing mechanical ventilator d) Calculation of ducts weight and surface of isolation Design of the ventilation systems using AutoCad. Measure length of ventilation ducts. Follow the process of construction.
Crèche Chapelle-les-Sciez	3	New building	Ventilation system: a) Calculation of air flow rate required for forced and return air for each room b) Sizing ducts of fresh air, exhaust air, forced air and return air c) Sizing grids and accessories Heating system and DHW production: a) Calculation of energy required for the heating system for each room using Win-Ht[e] b) Sizing conduits of distribution c) Sizing boiler d) Sizing the water tank e) Sizing components of radiant floor heating system Design of the ventilation and heating systems using AutoCad.
Vélodrome	5	New building	Annual report.
Clos Voltaire	5	Renovation	Monthly measures. Annual report
Codah Pommiers	5	New building	Monthly measures. Annual report
Gascons	6	Analysis existing building	Diagnostic of condensation problems: - analyze of thermographies - analyze of temperature and humidity measures.
Maison Bindder	6	Analysis existing building	Collaboration in the perform of an Energy Audit.
Connétable	6	Analysis existing building	Diagnostic of condensation problems: - analyze of temperature and humidity measures - study of thermal bridge using Flixino.

a - Polysun is a certified simulation program used for the sizing of solar systems; b - Flixino is a software to analyze the thermal properties of a construction; c - Lesosai is a software for the certification and thermal balance calculation of buildings; d - AutoCad is a software application for both 2D and 3D computer-aided design; e - Win-Ht is a software for thermal balance calculation of buildings based in the SIA norms.

3.1 Preliminary studies

A preliminary study can be done by request of the project owner or architect to study a particular part of the energy component of a project. This analysis helps to define the characteristics of the project.

3.1.1 Caves de Mandemant

3.1.1.1 Characteristics of the project

The project Caves de Mandemant is a group of five buildings with 186 residential units and 3200m^2 of commercial activity.

The heat production for the five buildings is planned to be obtain from a centralized wood boiler and solar panels. This production will also be used, when needed, in two other independent buildings.

Table 2 describes the main characteristics of the project.

Table 2 - Characteristics of the project Caves de Mandement

Type of project	New buildings Minergie
N° of buildings	5
N° of sub-stations[1]	6
Type of buildings	Multi-family houses and commercial
Location	Comune Satigny, Canton of Geneva
Heat production for heating system	Wood boiler
Heat production for DHW	Wood boiler and solar panels
Ventilation	Double flow with energy recovery
Heating distribution system	Radiant floor

As requested by the project owner a preliminary study was performed to compare four different kinds of solar systems in order to know which type was better suited for this particular project.

After analyzing the conditions of the project and the different options, the following variants were considered:

- Variant A – Totally decentralized solar systems: six independent solar systems for each sub-station with one group of standard solar panels, one solar accumulator and one water tank for each system.
- Variant B – Partially centralized solar system: one group of standard solar panels connected to one solar accumulator and six water tanks, one for each sub-station.
- Variant C – Totally centralized solar system: one group of standard solar panels connected to one solar accumulator and one water tank to serve all the sub-stations.
- Variant D – Partially centralized solar system: one group of high-temperature solar panels connected to two solar accumulators and six water tanks, one for each sub-station.

For variants A, B and C the solar system is only used in the DHW production while in variant D the energy from the solar system is also used in the heating system. The advantage of variant D compared to variant B is to have fewer conduits in the network.

In Annexes-II, an illustration and an operating diagram of the four variants are presented.

In order to compare each variant the following criteria were used: i) Price; ii) Occupation area of the solar panels; iii) Difficulty in re-selling the buildings; iv) Risks of the system.

3.1.1.2 Legal context

In this study, according to the Canton of Geneva Energy law, the solar system must cover a minimum of 30% of Q_{ww}. The list of prescriptions described in the Production of DHW article of the Canton of Geneva Implementing Regulation must also be respected [13, 14].

3.1.1.3 Sizing the systems

The system sizing was done using Polysun, which is a certified simulation program used for the sizing of solar systems. Before using the program I had to pre-calculate the following components:

a) Energy need for production of DHW (E_{ww}) to all the buildings in units of MJ/year.

According to the SIA norm 380/1 this value can be estimated using the following expression:

$$E_{ww} = \sum_{x} (Qww_x \times EBF_x), \quad (1)$$

where *EBF* is the total area of ground of the heated or acclimatized rooms, measured from outside the building thermal envelope and Q_{ww} is the energy need for production of DHW in units of MJ/m^2 of EBF. In this formula Q_{ww} are theoretical values according to the type building, as it will be explained in the next section. The *x* refers to the type of building.

b) Number of solar panels (*n*) needed to cover 30% of $E_{ww.}$ For this calculation the area of the solar panels considered ($a_{solar\ panel}$) was the one of the standard solar panel *Azur 8* and the efficiency of the solar panel used ($\eta_{solarpanel}$) was the one suggested in the Polysun manual.

$$n = \frac{E_{ww} \times 0{,}3}{\eta_{solarpanel} \times a_{solarpanel}}, \quad (2)$$

where $\eta_{solar\ panels}$ = *500 kWh/(m^2 solar panel. year)* and $a_{solar\ panel}$*=2,5 m^2*.

c) Dimensions of the solar accumulator (dim_{sol}) in units of L, which is calculated according to Polysun manual, as:

$$\dim_{sol} = 50 \times A_{solarpanel}, \quad (3)$$

where $A_{solar\ panels}$ is the total area of solar panels in units of m^2.

d) Dimensions of the water tanks ($dim_{wheater}$) in units of L, according to a table given by the enterprise *Hoval*[2]. This table is based on the number of habitants, assuming a DHW temperature of 60°C, and the needs per hour [16].

e) The daily needs in DHW ($E_{ww\ day}$) for each sub-station in units of L/day, according to a table given by the enterprise *Hoval*. This table is based on the number of habitants, assuming a DHW temperature of 60°C, and the needs per day [16].

f) Power of the boiler (P) in units of kW, using the expression (4) suggested by the enterprise *Hoval* [16].

$$P = \frac{0{,}7 \times V_{DHWneeds} \times \Delta T}{860}, \qquad (4)$$

where $V_{DHW\ needs}$ is the flow rate needed, according to *Hoval* table in units of L/h, based on the number of habitants, assuming an DHW temperature of 60°C and $\Delta T = T_{final} - T_{initial}$=60°C-10°C.

g) Flow rate of the solar pump ($V_{solar\ pump}$) in units of L/h, according to the technical information of the standard solar panel *Azur 8*

$$V_{solarpump} = 40 \times A_{solarpanel}, \qquad (5)$$

where $A_{solar\ panels}$ is the total area of solar panels in units of m^2.

h) Flow rate of the DHW pump ($V_{DHW\ pump}$) in units of L/h, from the physics expression:

$$V_{DHWpump} = \frac{P}{Cp_{water} \times \rho_{water} \times \Delta T}, \qquad (6)$$

where $Cp_{\ water}$ is the specific heat of water in units of kJ/kg.K, ρ_{water} is the density of water in units of kg/L, $\Delta T = T_{final} - T_{inicial}$ = 60°C - 10°C and P is the power of the boiler in unit of kJ/h.

i) Thermal conductance of the solar heat exchanger (C_{solar}) in units of W/k, using the expression (7) suggested by the Polysun manual to a plate heat exchanger.

$$C_{solar} = 100 \times A_{solarpanel}, \qquad (7)$$

where $A_{solar\ panels}$ is the total area of solar panels in units of m^2.

j) Thermal conductance of the DHW heat exchanger (C_{DHW}) in units of W/k, using the expression (8) suggested by the Polysun manual to a plate heat exchanger.

$$C_{DHW} = 10 \times V_{DHWneeds}, \qquad (8)$$

where $V_{DHW\ needs}$ is the flow rate needed, according to *Hoval* table in units of L/h, based on the number of habitants, assuming a DHW temperature of 60°C.

k) Distances between the different components of the system, measured in the architectural plants.

In this project I measured the distance between: i) the solar panels and the solar accumulator; ii) the solar accumulator and the water tank; iii) the water tank and the consumers.

With those components calculated for each of the four variants, the information was introduced in the program Polysun along with the type of boiler, location of the project and orientation and inclination of the solar panels (orientation: south; inclination: 30°).

For the variant D the Polysun simulation was done by the company that produces the high-temperature solar panels, since this is a new technology and the Polysun standard program did not have all the information needed for the simulation.

During the simulation the dimensions of some components needed to be readjusted due to the solar system losses.

After readjust all the components, the simulation gave information about the following elements:

- Meteorological information about the place
- Annual consumption of electric and/or combustible energy of the system;
- Annual and monthly information about the solar system production
- Characteristics of the solar panels and boiler;

3.1.1.4 Analysis

Considering the system simulation of each of the four variants, the information was sent to the two solar system companies for them to determine the price of the different elements.

Table 3 summarizes the results obtained in the study.

Table 3 - Comparison of variants for the solar system

		Units	**Variant A**	Variant B	Variant C	Variant D
Price	Solar Field and accessories	[CHF]	**288'920**	277'432	263'518	674'564
	Distribution system; hydraulic material; meters; water tanks; accumulators; transport; assembly	[CHF]	**273'496**	338'424	417'494	230'424
	Total investment	[CHF]	**562'416**	615'856	681'012	904'988
	Energy consumed [a]	[CHF/an]	**77'005**	77'566	69'705	59'402
	Price difference comparing with the less expensive variant (according with SIA 480)	[%]	**0%**	3%	1%	5%
Occupation area of the solar panels		[m^2]	**364**	366	341.6	510.8
Difficulty in re-selling the buildings		1=easy ; 5=difficult	**1**	2	3	2
Risks of the system [b]		1=small risk; 5= large risk	**1**	2	3	4

a – Price for energy considered: 0,08CHF/kWh; b – The calculation of risks of the system considered the risk of water leakage and difficulty in renovation and reparation.

This table was shown to the project owner, jointly with the illustration and operating diagram of the four variants. The advice was to install the system described in the variant A.

1- A substation is where the energy components, in this case heating system and DHW conduits arrive from the central production and are then distributed to the users.

2- *Hoval* is a designing, manufacturing and installing company of heating, ventilation and air conditioning technologies.

3.2 Construction and renovation authorization

Every project of new building, renovation or extension, must have the authorization of construction from the Department of Energy of the Cantonal Office. Obtaining this authorization requires preparing a group of documents showing that the project will be developed under the legal limits.

In some building projects, the project owner requests a Minergie certificate. This Swiss standard launched in 1998 stands for lower energy consumption at a higher level of comfort [17, 18].

In this stage the first step is to talk with the project owner and the architect to be informed of the type of project and its characteristics. This information, together with the detailed architectural plans, cross-sections and façades, will allow studying the energy gains and losses of the building and the energy it will consume.

In the calculation of the energy needs the role of the energy engineer is to propose solutions, in terms of the energy component of the project, to make sure that the values are under the legal limits.

After developing a solution approved by the project owner, the final step is to prepare the requested documents and fill out the forms for the construction authorization.

3.2.1 Chemin des Manons

3.2.1.1 Characteristics of the project

This project is composed by two houses (Villa A and Villa B) independent of each other but with very similar characteristics. Table 4 describes the main characteristics of the project.

Table 4 - Characteristics of the project Chemin des Manons

Type of project	New buildings Minergie
N° of buildings	2
Type of buildings	Single family houses
Location	Comune Grand-Saconnex, Canton of Geneva
Type of isolation	From outside
Heating production	Geothermic heat pump and Solar panels
Ventilation	Double flow with energy recovery
Heating distribution system	Radiant floor

3.2.1.2 Legal Context

In this stage a new construction project in the canton of Geneva must be granted HPE, plan a solar system covering 30% of Q_{ww} and respect the list of prescription described in Canton of Geneva Implementing Regulation.

In order to be granted HPE, the requirements are mainly focus in two parameters: i) the energy needs for the heating systems (Q_h); ii) the percentage of non-renewable energy used for heating systems and for production of DHW. A new construction or a building renovation is also considered by law as HPE if it has been granted a Minergie certificate, which will be the case of this project.

In the Canton of Geneva Energy Law is also mention that for a housing building with more than 3000 m^2 of Energy Reference Area (EBF), it is mandatory to perform the particular study *Concept Energétique* which aims to reduce the energy need for heating systems as well as to reduce the use of non-renewable energy sources [13, 14].

3.2.1.3 Calculation of EBF

The calculation of the EBF is one of the first steps for obtaining the construction authorization, since the type of procedure will change depending of the EBF, as described above.

Calculating the EBF requires first to analyze the architectural plants and decide where the thermal isolation is going to be, which will define the thermal envelope of the building. Then the EBF is calculated as the sum of the areas of the heathen or acclimatized rooms inside the thermal envelope for each floor [19]. Figure 2 shows the thermal envelope with the blue dotted line and the EBF in the yellow area for the Villa B. The Villa A had 292 m^2 of EBF and the Villa B 255 m^2. This difference in the EBF was due to the double high living room of Villa B, while Villa A had another room in the first floor. In this project, performing a *Concept Energétique* was not necessary, since the EBF was lower than 3000m^2.

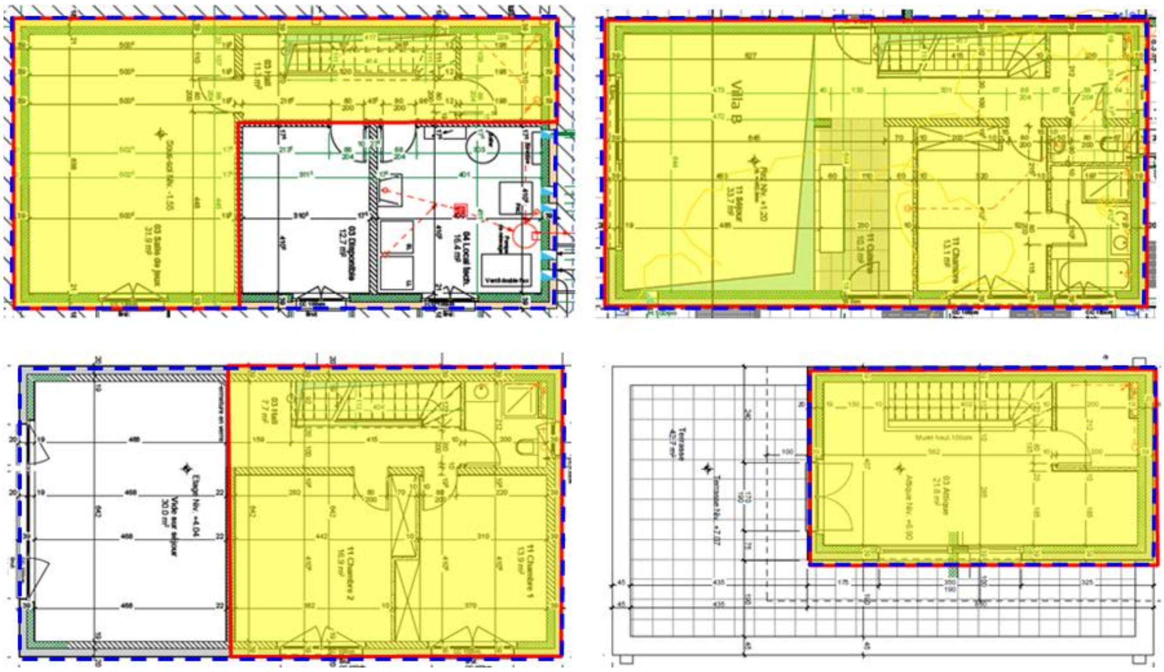
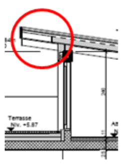
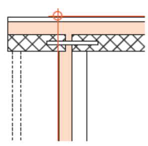


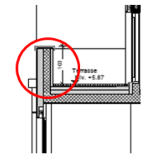
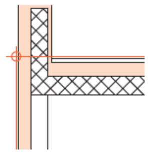
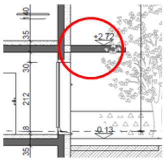
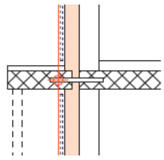
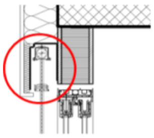
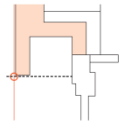
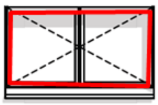
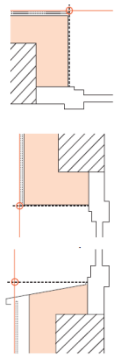
Fig. 2 - Thermal Envelope and EBF of Villa B – basement, ground floor, first floor and attic

3.2.1.4 Thermal bridges

Around the thermal envelope, when there is an interruption or diminution of the thermal isolation it means that there is a thermal bridge. In this project there were five types of thermal bridges, they were studied in order to decrease their impact in heating loss, by making sure there was a certain thickness of thermal isolation. Table 5 shows the places in the architectural plants where there were thermal bridges, along with its corresponding type, chosen from the catalogue of thermal bridges of the Swiss Federal Office of Energy [20].

Table 5 - Thermal Bridge of the project

N	Place	Description	Type	Coefficient ψ^a [W/(m•K)]
PT1		Eaves		0,04

PT2		Roof parapet		0,193
PT3		Eaves		0,147
PT4		Blind casing		0,3
PT5		Around the window		0,14

a - Coefficient ψ represents the rate at which heat is transmitted through one linear meter of intersection between building elements or components [21]. In the catalogue of thermal bridges of the Swiss Federal Office of Energy the calculation of this coefficient ψ is based in the length of the thermal bridge measured from outside of the thermal envelope [20].

3.2.1.5 Type of building

The type of building is a parameter defined in the SIA norm 380/1 [22]. The norm describes twelve types of building: multi-family houses; single family houses; administration; school; commerce; restoration; gathering place; hospital; industry; deposit place; sport centre; covered swimming pool.

This parameter is very important for the calculation of the theoretical values of energy needs of the system, namely for the Q_{ww}, the limit value for the energy needs for the heating systems ($Q_{h,li}$) and the Minergie Value Limit (Annexes-III).

The type of the buildings of the project was considered as "single family house" since each house had their own independent heating production system.

3.2.1.6 Calculation of Energy Needs for Heating Systems

Every project of a new building needs the calculation of the $Q_{h,li}$ and the Q_h, according to the SIA norm 380/1 [21] in order to evaluate the quality of the thermal envelope. The calculation of $Q_{h,li}$ depends of: the type of building; the average annual temperature of the place; and the form factor of the building (F), which is the ratio between the surface of the thermal envelope and the EBF [22].

$$Q_{h,li} = Q_{h,li0} + \Delta Q_{h,li} \times F \quad (1)$$

The expression (1) is used for new buildings projects where the annual average temperature is 8,5°C.

If the annual average temperature is lower resp. higher more than 1°K the $Q_{h,li}$ has to be increased resp. decrease by 4%. The $Q_{h,lio}$ and $\Delta Q_{h,lio}$ are normative values based on the type of building.

Calculating the Q_h requires doing an energy balance of the building, using the following expression:

$$Q_h = \Sigma\left[Q_T + Q_V - \eta_g (Q_i + Q_s)\right], \quad (2)$$

where Q_T are the losses by transmission per month in unit of MJ/m^2 of EBF; Q_V are the losses by air renewal per month in unit of MJ/m^2 of EBF; Q_i are the internal gains per month in unit of MJ/m^2 of EBF; Q_s are the solar gains per month in units of MJ/m^2 of EBF; η_g is the utilization gain factor, as described in SIA 380/1 [22].

In this project, for the calculation of $Q_{h\ li}$ and Q_h I used Lesosai, which is a software of certification and thermal balance calculation of buildings.

In this program the following components were introduced:

a) Type of building;

b) Type of temperature ambient regulation;

c) Meteorological station of the project location;

d) Information related to the EBF;

e) Information related to the thermal envelope (surfaces, U-values[1], ambient temperature of a eventual contiguous local, heat distribution systems integrated in the envelope);

f) Thermal Bridges (dimensions, Coefficient ψ[2] or Coefficient χ[3]);

g) Information related to the reduction of losses against non-heated places or the ground;

h) Complementary information about the windows (g-value[4], the percentage of glass surface of the window, shadow factor);

i) Information regarding the heat capacity of the building[5].

After introducing all elements in Lesosai, there is an option to see the summary of the thermal characteristics of the building (fig.3).

Based on this summary the components from e) to i) were adjusted, in order to have a Q_h lower than the limit. In this project the limit was 90% of $Q_{h,\ li}$, which corresponds to one of the Minergie limits described in the next point ($Q_{h,li,mi}$).

Table 6 shows the characteristics of the thermal envelope components chosen for the project.

Table 6 - Components of the thermal envelope

	Units	Façades	Wall in contact with the land	Floor	Roof terrace	Roof	Windows	Blind casing
U value [a]	W/(m^2.K)	0,16	0,18	0,17	0,19	0,13	0,7	0,5
Thickness of isolation	Cm	18	18	18	20	16	-	-

a – U value is the heat flux that passes through a construction element divided by the difference in temperature across that element, in a stationary process [23].

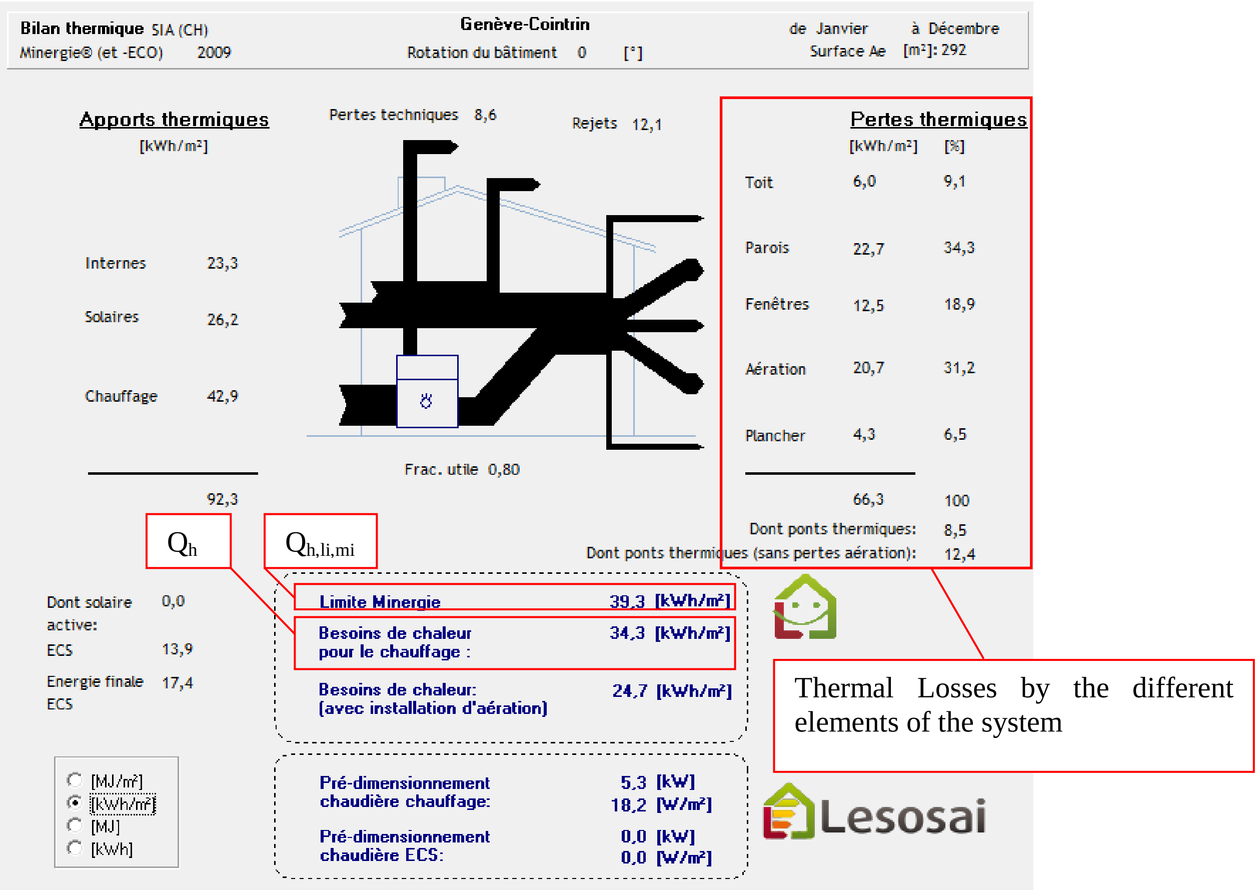


Fig. 3 - Summary of the thermal characteristics of Villa A

3.2.1.7 Limits Minergie

To be granted Minergie, the project must respect three limits [24]:

a) The Q_h must be lower than $Q_{h,li,mi}$, which correspond to 90% of the $Q_{h\ li}$

b) The Minergie Value must be lower than the Minergie Value Limit.

These values are related to the energy consumed in a building. The Minergie Value is calculated by adding the electric energy and other kind of energy that the building will consume for space heating, DHW production and for the ventilation system. This sum is weighted using a pre-defined weighting for each type of energy source used, as shown in table 7. The energy need for the DHW are based in the SIA norm 380/1 and for the ventilation system the energy need is calculated in the Minergie formulary based in estimated values of air flow rate. For the Minergie Value Limit there are pre-defined values for each type of building [22, 24] (Annexes-III).

Table 7 - Primary energy indexes in the calculation of Minergie Value

Type of energy source	Weighting
Solar energy / ambiance heat / geothermal energy	0
Biomass (wood, biogas, treated gases)	0,5
Thermal discharge (district heating from Gas treatment plants, household refuse incineration, industry)	0,6
Fossil fuels (fuel oil, gas)	1,0
Electricity	2,0

c) Guarantee thermal comfort during summer

The guarantee that the thermal comfort is respected consists of a declaration of the applicant. This declaration is obtained using a formulary which can be of three variants:

• Variant 1: Global evaluation of a standard case, consisting of a list of yes/no/NA questions;
• Variant 2: Extern calculation according to SIA norm 382/1, used in case variant 1 is not respected;
• Variant 3: Extern calculation according to SIA norm TEC 382, used in case neither variant 1 nor variant 2 are respected.

Table 8 describes the results for the three Minergie criteria

Table 8 - Minergie values - Villa A and Villa B

	Q_h [kWh/m^2]	**$Q_{h,li,mi}$** [kWh/m^2]	**Mimergie Value** [kWh/m^2	**Minergie Value Limit** [kWh/m^2]	**Thermal Confort in Summer**
Villa A	34,3	39,3	25,6	38	Respected
Villa B	36,5	43,4	27,8	38	Respected

As observed in table 8 there was a 6% difference between Q_h of Villa A and Villa B. This difference was mainly due to:

a) Differences in the thermal envelope that induced more thermal losses in Villa B than in Villa A. First because Villa A had more surface of façade underground, so less outside façade and secondly because Villa B had more glass surface then Villa A with a U-value of the windows higher than the one of the façades.

b) Differences in EBF. Villa B had a lower EBF, which means that for heating the same volume more energy per m^2 of EBF was needed.

It is also worth pointing out the differences between the energy needs and its limits. The $Q_{h,li,mi}$ was in average 17% higher than the Q_h and the Minergie Value Limit was in average 40% higher than the Minergie Value. In order to have a good performance during the building operation, it is important to have a considerable difference between the calculated values and its limits, particularly, since these values are theoretical, as it will be explain more in detail in point 3.5.

3.2.1.8 Solar system

The Canton of Geneva legislation requires that 30% of Q_{ww} are covered by a solar system.

In this project for the calculation of the percentage of Q_{ww} covered by the solar system it was used the formulary Minergie. In this, the area of roof covered by the solar system was introduced, which was a value defined by the project owner. For 6 m^2 of solar panels it was obtained 61% of $Q_{ww.}$

3.2.1.9 Calculation of Energy Expenditure Index Allowed

As describe in the Canton of Geneva legislation, the calculation of an Energy Expenditure Index Allowed (*Indice de Dépense de Chaleur Admissible,* IDC_{adm}) is mandatory when requesting an authorization of construction [13,14]. This index represents the maximum quantity of final energy that the building should consume for its production of heat for the heating system and for production of DHW per year in MJ/m^2 [25].

For a new buildings construction the IDC_{adm} is obtained using the expression (2) which is based on the $Q_{h,li}$, the Q_{ww}, the efficiency of the heating production system ($\eta_{h,\ moy}$) and the efficiency of the DHW production system ($\eta_{ww,\ moy}$). The values for Q_{ww}, $\eta_{h,\ moy}$ and $\eta_{ww,\ moy}$ are obtained from the SIA norm 380/1.

$$IDC_{adm} = \frac{Q_{h,li}}{\eta_{h,moy}} + \frac{Q_{ww}}{\eta_{ww,moy}} \quad (2)$$

Table 9, describes the values used for the calculation of IDC_{adm}

Table 9 - Values used in the calculation of IDC_{adm}

	$Q_{h,li}$ [MJ/m^2.year]	Q_{ww} [MJ/m^2.year]	$\eta_{h, moy}$ (Heat Pump)	$\eta_{ww, moy}$ (Heat pump)	IDC_{adm} [MJ/m^2.year]
Villa A	157,3	50	0,95	0,65	**242,5**
Villa B	173,4	50	0,95	0,65	**259,4**

3.2.1.10 Documents to prepare

For every project there is a need to prepare a group of documents for the Cantonal Office.
For the project Chemin des Manons, apart from the documents for the Cantonal Office, a group of documents for the Minergie Association were also needed. The documents were the following:

a) Documents for the Cantonal Office of Geneva [26]
- Formulary EN-G1 (simplified process[6])
- Formulary EN-2b
- Proof of having HPE[7], which in this case consists of a copy of Minergie documents
- Proof that at least 30% of Q_{ww} are covered by renewable energy sources, which in this case can be calculated using the Minergie formulary
- Document with the calculation of IDC_{adm}
- Document showing Global Performance, which can be a LESOSAI report

b) Documents for Minergie Association [24]
- Formulary Minergie
- Document showing Global Performance, which can be a LESOSAI report
- Document with the calculation of EBF
- Schema of the heating system and DHW production
- Schema of the ventilation system

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[1]- The U-value is the heat flux that passes through a construction element divided by the difference in temperature across that element, in a stationary process. This parameter is used to evaluate the thermal performance of a construction element, in that lower values indicate better insulating properties [23].
[2]- The coefficient ψ is the linear thermal transmittance, which represents the rate at which heat is transmitted through one linear meter of intersection between building elements or components [21].
[3]- The coefficient χ is the point thermal transmittance, which represents the rate at which heat is transmitted through a specific point with no uniform cross section in any direction [21].
[4]- The g-value indicates the level of energy transmitted through glass regarding the incident energy. Higher values indicate better energy transmission [23].
[5]- The heat capacity measures the ability of a material to store thermal energy [27].
[6]- A simplified process is applied for all constructions except for the following cases [26]:
- Projects that cannot reach the legal obligations for some reason, and demand an exception;
- Large buildings: EBF domestic buildings> 3000m^{2}or EBF other buildings>2000m^2;
- Public buildings;
- Projects that demand financial support
- Projects where the technical installations need a special authorization (for example air conditioning)

[7]- If the project was not Minergie, instead of the Minergie documents another formulary with the HPE certificate would be necessary [26].

3.3 Sizing and design of heating, ventilation and air conditioning systems

The correct sizing of the HVAC systems is extremely important to ensure a rational use of energy [28]. In this stage there are three main moments: i) calculation of the heating and ventilation needs; ii) sizing the systems; iii) design in the plants.

During this stage the energy engineer has to plan the HVAC system in coordination with the other protagonists responsible for the other infrastructures of the building, making sure the architect/project owner agree with the location of each part of the system.

3.3.1 Crèche Chapelle-les-Sciez

3.3.1.1 Characteristics of the project

Crèche Chapelle-les-Sciez is a project for a public nursery. Table 10 describes the main characteristics of the project.

Table 10 - Characteristics of the project Crèche Chapelle-les-Sciez

Type of project	New building
N° of buildings	1
Type of buildings	School
Location	Commune Lancy, Canton of Geneva
Heating production	Gas boiler and Solar panels
Ventilation	Double flow with energy recovery
Heating distribution system	Radiant floor
EBF total	1820 m^2

3.3.1.2 Ventilation system

a) Legal Context

Regarding the ventilation system in this stage of a project, the prescriptions that need to be respected are described in the following articles of the Canton of Geneva Implementing Regulation: Ventilation; Thermal insulation and summer protection [13, 14].

b) Components of the system

The ventilation system can be divided in three types of components:

1. Electric devices used for the ventilation process;

2. Ducts and grids for the circulation of the air;

3. Accessories needed for the correct performance of the system, such as throttle valves, sound absorbers, fire protections, thermometers, chimneys, rain caps and regulation and meter devices [28].

For this project two electric devices were used: a mechanical energy recovery ventilation system and a circulation pump in the roof.

As can been seen in fig.4, the fresh air enters the ventilator where it is heated by the return air and sent to some rooms. There are rooms where the air is supplied (forced air) and others where the air is extracted (return air). The air circulates from one room to the other by a system of grids [29].

In the forced air of this particular project there was a separation between the air that went to the kitchen and the rest of the air, because the kitchen needed air supply during a shorter period.

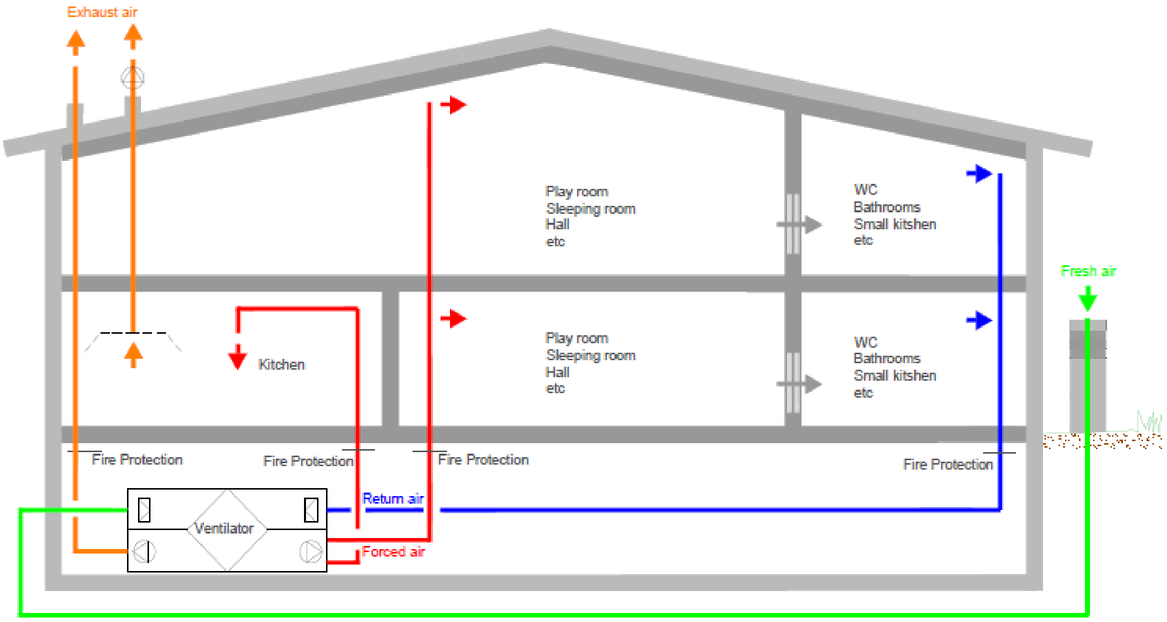

Fig. 4 - Schema of the ventilation system of the project

c) Calculation of flow rate necessary for each room

The first step of the flow rate calculation is to choose the rooms that need forced air and the ones that need return air. After dividing the room by type of ventilation, is calculated the flow rate needed for each room. In this project this calculation was based on the area of the room and on the normative values given for each type of room in units of $(m^3/h)/m^2$, as stated in SIA norm 2024 [30].

The total flow rate of forced air is then compared with the total flow rate of return air of the building and some values are readjusted in order to have similar values in both types of air to avoid pressure or under pressure inside the building.

Table 11 shows the flow rate of each type of air flow after the calculations.

Table 11 - Flow Rate of the different types of air

Fresh Air [m^3/h]	Exhaust Air Building [m^3/h]	Exhaust Air Kitchen [m^3/h]	Forced Air kitchen [m^3/h]	Forced Air Building [m^3/h]	Return Air Building [m^3/h]
5790	2970	2600	2600	3190	2970

d) Sizing of the ventilation system

- **Electric devices**

The sizing of the electric devices is based on the total flow rate and on the available place. With that information different manufactures catalogues are consulted to find the model that better suit the project.

For the project in study, a ventilator manufacturer was asked to suggest directly the right type [31,32] based on the criteria described above.

- **Ducts and Grids**

The ducts and grids sizing is directly related with the flow rate. For each component with a different flow rate (Q) its section (S) is calculated in units of m^2 using the expression (1), based on the air velocity (v).

The air velocity used is described in the Geneva legislation and based on the SIA norm 382/1, as shown in table 12 [14, 33]. These values are meant to restrict the energy consumption, since for higher velocities there will be higher energy consumption in the circulation pumps [29].

$$S = \frac{Q}{v} \tag{1}$$

Table 12 - Air velocity in the ducts according to the flow rate

Flow Rate	Air speed
Until 1,000 m^3/h	3 m/s
Until 2,000 m^3/h	4 m/s
Until 4,000 m^3/h	5 m/s
Until 10,000 m^3/h	6 m/s
More than 10,000 m^3/h	7 m/s

For each different type of piece, I chose the shape and dimension (width and height or diameter) according to the available space. The specifications of each piece described in a ducts manufacturer catalogue, were also respected, as they are designed to avoid pressure drops [1] [34].

In this project the height of the ducts was an important aspect that needed a special attention. This was because the ducts had to be located in a false ceiling, and the project owner wanted false ceiling only in some places. Because of that there were many ducts that needed to pass in the same place and, thus, had to intersect with others.

The thickness of isolation necessary for the ducts that need to be protected from the heat transmission is another aspect to consider. The values to use, as described in Canton of Geneva Implementing Regulation, are based on the temperature difference between the air flow inside the ducts and the ambient air [14]. In this project, since there was no important temperature difference between the air flow inside the ducts and the ambient air, there was no need to isolate the ducts.

- **Accessories**

Most of the accessories have standard dimensions, hence, the sizing is not necessary.

In this project it was necessary to size the fire protection valves[2] and the throttle valves. The sizing of these elements takes in consideration: flow rate; pressure; air velocity (according to table 12); and level of noise. In this project, as described in SIA norms 2024, the decibels should be lower than 33 DB for the play rooms and lower than 28 DB for the sleeping rooms.

For this project, I used a software from an accessories manufacturer [35], which based on the accessories dimensions and flow rate, calculates the pressure, air velocity and decibels.

3.3.1.3 Space heating and DHW production system

a) Legal context

Regarding the space heating and the DHW production system in this stage of a project, the prescriptions that need to be respected are described in the following articles of the Canton of Geneva Implementing Regulation: Heating system; Production of DHW; Thermal insulation and summer protection [13, 14].

b) Components of the system

The system can be divided in four types of components:

1. Heat generator system;

2. Pipes;

3. Accessories needed for the correct performance of the system, such as expansion tanks, pumps, valves, thermometers and regulation and meter devices;

4. Heat distribution.

In this system, as it can be seen in fig.5 the heat generator system was composed by: solar system, gas boiler and water tank, where the water is heathen and stored. For the DHW production, solar panels as well as the gas boiler were used. The gas boiler was also used for heating the building via two systems: radiant floor and a water battery inside the ventilator. The radiant floor heating system was the main heat distribution system by supplying heat directly to the floor [36]. In this project the heat was provided by pumping heated water through tubing laid in a pattern under the floor. The ventilator water battery was used to heat the forced air after passing through the energy recovery system.

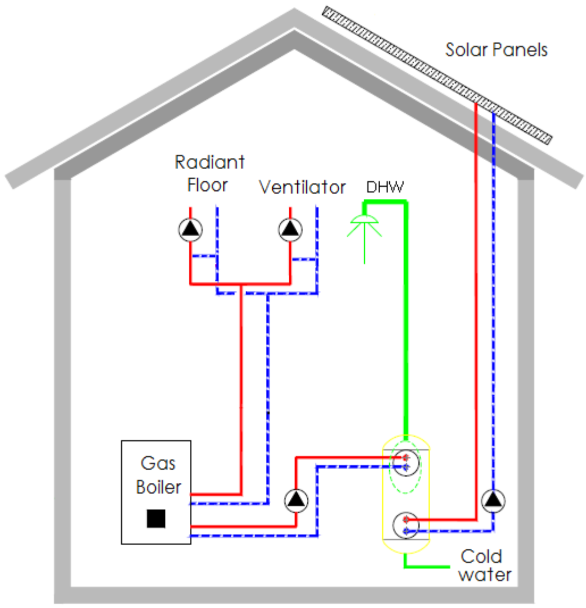

Fig. 5 - Schema of the space heating and DHW production system of the project

c) Calculation of energy needs for heating each room

The calculation of the energy needs for heating each room (Φ_{HL}) was based in the expression (1) described in the SIA norm 384/1 [37].

$$\Phi_{HL} = \Phi_T + \Phi_V , \qquad (1)$$

where, Φ_T are the losses by conduction in units of W and Φ_V are the losses by ventilation in units of W.

This calculation was done using Win HT, which is a Swiss software for thermal balance calculation of buildings based in the SIA norms.

In this program, the following components were introduced:

- Characteristics of the building;

- Meteorological station of the project location;
- General information about each room: Surface of ground, height and ambient temperature;
- Information related with the losses by conduction: surfaces in contact with non-heated places, temperature of the adjacent non-heated places, U-values, orientation, thermal bridges, depth for the rooms in the basement;
- Information related with the losses by ventilation: flow rate entering the room and temperature difference between the ambient air and the forced air;

Table 13 shows the final results of the energy needs calculation.

Table 13 - Final result of the energy needs calculation

Φ_T [kW]	Φ_V [kW]	Φ_{HL} [kW]
20	10	30

d) Sizing of the space heating and DHW production system

The components of the system were sized in collaboration with the sanitary engineer and the energy engineer in charge in the authorization of construction stage.

- **Boiler**

The sizing of the boiler is based on the power needed for the heating needs of the building, the type of fuel and on the available place in the technical installations. The power needed is the highest value between the power needed for the production of DHW and the power needed for space heating. Using that information different manufactures catalogues are consulted to find the model that better suit the project.

In this project the power needed for the production of DHW was 44kW[3] and for space heating was 61kW (i.e. 31kW[4] for the water battery and 30kW for the radiant floor). Hence the power chosen for the boiler was 70kW [16].

- **Solar System**

The solar system was sized by the solar system manufacturer, with the information given by the energy engineer that was in charge of the authorization of construction stage.

- **Water tank**

The dimensions of the water tank correspond to the volume of DHW needed per hour, as described in the point 3.1. Considering that information different manufactures catalogues are consulted to find the model that better suit the project.

In this project because the water tank was also the solar accumulator, the dimensions of the water tank were calculated as the sum of the volume needed for the solar accumulator with the volume needed for the DHW[1]. The solar accumulator volume was calculated using the same expression as in point 3.1, considering that there were 12m^2 of solar panels. The sum of the two components was 1115 litters, thus, we chose a water tank of 1500 litters [16].

The thickness of isolation necessary for the water tank is another aspect to consider. The values to use, as described in Canton of Geneva Implementing Regulation, are based on the capacity of the water tank [14]. In this project the water tank had 10 cm of thermal isolation with a thermal conductivity[5] of 0,035 W/(m.k).

- **Pipes**

For the calculation of the pipes diameter, the flow rate (V) in each pipe has to be calculated using the expression (1), which is based on the heating power that the pipe needs to transport (P).

Then the most appropriate standard diameter is chosen according to tables from the swiss association of heating and ventilation enterprises [38]. These tables are based on: flow rate in the pipes; temperature of the heated water; and the linear pressure drop of the pipes (Annexes- IV). We chose a 50 Pa/m linear pressure drop, as this is the most appropriate value for this kind of systems [39].

$$V = \frac{P}{Cp_{water} \times \rho_{water} \times \Delta T}, \quad (9)$$

where V is the flow rate in the pipes in unit of l/h, Cp_{water} is the specific heat of water in unit of J/(kg.K), ρ_{water} is the density of water in unit of kg/l, $\Delta T = T_{intial} - T_{final}$ = 35°C - 25°C and P is the power needed for heating in unit of J/h.

In this project, the pipes connected the boiler to: ventilator battery; water tank; and radiant floor collectors. For the sizing of the pipes connected to the radiant floor collectors it was first necessary to know the rooms associated to each collector, so that the power considered for each pipe was the sum of the power that needed to arrive to each collector.

The thickness of isolation needed for the pipes that pass through non-heated room, is another aspect to consider. The values to use, as described in Canton of Geneva Implementing Regulation, are based on the diameter of the pipes [14]. In this project, since there was no important temperature difference between the heated and non-heated rooms, it was consider the same thermal isolation thickness in all the pipes, namely, 2,5 cm with a thermal conductivity of 0,042 W/(m.k).

- **Radiant floor heating system**

In a radiant floor heating system it is necessary to calculate the number of collectors and the number of loops. A loop is a single run of radiant floor pipes as explained in fig. 6.

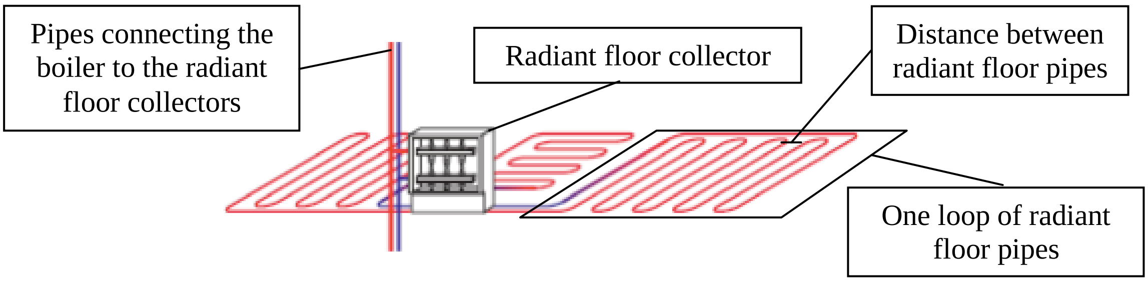

Fig. 6 - Radiant floor heating system [40]

The first step is to calculate the total length of radiant floor pipes needed for each room. For this calculation is first found the distance between the pipes, which takes in consideration four aspects: the diameter of the pipe; the power needed per available surface of ground; temperature of the heated water in the pipes; ambient temperature of the room (table 14). The length of the pipes is then calculated by a ratio of the available surface of ground to the distance between pipes.

Table 14 - Distance between pipes of radiant floor heating system [a] [41]

Temperature of the heated water [°C]	Ambient temperature [°C]	Distance between the radiant floor pipes [mm]					
		200		150		100	
		Power [W/m^2]	Floor temperature[°C]	Power [W/m^2]	Floor temperature[°C]	Power [W/m^2]	Floor temperature[°C]
35	20	56	25.8	63	26.2	71	26.8
	22	48	27.1	55	27.5	62	27.9
	24	41	28.4	46	28.7	52	29.1

a – The pipes diameter considered in this tables is between 14 and 20 mm

Considering the length of pipes, the number of loops needed for each room is calculated. In this calculation the length of pipes needed for a room is dived by the maximum length of one loop, adjusted to the quantity of pipes that have to pass by that room to arrive to the next one.

Finally the number of loops indicates the number of collectors needed, since each collector have a limited number of loops connected

For this project, we chose pipes with a diameter of 1,6 cm separated by 20 cm, that corresponded to 93 loops of 100 m, distributed by 13 collectors [40].

- **Accessories**

The accessories of the system were sized by another member of the company specialized in this component.

3.3.1.4 Design in Plants

For the design of the HVAC systems, I used AutoCad, a software application for both 2D and 3D computer-aided design.

This process had a first stage where the locations of each component of the HVAC systems were set. The systems were designed without the precise dimensions and the plants were discussed by all the protagonists until the general concept was decided.

After defining the exact location of each component, the devices and the distribution system network were designed with the precise dimensions.

In the distribution system design, considering the following parameters is essential:

- Minimum distances needed for the conduits fixation [33];
- Dimensions and location of the outdoor fresh air supply and the outdoor exhaust air as defined in the SIA norms;
- Dimensions described by the manufacturer for each different kind of piece of the ventilation system in order to guarantee that the air flow has the expected behavior [33];
- The fact that water pipes cannot go up and down in order to avoid air bubbles.

Regarding the devices, it is also important to provide enough space for their correct performance and for maintenance, according to their technical information.

The dimensions of the conduits, the flow rate and the distances to the ceiling or to the floor were also described in the plants.

In some critical places a cross-sectional view was designed.

In Annexes-IV, I present the plant of one of the projects floor and a cross-sectional view.

---

[1] - The pressure drop is the difference between two pressure levels in a hydraulic circuit. This factor is the only one which is possible to adjust to decrease the energy consuming without changing the quality of the inside air. As higher is the pressure drop higher is the energy consumption [42, 43].

[2] -The rooms where fire protection is needed are described in the norms and directives of the cantonal association against fire [44].

[3] - Calculated by the sanitary engineer.
[4] - Information given by the ventilator manufacturer.
[5]- Thermal conductivity indicates the ability of a material to conduct heat. A low value indicates high levels of insulation [21].

3.4 Description installations and Construction

The description installation phase requires writing a descriptive document of the HVAC system to send to the enterprises that are going to be responsible for the installation of the system. Normally there is an independent document for the ventilation system and another for the heating/cooling system. Each of those documents has a brief explanation of how the system works and a description of all the necessary material. All the devices, ducts and accessories that compose the system are described in detail as well as the different steps for assembly the system. The enterprises of installation fill out the document writing the estimated price for each group and re-send it. Then all tenders are compared in order to advice the project owner on the installation enterprise to choose.

Finally, in the construction phase the responsibility of an energy engineer is to follow the process of construction, and making sure the energy component of the project is constructed as planned.

3.4.1 Séracs

3.4.1.1 Characteristics of the project

Séracs is a project for a partial renovation of the HVAC system of a mountain housing building. The renovation work was to be done in the garage and basement of the building. Table 15 describes the main characteristics of the project.

Table 15 - Characteristics of the project Séracs

Type of project	Renovation
N° of buildings	1
Type of buildings	Multi-family house
Location	Commune Bagnes, Canton of Valais
Heating production	Fuel oil boiler and Solar panels
Ventilation	Double flow with energy recovery
Heating distribution system	Radiators
EBF total	3040 m^2

3.4.1.2 Legal context

The Canton of Valais Energy Law, describes for this stage the following obligations:

- The HVAC system must be installed and regulated according to the law prescriptions, and there must be a document where the system characteristics are described;

- After the HVAC system installation is done, there must be a conformity control. An attestation confirming that the installations correspond to what was planed must be sent to the competent authority [45, 46].

3.4.1.3 Description Installation

In the description of the HVAC installations I was responsible for the description of the ventilation distribution system.

The ventilation distributing system was described regarding the dimensions and type of ducts, by calculating their length, by preparing a plant showing the conduits to disassemble and the ones to assemble, and by preparing a schematic elevation of the ventilation system (Annexes-V).

3.4.1.4 Construction

The construction period was performed during the summer season for approximately two months. These procedures take place normally in this season, because this is the moment in the year where there is less heat demanding. During this period there was a temporary fuel oil boiler for the DHW production.

Every two weeks there was a meeting in the construction site. In most of these meetings the following protagonists were present: the energy engineer; the representative of the project owner; the responsible for the maintenance of the building; the heating system enterprise; the ventilation system enterprise; the electric system enterprise; the plastering enterprise; the water treatment enterprise; and the chimney-sweeping enterprise. During these meetings, it was discussed what had been done since the previous meeting and the next steps were planned. Some unpredicted problems were also solved at these times. A document summarizing each of these meetings was prepared and sent to all the protagonists.

3.5 Operation monitoring

At this stage, a building operation monitoring can be performed by request of the building owner.

During a fixed period several energy component of the building are regularly measured. Considering that information it is possible to do a monthly control and in the end of the established monitoring period a report analyzing the operation of the building is written.

3.5.1 Vélodrome

3.5.1.1 Characteristics of the project

The project Vélodrome is a group of five residential buildings that use the same heating and DHW production system. For the heat production two wood boilers and 227 m^2 solar panels are used. 500 m^2 of photovoltaic panels for electricity production are also installed. The energy consumption is automatically registered every month, since November 2010, when the buildings started their operation.

The table 16 describes the main characteristics of the project.

Table 16 - Characteristics of the project Vélodrome

Type of project	New buildings Minergie
N° of buildings	4
N° of sub-stations	5
Type of buildings	Multi-family house
Location	Plan-les-Ouates, Canton of Geneva
Heat production for heating system	Wood boiler
Heat production for DHW	Wood boiler and solar panels
Ventilation	Double flow with energy recovery
Heating distribution system	Radiant floor

In the end of September 2012, as asked by the building owner, the building operation during the period from October 2011 till September 2012 was analyzed.

3.5.1.2 Legal Context

In this stage of a building project, the prescription described in the article Energy consumption control of the Canton of Geneva Energy Law must be respect.

3.5.1.3 Energy Consumption

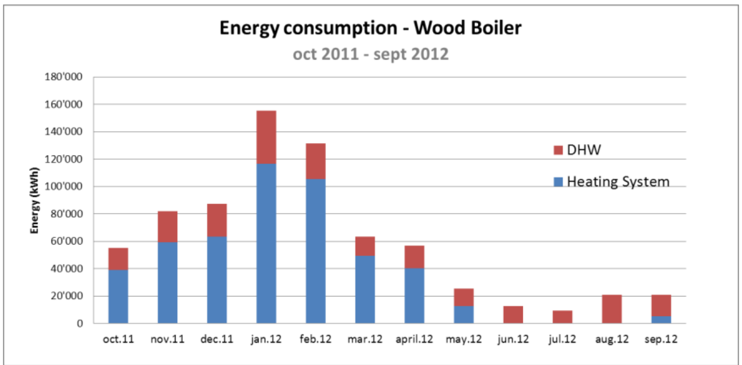

Fig. 7 - Monthly energy consumption of the wood boiler

In terms of annual energy consumption of the wood boiler, it was observed that 32% of the energy of the five buildings was used for the production of DHW and 68% for heating the building.

In the graphic shown in figure 7 is possible to observe that the total energy consumption decreased after the month of April.

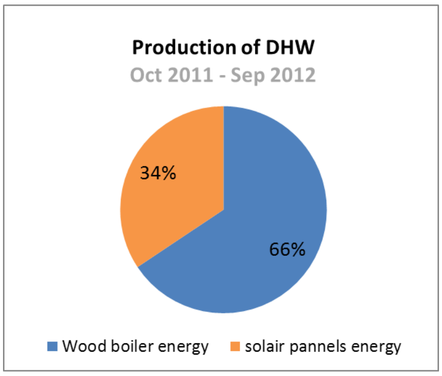

Fig. 8 - Production of DHW

This can be explained by the diminution of the heating needs and higher production of the solar panels.

During the year in study, 34% the production of DHW was due to the solar panels and the remaining 66% with the wood boiler, as can be seen in the graphic of figure 8.

3.5.1.4 Photovoltaic system

In the analyzed period the photovoltaic system produced 88'674 kWh, which was a predictable value.

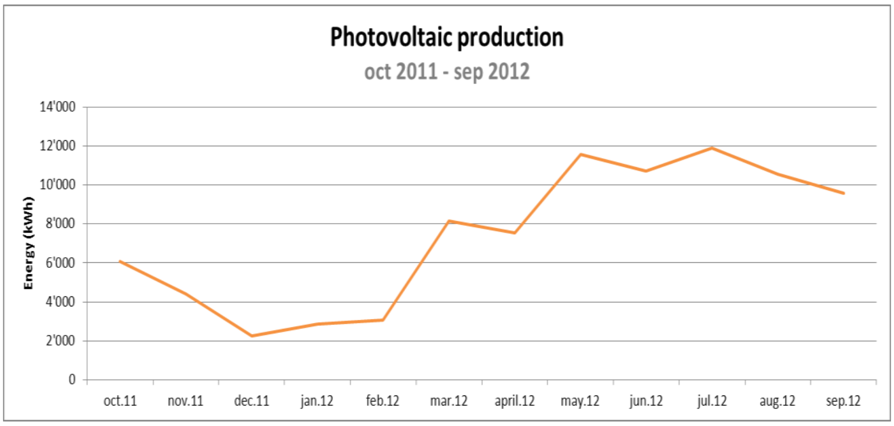

Fig. 9 - Photovoltaic production

In theory, the photovoltaic production could cover a quarter of the electricity needs for the five buildings of the project.

In the figure 9 is possible to observe the clear difference between the energy production in the summer and the winter months.

3.5.1.5 Calculation of Energy Expenditure Index

In the canton of Geneva, it is mandatory for all the heated buildings, to calculate the Energy Expenditure Index (IDC), in order to know the thermal quality of the buildings [13, 14]. The IDC represents the quantity of final energy consumed for the production of heat for the heating system and for production of DHW [47].

This index has to be calculated once per year during three years every ten years. If the average of the three years is higher than 800 MJ/(m^2.year) it has to be done an energy audit and then a building renovation must be performed.

The IDC is obtained by adding two components:

- The partial index of the heating system, E_h

- The partial index of the DHW production system, E_{ww}

The calculation of E_h is based on the consumption of energy for the heating system during the period in study adapted to the meteorological condition during that period.

The E_{ww} is based on the consumption of energy for DHW production during the period in study. This index is not influenced by the meteorological condition.

For the calculation of IDC I used a spreadsheet from the Cantonal Office, where the following information was introduced: EBF of all the buildings; type of buildings; type of boiler; analyzed period; energy consumed; and if this energy was used for the DHW production.

The IDC calculated was 253 MJ/(m².year). This is a very low IDC, since the IDC average in the canton of Geneva is 600 MJ/(m².year).

3.5.1.6 Comparison with theoretical values

a) Energy Need for the heating system

During the authorization of construction stage it was calculated two different values for the energy need for the heating system: i) Q_h – energy need without considering the heat recovered from the ventilation system; ii) $Q_{h\ eff}$ – energy need considering the heat recovered from the ventilation system [24].

In the Minergie form the value that has to be below the limit is the Q_h but in theory the value that should correspond to the real needs is the $Q_{h\ eff}$.

By analyzing the real needs during the building operation, it was observed that the Q_h values are closer to reality than the $Q_{h\ eff}$ values. This fact does not have to be directly related with the efficiency of the heat recovery system, it could also be due to the calculation of the Q_h and $Q_{h\ eff}$ in the authorization of construction stage, which are based in a standard utilization conditions, and may not correspond to the real utilization conditions. During the building operation, the user's behavior, as well as the exterior temperature by being different than the standards, can change the energy consumption significantly. One of the most important factors is the variation of the demanded interior temperature, since rising 1°C increases approximately 7% of the energy consumption [48, 49].

The Q_h was in average 4% higher than the calculated in the authorization of construction stage.

b) Minergie Value

A new Minergie Value, was calculated with the real energy consumed, using the formula of the Minergie forms 2007, which were the forms used in the authorization of construction stage.

The values were in average 36% higher than the calculated in the authorization of construction stage.

This fact can be explained by the increase of demand for the heating system, as well as the higher consumption of DHW. It is important to note that the Minergie value calculated during the authorization of construction stage was based in the Q_{heff} and not in the Q_h [24].

Even though the values during the buildings operation were in general higher than the theoretical values, all the buildings were still under the limits for a Minergie building, as showed in table 17.

Table 17 - Comparison between Minergie limit during the authorization of construction stage and the building operation stage

	Q_h				Minergie Value		
Building	**$Q_{h\ eff}$ Authorization construction stage [kWh/m² EBF]**	**Q_h Authorization construction stage [kWh/m² EBF]**	**Q_h During building operation [kWh/m² EBF]**	**$Q_{h,li,mi}$ Limit Minergie [kWh/m² EBF]**	**Authorization construction stage [kWh/m² EBF]**	**During building operation [kWh/m² EBF]**	**Minergie Value Limit [kWh/m² EBF]**
1	20,8	29,4	32,2	32,4	27	37	42
2	24,1	33,8	36,5	38,8	28	38	42
3	22,4	31	29,0	33,9	28	37	42
4	22,4	31	31,6	33,9	28	39	42

3.6 Punctual studies

These kind of studies are independent of the process of a building construction. They consist in analyzing the energy component of existing buildings. There are two main groups: energy audits and analysis of problems related to the HVAC systems or the thermal envelope.

3.6.1 Connétable

3.6.1.1 Characteristics of the project

The project Connétable consisted in the analysis of humidity problems in a domestic house. Different rooms were analyzed to understand if the causes of the problems were related to the HVAC system or/and to the thermal envelope.

In this project, I was responsible to study a particular room that is going to be described in this section.

This analysis was based on:

- Local observation;

- Temperature and humidity measures;

- Analysis of the architectural plans of the building;

- Thermal bridges modeling.

3.6.1.2 Temperature and humidity measures

In this room there was a problematic corner covered with black marks, where the analysis was focus in (Annexes-VI). In this corner was left a device to measure the surface temperature and the humidity. These two parameters were measured every 30 minutes from mid-April until beginning of May.

Figure 10, shows the results of the measures. During this period the average relative humidity was approximately 80% and the average temperature approximately 16°C.

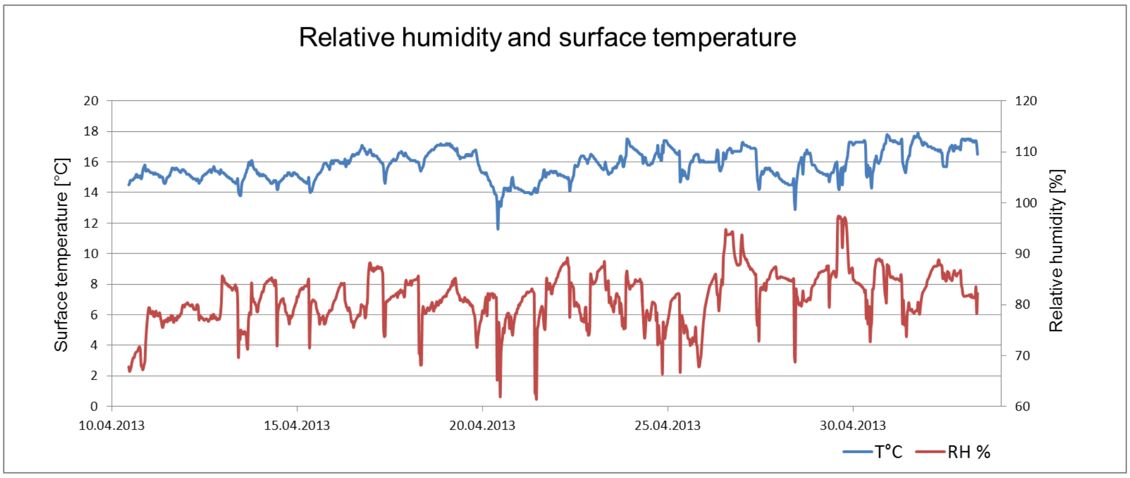

Fig. 10 - Relative humidity and surface temperature in the corner of the room in study

As suspected the relative humidity was too high, since when the relative humidity rises to 100% there are water vapor condensation.

The temperature measured was also a sign of problem, for being considerable lower than the ambient temperature of the room. This difference of temperature was an indication of a possible thermal bridge in the corner.

3.6.1.3 Thermal bridges modeling

In the thermal bridges modeling, I considered three types of wall constructions, in order to understand how these influence the interior humidity problems. The differences between the three variants were the thickness and type of isolation between the wall-1 and wall-2 (fig.11).

The following variants were considered:

- Variant-1, with 2 cm of silicon isolation, based on the wall structure from the architectural plans, since the execution plans of the building were not available;

- Variant-2, without isolation;

- Variant -3, with the minimum thickness of isolation to avoid humidity problems.

In variant-3, in order to find the minimum thickness, several thermal bridges were modeled.

To calculate the condensation risk of these variants, I used Flixino. This software analyses the thermal properties of a construction according to the European Standards EN ISO 12211: 2007 and EN ISO 10211.

In Flixino, I first introduced the construction structure at the plan view and then I defined the boundary conditions, as showed in figure 11.

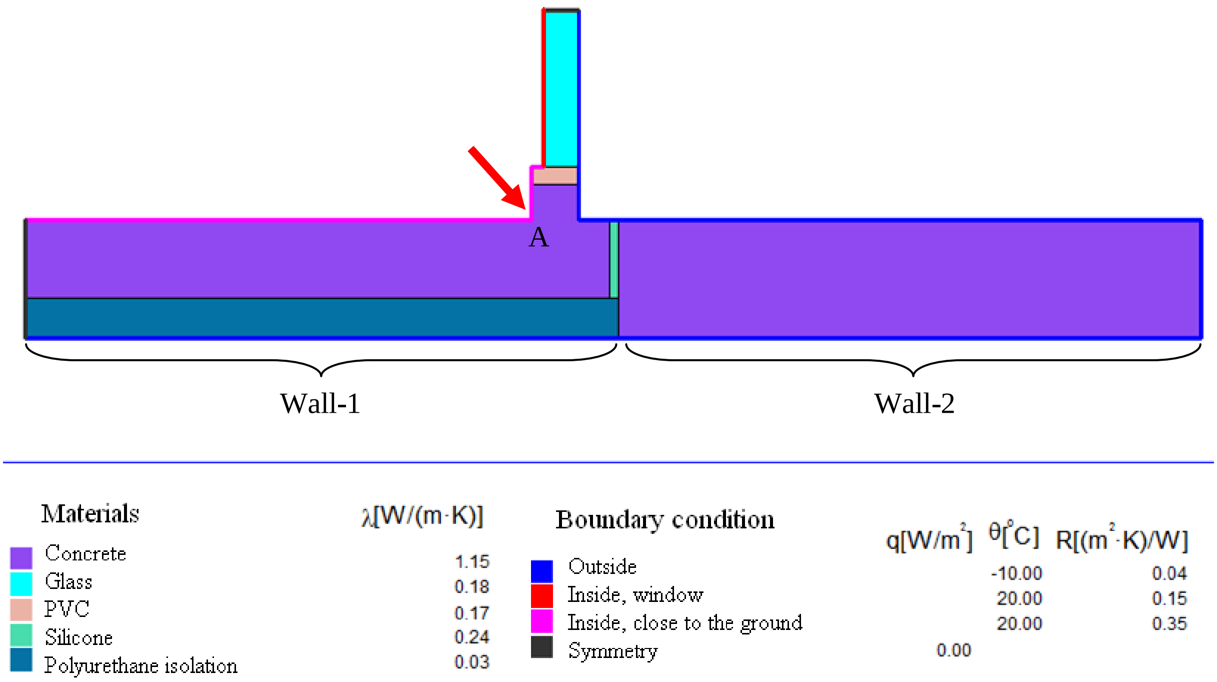

Fig. 11 - Flixino simulation: Plan view of the corner in study with the wall structure of variant-1

After defining the structure it was calculated the temperature factor at the internal surface (f_{Rsi}) in the corner in study (point A – fig.11). This factor evaluates the risk of condensation in the internal surfaces.

According to the EN ISO 10211, f_{Rsi} is the difference between internal surface temperature and external temperature, divided by the difference between internal temperature and external temperature, calculated with a surface resistance at the internal surface [50].

Whenever f_{Rsi} is lower than 0,75, there is a risk of condensation [51].

3.6.1.4 Result analysis

The thermal bridges modeling showed that in both variant-1 and variant-2 the f_{Rsi} is lower than 0,75, as described in table 18.

According to those results, we concluded that a thermal bridge in the corner in study explains the humidity problems in the type of construction of variant-1 and variant-2.

Table 18 - Condensation Risk in the variants in study

	Variant-1	**Variant-2**	**Variant-3**
Isolation	2 cm silicon isolation betwen the wall-1 and wall-2	No isolation	5 cm of polyrethane isolation betwen the wall-1 and wall-2 until the window frame
f_{Rsi}	0,416	0,402	0,757

This problem could have been solved by using a minimum of 5 cm of polyrethane isolation between the wall-1 and wall-2 until the window frame, as studied in variant-3.

However it was also important to mention that these results do not exclude the possibility of water infiltrations, which was not considered in the analysis.

4. Conclusions

During these twelve months of internship in the company Putallaz Ingénieurs-Conseis, I participated in several projects from different stages of a building project. This experience gave me the opportunity to participate in the process of a building construction and operation in Switzerland, where I learned about the Swiss legislation regarding the energy component of buildings, its requirements and its main actors.

In Switzerland, even though each canton has its own energy laws, their legislation is based on the same guide-document, the MoPEC [10]. This fact simplifies the use of the cantonal legislation and standardizes the national energy demands [52]. Some external actors are also frequently mentioned in these legislations, such as the Minergie Association and the SIA, which allows a better connection and proximity between the different actors of a building project.

Concerning the canton of Geneva, where my study was focused, the energy demands in the building sector are one of the highest in Switzerland [52]. In order to ensure a rational use of energy and give priority to renewable energies, there are several requirements to respect. They are described in a very objective and coherent way.

The requirements described in the legislation are mainly focus in the following aspects:

- Quality of the thermal envelope;
- The obligation of using renewable energies;
- The use of an air conditioning system only when justified;
- Higher requirements for public buildings and large buildings;
- Correct sizing and installation of the HVAC system;
- Energy consumption control [13, 14].

In this report, I decided to describe the procedure in each of the different stages of a building project, since the energy efficiency of a building is affected by all of these stages. For this study, six stages were considered:

1. Preliminary studies;
2. Construction and renovation authorization;
3. Sizing and design of HVAC systems;
4. Description of installations and construction;
5. Operation monitoring;
6. Punctual studies.

In each of these stages there are different requirements to respect, as described above for the canton of Geneva.

The first two stages are the most important stages. In these the characteristics of a building are defined, namely the quality of the thermal envelope, type of ventilation system and type of heating system. The quality of the thermal envelope is one of the most significant parameters in this stage. For a new building in the canton of Geneva this parameter is evaluated by performing a thermal balance. In this calculation the characteristics of the thermal envelope elements are adjusted in order to have a value for the energy needs for space heating lower than the one imposed.

Concerning the third stage, its influence in the energy consumption depends of the complexity and size of the HVAC system. In a complex system, the correct sizing can save a higher percentage of energy. In this stage the most important aspects to consider are the thickness of thermal insulation of the different components of the system to avoid heat losses and the correct sizing of the conduits in order to reduce the energy consumption in the circulation pumps.

After these three stages, in which the energy components of a building are planned, the following step is to describe the installations and then to construct the building. In this forth stage, guarantee that the energy components of the building are constructed as planed is crucial for its correct performance.

Finally in the last stages, during the building operation a regular control of the building performance enables to detect possible problems in the system that may induce not only high energy consumption but also the deterioration of the building elements. In the canton of Geneva, in order to control the energy consumption of the buildings, for all the heated buildings the calculation of the IDC is mandatory. Whenever this value is higher than an imposed value, an energy audit and then a building renovation must be performed.

In this study it was also interesting to realize how these stages are connected and their influence in the other stages. When some stages are not well performed, several problems can occur in the following stages. An example of such situation was observed in the project described in point 3.6, where humidity problems and deterioration of the building elements were observed during the building operation caused by a neglected thermal bridge.

Overall, Switzerland has a mature legislation regarding energy consumption in buildings with a strong focus to increase the use of renewable energy sources. Moreover, a strict inspection system is in place which assures a good application of the legislation.

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Annexes-I: Canton of Geneva: Energy Law and its Implementing Regulation

Minimum legal obligations to respect in the canton of Geneva

<table>
<tr><th colspan="2">Building Procedure</th><th colspan="2">Requirements</th></tr>
<tr><td>New Building</td><td>Non large building nor public building [a]</td><td>Minergie certificate
+
>30% of Q_{ww} with renewable energies
+
Comply with the list of prescriptions</td><td>HPE certificate:
$Q_{h} < 80\% \, Q_{h,li} + E_{non\text{-}renewable} \leq 60\% \, E_{total}$
+
>30% of Q_{ww} with renewable energies
+
Comply with the list of prescriptions</td></tr>
<tr><td rowspan="3">Extension</td><td>Non large building nor public building:
EBF extension < 50m^2
or
< 20% of the EBF total and EBF extension < 1000m2</td><td colspan="2" rowspan="2">HPE certificate:
Opaque isolation elements in contact with the exterior must have an energy performance 25% higher than the limits of SIA norms; translucent isolation elements in contact with the exterior must have:
15% more performing then the limits of SIA norms if their surface is < 60% of all the isolation surface in contact with exterior or
25% more performing then the limits of SIA norms if their surface is > 60% of all the isolation surface in contact with exterior
+
>30% of Q_{ww} with renewable energies
+
Comply with the list of prescriptions</td></tr>
<tr><td>Large building:
EBF extension < 15% of total EBF and EBF extension < 1000m^2</td></tr>
<tr><td>Non large building nor public building:
EBF extension > 50m^2
or
> 20% of the EBF total</td><td colspan="2">HPE certificate:
$Q_{h} < 80\% \, Q_{h,li} + E_{non\text{-}renewable} \leq 70\% \, E_{total}$
+
>30% of Q_{ww} with renewable energies
+
Comply with the list of prescriptions</td></tr>
<tr><td rowspan="2">Renovation</td><td>Non large building nor public building</td><td colspan="2" rowspan="2">The elements of the building that are renewed have to comply with the list of prescriptions</td></tr>
<tr><td>Large building:
EBF renovated < 500m2</td></tr>
</table>

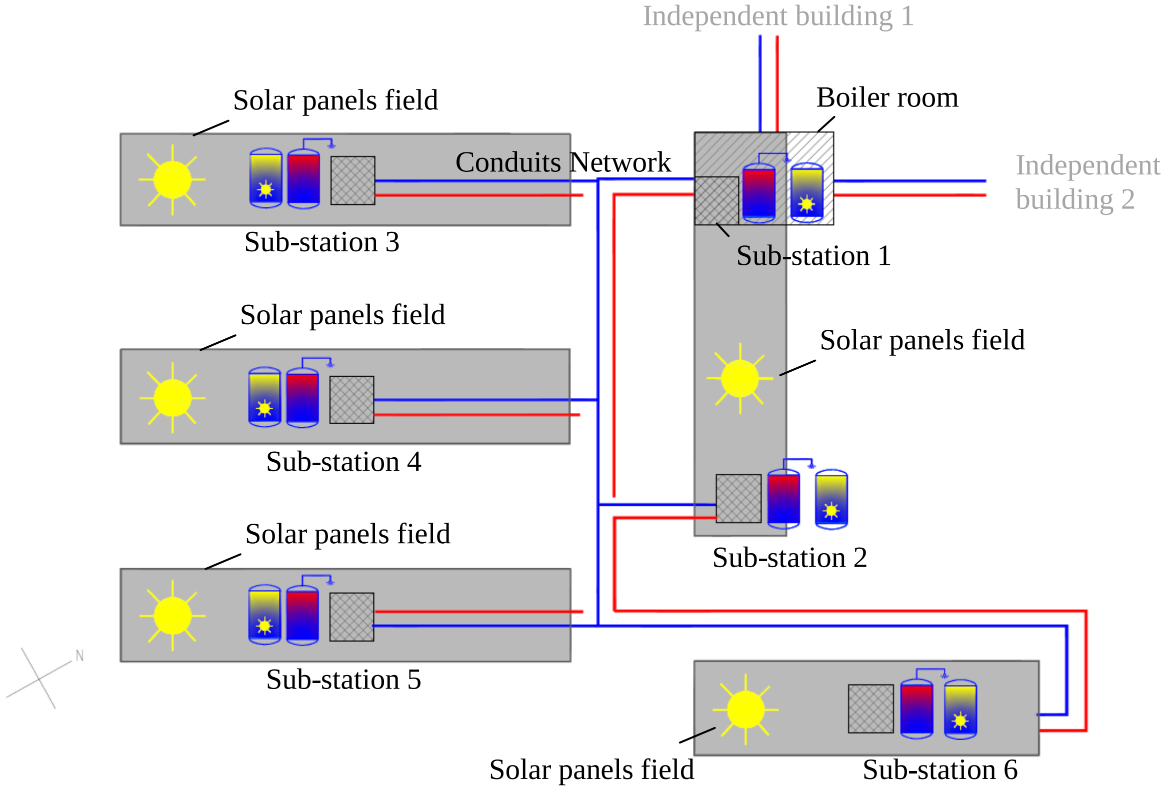
Abbreviations: EBF, Energy Reference Area; Q_h, energy needs for the heating systems; $Q_{h,li}$, energy needs for the heating systems as calculated using the SIA norms; Q_{ww}, Energy Need for production of domestic hot water; $E_{non\text{-}renewable}$, percentage of non-renewable energy used for heating systems and for production of domestic hot water; E_{total}, energy needs allowed from renewable or non-renewable sources according to the SIA 380/1; SIA, Society of Engineers and Architects

a - A housing building with more than 3000 m^2 of EBF or non-housing with more than 2000 m^2 is considered a large building. For these buildings as well as for public building is mandatory to perform the particular analyze *Concept Energétique*, which aims to reduce the energy need for heating systems as well as to reduce the use of non-renewable energy sources.

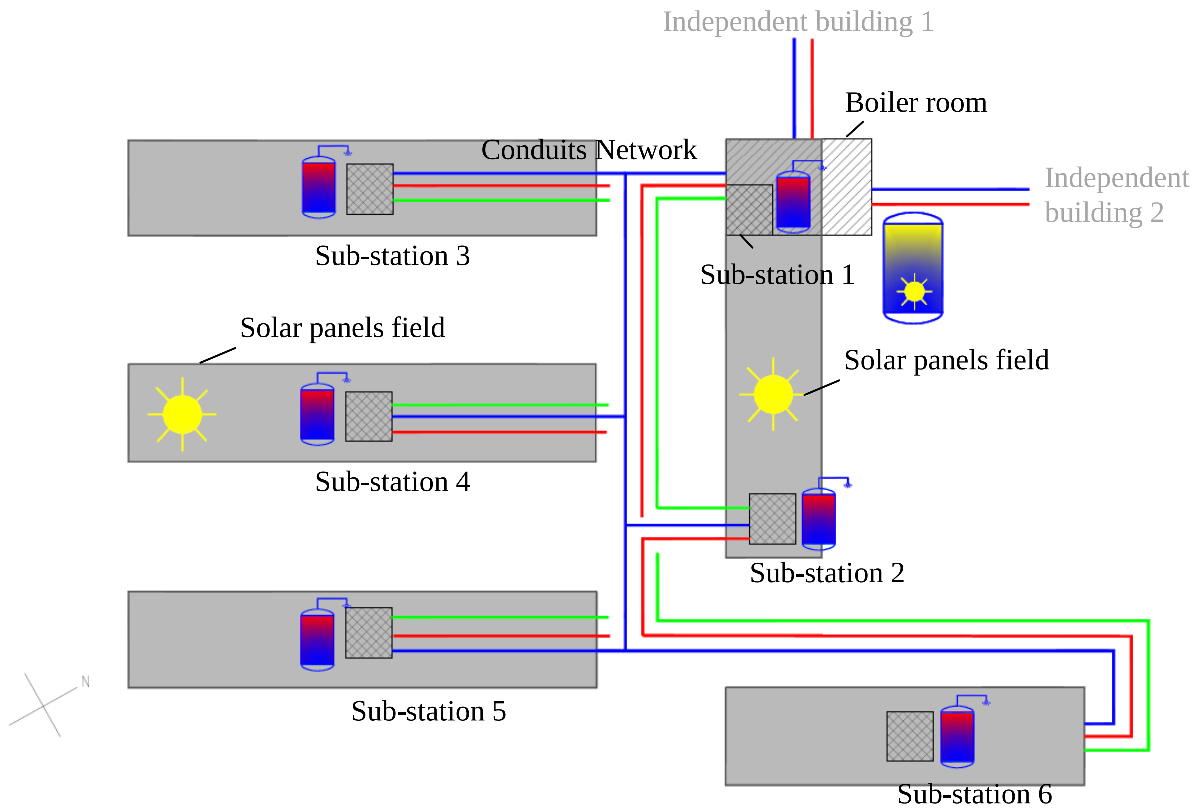
Annexes-II: Caves de Mandement

Illustration of the four variants of the solar system

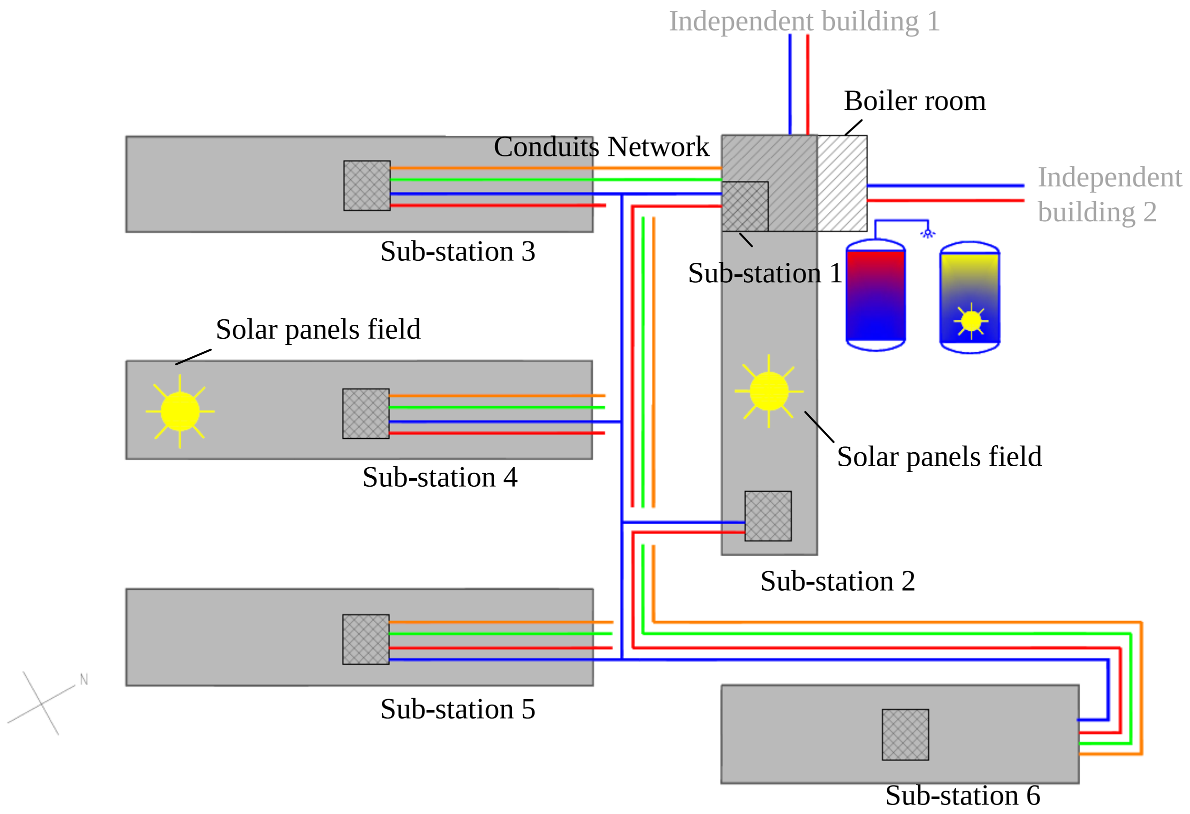
Variant A



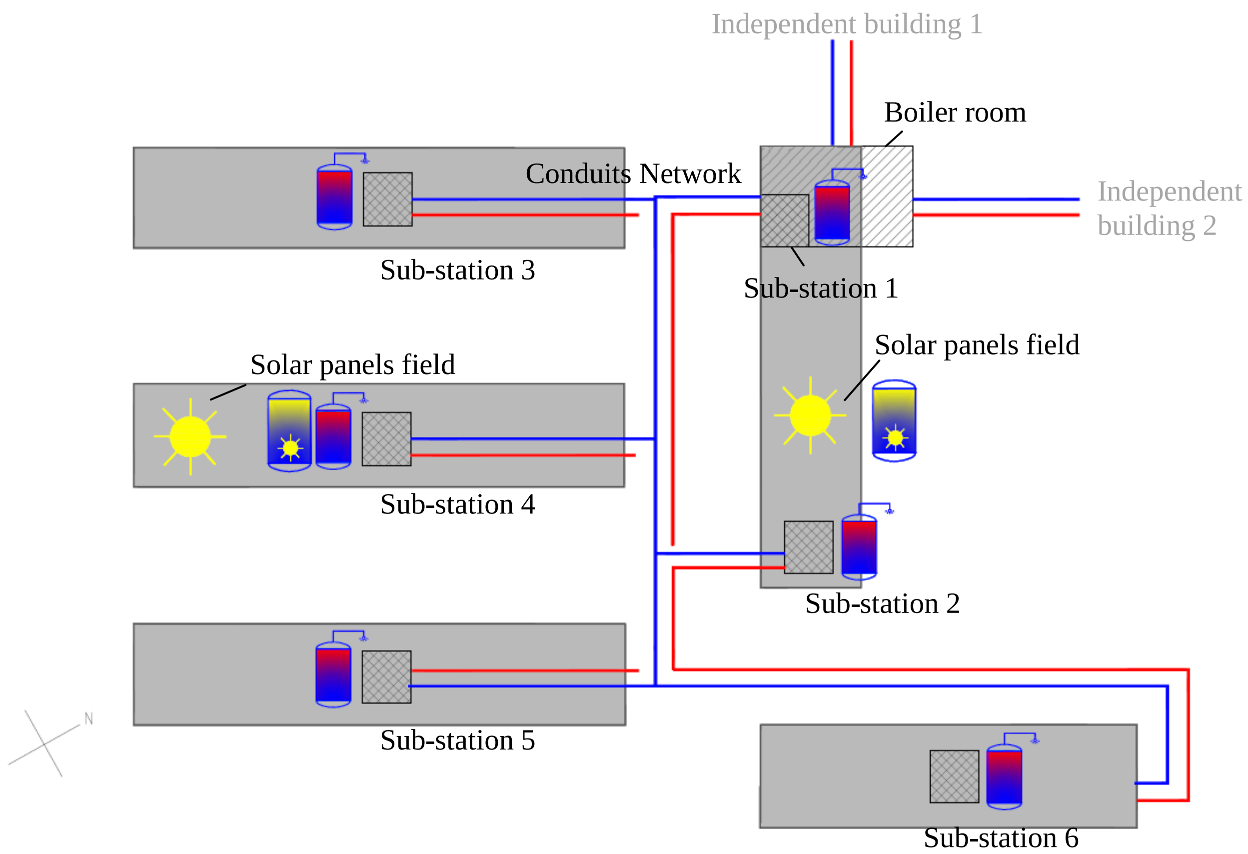
Variant B



Variant C

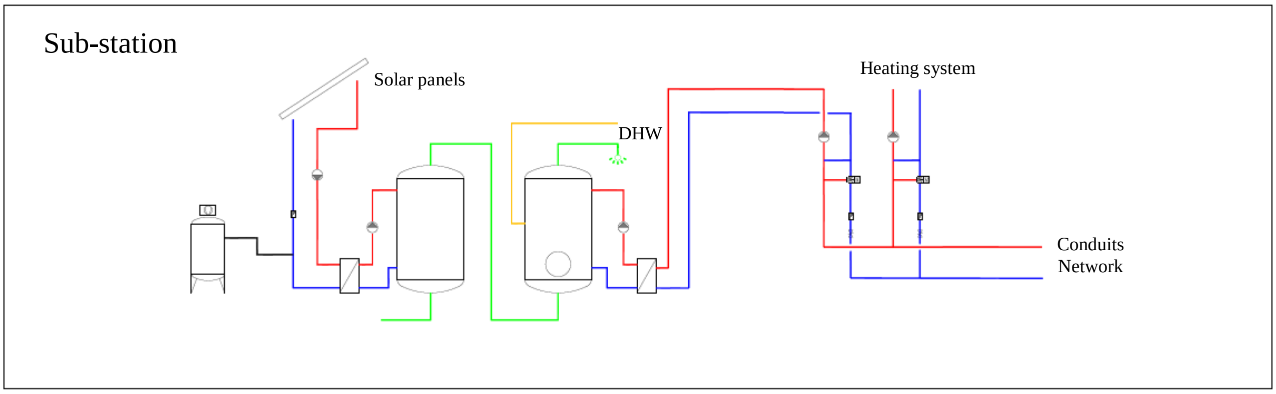


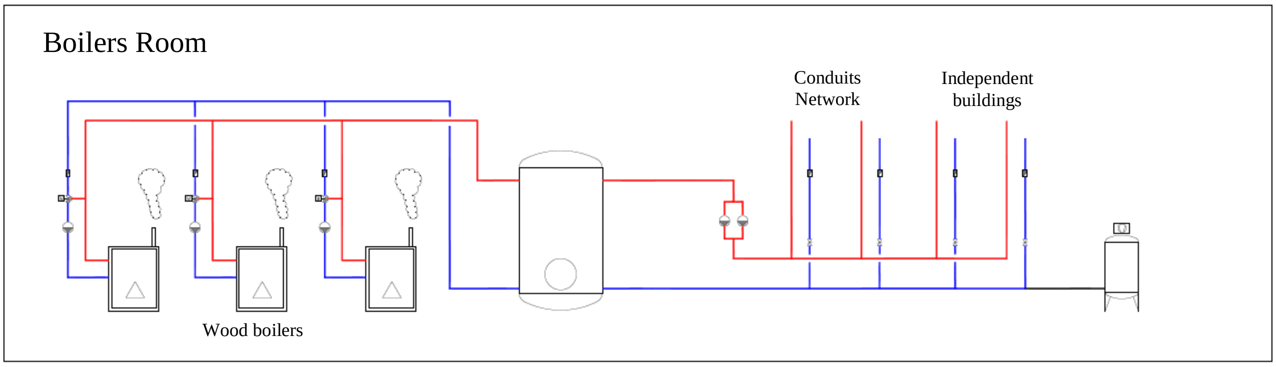
Variant D



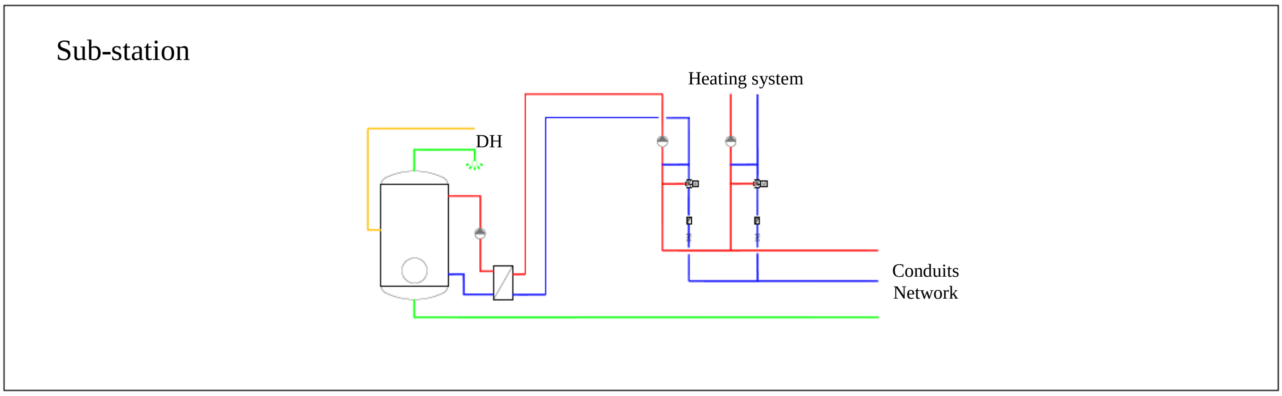
Operating diagram of the four variants of the solar system

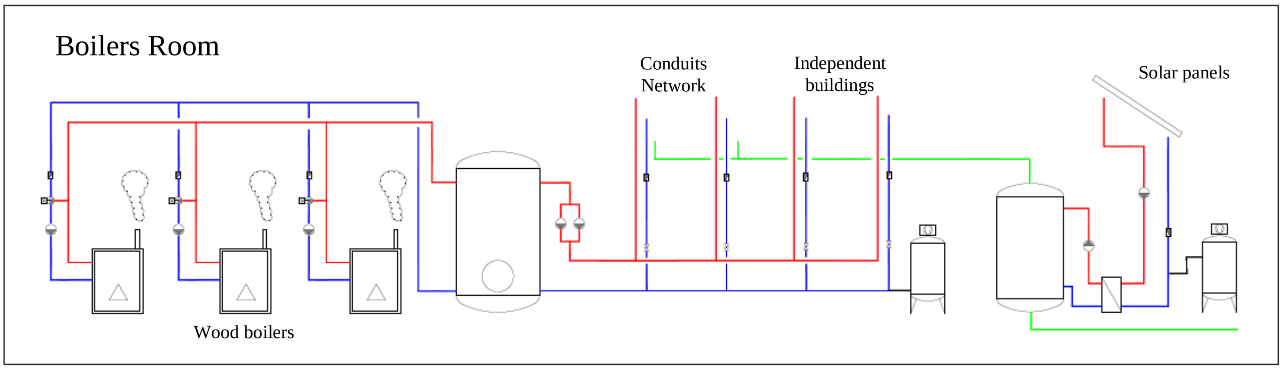
Variant A



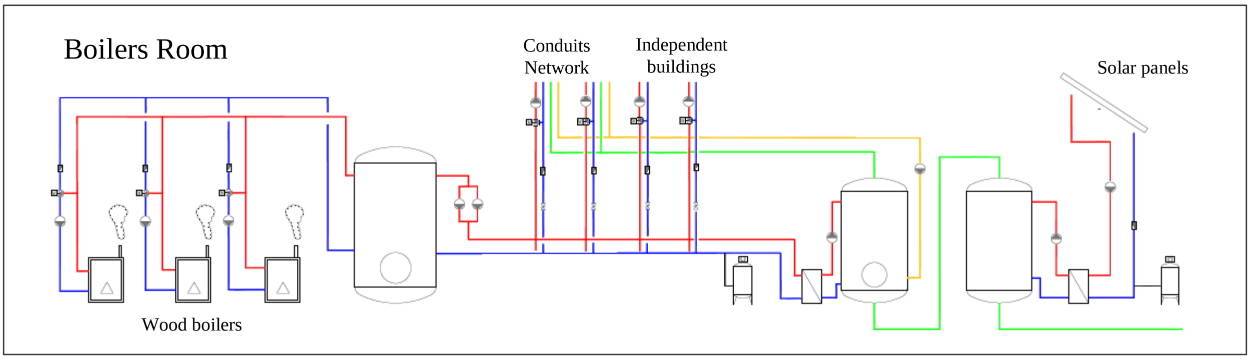


Variant B

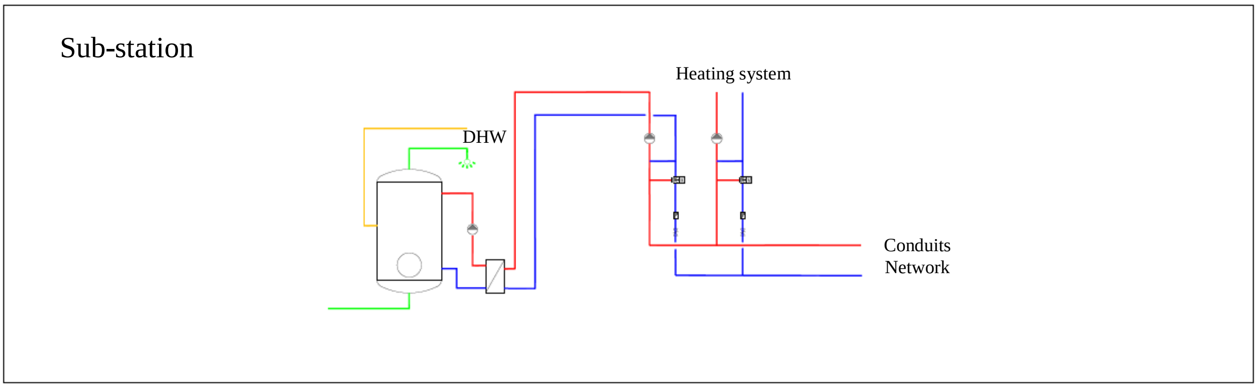


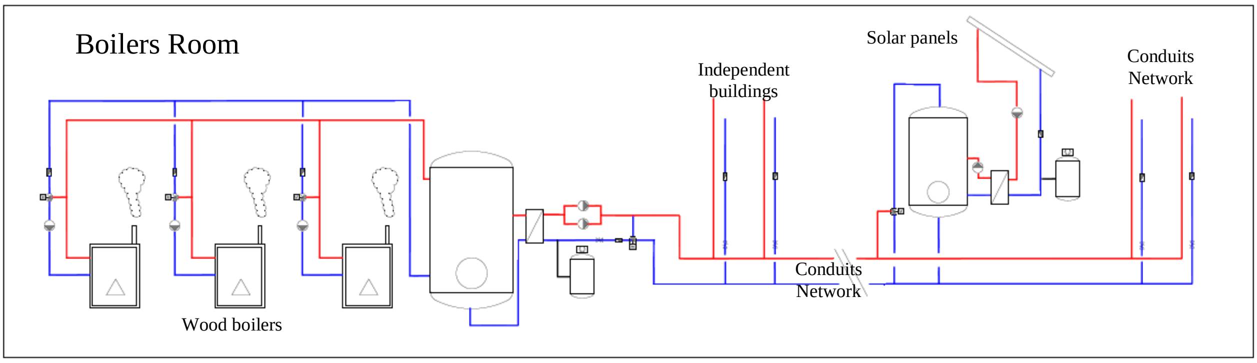


Variant C



Variant D





Solar panels standard

Fonctionnement

Principe de captage du rayonnement solaire

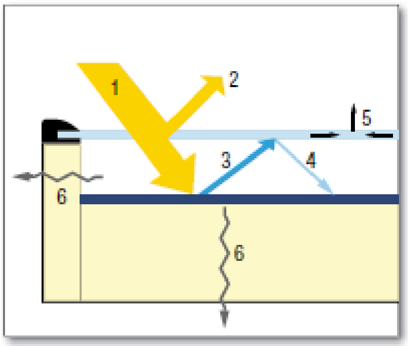
Le rayonnement solaire traverse le vitrage du capteur AZUR et frappe une surface métallique foncée: **l'absorbeur**. Constitué d'une tôle mince parcourue d'un réseau de serpentins soudés dans lequel circule un mélange d'eau et d'antigel, il est revêtu d'une couche sélective à haut pouvoir absorbant et faible émissivité.

Sous l'effet du rayonnement, la température de l'absorbeur s'élève et chauffe le liquide en circulation dans les tubes.

Le vitrage sécurisé à l'avant de l'absorbeur crée l'effet de serre. Il augmente l'efficacité du capteur lorsque sa température est supérieure à la température extérieure.

Un isolant efficace et imputrescible à l'arrière et sur les côtés de l'absorbeur limite les pertes thermiques.

Coupe d'un capteur solaire



1. Rayonnement solaire
2. Rayonnement réfléchi par le vitrage
3. Rayonnement émis par l'absorbeur
4. Rayonnement réfléchi par le vitrage
5. Rayonnement émis par le vitrage
6. Pertes thermiques du coffre

Solaire thermique, fonctionnement ?

Une pompe de circulation véhicule le mélange d'eau et d'antigel chauffé dans les capteurs. Ce liquide caloporteur fonctionne en circuit fermé. La chaleur est transmise à l'accumulateur (chauffe-eau ou cuve combinée) par l'intermédiaire d'**un échangeur** de chaleur.

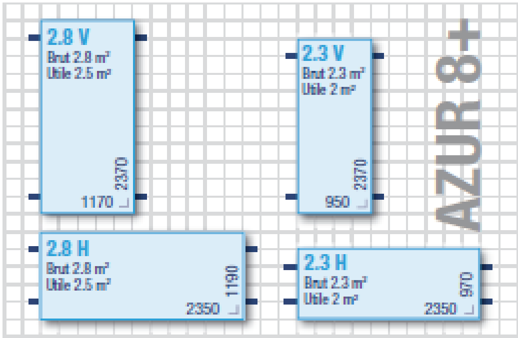
La régulation compare en permanence la température des capteurs à celle de **l'accumulateur**. Dès qu'une différence positive est atteinte, le circulateur fonctionne automatiquement. Il s'arrête lorsque cette différence redevient négative.

L'accumulateur bien isolé permet de bénéficier de l'énergie solaire stockée lorsque le soleil a disparu.

En cas d'apport solaire insuffisant et lorsque l'énergie solaire emmagasinée dans l'accumulateur est épuisée, une énergie traditionnelle (mazout, gaz, bois ou électricité) fournit **l'appoint** nécessaire.

Technique AZUR 8+

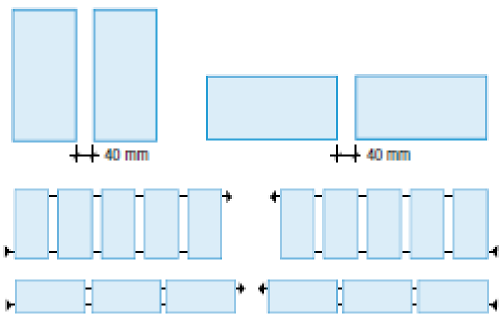
Modèles



Caractéristiques techniques

Type	Unité	2.8 V	2.8 H	2.3 V	2.3 H
Hauteur	mm	2370	1190	2370	970
Largeur	mm	1170	2350	950	2350
Epaisseur	mm	100	100	100	100
Surface brute	m²	2.8	2.8	2.3	2.3
Surface **utile**	m²	2.5	2.5	2	2
Poids	kg	50	52	40	41
Contenance	l/capteur	2.9	3.5	2.2	2.9
Pression d'essai	bar	20	20	20	20
Pression maximum de service	bar	6	6	6	6
Débit	l/h par m²	15 - 40	15 - 40	15 - 40	15 - 40
Raccords hydrauliques	nombre	4	4	4	4

Implantation - Raccordement



Pertes de charges

		Unité/nb	Low Flow			High Flow	
Débit		l/h m²	15	20	25	30	40
		l/h capteur	37.5	50	62.5	75	100
Type V 2.8	Nombre capteur(s)	1	73	98	122	147	196
		5	75	100	125	150	201
		10	81	108	138	168	231
		15	93	128	168	209	298
Type H 2.8	Nombre capteur(s)	1	69	93	116	140	187
		5	73	98	122	147	197
		10	84	113	146	182	258
		15	110	154	208	266	394

Les pertes de charges sont indiquées en **millibar** par séries de X capteurs

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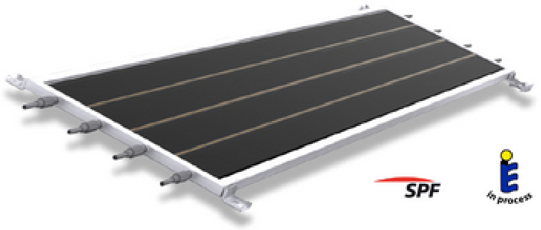
Solar panels High temperature

COLLECTOR FEATURES

The solar thermal collector manufactured and distributed by SRB Energy reaches stagnation temperatures exceeding 400°C, assuring a high performance at nominal temperatures up to 200°C for several applications of industrial process heat without the need for solar tracking.



Among the adopted technologies, there are:

Ultra High Vacuum (UHV) technology, (10^{-8} mbar at ambient temperature).

Nano-technology based getter pumping, regenerated by solar energy.

Black-Chromium selective coating of the absorber surface ensuring high absorptivity in the visible spectrum and low emissivity in the infrared spectrum.

Glass-metal sealing technology, which allows the perfect sealing of the collector evacuated enclosure.

The development of the solar collector is based originally on a CERN patent, of which SRB Energy is the sole licensee. 6 other patents have been obtained by SRB Energy on various aspects of the collector manufacturing process:

The UHV solar thermal collector is manufactured in the production plant of SRB Energy in Valencia, supported by Segura Group's experience as manufacturer of automotive components since the 1970s.

Annexes-III: Chemin des Manons

Formulary EN G1 - Cantonal Office of Geneva

Service de l'énergie du canton de Genève (ScanE)	Formulaire énergétique Nouvelle construction	EN-GE1 V2 22.03.2011

Nouvelle construction ou extension de bâtiment existant
- Procédure simplifiée -

La procédure simplifiée permet au requérant de joindre uniquement le présent formulaire à sa requête en autorisation de construire. Pour bénéficier de cette procédure simplifiée, il faut pouvoir répondre négativement aux trois questions ci-dessous :

- le projet déroge-t-il à une des prescriptions énergétiques applicables? ☒Non ☐Oui
  Si le requérant souhaite demander une dérogation à l'une d'entre elle, il doit suivre la procédure normale (cf. formulaire EN-GE2) ;
- le projet est-il assujetti au concept énergétique? Sont assujettis au concept énergétique : ☒Non ☐Oui
  - les constructions ou transformations de bâtiments des collectivités publiques, des établissements et des fondations de droit public et de leurs caisses de pension ;
  - les constructions bénéficiant de lois de subventionnement ;
  - les bâtiments d'importance : constructions et transformations destinées au logement d'une SRE totale > 3'000 m^2 et aux autres affectations d'une SRE totale > 2'000 m^2. Le concept énergétique n'est pas exigé pour les extensions représentant moins de 15% de la SRE du bâtiment sans dépasser 1'000 m^2 et les rénovations concernant moins de 500 m^2.
- le projet prévoit-il la mise en place, la modification ou le remplacement d'installations techniques soumises à autorisation énergétique : climatisation de confort, production d'électricité ou de chaleur alimentées en combustible, chauffage électrique fixe, chauffage d'endroit ouvert (p.ex. chauffage de piscine extérieure) ? ; ☒Non ☐Oui

Cette procédure simplifiée inclut la remise des pièces énergétiques suivantes, au plus tard, 30 jours avant l'ouverture du chantier.

Objet / Projet **N° EGID du bâtiment:** -

Description et étendue des travaux	Nouveau bâtiment		
Adresse	Chemin des Manons Grand-Saconnex Villa A	SRE neuf	291.6 m²
		SRE existante	- m² (si extension)
N°parcelle(s)	2165 et 2166	Cat. ouvrage(s)	habitat individuel

Pièces à remettre au ScanE par courrier avec référence au numéro d'autorisation de construire, au plus tard 30 jours avant le début des travaux

Stipuler si l'élément est concerné en cochant oui ou non pour tous les éléments

Standard de haute performance énergétique (HPE)	☐Non ☒Oui	Justificatif de conformité à un standard HPE
Couverture renouvelable ECS min. 30%	☐Non ☒Oui	Preuve calculée
Enveloppe thermique du bâtiment	☐Non ☒Oui	EN-2b (EN-2a autorisé selon directive)
Performance électrique	☐Non ☒Oui	Justificatif SIA 380/4 (sauf pour logements)
Calcul de l'indice de dépense de chaleur admissible	☐Non ☒Oui	Annexe selon directive
Locaux frigorifiques	☒Non ☐Oui	EN-6
Serres artisanales ou agricoles	☒Non ☐Oui	EN-7
Halles gonflables	☒Non ☐Oui	EN-8

Pour tout renseignement relatif aux pièces justificatives ci-dessus, se référer à la directive d'application relative aux projets de construction, de rénovation ou de transformations de bâtiment publiée par le ScanE. (www.ge.ch/scane)

Justificatif et annexe demandée à joindre si élément concerné 1

Formulary EN 2b - Cantonal Office of Geneva

EnFK Konferenz Kantonaler Energiefachstellen
Conférence des services cantonaux de l'énergie

EN-2b

Justificatif énergétique
Isolation
Performance globale

Commune: Grand-Saconnex N° cadastre: 2165&2166 N° bâtiment: -
Objet: Chemin des Manons - Grand-Saconnex Villa A

Performance globale (→ joindre le calcul)

Valeur limite respectée: ☒ Oui ☐ Non
Le calcul annexé est-il effectué à l'aide d'une programme certifié? ☒ Oui ☐ Non

Hygiène de l'air intérieur

Concept de ventilation:
- ☒ Système de ventilation avec air fourni et air repris
- ☐ Installation simple d'air repris avec entrées d'air neuf définies
- ☐ Aération par fenêtres avec commande automatique
- ☐ Aération par ouverture manuelle des fenêtres
- ☐ Autre:

Protection thermique en été

Valeur g
- ☒ Protection solaire extérieure
- ☐ Justificatif de la valeur g du vitrage et de la protection solaire selon SIA 382/1:2007 annexé
- ☐ Valeur g non respectée; motif:

Refroidissement
- ☒ Non, ni «nécessaire» ni «souhaitable» selon SIA 382/1:2007
- ☐ Oui ☐ Commande automatique des protections solaires
- ☐ Pas automatique; motif:

Explications (→ Informations au verso)

Annexes

- ☒ Calcul de la SRE, enveloppe thermique
- ☐ Plans (1:100) avec désignation des éléments
- ☒ Liste des éléments, calculs des valeurs U
- ☒ Check-list des ponts thermiques

Autre:

Signatures

	Justificatif établi par:	**Contrôle du justificatif/Contrôle privé:** Le justificatif est certifié complet et correct:
Nom et adresse, ou tampon de l'entreprise	Putallaz Ingénieurs-Conseils 9a rue de Vermont, 1202 Genève	
Responsable, tél.:		
Lieu, date, signature:		
		Contrôle d'exécution: ☐ même personne ou:

403-004–EN-2b–002–fre Page 1 de 2 Version janvier 2009
valable jusqu'au 31.12.2013

EnFK Konferenz Kantonaler Energiefachstellen / Conférence des services cantonaux de l'énergie	EN-2b	Justificatif énergétique **Isolation Performance globale**

Documentation (→ joindre les plans)

Les plans et coupes à échelle réduite (A4 ou A3) doivent montrer les étages chauffés, les surfaces de référence énergétique SRE et l'enveloppe thermique. En cas de transformation ou de changement d'affectation, ces renseignements ne sont à fournir que pour les zones concernées, mais la documentation remise doit permettre de déterminer ce qui est concerné et ce qui ne l'est pas.

Justificatif des valeurs U (→ joindre calculs et documentation)

Tous les calculs des valeurs U sont à annexer. A cet effet, les documents suivants peuvent être utilisés:

- Eléments d'un catalogue de construction ou de fournisseur, avec mention du coefficient de conductivité thermique de l'isolant et de son épaisseur
- Calcul de la valeur U de l'élément
- Fenêtre selon cahier technique

403-004–EN-2b–002–fre Page 2 de 2 Grand-Saconnex / 2165&2166 / - Version janvier 2009
valable jusqu'au 31.12.2013

Formulary Minergie - Summary page

Projet: MINERGIE, Version 2013, à utiliser jusqu'au 31. 12. 2013

Chemin des Manons - Grand Saconnex_Villa A
Grand-Saconnex, Parcelles 2165 et 2166

	Données bâtiment, aération et valeur limite:		1	2	3	4	Total/moy.
N1	Station climatique + catégorie	Genève	Hab. individue				
N2	Nouvelle construction/transformation		nouvelle const				
N3	SRE	m2	291,6				**291,6**
N4	Qh avec débit d'air neuf standard	kWh/m2	34,3				**34,3**
N5	Q_{ww} Besoins de chaleur eau chaude	kWh/m2	13,9				**13,9**
N6	Débit d'air neuf thermiquement actif	m3/m2h	0,33				**0,33**
N7	Qh avec débit d'air neuf therm. actif	kWh/m2	24,7				**24,7**
N8	Type d'installation d'aération		a.d. + RC				
N9	Mode de distribution de chaleur		par le sol				
N10	Besoins d'électricité pour l'aération	kWh/m2	2,82				**2,82**
N11	Electricité pour la climatisation	kWh/m2					
N12	Valeur limite sans supplément	kWh/m2	38,0				**38,0**
N13	Supplément climatique et/ou d'ombrage	kWh/m2					
N14	**Valeur limite déterminante**	**kWh/m2**	**38,0**				**38,0**

	Production de chaleur: (chauffage + eau chaude)	η ou COP	Pondé-ration	Taux de couverture Chauffage	Taux de couverture Eau chaude	Bes. d'énergie finale pondérés Electricité kWh/m2	Bes. d'énergie finale pondérés autre kWh/m²	Chaleur prod. kWh/m²
N15	PAC sonde géotherm., chauff.	3,1	2	100,0%		15,9		24,7
N16	PAC sonde géotherm., eau chaude	2,7	2		39,3%	4,0		5,5
N17	Solaire therm., ECS				60,7%			8,4
N18								
N19								
N20	Besoins d'électricité pour l'aération		2			5,6		
N21	Electricité pour la climatisation							
N22	Total:			**100%**	**100%**	**25,6**		**38,6**

	Respect des exigences:	Exigence	Valeur calculée	Respectée?
N23	Exigence primaire posée à l'enveloppe du bâtiment	**39,4** kWh/m2	**34,3** kWh/m2	**oui**
N24	Valeur limite MINERGIE	**38,0** kWh/m2	**25,6** kWh/m2	**oui**
N25	Confort thermique en été			**oui**

N26

	Exigences supplémentaires remplies?	☑ Justificatif annexé (cocher ce qui correspond)
N27		☐
N28		☐
N29		☐
N30		☐
N31		☐
N32		☐
N33		☐
N34		☐

	Annexes (remettre toutes celles de la colonne de gauche)	☑ Cocher ce qui correspond
N35	☐ Performance globale selon SIA 380/1 avec débit d'air neuf standard	☐ Caractéristiques techn. appareil d'aération
N36	☐ Performance globale selon SIA 380/1 avec débit d'air neuf therm. actif	☐ Données techniques production chaleur
N37	☐ Liste des éléments de constr. et calcul des valeurs U, avec les fenêtres	☐ Calcul externe installation d'aération
N38	☐ Calcul de la SRE, volume et surface de l'enveloppe du bâtiment	☐ Calcul externe installation frigorifique
N39	☐ Plans 1:100 avec désignation des éléments, détails, plan de situation	☐ Feuille de calcul 'Electr. pour des auxiliaires'
N40	☐ Schéma du chauffage et eau chaude	☐
N41	☐ Schéma de l'aération	☐ confort thermique en été (SIA 382/1)

N42 Lieu, date — Signature du requérant :

N43 Lieu, date — Signature des planificateurs spécialisés 1 et 2:

NachweisVers2013-fr_villa_A / Justificatif / 30-08-2013, 07:48 — MINERGIE-Nachweis

Building type and the associated parameters

According to SIA norm 380/1 and the Minergie Association

Type of building	Calculation $Q_{h,li}$ [MJ/m² EBF]		Q_{ww} [MJ/m² EBF]	Minergie Value Limit For constructions after the year 2000 [kWh/m² EBF]
	$Q_{h,li0}$	$\Delta Q_{h,li}$		
Multi-family house	55	65	75	38
Single family house	65	65	50	38
Administration	65	85	25	40
School	70	70	25	40
Commerce	50	65	25	40
Restoration	95	75	200	45
Gathering place	95	75	50	40
Hospital	80	80	100	70
Industry	60	70	25	20
Deposit place	60	70	5	20
Sport centre	75	70	300	25
Covered swimming pool	70	90	300	There is no limit

Annexes-IV: Crèche Chapelle-les-Sciez

Result of the energy needs for heating calculations

AAA EDV pour la technique du bâtiment

SIA 384.201:2003
Puissance thermique à installer dans un local

Page 89

Crèche Chapelle-les-Sciers

Bàtiment Crèche

~~A du bâtiment 2418.35 m² SRE(380/1) 1575.12 m² Surface des fen./portes 331.80 m²~~

Sous-sol

Locale	Désignation	ti [°C]	ta [°C]	Surface [m²]	Volume [m³]	V' [m³/h]	V'th [m³/h]	Φ_T [W]	Φ_V [W]	Φ_{HL} [W]
-01/001/0	WC H	22	-5	3.90	9.87	30.0	2.2	101	19	121
-01/002/0	Vestiaire H	22	-5	15.40	38.96	120.	8.9	571	78	649
-01/003/0	WC F	22	-5	3.90	9.87	30.0	2.2	104	19	124
-01/004/0	Vestiaire F	22	-5	22.60	57.18	160.	11.9	361	103	465
-01/005/0	Buanderie	20	-5	19.90	50.35	85.0	11.4	680	92	772
				65.70	166.22	425.	36.6	1818	312	2130

Rez

Locale	Désignation	ti [°C]	ta [°C]	Surface [m²]	Volume [m³]	V' [m³/h]	V'th [m³/h]	Φ_T [W]	Φ_V [W]	Φ_{HL} [W]
00/006/0	g.4m-1an_salle de sieste 1	20	-5	20.00	56.20	85.6	21.6	229	175	403
00/007/0	g.4m-1an_salle de sieste 2	20	-5	12.60	35.41	83.5	19.5	104	158	261
00/008/0	g.4m-1an_salle de sieste 3	20	-5	13.50	37.94	83.8	19.8	105	160	265
00/009/0	g.4m-1an_vestiaires	20	-5	46.50	130.66	39.2	39.2	292	317	609
00/010/0	g.4m-1an_biberonnerie	20	-5	7.60	21.36	140.	11.2	20	90	111
00/011/0	g.4m-1an_salle de change 1	22	-5	10.00	28.10	152.	13.9	114	121	236
00/012/0	g.4m-1an_salle de change 2	22	-5	10.00	28.10	152.	13.9	114	121	236
00/013/0	g.4m-1an_salle de vie 1	20	-5	40.50	113.81	111.	31.4	793	254	1046
00/014/0	g.4m-1an_salle de vie 2	20	-5	40.50	113.81	111.	31.4	793	254	1046
00/015/0	g.1-2ans_salle de sieste 1	20	-5	19.60	55.08	85.5	21.5	196	174	370
00/016/0	g.1-2ans_salle de sieste 2	20	-5	28.01	78.71	107.	27.9	136	225	361
00/017/0	Grand Hall	20	-5	200.00	562.00	256.	96.2	2198	777	2975
00/018/0	g.1-2ans_vestiaires	20	-5	46.50	130.66	39.2	39.2	270	317	586
00/019/0	g.1-2ans_biberonnerie	20	-5	7.60	21.36	120.	9.6	19	78	96
00/020/0	g.1-2ans_salle de change 1	22	-5	10.00	28.10	152.	13.9	114	121	236
00/021/0	g.1-2ans_salle de change 2	22	-5	10.00	28.10	152.	13.9	114	121	236
00/022/0	g.1-2ans_salle de vie 1	20	-5	40.50	113.81	111.	31.4	793	254	1046
00/023/0	g.1-2ans_salle de vie 2	20	-5	40.50	113.81	111.	31.4	793	254	1046
00/024/0	S.Renc	20	-5	14.50	40.74	54.1	14.1	257	114	371
00/025/0	Economat	20	-5	16.70	46.93	20.0	1.6	142	13	155
00/026/0	petite hall	18	-5	4.70	13.21	21.3	5.7	182	42	224
00/027/0	WC H	22	-5	4.60	12.93	40.0	3.0	14	26	39
00/028/0	WC	22	-5	6.30	17.70	100.	7.4	62	65	126
00/029/0	Bureau Psy.	20	-5	14.60	41.03	54.1	14.1	118	114	232
00/030/0	Direction	20	-5	18.70	52.55	55.3	15.3	158	123	281
00/031/0	Secretariat	20	-5	13.30	37.37	53.7	13.7	103	111	214
00/032/0	Local Poussettes	20	-5	29.20	82.05	38.2	10.6	448	86	534
00/033/0	g.4m-1an_WC	22	-5	2.90	8.15	30.0	2.2	12	19	31
00/034/0	g.1-2ans_WC	22	-5	3.01	8.46	30.0	2.2	8	19	27
				732.42	2058.10	2594	576.	8700	4702	13402

AAA EDV pour la technique du bâtiment

SIA 384.201:2003
Puissance thermique à installer dans un local

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Etage

Locale	Désignation	ti [°C]	ta [°C]	Surface [m²]	Volume [m³]	V' [m³/h	V'th [m³/h	Φ_T [W]	Φ_V [W]	Φ_{HL} [W]
01/035/0	g.2-3ans_salle du personnel	20	-5	13.30	41.63	54.2	14.2	228	114	343
01/036/0	g.2-3ans_salle du personnel	20	-5	23.00	71.99	107.	27.2	495	220	714
01/037/0	g.2-3ans_salle de sieste 1	20	-5	25.50	79.82	128.	32.0	235	258	493
01/038/0	g.2-3ans_salle de sieste 2	20	-5	24.30	68.28	126.	30.8	184	249	433
01/039/0	g.2-3ans_vestiaires	20	-5	77.30	217.21	65.2	65.2	537	526	1063
01/040/0	g.2-3ans_biberonnerie	20	-5	7.70	21.64	180.	14.4	23	116	139
01/041/0	g.2-3ans_WC 1	22	-5	8.60	24.17	142.	12.8	120	112	232
01/042/0	g.2-3ans_WC 2	22	-5	8.60	24.17	142.	12.8	120	112	232
01/043/0	g.2-3ans_WC 3	22	-5	3.00	8.43	30.0	2.2	10	19	29
01/044/0	g.2-3ans_salle de vie 1	20	-5	57.50	161.57	156.	44.2	922	357	1278
01/045/0	g.2-3ans_salle de vie 2	20	-5	57.50	161.57	156.	44.2	760	357	1117
01/046/0	g.3-4ans_salle du personnel	20	-5	9.10	28.48	52.8	12.8	211	104	314
01/047/0	g.3-4ans_salle de sieste 1	20	-5	35.20	110.18	131.	35.0	438	283	721
01/048/0	g.3-4ans_salle de sieste 2	20	-5	23.50	66.04	126.	30.6	261	247	508
01/049/0	g.3-4ans_vestiaires	20	-5	70.90	199.23	59.8	59.8	512	483	994
01/050/0	g.3-4ans_biberonnerie	20	-5	7.80	21.92	140.	11.2	23	90	114
01/051/0	g.3-4ans_WC 1	22	-5	8.60	24.17	122.	11.3	120	99	219
01/052/0	g.3-4ans_WC 2	22	-5	8.60	24.17	122.	11.3	120	99	219
01/053/0	g.3-4ans_WC 3	22	-5	3.00	8.43	30.0	2.2	10	19	29
01/054/0	g.3-4ans_salle de vie 1	20	-5	57.50	161.57	156.	44.2	762	357	1119
01/055/0	g.3-4ans_salle de vie 2	20	-5	57.50	161.57	156.	44.2	922	357	1278
01/056/0	Salle Movement	20	-5	118.20	332.14	273.	81.2	1141	656	1797
01/057/0	Grand Hall	20	-5	70.80	198.95	59.7	59.7	975	482	1458
				777.00	2217.32	2718	703.	9129	5716	14845
Total				1575.12	4441.64	5738	1316	19648	10729	30377
Total bâtiment				1575.12	4441.64	5738	1316	19648	10729	30377

Swiss standard diameter of pipes

Based on flow rate, temperature and linear pressure drop

According to the swiss association of heating and ventilation enterprises

Swiss standard diameters of pipes

12 **40 °C**

Spezifische Druckverlust-Werte in Stahlrohren für Wasser
Perte de charge spécifique dans des tubes en acier pour eau

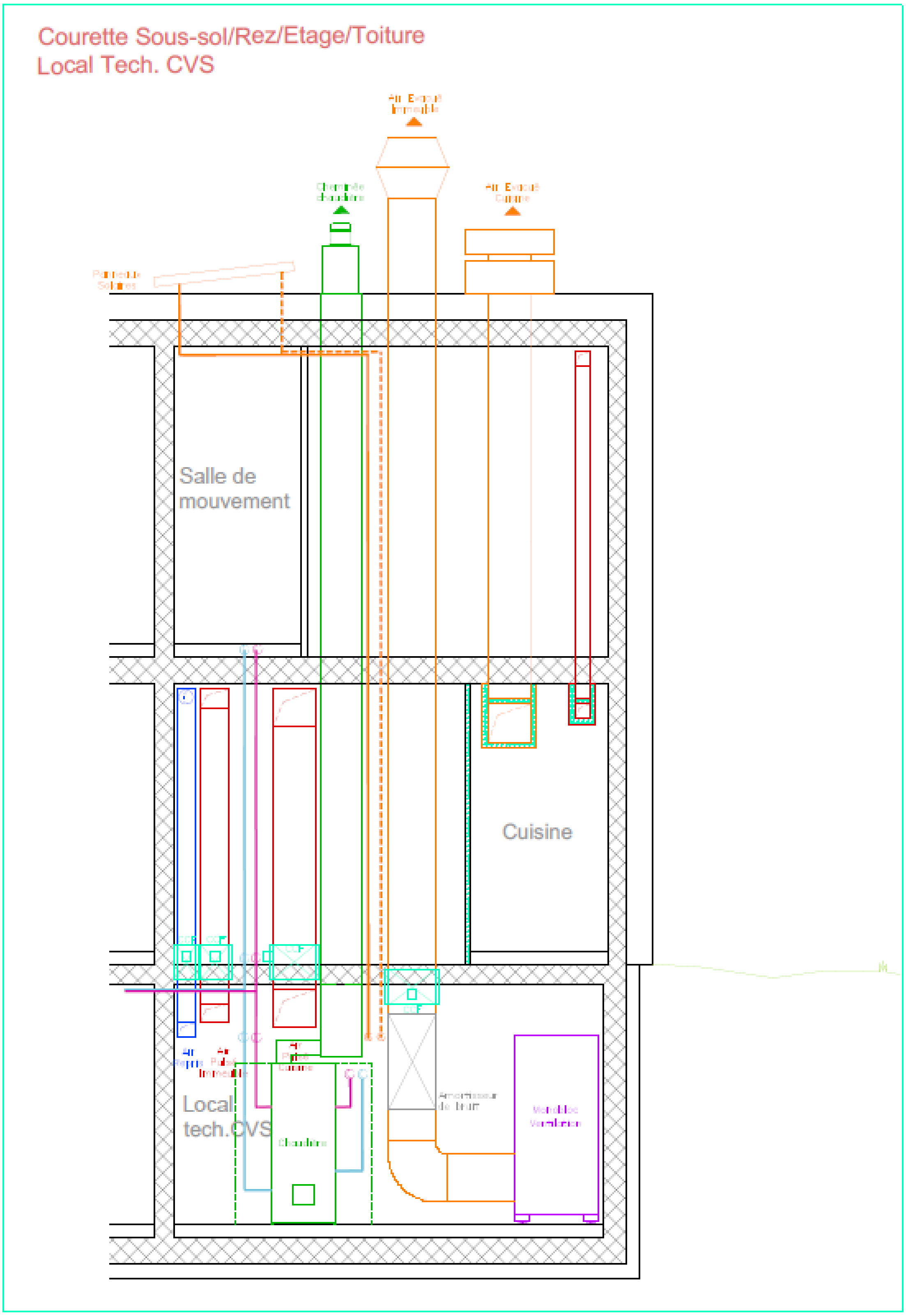
AUSSENDURCHMESSER/WANDDICKE DIAMETRE EXTERIEUR/EPAISSEUR DES PAROIS [MM]/[MM]
NENNWEITE [ZOLL ODER MM] DIAMETRE NOMINAL [POUCES OU MM]

R [PA/M]	17.2 2.35 3/8	21.3 2.65 1/2	26.9 2.65 3/4	33.7 3.25 1	42.4 3.25 5/4	48.3 3.25 6/4	38.0 2.3 32	42.4 2.3	44.5 2.3	48.3 2.3 40.	57.0 2.3 50
25.	48.5 .11 6.	96.1 .13 9.	219. .17 14.	412. .20 20.	876. .24 29.	1322. .27 36.	720. .23 26.	1007. .25 31.	1166. .26 34.	1491. .28 38.	2433. .32 49.
30.	53.9 .12 8.	106.8 .15 11.	243. .19 17.	456. .22 24.	970. .27 36.	1463. .30 44.	797. .25 32.	1115. .28 38.	1290. .29 41.	1649. .31 47.	2690. .35 60.
35.	59.0 .13 9.	116.6 .16 13.	266. .20 20.	498. .24 29.	1056. .29 42.	1593. .32 52.	869. .28 38.	1214. .30 46.	1405. .31 49.	1796. .34 56.	2927. .38 72.
40.	63.7 .15 10.	125.9 .18 15.	286. .22 24.	536. .26 33.	1137. .31 49.	1715. .35 61.	936. .30 44.	1307. .33 53.	1513. .34 57.	1933. .36 65.	3149. .41 83.
45.	68.2 .16 12.	134.6 .19 17.	306. .23 27.	573. .28 38.	1214. .34 56.	1829. .37 69.	999. .32 51.	1395. .35 60.	1614. .36 65.	2062. .38 73.	3358. .44 94.
50.	72.5 .17 14.	142.9 .20 20.	325. .25 31.	607. .29 42.	1286. .36 63.	1938. .40 78.	1059. .34 57.	1478. .37 67.	1710. .38 73.	2185. .41 82.	3557. .46 106.

Pressure drop in units of Pa/m

Flow rate in the pipes in units of l/h for a pressure drop of 50Pa/m

Cross-sectional view and



Plant of ground floor

PUTALLAZ
Ingénieurs-conseils Sàrl
9A,rue de Vermont
1202 Genève
CHAUFFAGE
VENTILATION
CLIMATISATION
TEL. 734 34 44
FAX. 734 34 54
E-MAIL: info@putallaz-ing.ch

DATE	26.08.2013
DESS.	CA
ECH.	1/50
MOD :	-
N°	32211

Crèche Chapelle-les-Sciers
Rez-de-Chaussée

Soumission

SYSTEME UNIFIE POUR LA COTATION

VENTILATION — CHAUFFAGE

VUE EN COUPE — VUE EN PLAN

Cotations en plan des gaines de ventilation
2500 ø40 -3 = [m3/h] [cm] [niveau sous dalle en cm]
4000 60/40 -3 = [m3/h] [cm/cm] [niveau sous dalle en cm]
Les coudes quadrangulaires ont par défaut un angle intérieur de 15

Cotations en plan des tuyauteries
DN50 (180) X-25 = [ø du tube] [ø ext. de l'isolation en mm] [Niveau de l'axe en cm]
X-15 = Niveau -15 sous dalle de l'axe de la tuyauterie en cm (X+15 = idem sur sol)

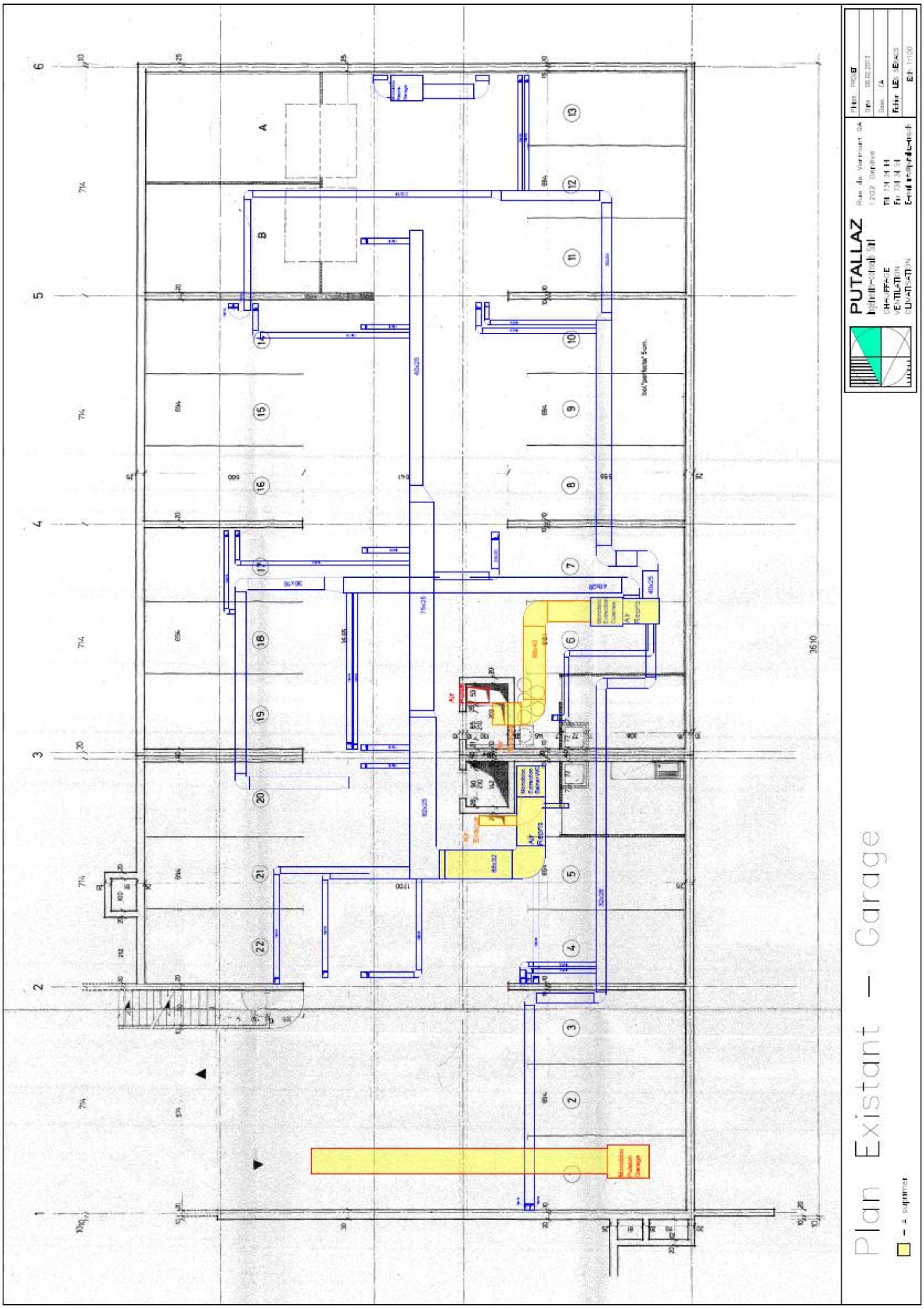
Remarques:
Les cotes sont par défaut en cm sauf les ø de l'hydraulique (ex. DN125, ø76 ou 11/4")
Sans indication de niveau, la ventilation est à -3 sous plafond

VENTILATION
- Air Neuf (AN) (de l'extérieur au traitement)
- Air Pulsé (AP) (du traitement au local)
- Air Repris (AR) (du local au traitement)
- Air Evacué (AE) (du traitement à l'extérieur)
- CCF Clapet Coupe-Feu
- Isolation Coupe-Feu (6 cm tout autour)

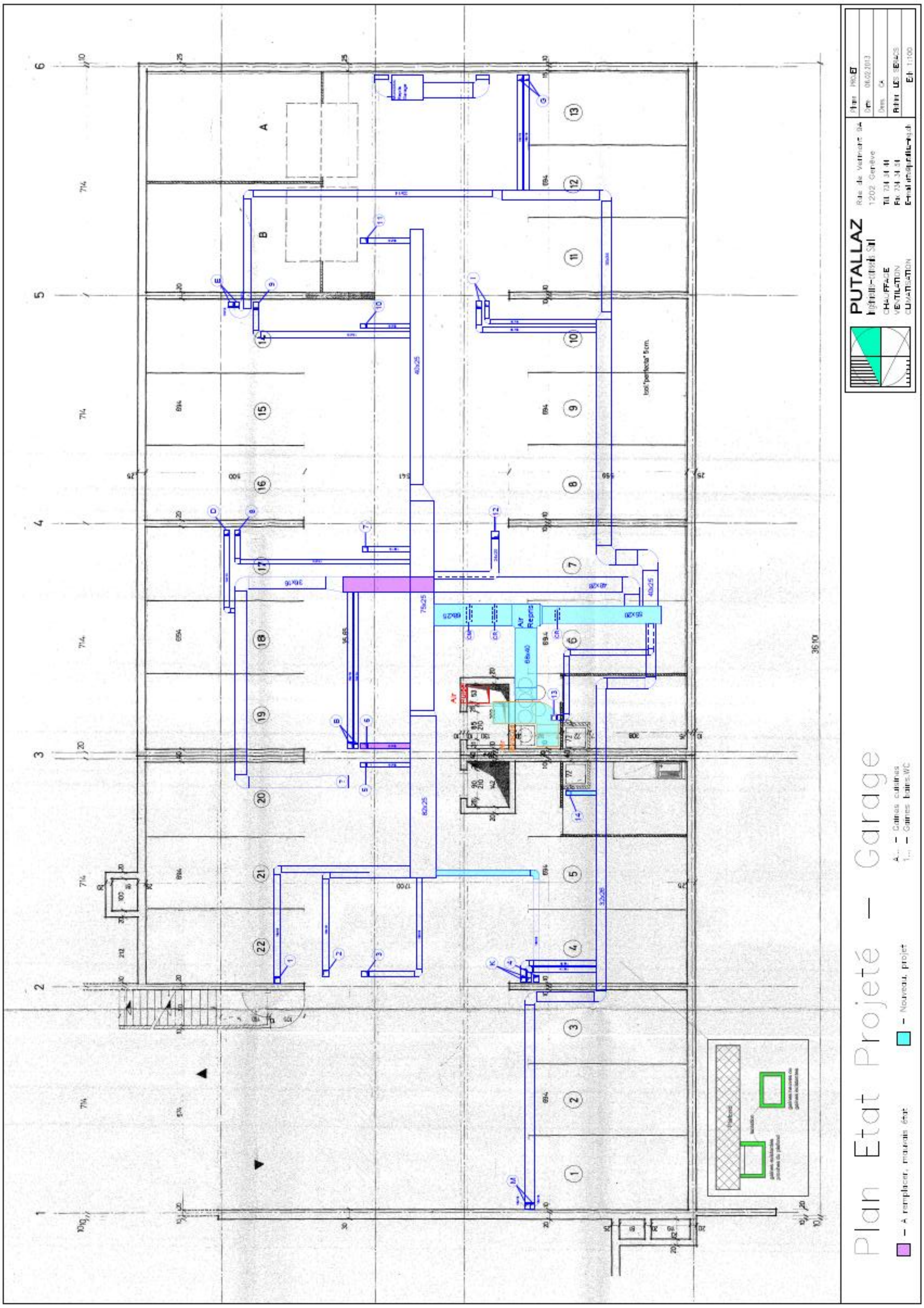
CHAUFFAGE
- Chauffage aller
- Chauffage retour
- Solaire

Annexes-V: Séracs

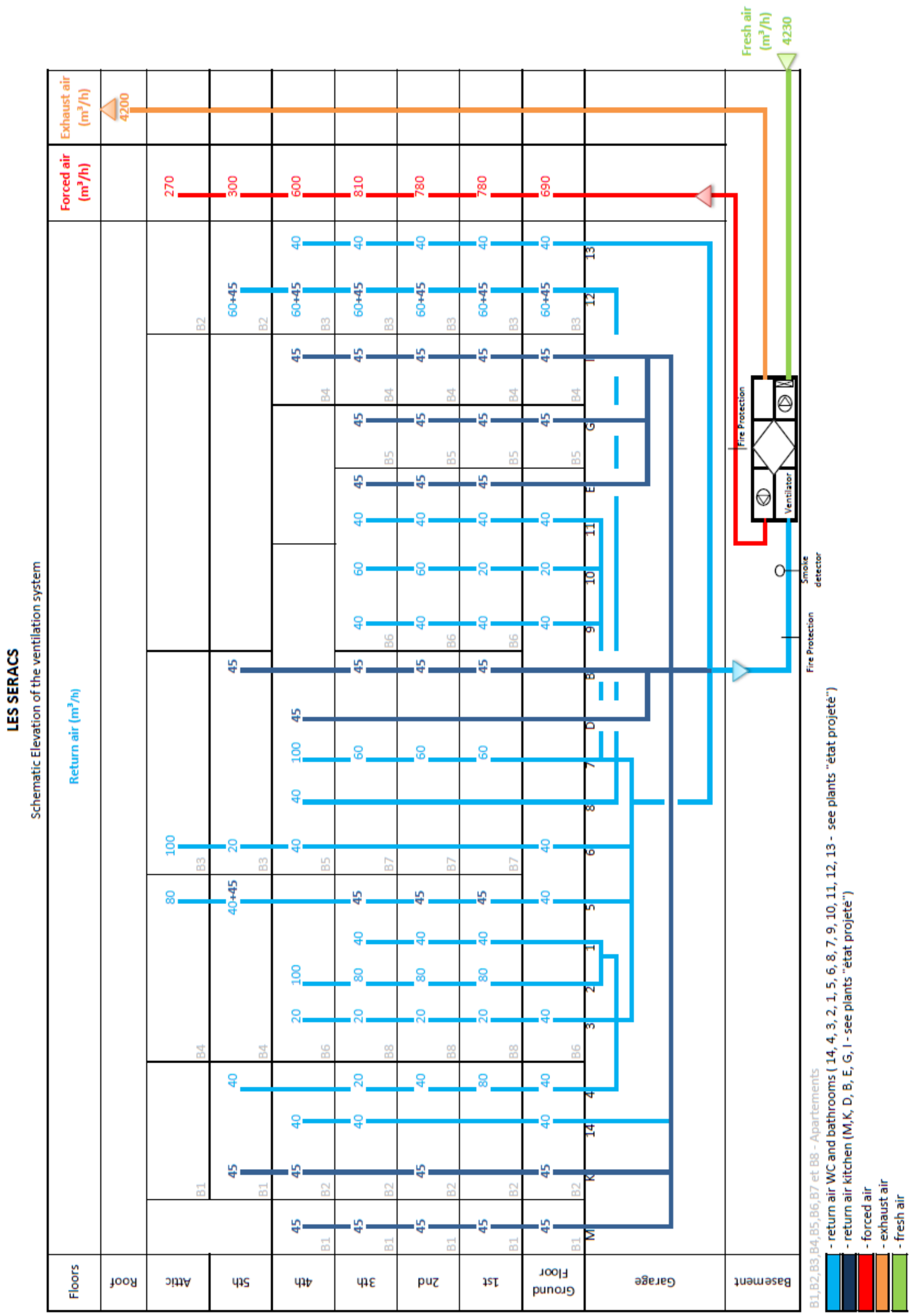
Garage plants - conduits to disassemble



Garage plants - conduits to assemble



Schematic Elevations – ventilation system



Annexes-VI: Connétable

Photo of the humidity problems in the analysed room