Characterization of post-world war residential buildings in Belgium

Shady Attia, Mathilde Cuchet, Ahmed Mustafa, Nicolas Giry, Mathieu Popineau, Numan Gulirmak, Théophile Canonge, Myriam Baskar

Publication: March 2021

Sustainable Building Design Lab, Technical Report, Liege, Belgium,

DOI: 10.13140/RG.2.2.18798.33601 - ISBN 978-2-930909-19-6

Characterization of post-world war residential buildings in Belgium

Shady Attia[1]*, Ahmed Mustafa[2], Nicolas Giry[1,3], Mathieu Popineau[1,4] Mathilde Cuchet[1,3], Numan Gulirmak[1], Théophile Canonge[3], Myriam Baskar[3]

[1] Sustainable Building Design Lab, Dept. UEE, Faculty of Applied Science, Université de Liège, Belgium
[2] Urban Systems Lab, The New School University, USA
[3] EPF Graduate School of Engineering, Montpellier, France
[4] ENSE3 Graduate School of Engineering, Grenoble, France
***** Correspondence: shady.attia@uliege.be

Abstract: In the context of the European carbon neutrality targets, building benchmarks are a key issue for the renovation of existing buildings. Although there are various benchmark methods for energy efficiency characterization, their application to the residential sector is still limited. This paper developed two building simulation models for post-world war II houses in Belgium based on data from post-occupancy measurements and field survey campaigns. The study reports the energy characteristics and occupancy profiled of detached single-family houses. An analysis of energy consumption (electricity and natural gas) and a walkthrough survey were conducted between 2016 and 2019. The benchmark model's validity has been further checked against public statistics and verified through model calibration and monthly energy bill comparison. Two reference models representing 633.702 post-WWII single-family houses in Belgium were created and validated. The first archetype has an average energy use intensity of 166 kWh/m^2/year and represents detached single-family houses built between 1945 and 1969. The second archetype has an average energy use intensity of 155 kWh/m^2/year and represents detached single-family houses built between 1970 and 1990. The paper provides a timely opportunity to evaluate the real performance of post-world war II most common archetypes concerning design assumptions and how building professionals can turn the energy performance gap challenge to their advantage. The findings on energy needs and intensity are useful for creating future renovation scenarios for similar archetypes in Western European countries.

Keywords: reference building, single-family detached home, energy audit, energy efficiency, energy use intensity, temperate climate

Highlights:

- Development of two benchmark models for post-world war II residential buildings
- Average energy use intensity per household (archetypes A and B) were 166 and 155 kWh/m^2/year.
- Models validated with four-year monitoring data on energy consumption.
- Senior adults dominate households, and their occupancy profiles are presented.
- Findings on energy needs and use intensity are useful in temperate and continental climates

Abbreviations:

ANN, Artificial Neural Networks; BPIE, Building Performance Institute Europe; BMS, Building Management System; CAV, Constant Air Volume; CDD, Cooling Degree Days; CBECS, Commercial Buildings Energy Consumption Survey; CIBSE, Chartered Institution of Building Services Engineers; CO2, Carbon Dioxide; COP, Coefficient of performance; CV(RMSE), Coefficient of Variation of the Root Mean Square Error; DHW, Domestic Hot Water; EPBD, European Energy Performance of Buildings Directive; EU, European Union; EUI, Energy Use Intensity; GDPR, General Data Protection Regulation; HDD, Heating Degree Days; HVAC, Heating, Ventilation and Air Conditioning; IAQ, Indoor Air Quality; IEQ, Indoor Environmental Quality; MBE, Mean Bias Error; MVHR, Mechanical ventilation with heat recovery; nZEB, nearly Zero Energy Building; nZES, nearly Zero

Energy Schools; OCCuPANt, On the Impacts Of Climate Change on the indoor environmental and energy PerformAnce of buildiNgs in Belgium during summer; PC, Personal Computer; PHS, Passive House Standard; PHPP, Passive House Planning Package; PMP, Platform Masion Passive (Belgium); Pixii, Onafhankelijk Kennisplatform Energieneutraal Bouwen (Belgium); QZEN, Quasi Zero Energie; SHGC, Solar Heat Gain Coefficient; TABULA, Building Database Typology in the European Union; TMY, Typical Meteorological Year; UK, United Kingdom; USA, United States of America; VAF, Variable Air Flow; WWR, Window to Wall Ratio; ZEBRA 2020, nearly Zero-Energy Building Strategy 2020

1. Introduction

Energy use in the residential sector accounts for 20% of the total energy use at the European level [1]. The European Union (EU) states will cut carbon emissions to 55% of 1990 levels by 2030 [2]. To achieve the new carbon reduction targets, member states must increase their renovation rate from 2% a year to 3% annually before 2023 before stabilizing at least 2% in 2030 [3]. Conversely, existing households exceed the number of newly built households in Europe [4]. The existing building stock will continue to dominate for the next 30 years. In Belgium, the annual renovation rate of the existing building stock is less than 1% [5]. As shown in Fig. 1, dwellings are responsible for 14% of Belgium's greenhouse gas emissions. Awareness about the carbon emissions reduction potential of existing residential buildings is widespread among European governments, builders, housing associations, and building owners [6].

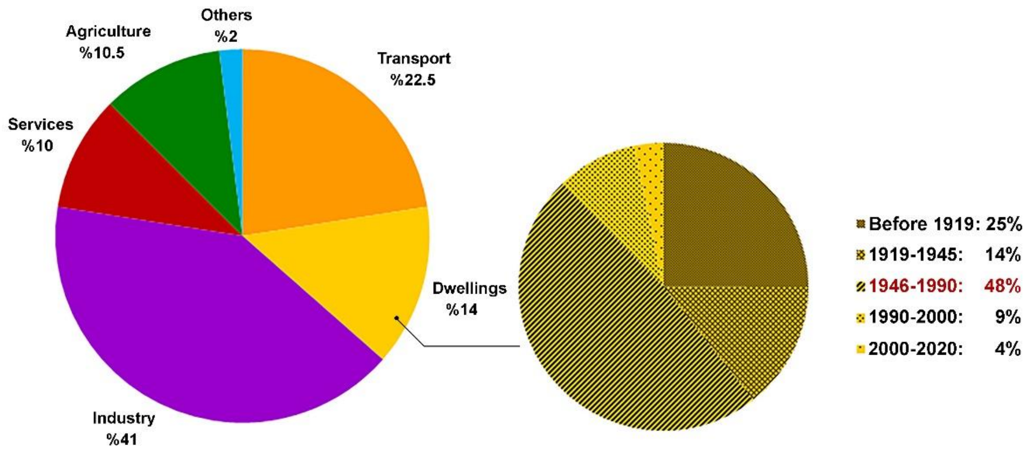


Fig. 1. Greenhouse gas emissions of Belgium in 2018 (%) and the Distribution of Belgian dwellings by the period of construction [7], [8]

While in North America and particularly the United States of America (USA), the benchmarking of existing buildings has acquired a consistent tradition [9], [10], [11], [12], [13], [14], in Europe this research is gaining more and more importance [15]. The TABULA [16] building typology project and the EPISCOPE [17] building monitoring projects are the most structured and central depository of building stock models. Since the Energy performance of buildings directive EPBD [18] came into force in 2003 and was implemented after 2008, member states across Europe had to develop 'reference building' representing their building stock [19]. According to the EU Commission Guidelines accompanying the Commission Delegated Regulation No. 244 (2012) [20], it is recommended that reference buildings are established representing the most typical building in a specific category (e.g., type of use and reference occupancy pattern or floor area or building envelope construction, etc.). However, in Belgium, the creation of representative benchmark models based on field measurements is still in its infancy. The *OCCuPANt* project [21], which developed two post-world war II (WWII) single-family reference models, characterized the energy use intensity of 1328 households (n=1328). Among other results, more than 85% of occupants are older people, with an average age above 65 years old.

In this context, the selection of a building vintage and archetype are particularly crucial. In Belgium, Denmark, France, Germany, the Netherlands, Scandinavian countries, and the United Kingdom (UK), suburbanization after

WWII encouraged the dwellers to live in single-family detached houses [22]. As shown in Figure 2, post-WWII single-family households often have gabled roofs and spacy plans. This large part of the building stock built after WWII did not comply with any energy efficiency requirements and was constructed inefficiently, even after the 1970s energy crisis. Today, post-WWII, traditionalist and baby-boom generations occupying those buildings reached their retirement age. However, the energy efficiency status of those buildings and their future remains unknown [23]. In Belgium, post-WWII households represent 48% of the existing building stock with an ownership rate exceeding 78% (see Figure 1) [22]. Understanding the root causes of the performance gap across the post-WWII building stock improves the future renovation programs and increases their renovation potential.

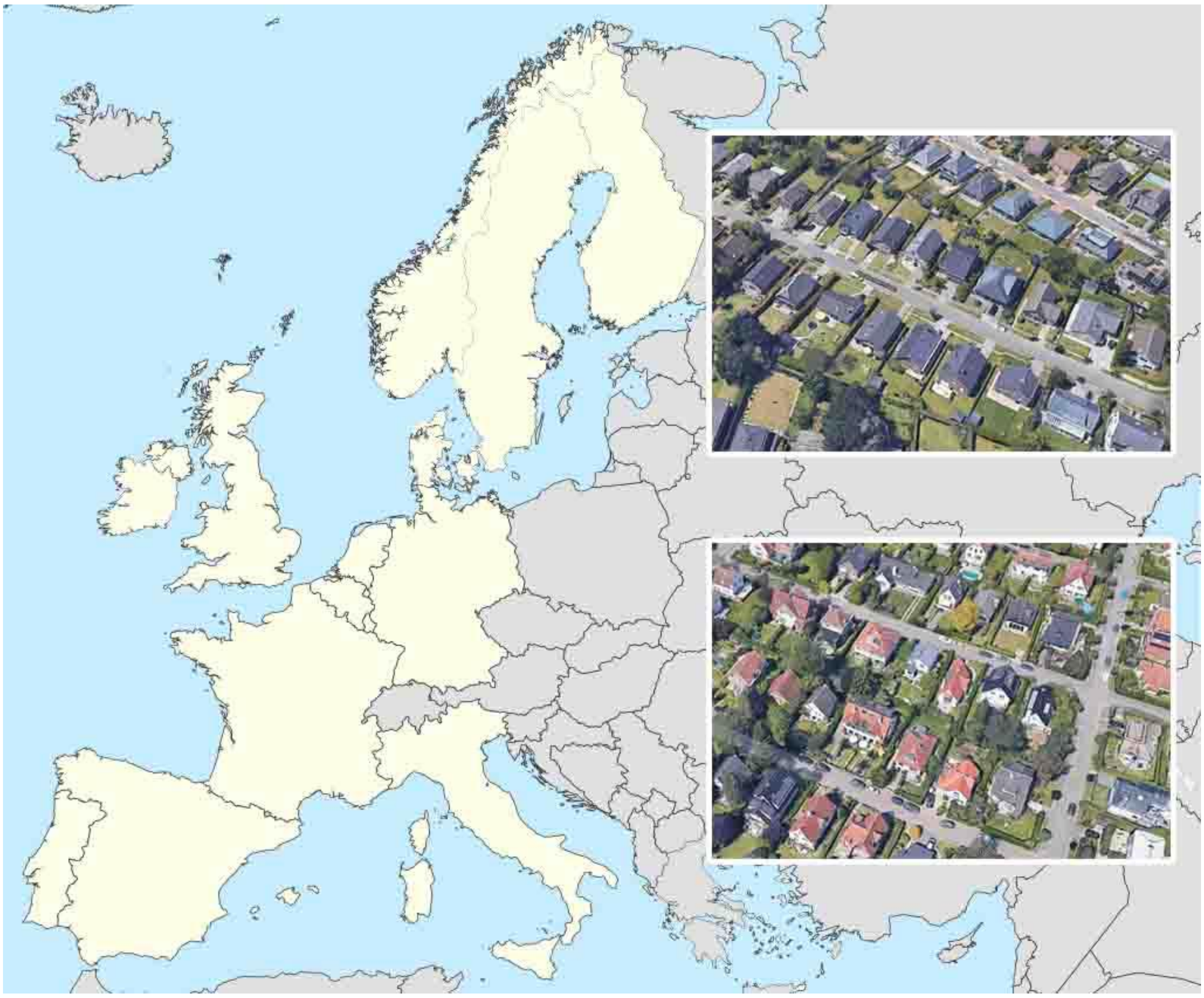


Fig. 2. Distribution of Belgian dwellings by period of construction

Therefore, this study aims to accelerate post-WWII single-family houses' renovation by creating two validated benchmark models representing those buildings. Describing 633.702 households and characterizing their energy efficiency and their occupant behavior offers a valuable foundation. The aging of the existing occupants provides an opportunity to renovate those buildings with the ownership transfer. However, without accurate and granular data collected about single-family post WWII houses, renovation policies and strategies won't be effective [24]. The current study follows a cross-sectional study design where field surveys and auditing for more than 1320 households. The research directly engaged occupants who completed self-reported surveys and shared their energy bills compiled in a dataset about their buildings. The research methodology combines mixed research methods involving qualitative (e.g., literature review) and quantitative empirical and modeling (e.g., walkthrough audits, building performance simulation, calibration) research. Our study approach and methodology are similar to the work of Touchi et al. [25], Kragh and Wittchen, and Attia et al.[26], [27] aiming to develop two simulation reference models based on monitoring and analyzing 1320 households. The building performance simulation models are implemented in EnergyPlus energy simulation program. A systematic and replicable approach for measurement and verification based on ASHRAE Guideline 14 was used to calibrate the building performance simulation models [28].

The study provides robust evidence of the extent of energy intensity use and the influence of occupant behavior of post-WWII single-family housing in a temperate climate. The calibrated simulation models provide an operationally accurate virtual representation of buildings' energy performance. The calibrated models can develop retrofit scenarios, calculate the potential energy-saving, and transform post-WWII buildings into energy-neutral buildings [29]. At the same time, its methodology and findings can be useful across Western Europe. The relationship between occupancy profiles and energy use represents one of the most extensive national studies that characterize a remarkable residential building stock sector. The building energy models were created using a multizonal modeling approach distinguishing living areas, sleeping areas, and short presence spaces. On these bases, the paper presents a fundamental construct of two building energy models and their occupancy profiles that represent residential buildings to predict future renovation potential. Finally, the recommendations of future work renovation roadmap milestones that lead to an accelerated renovation rate are discussed.

2. Methodology

The research methodology is based on creating representative reference models for post-WWII detached single-family housing in Belgium. As shown in Figure 3, the methodology implemented in this paper followed a hybrid approach involving empirical monitoring and modeling techniques. The literature review and field visits of more than a thousand dwellings allowed creating a WWII detached single-family housing database. The analyses allowed selecting two representative reference houses, determining their energy consumption, and characterizing their building performance systems and occupant's behavior. A complete energy audit and four years of energy monitoring allowed generating high-quality data. This data was then analyzed and used to create two building performance models. The model was calibrated and validated based on the monitored data. The methodology followed in this research is similar to other recent international energy modeling and benchmarking studies [26]. The methodology is similar to the approach of Tereci (2013) [30], who defined a reference building and calculated their energy use for different German archetypes; and Ghajarkhosravi (2020), who developed an energy benchmark models for multi-unit residential buildings (MURBs) in Toronto, Canada [31]. The following sections describe in detail the steps undertaken in this research.

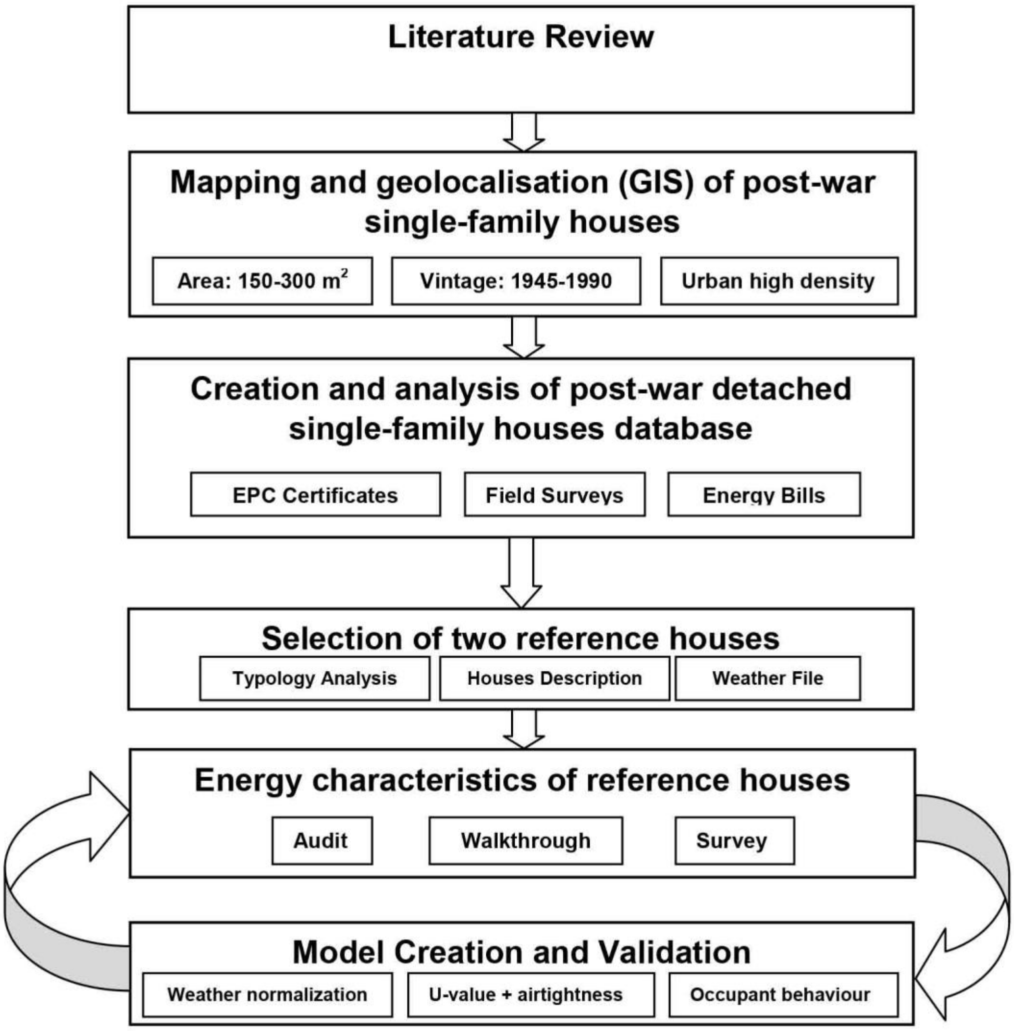


Figure 3, Study conceptual framework for the research methodology

2.1. Literature review

A literature review was conducted, including international publications that aimed to develop energy performance benchmarks for post-world war residential buildings. More than sixty publications were reviewed in the Belgian content concerning residential building benchmarking and energy efficiency characterization. The review included residential benchmarking reports that were developed as part of the EU cost-optimality approach for the three regions of Belgium; Brussels [32], Flanders [33], and Wallonia [34]. An exhaustive list of the reviewed studies and their content analysis can be found in this study's technical report [21]. Moreover, vital international studies on benchmarking were reviewed and summarized in the introduction. The review focused on state-of-the-art benchmark model creation approaches [19] and their calibration techniques for model validation [35]. The study also covered the most well-known building archetype databases, such as the US Department of Energy's archetypes database for residential buildings [13] and the European Projects TABULA EPISCOPE [17] that aim to provide reference buildings for the European building stock.

2.2. Selection, mapping, and geolocalisation of post-WWII single-family houses

A mapping study followed the literature review to select one of the most representative building archetypes in Belgium. The selection criteria of the archetype and construction vintage for benchmark model creation involved four main aspects. First, a high numerical representation of the selected archetypes for the existing building stock. Focusing on representative archetypes is a priority strategy for deep renovations [36] because it stimulates the standardization and cost reduction of renovation packages resulting in remarkable renovation increase [37]. Second, a low EPC rating of the chosen archetypes, based on elements including the building materials, its airtightness, and the building services installed. A poor EPC rating suggests low energy efficiency, which makes the renovation potential high [38]. Thirdly, an archetype with geometry can allow for an external renovation without restrictions on appearance changes or being listed as monuments [39]. Fourth, owner-occupied single-family detached houses. Mixed ownership complicated the renovation decision, and private ownership allows easier access to renovation subsidies [40]. Thus, owner-occupied housing remains to have a high potential for energy savings [41], and ownership has a positive influence on the renovation decision [42].

As a consequence, post-WWII single-family detached houses were selected. Post-WWII single-family detached houses are generally speaking less homogenous than pre-war buildings [4]. In Belgium, most of those archetypes fall under the EPC label F or G. They are fastly built using low-quality materials. They are poorly insulated at the time of construction. Therefore, they show a relatively high need for renovation.

Next, all existing detached residential buildings were mapped on the Belgian Cadastral Parcel Data (BCPD). The BCPD is a vectorial polygon map representing the cadastral parcels of the entire Belgian territory made available by the Land Registry Administration of Belgium [43]. The Geographical Information Systems (GIS) cadaster maps provide information about each building in Belgium, such as construction data, building use, number of floors, etc. [44]. Using construction date and building use, we extracted all residential buildings built before 1991 and after 1945 with an area ≥ of 55m² and ≤ 350m². We limited our mapping to detached single-family houses built before 1990 because energy efficiency regulations became only effective in Belgium in 1991. In terms of regulations, thermal insulation for new buildings was introduced in 1984 in the Walloon Region [45] and in 1992 in the Flemish Region [46]. The regulatory energy efficiency requirements applicable to new housing were only strengthened after the 1990s in the three regions (Flanders, Wallonia, and Brussels).

Table 1 list the portion of extracted buildings before 1945 and between 1945 and 1990. Table 1 demonstrates that most of the extracted buildings have been built between 1945 and 1990 (more than 70%). Consequently, this study focuses on all residential-detached buildings in Belgium constructed between 1945 and 1990.

Table 1 Distribution of single-family detached houses in Belgium

	Num of buildings	Percentage
Before 1945	245.070	27.89
1945-1969	**275.915**	**31.40**
1970-1990	**357.787**	**40.71**
Total (before 1990)	878.772	100

Entire Belgium was divided into grids to conduct our field audits and surveys; each represents one ha (100mx100m). Each grid has been assigned a density index, which represents the number of buildings within the grid. Eighty-two grids distributed over Belgium were selected. They contain about 1500 buildings. Data were geo-processed with the help of a selection algorithm to rasterize and aggregate the vector data. The chosen sample represents 72% (633.702 households) of single-family detached houses built before 1991 in Belgium. According to [47], a sample size of 1000 can be considered an excellent representation of the study's phenomena. The developed mapping approach allowed identifying single-family detached houses grouped by hectare. The aim of identifying the detached houses by hectare is to reduce the number of field visits and facilities the audits. Each selected hectare represents about fifteen houses, as shown in the results Section 3.1.

2.3. Creation and analysis of post-WWII single-family houses database

An initial database of 1500 households was created and updated based on the input from different regional databases (Brussels, Flanders, and Wallonia), field audits, and self-reported occupants' surveys. It included several details on each building such as the location, construction age, area, information on the architecture, type of materials, airtightness, heating system, ventilation system, renovation, occupancy, electrical appliances used, comfort in the home, etc. The EPC databases in the three regions were consulted. Fortunately, the EPC details of all houses located in the Brussels Region were identified from the open-access Brussels Environment Database [48]. With the help of real estate websites, the EPC labels and EPB audits were retrieved for hundreds of houses. In this initial stage, this initial stage allowed us to compile the database and prepare for the following stage of field visits and audits.

Field visits were organized to visit the 82 hectares representing the 1500 households between 2017 and 2021. All houses were visually inspected to assess the building envelope characteristics. The field surveys also enabled identifying and characterizing the energy systems (air and water heating systems, ventilation, lighting, smart meter, etc.) of individuals who could submit the survey by mail or online. Households' occupants were invited to sign a consent form to share their electricity and fuel bills (gas or fuel oil) via their energy providers. Once signed, it was possible to access their bills via the energy suppliers. Also, occupants were invited to fill in an online or paper survey that characterizes their building's energy efficiency. The consent form and survey content covered the building characteristics, domestic hot water, energy systems, and occupant behavior. Logbooks were also distributed to owners so that they could indicate their monthly consumption. In some dwellings, data loggers were installed to record consumption. Access to the forms and surveys can be found in the project report [21]. Finally, neighborhood organizations could also be contacted directly as it was often easier to convince people to communicate their bills through the local community.

Moreover, walkthrough audits were organized in more than 160 households voluntarily. Detailed energy audits involving blower door tests, u-value monitoring, energy system inspection, and occupancy behavior characterization were performed. Finally, the database was compiled, and missing information was completed to include 1050 households. The data collection process, analysis, and storage were done in line with the European Union General Data Protection Regulation, which was applied retrospectively [49].

2.4. Selection of two representative reference houses

A typology analysis took place for the 1328 houses to select two representative building configurations. The architectural and energy characteristics of the buildings have been analyzed concerning the building vintage. The analysis indicated a strong divide between the two vintages of post-WWII households.

First, (archetype A) detached houses built the late 1940s throughout the 1969s had similar geometry, surface area, building materials, and occupant density. After WWII, it was necessary to house the population and rebuild the country. Under the federal law proposed by minister De Taeye, a new law allowed for the construction of 100,000 detached houses from its entry into force in 1954 [50] and reached 285,166 detached houses by 1969. Taeye's law resulted from a compromise between two great movements: the socialist and catholic movements [51]. Taeye's law was the fruit of a campaign by Christian Democrats wishing to promote low-cost construction [52] of private dwellings outside the cities [53]. At that epoch, the Law of 1939 started to get implemented and made it mandatory to submit building permit applications accompanied by plans drawn up by an architect [54]. Consequently, many house owners resisted hiring an architect and opted to select identical house designs found in catalogs offered by architects for reduced fees. We interviewed several house owners from this epoch who confirmed this information. Contractors offered limited design alternatives of architectural designs against reduced costs for reproduction.

Typical De Taeye-archetype houses emerged with red bricks and ceramic roof tiles (see Result Section 3.2) [55]. Another point of similarity was construction materials. Single-family houses were constructed with inner walls of Ytong and were covered with external walls of traditional bricks [56]. Floors were built with lightweight concrete [57]. Other influential factors that lead to grouping single-family houses built between 1945 and 1969 under one archetype to represent a vintage were demographics and household surface area. Our field studies revealed that houses built before 1970 exceeded the 200m^2 area threshold and homeowners had an average of three to four children per household. Between 1945 and 1969, birth rates boomed in Belgium [58]. On the opposite, households built between 1970 to 1990 were less than 200m^2 and witnessed a decline in birth rate per household, reaching on average two children.

Second, (archetype B) detached houses built between the 1970s throughout 1990s had similar geometry, surface area, building materials, and occupant density. Despite this archetype's geometrical similarity, the facades and envelope cladding became more heterogeneous [59]. There has been an evolution in lightweight concrete for walls, from infills principally to loadbearing walls [56]. A proliferation of insulation materials and systems occurred. Norms and regulations evolved, and the BBRI published several technical reports on the insulation of flat roofs. The BBRI promoted construction standards and published the 'General specifications for the execution of private buildings,' co-edited with the Royal Federation of Architects' Associations in Belgium (FAB) and the National Confederation of the Building Industry (NCB) [56]. Despite the emergence of the oil crisis in the 1970s, there was no systematic improvement in building energy efficiency. However, the occupied areas were remarkably reduced. The single floor bungalow archetypes with I or L plans dominated the single-family households' construction scene.

Finally, the two representative buildings were also selected strategically. Plans and geometric forms of the two houses were described and analyzed. Based on the typology analysis and classification, two theoretical reference models were created. The energy performance data compiled in the database (Section 2.3) allowed us to select two typical archetypes to represent the 1945-1969 and 1970-1990 vintages.

2.5. Energy characteristics of reference houses

Two levels of energy characterization are carried out for the selected houses based on the recommendations of Krarti [60]. An analysis of energy use intensity (electricity and natural gas) and a walkthrough survey is conducted between 2016 and 2019 for 1500 households. Key informant interviews are conducted in Dutch and French one-to-one with main stakeholders living in the selected hectares with first-hand knowledge of the location. The key informal interviews assured introducing the project, building trust, and maintaining confidentiality. The walkthrough surveys allowed us to inspect the energy efficiency characteristics and energy use for 2016-2019 based on monthly bills. The walkthrough audits allowed us to understand the performance of the building and to identify the usage patterns. Monthly energy use was retrieved via private databases. Private companies such as Engie, Lampiris, and Luminus provided access to the consumption data based on the occupant's consent. The *Commission de Régulation de l'Electricité et du Gaz* (CREG) database was also used as part of the study. The CREG is the federal organism for the regulation of the electricity and natural gas markets in Belgium. This allows consumers to compare their current energy contract with the current market offer. It collects data on the production and consumption of electricity and gas in Belgium and reports on price trends. As a result of this step, 250 households were excluded from the 1500 households sample due to data discrepancies or none constituent consent. As a consequence, 1328 audits were conducted via field visits and self-administered online and paper-based surveys.

The second type of energy characterization was highly detailed and involved several techniques to reduce the uncertainty of energy efficiency characterization parameters and occupancy patterns. The smartphone-based survey was developed to identify the occupancy density and profiles in the different households' thermal zones on a daily, weekly, monthly and seasonal level. With some modifications made to meet the current occupancy profiling exercise's objectives, the survey was replicated at the building level for representative samples of archetypes A and B. The sampling design consisted of a random sample—a free, open-source application that allowed collecting the responses and compiling them on the server via the cloud. Once repetition of the answers patterns was found, the request of occupancy information input was stopped.

As a consequence, 160 household occupants participated in the occupancy surveys between 2016 and 2019. The collected data was compiled with the central project database and analyzed to describe the representative households' energy performance to serve later the building modeling stage. The occupancy surveys provided insights to justify the choice of the two representative archetypes.

The annual occupancy schedule has been set based on an average yearly schedule representing 2016-2019. The occupancy surveys and data loggers data were used to determine households' heated thermal zones, size, composition, age, and occupants' presence. The survey involved information about water consumption and Domestic Hot Water (DHW) use. The number of vacation days was determined per household. The daily occupancy schedule has been established in line with ISO 18523 recommendations [61]. A special section in the energy audit involved characterizing artificial lighting, HVAC systems, and energy sources. The audit questionnaire included questions describing the mechanical ventilation systems and components. Mobile heating units and heating were checked. Visual inspection for all chimneys took place to trace and understand the heating strategy and energy sources.

2.6. Development of the benchmark models

Two representative simulation models were made based on the previously described selection process and building characterization. The building energy models were created using EnergyPlus (Version 8.2.0) [62].). All simulations were performed for the location of Uccle, in the Brussels-capital region, in Belgium. The country falls almost entirely within the Köppen-Geiger classification of temperate oceanic climate (Cfb) with no dry season and warm summer [63]. Overall, Belgium's climate is mild-cold and humid, with significant rainfall during the year. Residential buildings are typically heating-dominated with an average of 2941 Heating Degree Days (HDD) and 90 Cooling Degree Days (2014-2019, base temperature 15°C HDD and 24°C CDD) [64]. Brussels meteorological weather data for 2016-2019 were requested from the Belgian Royal Meteorological Institute [65].

2.6.1. Calibration

The building energy models' validity has been further checked against the public statistics and verified through a model calibration and utility bill comparison. According to ASHRAE Guideline 14 [58], calibration was done to evaluate the goodness-of-fit of the energy models. The ASHRAE Guideline 14 uses two indices to assess the goodness-of-fit of the building energy model [66]. The Mean bias error, MBE, and the Coefficient of variation of the Root mean square error, CV (RMSE). MBE is a non-dimensional measure of the overall bias error between the measured and simulated data in a known time resolution, and it is usually expressed as a percentage:

$$MBE = \frac{\sum_{i=1}^{N_p}(m_i - s_i)}{\sum_{i=1}^{N_p} m_i} \qquad [\%] \qquad \text{Equation 1}$$

where mi (i = 1, 2, . . ., Np) are the measured data, si (i = 1, 2, . . ., Np) are the simulated data at time interval i and Np is the total number of the data values.

CV(RMSE) represents how well the simulation model describes the variability in the measured data. It is defined as:

$$CV(RMSE) = \frac{1}{m}\sqrt{\frac{\sum_{i=1}^{N_p}(m_i - s_i)^2}{N_p}} \quad [\%] \qquad \text{Equation 2}$$

where, besides the quantities already introduced in Eq. (1), m is the average of the measured data values. The evaluation of a building energy simulation model's accuracy is made according to the model's conformity with the recommended criteria for MBE and CV(RMSE).

According to the ASHRAE Guideline 14, the simulation model is considered calibrated if it has MBE that is not larger than 5%. CV (RMSE) is not larger than 15% when the monthly data are used for the calibration.

To get reliable building energy models and increase the accuracy of estimating the building's performance, the models of detached single-family houses underwent two subsequent calibrations. The building model was first calibrated based on the building's measured monthly gas consumption. An uncertainty analysis was then performed to identify the most influential independent input variables, including the weather, building envelope, and occupancy [67].

2.6.2. Weather normalization

Weather normalization was applied to isolate weather changes on the archetypes energy performance for 2016-2019 [68]. The degree-days method was used to represent the total positive or negative difference [69]. The degree day is the difference between a base temperature and an average temperature of the place taken as a reference. This notion considers that the heat losses are proportional to the difference between the indoor T° and the outdoor T° of modeled building. This degree-days method, therefore, allows establishing the normalized consumption. The relationship between these two consumptions can be selected based on the equation below:

$$\text{Normalized consumption} = \frac{\text{monitored energy use} \times \text{normal degree days onsite}}{\text{observed degree days onsite}} \quad \textit{Equation 3}$$

2.6.3. Building envelope performance monitoring

The envelope airtightness and conductivity values were identified as influential modeling input parameters with high uncertainty. Despite the airtightness values found in several studies [70], including the earliest work of Bossaer et al. (1998) [71], we could not find a reliable value of envelope infiltration at 50 Pa [m^3/h.m^2] for the detached houses built between 1945 and 1990. Therefore, an airtightness test took place using the pressure measuring device DG-700 and software TECTITE Express 5.1 and BlowerDoor® measurement according to EN 13829 [72] and STS P 71-3 [73].

Moreover, a 21 days U-value monitoring took place on different envelope surfaces using gSKIN® KIT-2615C (U-Value Kit) according to ISO 9869-1:2014 [74]. The kits were installed to measure a representative brick cavity wall [75], the roof, and the attic (loft) floor. Most of the investigated attic slabs were insulated, and literature [16] did not provide accurate and representative values. Therefore, the conductivity and heat capacity of the attic slab required special attention.

2.6.4. Occupancy behavior verification

Three data loggers, namely TESTO IAQ 160, were placed in the two selected houses with the house owners' consent. The data loggers uploaded five readings (temperature, humidity, CO2, and pressure) every 15-minutes to the cloud. The field measurements took place in the summers of 2018 and 2019 to refine residents' specific behavioral characteristics. With the help of the survey responses and the monitoring data, occupancy schedules were verified. Lighting, plug loads, and domestic hot water schedules were developed based on the energy and indoor environment monitoring data. The profiles were accordingly scaled to match the needs of the building energy modeling software based on the work of Koupaei et al. 2019 [76]. After defining both daily and yearly periods of heating (and cooling), and natural ventilation using meteorological weather, the heating, cooling, and natural ventilation schedules were created. The results of the database are presented in this section. The two selected reference buildings are described in detail regarding their energy characteristics, energy models, and validation results.

2.7. Database of Belgian post-WWII single-family houses

The buildings are grouped according to their archetype and organized by hectare. Fig. 4a shows the Distribution of extracted buildings per municipality in Belgium. Fig. 4b indicates that most detached residential buildings are concentrated in the northern and middle parts of Belgium. Accordingly, our selected grids contain 1500 buildings located within the north and middle of Belgium (Fig. 2) to ensure well representation of extracted buildings.

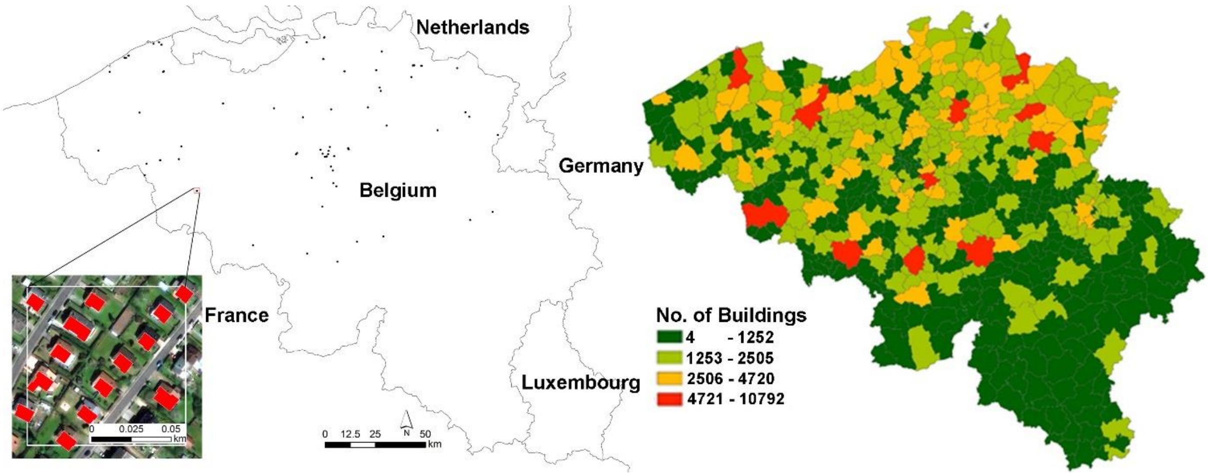


Fig. 4a, number of detached residential buildings per municipality between 1945 and 1990. Fig. 4b, Distribution of the 1328 representative buildings in 82 hectares throughout Belgium,

However, a comprehensive database of 1328 households was created, bringing together all the post-WWII single-family houses database's geometric and energy efficiency characteristics. The architecture of the one thousand houses was analyzed. Two archetypes of houses were identified from the data collected: archetype A corresponding to dwellings built between 1945 and 1969 and archetype B corresponding to homes constructed between 1970 and 1990. Both archetypes had to be distinguished due to the disparity in architecture, house configuration, occupancy density, and energy performance. Fig.5 represents the one thousand reference dwellings visited during the field surveys for typology A and B.

Fig.5a. Dwellings representative of archetype A, Fig.5b. Dwellings representative of archetype B

As shown in Figure 5, the architectural style and the vintage, and other characteristics such as the occupant density and construction materials differ between these two periods. Archetype A (1945-1969) included 716 audited households. The measured energy use (electricity and natural gas) for archetype A in 2018 is presented in Figure 6. The measured energy use (electricity and natural gas) for archetype A in 2018 is presented in Figure 6. Archetype B (1970-1990) included 612 audited households, and its measured energy use breakdown is presented in Figure 6.

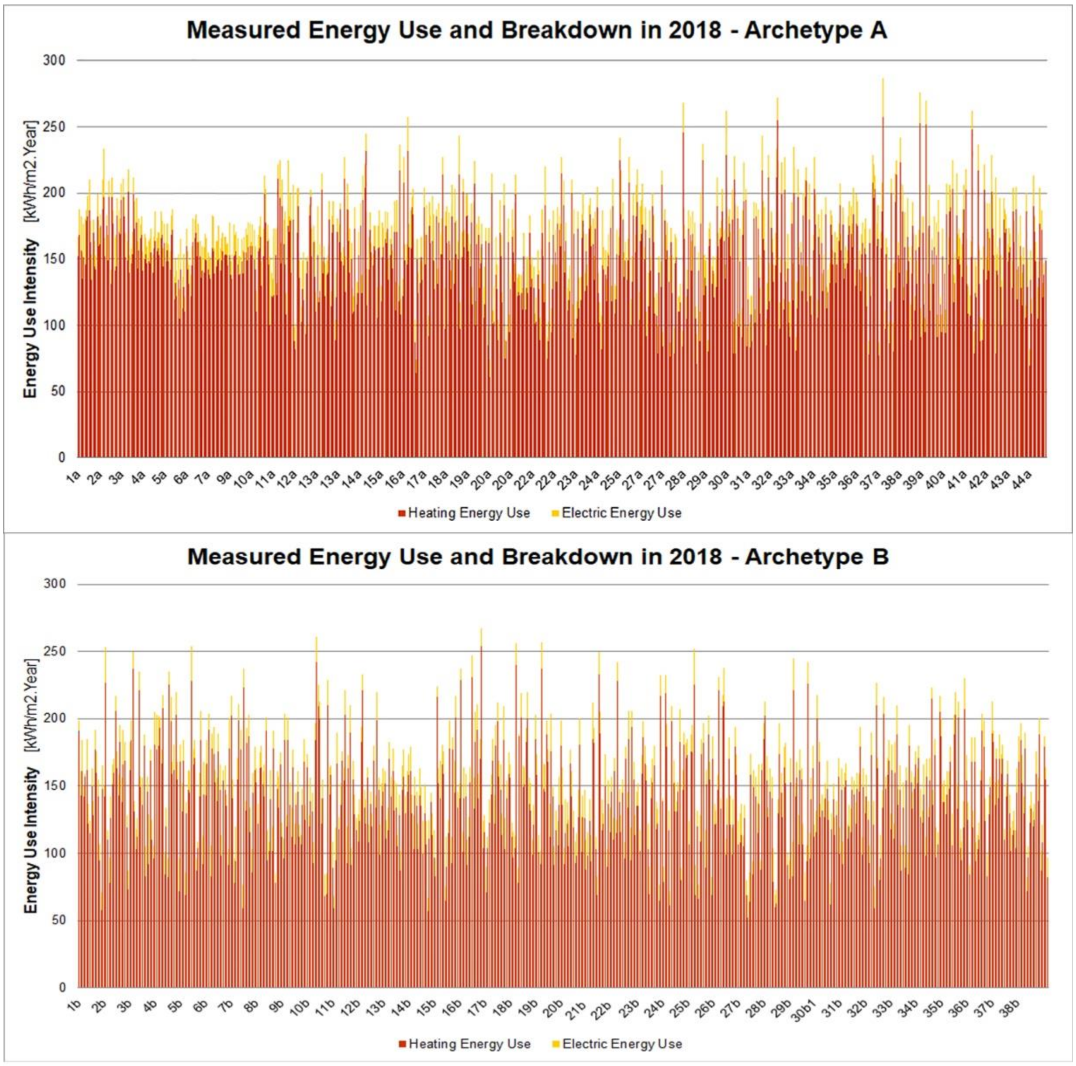


Fig.6a. Measured energy use intensity for archetype A, Fig.6b. measured energy use intensity of archetype B

2.8. Selected reference buildings

Two reference buildings were identified as a representative, as shown in Figure 7 and described in Table 2. Archetype A represents the 1950s and 1960s free-standing housing. First, archetype A represents a standardized rectangular plan with a cavity wall cladding with brick. The typical house comprises two floors with unoccupied attics and is covered with a sharply gabled roof. Most of the households had an underground garage and a cave. The archetype came within reach of broad sections of the Belgian population from the 1950s onwards [77] and was named the 'Belgian Villa,' or the 'Fermette' or 'De Taeye-houses' [78]. The average surface area is often between 250 m^2 and 300 m^2. The houses historically comprised at least two chimneys and were heated with fuel oil. From the audited sample (716 homes) we found that more the 70% of households went through an energy retrofit and replaced the fuel oil with natural gas boilers.

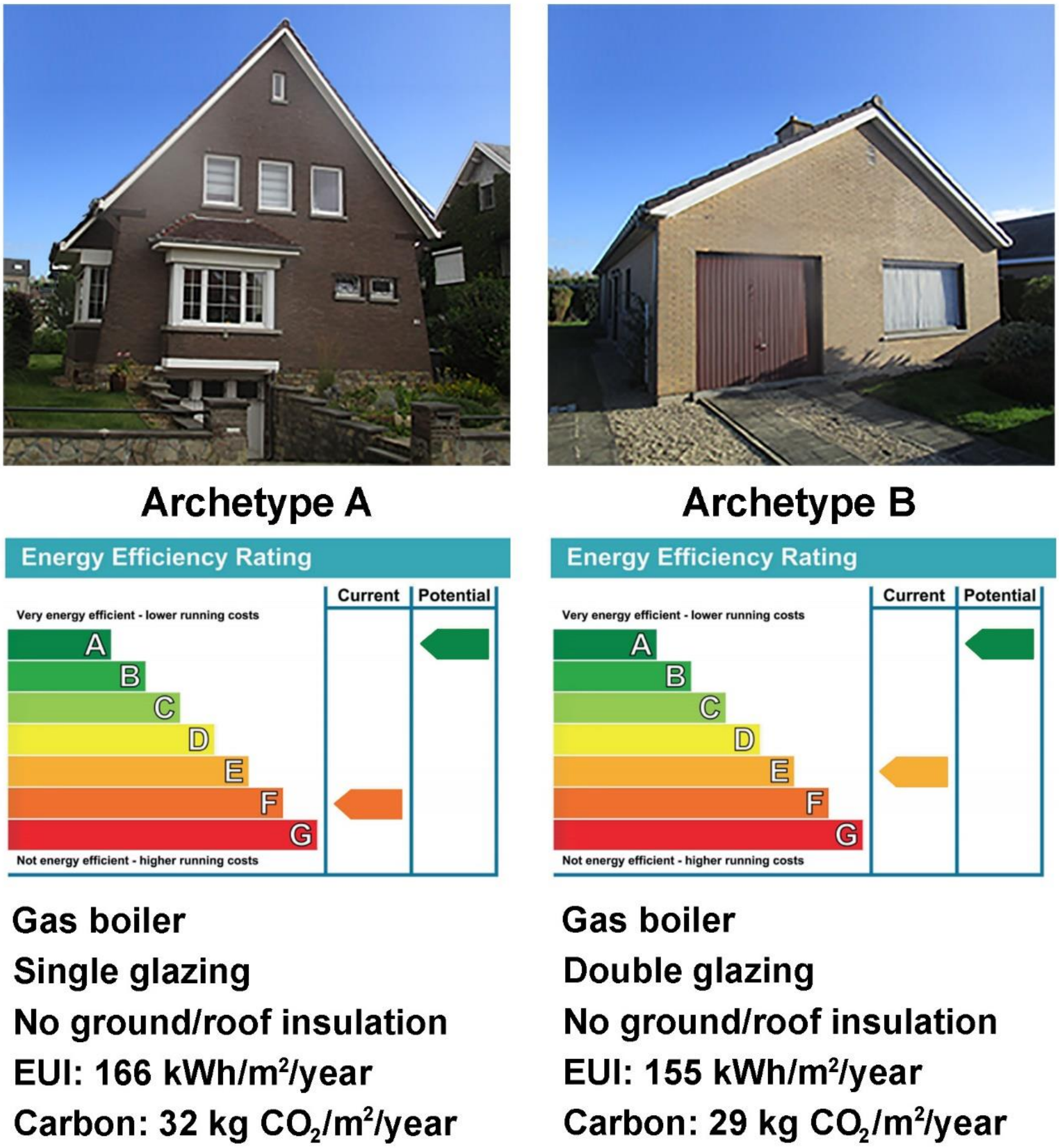


Fig.7. Measured energy use intensity and carbon emissions between 2016 and 2019 for archetype A in Wezembeek-Oppem, Flanders, and archetype B in Frasnes-lez-Anvaing, Wallonia.

Table 2. General description of archetypes A and B

Building description	Archetype A	Archetype B
Number of floors	2	1
Total area (m^2)	259	148
Occupants	2	2
Total volume (m^3)	774	636
External wall area	254	198
Roof area	192	187
Floor area	259	148
Windows area	24.7	20.4

Windows U-value	2.90	2.76
Windows G-value	0.74	0.60
Wall surface absorptance	0,80	0.70
Walls U-value (W/m²K)	1.72	1.70
Roof U-value (W/m²K)	1,25	1.40
Ground U-value (W/m²K)	0.46	0.46
Attic Floor U-value (W/m²K)	1,1	1.1

Second, archetype B is characterized as a single-floor house, unoccupied attic, and a separate garage unit next to the house. Archetype B represents standardized rectangular or L-shaped plans with a cavity wall, which is cladded with brick. Fig.7 shows the selected reference building. The archetype gained importance in Belgian living culture in suburbia. It represented the rural and rustic style of pseudo farm housing [79]. Facades comprised of retroelements and washed old brick (cavity walls) [78]. The house plan was more open, avoiding a reception space with an open kitchen. The average surface area is often between 180 m^2 and 240 m^2. The archetype was named the 'Bungalow' with prefabricated concrete attic floors and ground slabs [78]. The attic side walls had a typical timber cladding, and the houses seemed to be more standardized and fabricated in an industrial way.

The building energy models are multizonal thermal spaces that are categorized as (1) living area (living, dining, and kitchen), (2) sleeping area (bedrooms), and (3) short-presence area (bathrooms and corridors. Figure 8 illustrates the two modeled archetypes in 3D view. Figure A, in Appendix I, shows the plans and facades of both archetypes. Further details regarding the thermal zoning schemes can be found in a detailed modeling report [21].

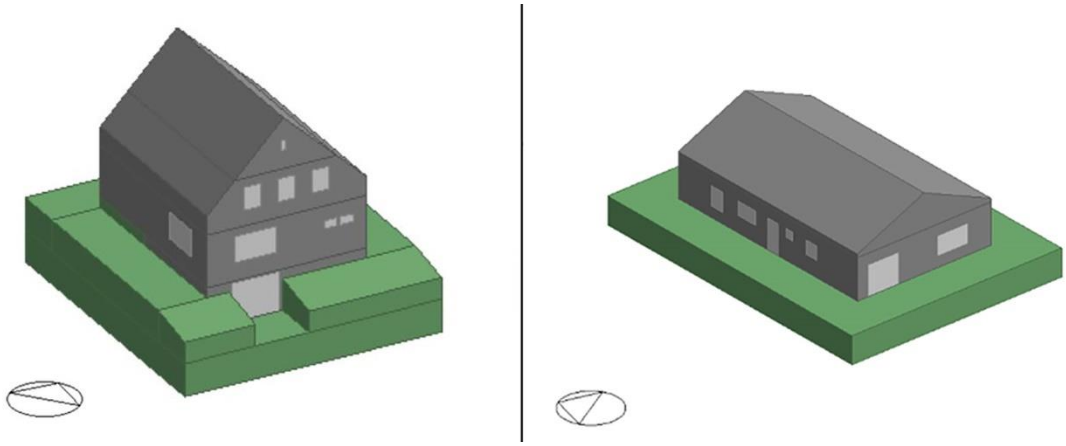


Fig.8. Typology A and B in 3D view

2.9. Energy characterization of the two reference buildings

The energy characteristics of the two reference simulation models are described in this section.

2.9.1. Energy use intensity

As shown in Figure 7, the EPC rating of archetype A is F, and the rating of archetype B is E. The carbon emissions calculations are based on the assumptions proposed by Georges et al. [80]. The characterization of the energy use of the 1328 households indicated that the average energy use intensity of archetype A is 148.7 kWh/m^2/year for heating (including DHW) and 17.7 kWh/m^2/year for electricity. Figure 7 indicates that archetype B's average energy use intensity is 139.8 kWh/m^2/year for heating (including DHW) and 14.9 kWh/m^2/year for electricity (see Table 3).

Table 3. Heating demand, electricity demand, and energy use intensity

Buildings Type	Average heating energy demand [kWh/m^2/year]	Variance	Average electricity demand [kWh/m^2/year]	Variance	Average energy use intensity [kWh/m^2/year]	Variance
Archetype A	148.7	33.5	17.7	7.6	166.4	
Archetype B	139.8	38.4	14.9	5	154.7	

2.9.2. Occupancy density and schedules

Archetype A was dominated by senior couples or single female seniors (> 70 years old). Almost all of the investigated occupants were first house owners. In the past, they had, on average, three children who all left the house. A significant amount of survey respondents indicated a usufrucuary ownership, which means they do not have full ownership of the property right. Most interviewed occupants granted the usufruct to their children or grandchildren to reduce the inheritance tax burden. Archetype B was dominated by senior couples (> 60 years old) where at least one occupant was pensioned. Overall the occupancy density in both archetypes was low, and several spaces were not used.

Based on the schedule available in the standard ISO 18523 part 2, we defined the occupancy period. However, ISO 18523 was developed for an average age category of 45-year old occupants. Therefore, our surveys and monitoring observations were used to create novel schedules. Figure 9 presents the occupancy schedules for the three space categories as (1) living area (living, dining, and kitchen), (2) sleeping area (bedrooms), and (3) short-presence area (bathrooms and corridors. Since occupants were mainly seniors, we considered the same schedules for a weekday and the weekend. Tables 4 and 5 summarize the holidays and occupation periods use for both archetypes.

Table 4: occupation status of apartment members in a typical apartment for five family members

		Archetype A		Archetype B	
2018/2019	Member	Senior 1	Senior 2	Senior 1	Adult 2
-	Status	Pensioned	Pensioned	Full-time	Pensioned
Days at home Weekday	06:00-09:00	Often	Often	Often	Often
	09:00-12:00	Often	Often	Seldom	Often
	12:00-15:00	Regularly	Regularly	Seldom	Regularly
	15:00-18:00	Often	Often	Seldom	Often
	18:00-23:00	Often	Often	Often	Often
	23:00-06:00	Often	Often	Often	Often
Days at home weekend*		Often	Often	Regularly	Regularly

*The same schedules for a weekday and the weekend were used with slight differences.

Table 5. Holidays schedules for the year 2021

Name	Start date	End date	Number of days
Easter Holidays	30/03/2021	05/04/2018	7
Summer Holidays	01/08/2018	15/08/2018	15
All Saints'Day Holidays	28/10/2018	05/11/2018	7
Christmas Holidays	24/12/2018	01/01/2018	7

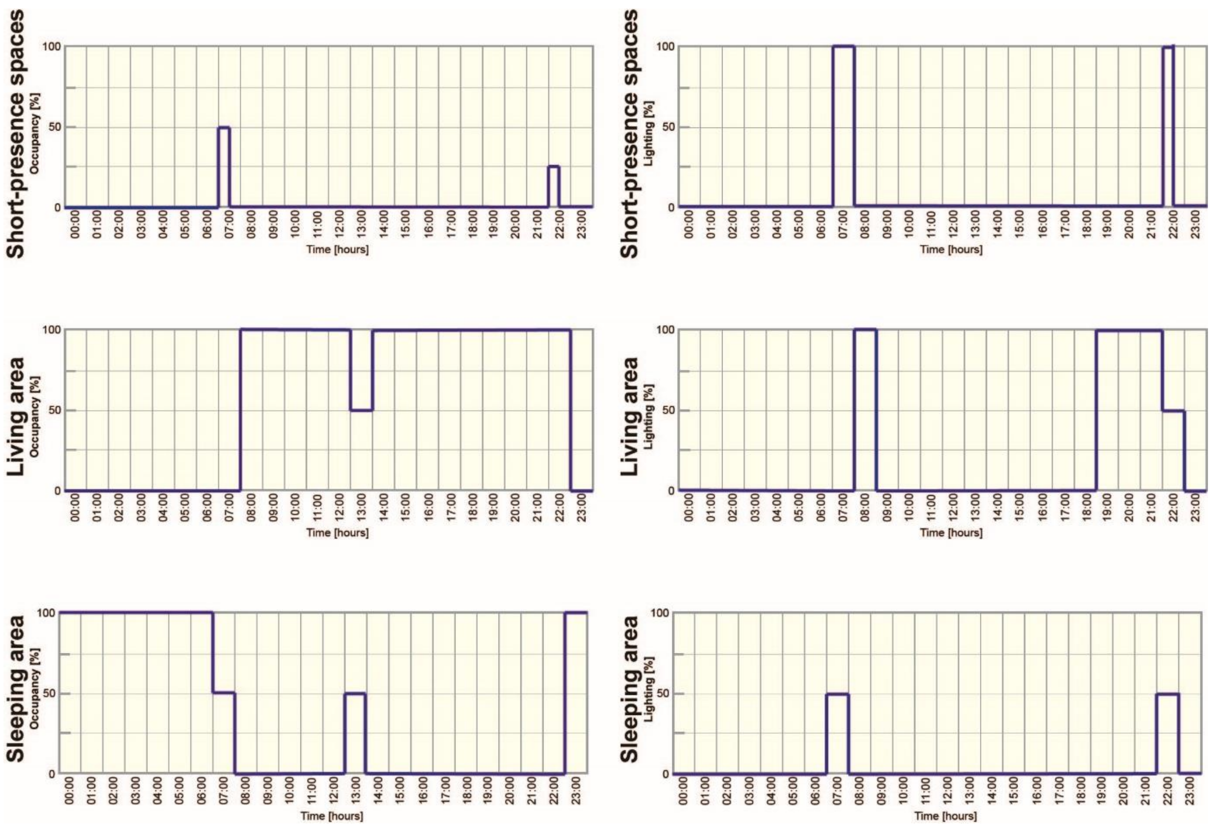


Fig.9. Occupation schedule

2.9.1. Lighting intensity and schedules

The data collected from the survey allowed us to define the most commonly used types and numbers of lamps. The dominant types of lamps used were mainly compact fluorescent lamps (64%) followed by LED lamps (28%). Halogen lamps were found primarily in the dining and living areas. Artificial lighting was not used during the daytime of the day or in the absence of occupants. As seen from the survey, the average lighting power intensity for living areas was 12 W/m^2. For the bedroom, for example, the average lighting power density is 8 W/m^2, with an average variance of 6.1 W/m^2. Figure 9 presents the lighting schedules applied to the three main space categories. Lighting schedules were modified during the winter period to extend the operation in the living areas 2 hours after 08:00 and 1 hour before 17:00. Several attempts to validate the lighting schedules were achieved by comparing the outcomes with the reports published by Flemish Energy Agency [81] and IP Belgium [82].

2.9.2. Plug load intensity and schedules

The penetration rates and saturation rates of house appliances were determined based on survey findings. Table 6 lists the most found house appliances in Belgian post-WWII single-family houses. The 20 listed appliances had a saturation rate higher than 65% in the surveyed sample. The national average of household appliances is 77appliance per household [83]. The unit capacity of the plugged appliances (standby and continuous) was estimated based on the running hours and power values. The average plug load power intensity is estimated at 9 W/m^2. Surprisingly, around 15% of households had an air conditioning unit (split), 17% had a dehumidification device, and 25% had mobile electric heating devices. Finally, the monthly and annual electricity use was used to validate the modeling assumptions.

Table 6, Appliances found in typical Belgian post-WWII single-family houses

Appliance	Watt-hour	Daily Operating Hours	Appliance	Watt-hour	Daily Operating Hours
Furnace fan	50	1.5	HD Television	50	5
Coffee machine	600	0.2	Deep Fryer	1500	0.05
Microwave	1500	0.2	Washing machine	680	0.8
Mobile charger	5	24	Refrigerator (2 doors)	95	24
Phone charger	3	3	Kettle	1500	0.2
Built in Oven	300	0.1	PC/ Laptop/Tablets	150/60/40	2
Electric Iron	1100	0.1	Freezer	15	24
Vacuum cleaner	330	0.05	Radio	15	0.1
Clothes Dryer	561	0.8	Dishwasher	720	1
DVD/CD Player	40	0.05	Electric Stove	650	0.9

2.9.3. Cooking and domestic hot water

Most visited households were connected to the district gas grid. Households located in Walloon and Flemish Brabant, Hainaut, Brussels, and Antwerp provinces were mostly using lean gas imported from the Netherlands. The households are in a transition phase since 2018 and until 2029 to replace it with rich gas. Lean gas will be replaced by rich gas imported from Norway, the United Kingdom, Qatar, and Russia. Most households had gas-fired boilers that were replaced after 1990 and thus are compatible with rich gas. The analysis of gas utility bills allowed defining the baseline of energy use for DHW and cooking (see Section 3.3). The water use per person was surveyed, representing an average of 30m^3 per household (2 senior occupants), which stands for 41 L/person/day. The DHW hot water (of 60°C) was calculated to reach 25 L/person/day. The cooking activities were assumed to reach 40-60 minutes per day.

2.9.4. HVAC systems and comfort setpoints

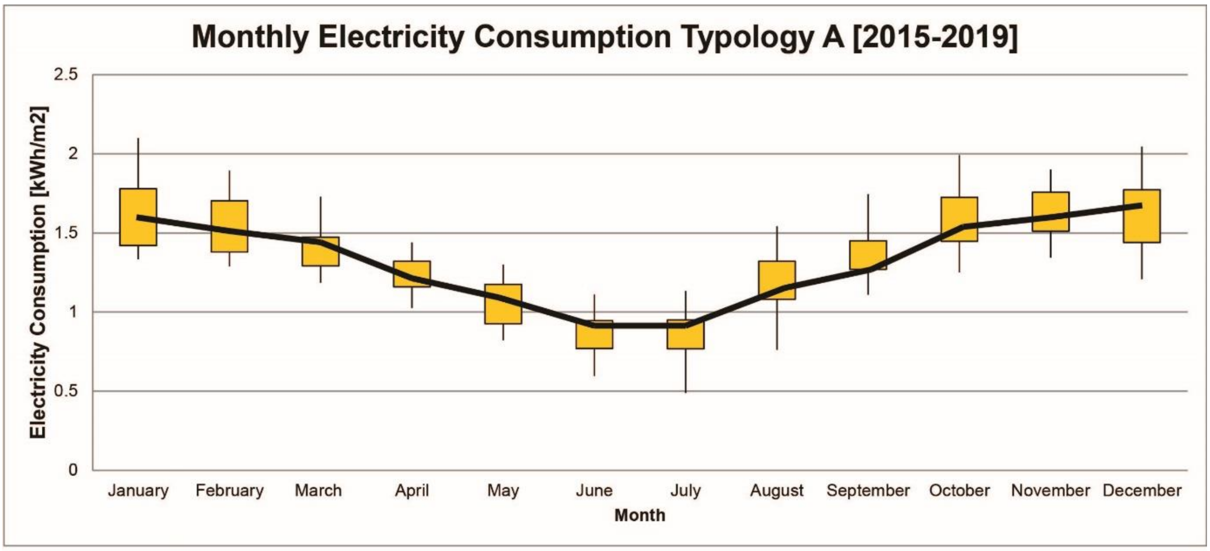
More than 80% of households were heated by natural gas. A small number of households had a fuel oil boiler or a pellet or wood logs heating system. More than 90% of households had a hydronic heating system with a hot water loop and radiators. The household owner indicated replacing the heating system at least once before the year 2000. Radiators were fitted with thermostatic valves to control hot water flow in response to the local sensed setpoint temperature. Radiators in children's rooms and non-occupied spaces were left closed. The thermostat average setpoint temperature was 23°C in living areas, including the kitchen. Radiators were completely open. The thermostat in the bathroom and short-presence areas were set to 16°C where radiators were left closed. Occupied bedrooms were set to 18°C, where radiators were left half-open. The real measured setback temperature in both households was 13°C when occupants were absent during holidays. Therefore, the thermal comfort setpoint criteria complied with ISO 17772-1,2 requirements (Category I) for senior adults with low metabolic rate and impaired control of body temperature [63] and [64]. Almost none of the investigated households had a mechanical ventilation system. 78% of survey respondents indicated opening windows for natural ventilation during winter and summer. Several attempts to validate the heating energy use and schedules were achieved by comparing the outcomes with the reports published by the Flemish [86] and Walloon [87] and federal government [88].

2.10.Numerical model calibration

Several iteration rounds tool place based on several input validation measures. The MBE and CV(RMSE) values of monthly energy use were calculated and are presented in Table 7. The obtained values are in acceptable ranges

Table 7. MBE and CV(RMSE) of the monthly energy heating and electricity consumption

Statistical indices	MBE (%)	CV(RMSE) (%)
Typology A Monthly calibration (Natural gas)	1,6	0,02
Typology A Monthly calibration (Electricity)	2,75	9,5
Typology B Monthly calibration (Natural gas)	0,1	0,38
Typology B Monthly calibration (Electricity)	3,1	10,8



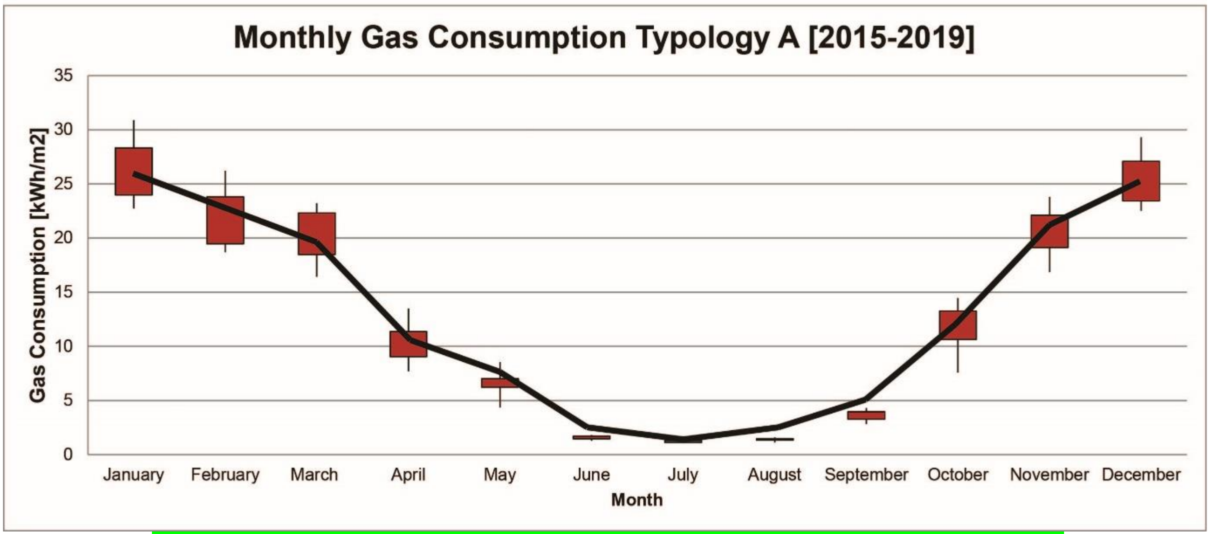


Fig.10. Surveyed and simulated monthly electricity and gas use of typology A

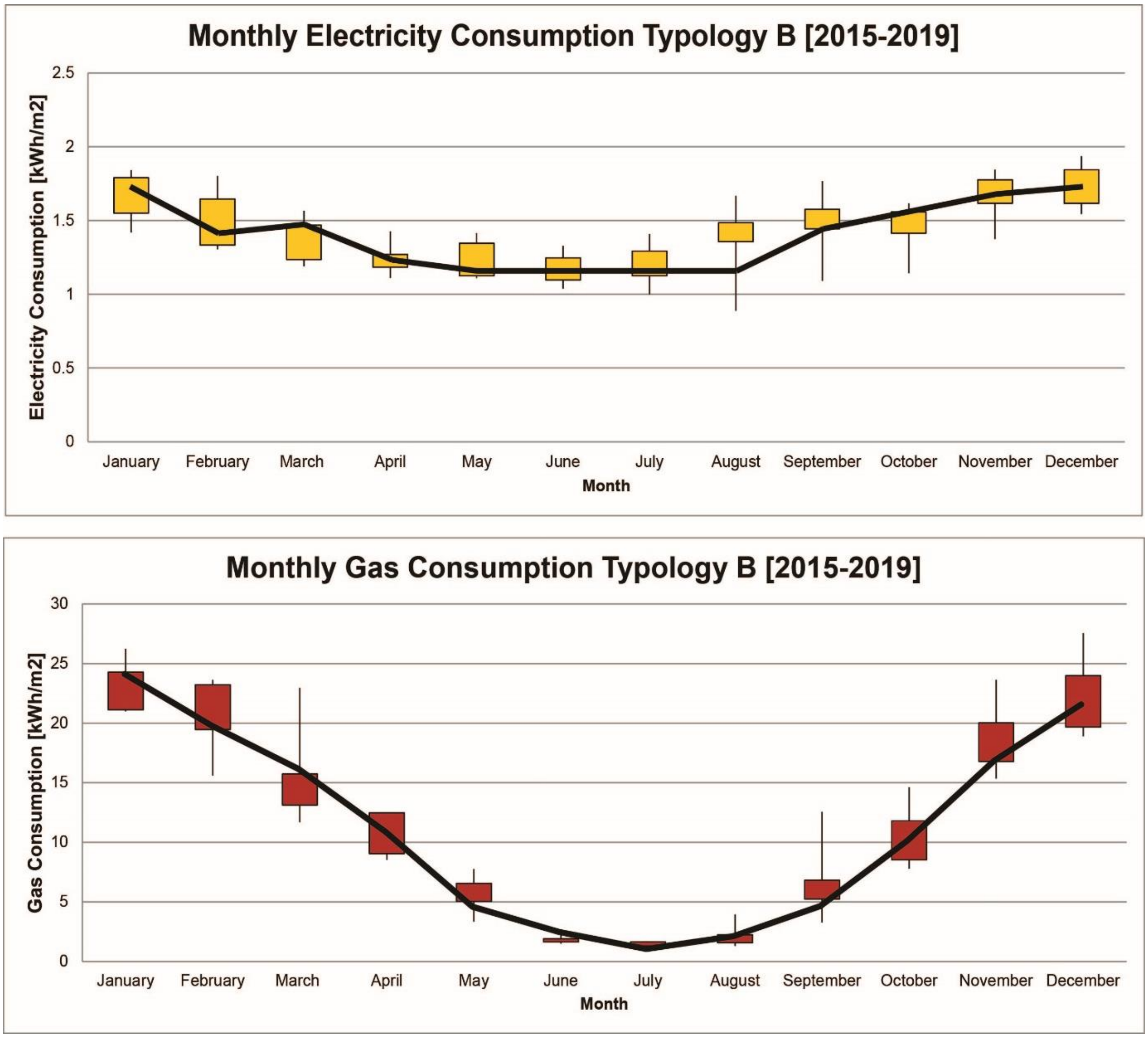


Fig.11. Surveyed and simulated monthly electricity and gas use of typology B

Table 8 indicates the energy use intensity normalization after weather normalization. Brussels' HDD days were extracted from the Eurostat website for the years 2016-2019 [64]. Both archetypes' energy use was compared with the observed energy use intensity extracted from the energy bills. The difference between the heating degree values lies between -4° and +3.5° HDD—the weather normalization allowed to neutralize the effect of weather and validate the results presented in Table 3.

Table 8: Normalised energy use intensity for archetypes A and B between 2016-2019

	2016		2017		2018		2019	
	A	B	A	B	A	B	A	B
Energy use intensity in kWh/m²/year	174	158	168	169	165	146	156	143
HDD base temperature 15°C [64]	2556		2448		2383		2379	
The difference compared to the average 2442 HDD (2016-2019)	-4%		+0%		+2.5%		+3.4%	

Normalized energy use intensity ($kWh/m^2/year$)	**167**	**152**	**168**	**169**	**169**	**150**	**161**	**148**

Moreover, the envelope input parameters were refined through U-value monitoring and airtightness measurements. The final U-values of the building envelope and internal floors are presented in Table 9. Also, the blower door test results are indicated in Table 9. The leaky nature of the households was confirmed due to the difficulty to reach 50 Pascal when depressurizing the tested buildings. Several plastic masks were taped over electricity outlets, chimney dampers, opening frames until we could calculate the total air change per hour from air leakage with an accuracy of 90%. Our findings are close to the assumptions reported by the Flemish [50] and Walloon [67] studies. More important than the absolute energy use per household, it was essential to provide reliable envelope performance values based on in-situ monitoring. The reported values reduced the uncertainty of the building energy model remarkably.

In a final attempt to validate the multizonal energy model, household occupancy profiles were refined. The repetition of the surveys allowed us to reach a high agreement on the most probable profiles. Despite the size of the large dwellings, the occupancy characterization confirmed that the elderly occupied both households. However, the most important observation revealed from the occupancy behavior verification stage (Section 2.6.4) was finding that occupants use mobile electric and gas heaters. There was a difficulty to match the simulated electricity use values with the measured ones during calibration for December, January, and February. The backtracking of survey respondents, logbooks and post-hoc interviews revealed that more than 25% of occupants used electric heating, electric heating mobile convectors, and fan-assisted heaters. The main reason was to improve the personalized thermal comfort and comfort perception. The use of electric heating devices justified the calibration problem and allowed to increase the curves fit shown in Figures 10 and 11. The monitoring of indoor quality parameters in both households confirmed several behavioral estimations concerning the heating setpoints and occupancy presence and patterns.

3. Discussion

Benchmarking allows characterizing existing buildings to enable reliable simulations and realistic future renovation scenarios. In this section, we discuss the study findings and position them regarding the state-of-the-art.

3.1. Summary of the main findings

Two reference models representing 633.702 post-WWII single-family houses in Belgium were created and validated. As shown in Table 9, archetype A has an average energy use intensity of 166 $kWh/m^2/year$ and represents detached single-family houses built between 1945 and 1969. Archetype B has an average energy use intensity of 155 $kWh/m^2/year$ and represents detached single-family houses built between 1970 and 1990. Both archetypes represent buildings built before or during the oil crisis in the 1970s, thus before any building energy efficiency requirement.

The results of the benchmarking of the two reference models are summarized in Table 9. The buildings hardly comply with any building energy efficiency criteria. The heat gains are low due to the small size of windows (see WWR values) and external roller shutters in most households. However, the heat losses are remarkably high, as indicated by the high U-value of the envelope and poor airtightness. The air change rate at 50 Pa pressure was 14.5 and 13.8 ACH, both benchmark models, respectively. Each building is equipped with one or two chimneys that act as passive stack ventilation. The openings in the envelope cause the leakage flow to be high. Also, the internal gains are low due to the low occupancy density. Older people choose to remain in their large homes, which host in the past 2-3 children on average. The most important and tangible outcomes of both building performance characteristics are described below:

Table 9. Summary of input parameters for both benchmark models after calibration

Model input measures		Typology A	Typology B
Envelope	Window to Wall Ratio (WWR in %)	12%	10%
	Solar Heat Gain Coefficient (SHGC)	0.74	0.60
	Light transmittance (LT)	0.80	0.70
	Solar protection (External)	Roller Shutters	Roller Shutters
	Windows U Value = [W/m²K)	2.90	2.76
	Roof U Value = [W/(m²K)]	1.25	1.4
	Airtightness (at 50 Pa m³/h-m²)	290 or 14.5 ACH	276 or 13.8 ACH
Heating system, ventilation, and air conditioning	COP Heating system	0.76	0.80
	Temperature set point [°C] for heating	23	22
	Heating system	Gas-fired boiler	Gas-fired boiler
	Heating fuel	Natural gas	Natural gas
Lighting	Lighting power density [W/m²]	8-12	8-12
Occupancy	Number of people	2	2
	Occupancy Density [m²/person]	129,5	74
	Occupancy schedule	See Fig.9	See Fig.9
Total	**Average consumption [kWh/m²/year]**	**166**	**155**

- One thousand three hundred twenty-eight representative single-family households have been selected nationally (out of 633,702) with an automated algorithm using GIS database (Belgian cadaster).

- Two multizonal energy benchmark models were created in EnergyPlus based on the representative building stock performance and were calibrated based on the ASHRAE BESTEST requirements

- A dataset containing the physical and thermal characteristics of more than 1300 buildings has been created

- The average annual electricity use intensity for archetypes A and B is 17,7 kWh/m²/year and 14,9 kWh/m²/year.

- The average heating use intensity for archetypes A and B is 148.7 kWh/m²/year and 139.8 kWh/m²/year.

- The EPC rating for archetypes A and B is F and E, respectively, higher than expected (G rating).

- The building envelope air permeability was very poor, with an average of 13.8 and 14.5 vol/h at 50 Pa, for both archetypes, respectively. Several chimneys, cracks around openings, and added extensions, such as verandas, are the leading cause of this problem.

- Most windows are double glazed due to window retrofits that took place before the year 2000. However, the overall windows performance is low, with a high conductivity value ranging around 2.8 W/m²K.

- Similarly, the envelope conductivity, around 1.7 W/m²K for walls and 1.3 W/m²K for roofs, is high. Surprisingly, more than 40% of households have poorly insulated bitumen felt shingles roofs.

- The households are dominated by elderly occupants (>65 years old) and have a low occupancy density with average households area of 250-300 m^2 and 180-240 m^2 for archetypes A and B.

3.2. Strengths and limitations of the study

The renovation of the post-WWII residential building stock offers many opportunities to neutralize the building sector's carbon emissions across Europe [4]. Therefore, building benchmarking is the basis for energy performance assessment approaches to reduce energy use and align with minimum performance requirements [89]. Using calibrated building simulation provides insights into the performance issues applicable across Europe. Moreover, the detailed characterization of the building performance allows closing the performance gap.

In this study, an essential vintage of single-family households was characterized by actual monthly energy use data for natural gas and electricity with four years of monitoring (2016 and 2019). The study identified a type of owners and age group that are not often studied in the literature [22]. Also, we are not aware of a West European study that characterized such a sample size of post-WWII single-family houses using GIS and fieldwork data collection techniques. Most of the existing studies found in the literature are based on statistical methods to create theoretical benchmark models [17]. The study results present a representative and accurate characterization of energy efficiency and occupant behavior. Using building performance simulation enables a systematic identification and classification of the performance gap's root causes for any future renovation scenario.

A novel approach was used to identify and verify performance issues using evidence-based calibration to increase the newly created models' confidence and accuracy. With the help of a mixed methodological approach, previously used [90], the study was able to survey house owners, collect energy bills, perform walkthrough audits and more importantly, perform in-situ blower door test and conductivity monitoring. The presence of smart meters in many households due to photovoltaic installation helped verify the monthly energy profiles. A systematic and structured data collection approach with a team of 15 participants allowed triangulating the data sources. The triangulation approach allowed revealing insights on the occupancy behavior and building energy efficiency. Despite the long investigation period that covered 5-years, the results are valuable, and the dataset will be further analyzed and exploited.

This study identified several lessons that can potentially be used to inform and improve current building renovation practices. However, the paper has some limitations, including the thermal comfort characterization. Therefore, a detailed comfort characterization is still underway. The poor envelope performance, air conditioners, mobile electric heaters, and the absence of mechanical ventilation systems were associated with overheating and winter discomfort problems. A thermal comfort assessment paper will deal with the indoor thermal quality issues based on the survey answers and dataset developed in this study.

3.3. Implication for the practice and future research

Belgium and many other industrial countries are facing an aging population. This study found that most households are too large concerning the low occupancy rate of two occupants per household. Unfortunately, the occupants of most of the investigated households ((>65 years of age) did not go through a deep renovation despite their financial capacity. On the other hand, the transfer of ownership of post-WWII households already started and intensified during the next 30 years. If Belgium and Europe wish to achieve the 2050 carbon emission reduction targets, new house owners and nuclear families shall occupy those households and pay for the renovation cost. However, it will be difficult to develop targeted renovation policies and subsidy programs without an accurate characterization. The study findings add to the evidence found in the literature [91] that nuclear families renovate their households at the beginning of their life [92] and not after being pensioned. The survey findings on usufrucuary ownership status confirm that too. Therefore, the moment of buying the post-WWII household will be crucial to implement any deep renovation.

In this context, local governments must prepare fiscal and financial regulation packages to encourage deep renovation endeavors. The decarbonizing of heating in post-WWII residential buildings requires policies, priorities, and timelines to ensure Belgium gets on track to achieve the carbon neutrality targets by 2050. Future research should also explore cost-effective renovation strategies and solutions based on the European Cost Optimality approach [93]. A detailed short-term and long-term road map on the renovation packages should be developed on the national level. Without a road map, it will address the renovation barriers that go beyond issues. Encouraging housing owners to renovate the post-WWII households and motivating them is part of any states' role. The development of an ecosystem of small and middle-size renovation enterprises with skilled labor is a vital element.

Finally, we invite international researchers to develop new occupancy schedules for senior adults beyond the limitations of ISO 18523 [61] and ISO 17772 [85]. The existing standards do not indicate how the elderly behave in the living environment. As a way to support this research endeavor, this study can be considered as starting point for further research on the development of senior adult occupancy profiles for building performance simulation.

4. Conclusions

The energy characterization of 1328 post-WWII single-family houses located in the three regions of Belgium (Brussels, Flanders, and Wallonia) took place based on four-year measurement data (2016-2019). To the authors' knowledge, this is the first energy characterization study of post-WWII single-family houses that have been reported from this part of Europe. The following key findings describe the study outcomes:

- Two accurate energy models representing 633,702 current households to predict energy use intensity and energy efficiency of single-family households built 1945 to 1990.

- The energy use characterization indicated that the average energy use intensity of archetype A is 155 kWh/m^2/year 166 kWh/m^2/year for archetype B.

- The EPC rating of archetype A is F, and the rating of archetype B is E.

- Two representative archetypes were identified and created in EnergyPlus software after several iteration rounds. The models were calibrated according to ASHRAE Guideline 14 using two indices to evaluate the goodness-of-fit of the building energy model.

- Rigorous validation measures consolidated the model input assumptions, namely (1) weather normalization, (2) envelope conductivity and airtightness, and (3) occupancy behavior observations.

The poor envelope performance and large heated house volumes/spaces appeared to be the most influential factor to the high energy use intensity. Despite that, the households were dominated on average by senior couples (>65 years old) the energy use remained relatively high. Consequently, the poor envelop physical and thermal properties resulted in discomfort problems and significant reliance on personalized plugged electric heating. Thus, the increased consumption of gas and electricity urges the need for renovation deep renovation (insulation, double glazing, blinds, mechanical ventilation, etc.). Further research aiming to characterize other post-WWII archetypes better and develop multi-objective renovation scenarios appears necessary to tackle carbon neutrality issues in existing households.

5. Appendix

Archetype B

Archetype A

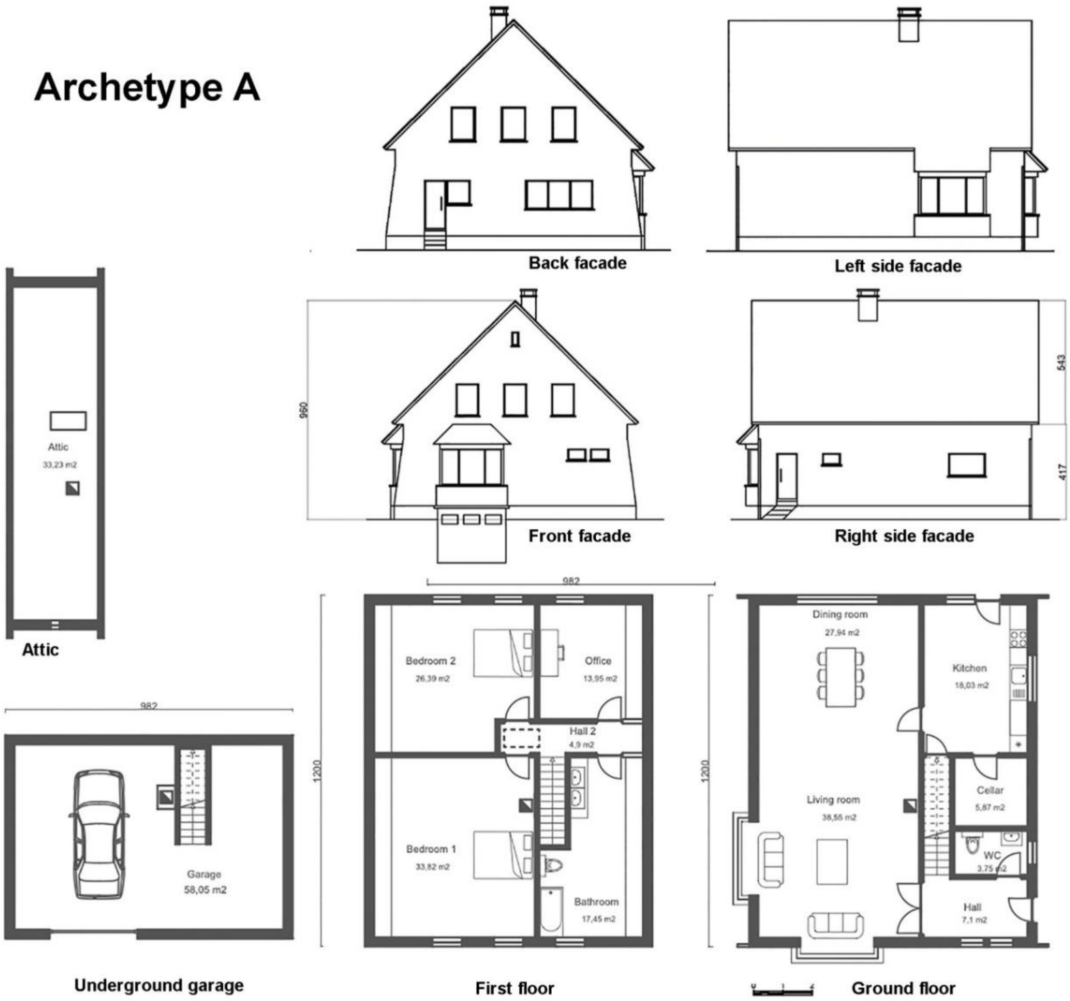


Figure A, floor plans and facades of archetype A and B

6. Acknowledgment

The authors express their thanks to all survey respondents. The Walloon Region partially funded this research under the call 'Actions de Recherche Concertées 2019 (ARC)' and the project OCCuPANt, on the Impacts Of Climate Change on the indoor environmental and energy PerformAnce of buildiNgs in Belgium during summer. The authors would like to acknowledge the Walloon Region and Liege University for funding gratefully. We would also like to recognize the Sustainable Building Design Lab for the use of monitoring equipment in this research and the valuable support during the experiments and data analysis.

7. References

[1] IEA, "Shares of residential energy consumption by end use in selected IEA countries," 2018. https://www.iea.org/data-and-statistics/charts/shares-of-residential-energy-consumption-by-end-use-in-selected-iea-countries-2018.

[2] EU, "State of the Union: Commission raises climate ambition and proposes 55% cut in emissions by 2030." European Commission, 2020, Accessed: Feb. 16, 2021. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1599.

[3] EU, "Questions and Answers on the Renovation Wave," 2020. https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_1836 (accessed Feb. 16, 2021).

[4] F. Meijer, L. Itard, and M. Sunikka-Blank, "Comparing European residential building stocks: performance, renovation and policy opportunities," *Build. Res. Inf.*, vol. 37, no. 5–6, pp. 533–551, 2009.

[5] G. Ruellan, M. Cools, and S. Attia, "Analysis of the determining factors for the renovation of the Walloon residential building stock," *Sustainability*, vol. 13, no. 21220, 2021.

[6] D. A. Pohoryles, C. Maduta, D. A. Bournas, and L. A. Kouris, "Energy performance of existing residential buildings in Europe: A novel approach combining energy with seismic retrofitting," *Energy Build.*, vol. 223, p. 110024, 2020.

[7] “Émissions par secteur,” *Klimaat | Climat*. https://climat.be/en-belgique/climat-et-emissions/emissions-des-gaz-a-effet-de-serre/emissions-par-secteur (accessed Dec. 08, 2020).

[8] FGOV, “CSTC sur base du census des logements.” 2011, Accessed: Feb. 16, 2021. [Online]. Available: https://www.census2011.be/download/downloads_fr.html.

[9] R. Hendron, R. Anderson, C. Christensen, M. Eastment, and P. Reeves, "Development of an energy savings benchmark for all residential end-uses," National Renewable Energy Lab., Golden, CO (US), 2004.

[10] P. Torcelini *et al.*, "DOE commercial building benchmark models," National Renewable Energy Lab.(NREL), Golden, CO (United States), 2008.

[11] N. Fumo, P. Mago, and R. Luck, "Methodology to estimate building energy consumption using EnergyPlus Benchmark Models," *Energy Build.*, vol. 42, no. 12, pp. 2331–2337, 2010.

[12] US DOE, "Residential Prototype Building Models," *Building Energy Codes Program*, 2020. https://www.energycodes.gov/development/residential/iecc_models (accessed Jan. 31, 2021).

[13] US DOE, "Commercial Prototype Building Models," *Building Energy Codes Program*, 2020. https://www.energycodes.gov/development/commercial/prototype_models (accessed Jan. 31, 2021).

[14] M. Deru *et al.*, "US Department of Energy commercial reference building models of the national building stock," 2011.

[15] K. Bettgenhäuser, *Integrated Assessment Modelling for Building Stocks: A Technical, Economical and Ecological Analysis*. Ingenieurwiss. Verlag, 2013.

[16] W. Cyx , N. Renders, M. Van Holm en S. Verbeke, "IEE TABULA - Typology Approach for Building Stock Energy Assessment." 2011, [Online]. Available: https://episcope.eu/fileadmin/tabula/public/docs/scientific/BE_TABULA_ScientificReport_VITO.pdf.

[17] IWU, "EPISCOPE and TABULA," *Monitor Progress Towards Climate Targets in European Housing Stocks*, 2016. https://episcope.eu/welcome/ (accessed Jan. 31, 2021).

[18] "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings," p. 23.

[19] S. P. Corgnati, E. Fabrizio, M. Filippi, and V. Monetti, "Reference buildings for cost optimal analysis: Method of definition and application," *Appl. Energy*, vol. 102, pp. 983–993, Feb. 2013, doi: 10.1016/j.apenergy.2012.06.001.

[20] "Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elementsText with EEA relevance," p. 19.
[21] S. Attia, A. Mustafa, G. Nicolas, M. Popineua, M. Cuchet, and N. Gulirmak, "Developing two benchmark models for post-world war II residential buildings," *Energy Build.*, p. 101, 2021.
[22] A. Berndgen-Kaiser, R. Fox-Kämper, and M. Wiechert, "Post-war Single-Family Houses in Europe under Pressure? A Demographic and Economic Framework for the Future Market of Elder Single-Family Housing Neighbourhoods," *Articulo-J. Urban Res.*, 2016.
[23] W. Bervoets and M. van de Weijer, "The Future of the Post-War Single-family House. The case of Flanders," 2015.
[24] H. Ben and K. Steemers, "Modelling energy retrofit using household archetypes," *Energy Build.*, vol. 224, p. 110224, 2020.
[25] M. F. Touchie and K. D. Pressnail, "Using suite energy-use and interior condition data to improve energy modeling of a 1960s MURB," *Energy Build.*, vol. 80, pp. 184–194, 2014.
[26] S. Attia, A. Evrard, and E. Gratia, "Development of benchmark models for the Egyptian residential buildings sector," *Appl. Energy*, vol. 94, pp. 270–284, 2012.
[27] S. Attia, N. Shadmanfar, and F. Ricci, "Developing two benchmark models for nearly zero energy schools," *Appl. Energy*, vol. 263, p. 114614, 2020.
[28] A. Guideline, "Guideline 14-2002, measurement of energy and demand savings," *Am. Soc. Heat. Vent. Air Cond. Eng. Atlanta Ga.*, 2002.
[29] S. Attia, *Net zero energy buildings (nzeb)*, 1st edition. Cambridge, MA: Elsevier, 2018.
[30] A. Tereci, S. T. E. Ozkan, and U. Eicker, "Energy benchmarking for residential buildings," *Energy Build.*, vol. 60, pp. 92–99, 2013.
[31] M. Ghajarkhosravi, Y. Huang, A. S. Fung, R. Kumar, and V. Straka, "Energy benchmarking analysis of multi-unit residential buildings (MURBs) in Toronto, Canada," *J. Build. Eng.*, vol. 27, p. 100981, 2020.
[32] Bruxelles Environnement, “Rapport à la Commission relatif l’établissement de niveaux optimaux en fonction des coûts des exigences minimales en matière de performance énergétique,” Bruxelles Environnement, Brussels, Belgium, May 2013.
[33] J. Van der Veken, J. Creylman, and T. Lenaerts, “STUDIE NAAR KOSTENOPTIMALE NIVEAUS VAN DE MINIMUMEISEN INZAKE ENERGIEPRESTATIES VAN NIEUWE RESIDENTIËLE GEBOUWEN,” Kenniscentrum Energie, Geel, Belgium, Jun. 2015. Accessed: Oct. 02, 2021. [Online]. Available: https://www.energiesparen.be/sites/default/files/atoms/files/verslag_NB_20150703.pdf.
[34] C. Leveau, M. Cherdon, M. Vismara, and B. Huberlant, “Détermination du niveau de performance énergétique optimal des bâtiments en fonction des coûts,” 3E, Brussels, Belgium, PR109008, Dec. 2018. Accessed: Oct. 02, 2021. [Online]. Available: https://energie.wallonie.be/servlet/Repository/cozeb-2-rapport-final.pdf?ID=54806.
[35] E. Fabrizio and V. Monetti, "Methodologies and advancements in the calibration of building energy models," *Energies*, vol. 8, no. 4, pp. 2548–2574, 2015.
[36] P. Caputo and G. Pasetti, "Boosting the energy renovation rate of the private building stock in Italy: Policies and innovative GIS-based tools," *Sustain. Cities Soc.*, vol. 34, pp. 394–404, 2017.
[37] P. Femenías, K. Mjörnell, and L. Thuvander, "Rethinking deep renovation: The perspective of rental housing in Sweden," *J. Clean. Prod.*, vol. 195, pp. 1457–1467, 2018.
[38] T. Johansson, T. Olofsson, and M. Mangold, "Development of an energy atlas for renovation of the multifamily building stock in Sweden," *Appl. Energy*, vol. 203, pp. 723–736, 2017.
[39] F. P. Chantrelle, H. Lahmidi, W. Keilholz, M. El Mankibi, and P. Michel, "Development of a multicriteria tool for optimizing the renovation of buildings," *Appl. Energy*, vol. 88, no. 4, pp. 1386–1394, 2011.
[40] P. Peda, G. Grossi, and M. Liik, "Do ownership and size affect the performance of water utilities? Evidence from Estonian municipalities," *J. Manag. Gov.*, vol. 17, no. 2, pp. 237–259, 2013.

[41] J. Weiss, E. Dunkelberg, and T. Vogelpohl, "Improving policy instruments to better tap into homeowner refurbishment potential: Lessons learned from a case study in Germany," *Energy Policy*, vol. 44, pp. 406–415, 2012.
[42] C. Wilson, L. Crane, and G. Chryssochoidis, "Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy," *Energy Res. Soc. Sci.*, vol. 7, pp. 12–22, 2015.
[43] FPS, "Belgian Cadastral Parcel Data," FPS Finances - General Administration of Patrimonial Documentation (GAPD), Brussels, Belgium, 2016.
[44] A. M. R. Nishimwe and S. Reiter, "Building heat consumption and heat demand assessment, characterization, and mapping on a regional scale: A case study of the Walloon building stock in Belgium," *Renew. Sustain. Energy Rev.*, vol. 135, p. 110170, 2021.
[45] DGO4, "Belgian Energy Efficiency Action Plan," Namur, Belgium, 2014. Accessed: Nov. 02, 2021. [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/documents/Belgium%20NEEAP.pdf.
[46] A. Deneyer, "Efficacité énergétique des bâtiments : un peu d'histoire," *BBRI*, 2006.
[47] C. R. Wilson Van Voorhis and B. L. Morgan, "Understanding Power and Rules of Thumb for Determining Sample Sizes," *Tutor. Quant. Methods Psychol.*, vol. 3, no. 2, pp. 43–50, Sep. 2007, doi: 10.20982/tqmp.03.2.p043.
[48] Bruxelles Environnement, "Register of EPB certificates for Brussels housing." Bruxelles Environnement, Brussels, Belgium, Nov. 02, 2021, [Online]. Available: https://www.peb-epb.brussels/certificats-certificaten/.
[49] P. Voigt and A. Von dem Bussche, "The eu general data protection regulation (gdpr)," *Pract. Guide 1st Ed Cham Springer Int. Publ.*, vol. 10, p. 3152676, 2017.
[50] Wikipedia, "Loi de Taeye," *Wikipedia*. Jul. 20, 2020, [Online]. Available: https://fr.wikipedia.org/wiki/Loi_de_Taeye#:~:text=que%20les%20logements.-,Contenu,acquisition%20de%20petites%20propri%C3%A9t%C3%A9s%20terriennes%20.&text=En%20effet%2C%20pr%C3%A8s%20de%2090,construire%20qu'avec%20des%20emprunts.
[51] C. Vandermotten, "Théorie géographique et empirie historique: site, situation et auto-reproduction spatiale. De Bruxelles à la ville européenne," *Rev. Belge Philol. Hist.*, vol. 89, no. 2, pp. 841–860, 2011.
[52] J. Puissant, "L'exemple belge: l'habitat privé, la maison individuelle l'emportent sur l'habitat collectif," *Rev. Nord*, no. 1, pp. 95–116, 2008.
[53] M. Reynebeau, *Histoire belge: 1830-2005*. Lannoo Uitgeverij, 2005.
[54] FAB, "Repères historiques," *FÉDÉRATION DES SOCIÉTÉS D'ARCHITECTES DE BELGIQUE*, 2019. http://www.fab-arch.be/fr/fab/historique#:~:text=La%20Loi%20de%201963%20cr%C3%A9ant,1980%2C%20la%20Belgique%20se%20r%C3%A9gionalise. (accessed Nov. 02, 2021).
[55] L. Flouquet, "La petite maison familiale," *Art&Technique*, 1950.
[56] S. Van de Voorde, I. Bertels, and I. Wouters, *Post-war building materials in housing in Brussels 1945-1975*. Brussels, Belgium: VUB, 2015.
[57] S. Van de Voorde, I. Bertels, and I. Wouters, "The emergence of a new generation of building products in post-war Belgium: the case of lightweight concrete," in *Proceedings of the First Conference of the Construction History Society: Queens' College, Cambridge, 11-12 April 2014*, 2014, pp. 423–433.
[58] A. O'Neill, "Total fertility rate in Belgium from 1800 to 2020," Statista, Brussels, Belgium, 2020. [Online]. Available: https://www.statista.com/statistics/1033487/fertility-rate-belgium-1800-2020/.
[59] F. Nicolai, *Archibelge - La loi De Taeye*. Brussels, Belgium, 2016.
[60] M. Krarti, *Energy audit of building systems: an engineering approach*. CRC press, 2020.
[61] ISO, "18523-2:2016. Energy performance of buildings - Schedule and condition of building, zone and space usage for energy calculation – Part 2: Residential buildings." International Organization for Standardization, 2016.

[62] DOE, "EnergyPlus." Department of Energy, 2021, Accessed: Dec. 02, 2021. [Online]. Available: https://energyplus.net/.
[63] M. Kottek, J. Grieser, C. Beck, B. Rudolf, and F. Rubel, “World map of the Köppen-Geiger climate classification updated,” 2006.
[64] eurostat, "Cooling and heating degree days by NUTS 2 regions - annual data," European Commission, Brussels, Belgium, 2021.
[65] IRM, "Royal Meteorological Institute of Belgium." 2021.
[66] Ashrae, "ASHRAE standart 140-2017 - standart method of test for evaluation of building energy analysis programs." 2017.
[67] C. J. Hopfe and J. L. Hensen, "Uncertainty analysis in building performance simulation for design support," *Energy Build.*, vol. 43, no. 10, pp. 2798–2805, 2011.
[68] E. ASHRAE, "ASHRAE Handbook Fundamentals. Atlanta, GA, American Society of Heating," *Refrig. Air-Cond. Eng.*, 2013.
[69] A. Makhmalbaf, V. Srivastava, and N. Wang, "Simulation-based weather normalization approach to study the impact of weather on energy use of buildings in the US," in *13th Conference of international building performance simulation association*, 2013, pp. 1436–1444.
[70] A. Bossaer, J. Demeester, P. Wouters, B. Vandermarke, and W. Vangroenweghe, “Airtightness performances in new Belgian dwellings,” in *DOCUMENT-AIR INFILTRATION CENTRE AIC PROC*, 1998, pp. 77–84.
[71] SPW, “Stratégie Wallonne de rénovation énergétique à long terme du bâtiment,” 2020.
[72] EC, "13829 Thermal performance of buildings-Determination of air permeability of buildings-Fan pressurization method." European Committee for Standardization, 2016.
[73] A. K. en Innovatie, N. Gate, K. A. II-laan, and G. De Poorter, “FOD ECONOMIE, KMO, MIDDENSTAND & ENERGIE.”
[74] A. Rasooli and L. Itard, "In-situ characterization of walls' thermal resistance: An extension to the ISO 9869 standard method," *Energy Build.*, vol. 179, pp. 374–383, 2018.
[75] H. Hens, A. Janssens, W. Depraetere, J. Carmeliet, and J. Lecompte, "Brick cavity walls: a performance analysis based on measurements and simulations," *J. Build. Phys.*, vol. 31, no. 2, pp. 95–124, 2007.
[76] D. M. Koupaei, F. Hashemi, V. Tabard-Fortecoëf, and U. Passe, "Development of a Modelling Framework for Refined Residential Occupancy Schedules," *Fifty-Sixth Annu. Rep.*, p. 68, 2019.
[77] E. De Vos and H. Heynen, "Shaping Popular Taste: The Belgian Farmers' Association and the Fermette During the 1960s–1970s," *Home Cult.*, vol. 4, no. 3, pp. 237–259, 2007.
[78] E. De Vos, “De fermette in Vlaanderen. Architecten, de overheid, het middenveld en enkele bewoners over deze droomwoning tijdens de jaren’60-’70,” *Van Mensen En Dingen Tijdschr. Voor Volkscult. Vlaan.*, vol. 6, no. 3–4, 2008.
[79] N. Janssens, “Afbetaald, niet afgeschreven: de fermette,” PHL University College, Hasselt, Belgium, 2011.
[80] L. Georges, C. Massart, G. Van Moeseke, and A. De Herde, "Environmental and economic performance of heating systems for energy-efficient dwellings: Case of passive and low-energy single-family houses," *Energy Policy*, vol. 40, pp. 452–464, 2012.
[81] TNS, “Het energiebewustzijn en -gedrag van de Vlaamse huishoudens.” Vlaams Energieagentschap, 2015.
[82] IP Belgium, “Life Observer 2018, Observons le temps des Belges.” 2018.
[83] Gfk, “Possession et mise au rebut d’équipements électr(on)iques en 2017 Ménages belges : mesure 2,” Recupel, Brussels, Belgium, 2018.
[84] ISO 17772-1, "ISO 17772-1: Energy performance of buildings - Indoor environmental quality. Part 1: Indoor environmental input parameters for the design and assessment of energy performance in buildings".," 2017.
[85] ISO 17772-2, "ISO 17772-2: Energy performance of buildings - Overall energy performance assessment procedures. Part 2: Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings.," 2018.

[86] G. Verbeeck and W. Ceulemans, “Analyse van de EPC Databank: Resultaten tot en met 2012,” Steunpunt Wonen, Leuevn, Belgium, 9789088360503, 2015.
[87] ICEDD, “Bilan Energetique de la Wallonie: Secteur Domestique et equivalents,” Service Public de Wallonie, Namur, Belgium, 2012.
[88] K. Jespers *et al.*, "Energy consumption survey for Belgian households," *Boeretang Vito*, 2012.
[89] S. P. Corgnati, E. Fabrizio, M. Filippi, and V. Monetti, "Reference buildings for cost optimal analysis: Method of definition and application," *Appl. Energy*, vol. 102, pp. 983–993, 2013.
[90] S. Attia, "Spatial and Behavioral Thermal Adaptation in Net Zero Energy Buildings: An Exploratory Investigation," *Sustainability*, vol. 12, no. 19, p. 7961, 2020.
[91] M. I. Abreu, R. A. de Oliveira, and J. Lopes, "Younger vs. older homeowners in building energy-related renovations: Learning from the Portuguese case," *Energy Rep.*, vol. 6, pp. 159–164, 2020.
[92] R. Das, R. Richman, and C. Brown, "Demographic determinants of Canada's households' adoption of energy efficiency measures: observations from the Households and Environment Survey, 2013," *Energy Effic.*, vol. 11, no. 2, pp. 465–482, 2018.
[93] M. Hamdy, K. Sirén, and S. Attia, "Impact of financial assumptions on the cost optimality towards nearly zero energy buildings–A case study," *Energy Build.*, vol. 153, pp. 421–438, 2017.

Appendices

Appendix 1: List of buildings of typology A and B

Archtype a (1945-1969)			
N° Hec	Address (rue incl. nom de ville)	Postal code	Type of visit
1a	Antoine de Preterlaan, Kalmthout	2920	Real
2a	Guido Gezellelaan, Kalmthout	2920	Real
3a	Begoniapad, Knokke-Heist	8301	Real
4a	Oud-Strijdersstraat, Knokke-Heist	8301	Real
5a	Korenbloemdreef, Knokke-Heist	8301	Real
6a	Henri Pitterylaan, De Haan	8420	
7a	Sint-Lucaslaan, Antwerpen	2180	Real
8a	Sint-Lucaslaan, Antwerpen	2180	Real
9a	Vinkenstraat, Dessel	2480	Real
10a	Vinkenstraat, Dessel	2480	Real
11a	Kijsberg, Dessel	2480	Real
12a	Kijsberg, Dessel	2480	Real
13a	Kijsberg, Dessel	2480	Real
14a	Dennenstraat, Overpelt	3900	Real
15a	Heggekapel, Lille	2275	Real
16a	Stationsstraat, Damme	8340	Real
17a	De Hassels, Mol	2400	Real
18a	Hoge Blokkenlaan, Olen	2250	Real
19a	Lûbeckstraat, Gent	9000	
20a	Lûbeckstraat, Gent	9000	
21a	Olmstraat, Sint-Katelijne-Waver	2860	Real
22a	Schoonderbeuk enweg, Aarschot	3202	Real
23a	Pastoor Breemanslaan, Lanaken	3621	Real
24a	Groendreef, Waregem	8790	Real
25a	Augustijnenstraat, Ypres	8900	
26a	Reigerlaan, Zaventem	1933	Real
27a	Astridlaan, Dilbeek	1700	Real

28a	Avenue Marie la Misérable, Woluwe-Saint-Lambert	1200	Real
29a	Rue du Fer à Cheval, Wezembeek-Oppem	1970	Real
30a	Sportlaan, Dilbeek	1700	Real
31a	Avenue des Aucubuas, Kraainem	1950	Real
32a	Avenue du Bois Soleil, Kraainem	1950	Real
33a	Avenue du Bois Soleil, Kraainem	1950	Real
34a	Avenue des Jockeys, Woluwe-Saint-Pierre	1150	Real
35a	Wielewaallaan, Kortrijk	8500	Real
36a	Rinkes / Mieke Merellaan, Kortrijk	8500	Real
37a	Memlingdreef, Overijse	3090	Real
38a	Avenue Nouvelle, Genappe	1472	Real
39a	Rue de la Chênaie, Chaudfontaine	4050	Real
40a	Rue des Clématites, Neupré	4121	Real
41a	Rue Charles Bouvier, Namur	5004	Real
42a	Rue De l'Europe, Jemeppe-sur-Sambre	5190	Real
43a	Avenue des Acacias, Mons	7022	Real
44a	Chemin Vert, Fontaine-L'évêque	6142	Real

Architype b (1970-1990)			
N° Hec	Address (rue incl. nom de ville)	Postal code	Type of visit
1b	Middelburgs, Antwerpen	2040	Real
2b	Eikendreef, Vosselaar	2350	Real
3b	Unnamed, Le coq	8421	
4b	Unnamed, Le coq	8421	
5b	Unnamed, Le coq	8421	
6b	Grotestraat, De Haan	8421	
7b	Grotestraat, De Haan	8421	
8b	Grotestraat, De Haan	8421	
9b	Bremstraat, Dessel	2480	Real
10b	Knodbaan, Ranst	2520	Real

11b	Knodbaan, Ranst	2520	Real
12b	Lepelaarstra	8400	Real
13b	Burgemeester Sabotlaan, Damme	8340	Real
14b	Gesneuveldenstr, Westerlo	2260	Real
15b	Struikheide, Heist-op-den-Berg	2221	Real
16b	Hagewijkpark, Dendermonde	9200	Real
17b	De Huttestraat, Houthalen-Helchteren	3530	Real
18b	De Huttestraat, Houthalen-Helchteren	3530	Real
19b	Rosalialaan, Lichtervelde	8810	Real
20b	Omlooplaan, Genk	3600	Real
21b	Omlooplaan, Genk	3600	Real
22b	Berreweide, Londerzeel	1840	Real
23b	Lorkenstraat, Hasselt	3510	Real
24b	Léon Boereboomlaan, Zaventem	1930	Real
25b	Het Moeleke, Bertem	3060	Real
26b	Streeklaan, Bertem	3060	Real
27b	Blankenheimlaan, Zaventem	1932	Real
28b	Panoramalaan, Tervuren	3080	Real
29b	Panoramalaan, Tervuren	3080	Real
30b	Hoogveld, Anzegem	8570	Real
31b	Biestlaan, Menen	8930	Real
32b	Sterrebeeldlaan, Overijse	3090	Real
33b	Rue du Calvaire, Mouscron	7700	Real
34b	Smoutmolen, Sint-Genesius-Rode	1640	Real
35b	Avenue des Tourterelles, Rixensart	1330	Real
36b	Laudel Asbl Clos des Primevères, Wavre	1300	Real
37b	Résidence de la Marlière, Frasnes-lez-Anvaing	7910	Real
38b	Rue du Prince de Liège, Gerpinnes	6280	Real

Appendix 2: Letter of introduction Dutch version

Huisnummer* : Kavel nummer :

*Dit nummer is niet gerelateerd aan uw postadres maar aan onze database, gebruik dit nummer om het formulier in te vullen

Geachte Mevrouw, Mijnheer,

Als onderdeel van een onderzoek naar een representatief model van vrijstaande huizen in België, gebouwd tussen 1945 en 1990, voer ik een onderzoek uit onder inwoners van België. Het doel van het onderzoek is om zoveel mogelijk informatie te verzamelen over vrijstaande woningen en hun bewoners om de energie-efficiëntie van deze woningen in kaart te brengen. We nodigen u uit om deel te nemen aan onze enquête, omdat u het beste bent in het beschrijven van uw woning.

Het invullen van de vragenlijst vereist **niet meer dan 10 minuten**. De vragen zijn over uw woning en uw gewoonten in huis met als doel om informatie te verzamelen over uw energieverbruik. Uw antwoorden zijn strikt vertrouwelijk. De resultaten van de enquête worden volledig anoniem behandeld.

Om mee te werken aan deze enquête en om ons de resultaten te sturen, volgt u simpelweg de volgende link (of QR-code) en dan voltooit u de enquête direct online waar u optioneel uw kavelnummer en uw huisnummer invullen, dat ons een indicatie geeft van uw adres. Als u meer informatie wenst, kunt u contact met ons opnemen, wij zullen u zo spoedig mogelijk antwoorden.

Nederlands: https://www.eSurveysPro.com/Survey.aspx?id=d87ecd41-fb77-4b63-a1a8-fb790704a3c2

Français: https://www.eSurveysPro.com/Survey.aspx?id=7734280c-3323-47d8-b4dd-8d3d245932b7

Als u de resultaten van de enquête wenste te ontvangen, vult u dan uw e-mailadres in de online enquête.

Alvast bedankt voor uw tijd en bijdrage,

Nederland

Met vriendelijke groet.

Shady ATTIA,

PhD, Faculté de l'USGBC et professionnel accrédité LEED

Prof. d'architecture durable et de technologie du bâtiment

Responsable du Sustainable Building Design Lab (SBD)

Université de Liège.

Français

SBD Lab : Office +0/542
Quartier Polytech 1, Allée de la Découverte 13A
4000 Liège, Belgium
Tél : +32 4366 9155 - Fax : +32 4366 2909
Mail : shady.attia@uliege.be
www.sbd.ulg.ac.be

Appendix 3: Letter of introduction French version

Numéro Maison* : Numéro Hectare :

*ce numéro n'est pas en lien avec votre adresse postale mais avec notre base de données, svp utilisez ce numéro pour remplir le formulaire

Madame, Monsieur,

Dans le cadre d'une recherche visant à créer un model représentatif des maisons 4 façades en Belgique construites entre 1945 et 1990, je réalise une enquête auprès des occupants Belges. Cette dernière a pour but la collecte d'un maximum d'informations sur les logements et leurs occupants afin d'obtenir par la suite une caractérisation de l'efficacité énergétique de ces logements. Nous vous invitons à y participer car vous êtes les plus à même pour décrire votre logement.

Compléter le questionnaire ne nécessite **pas plus de 10 minutes**. Les questions interrogent uniquement votre logement et vos habitudes dans une optique de collecter des informations sur votre consommation énergétique. Vos réponses sont **strictement confidentielles**. Les résultats de l'enquête seront traités de façon totalement anonyme.

Pour réaliser l'enquête, il vous suffit de suivre le lien suivant (ou QR Code), et de compléter l'enquête directement en ligne en rentrant optionnellement votre numéro d'hectare et de maison que nous vous fournissons ou votre adresse. Si vous souhaitez plus de renseignements, vous pouvez nous contacter, nous vous répondrons dans les plus brefs délais.

Français: https://www.eSurveysPro.com/Survey.aspx?id=7734280c-3323-47d8-b4dd-8d3d245932b7

Nederlands: https://www.eSurveysPro.com/Survey.aspx?id=d87ecd41-fb77-4b63-a1a8-fb790704a3c2

Si vous souhaitez recevoir les résultats de l'enquête vous pouvez renseigner votre adresse mail dans l'enquête en ligne.

Merci de votre patience et de votre contribution,

Je vous prie d'agréer, Madame, Monsieur, l'expression de mes salutations distinguées.

Français

Shady Attia,

PhD, Faculté de l'USGBC et professionnel accrédité LEED

Prof. d'architecture durable et de technologie du bâtiment

Responsable du Sustainable Building Design Lab (SBD)

Université de Liège.

SBD Lab : Office +0/542
Quartier Polytech 1, Allée de la Découverte 13A
4000 Liège, Belgium
Tél : +32 4366 9155 - Fax : +32 4366 2909
Mail : shady.attia@uliege.be
www.sbd.ulg.ac.be

Nederland

Appendix 4: Letter of consent Dutch version

Toestemmingsformulier voor de verwerking van persoonlijke energieverbruiksgegevens

Huisnummer* : **Kavel nummer*:**

*Deze nummers zijn niet gerelateerd aan uw postadres maar aan onze database, gebruik deze nummers op de introductiebrief om het formulier in te vullen

Naam: ……………………………………………………. Voornaam: …………………………………………………….

Adres : ………..

Elektriciteitsleverancier: …………………………………. Klantnummer: ………………………………………….

Gasleverancier: ………………………………………………. Klantnummer: …………………………………………..

Mevrouw, meneer,

Met uw voorafgaande toestemming worden uw persoonlijke gegevens verzameld en gebruikt in het kader van een studie die wordt uitgevoerd in het Laboratorium voor Duurzame Architectuur van de Universiteit van Luik en die tot doel heeft het energieverbruik van vrijstaande woningen in België nauwkeurig te karakteriseren.

We kunnen de volgende gegevens verwerken en verzamelen:

- Uw naam
- Uw voornaam
- Uw verbruik en de hoogte van uw maandelijkse, seizoensgebonden en jaarlijkse elektriciteitsrekening van de afgelopen 5 jaar
- Uw verbruik en de hoogte van uw maandelijkse, seizoensgebonden en jaarlijkse gasrekening van de afgelopen 5 jaar

De Universiteit van Luik verbindt zich ertoe om enkel die persoonsgegevens te verwerken die adequaat, relevant en niet buitensporig zijn in verhouding tot de doeleinden waarvoor ze worden verzameld. Uw gegevens zullen strikt vertrouwelijk en anoniem worden behandeld.

In overeenstemming met de wet op de gegevensbescherming van 6 januari 1978 kunt u zich om legitieme redenen verzetten tegen de verwerking van uw persoonsgegevens. U kunt ten alle tijden een schriftelijk verzoek indienen en uw toestemming intrekken.

De gegevens worden bewaard voor een periode van 5 jaar vanaf de datum van ondertekening.

De gegevens zullen worden verzameld bij uw elektriciteit en gasleverancier. Zij zullen alleen aan de volgende geadresseerde worden meegedeeld: Shady ATTIA en niet worden gedeeld met derden.De heer Shady ATTIA, directeur van het laboratorium voor duurzaam bouwen van de Universiteit van Luik, is verantwoordelijk voor uw gegevens. U kunt hem per post contacteren op het volgende adres: Quartier Polytech 1, Allée de la Découverte 13A, 4000 Luik, België of per e-mail op het volgende adres: shady.attia@uliege.be

Bevestig uw akkoord door deze pagina te ondertekenen en dit document aan ons terug te sturen, bij voorkeur in elektronische vorm, naar het volgende e-mailadres: shady.attia@uliege.be

Bij deze geef ik toestemming aan Prof. Dr. Shady Attia om mijn gas en elektriciteitsgegevens te verzamelen bij mijn (bovengenoemde) gas en elektriciteit leveranciers.

Ondertekening ………………………………………… Datum …………………………………….

Appendix 5: Letter of consent French version

Formulaire de consentement du client pour le traitement de ses données personnelles de consommation énergétique

Numéro maison* : **Numéro d'hectare* :**

*ces numéros ne sont pas en lien avec votre adresse postale mais avec notre base de données, svp utilisez ces numéros présents sur la lettre d'introduction pour remplir le formulaire

Nom : ……………………………………………………. Prénom : …………………………………………………….

Adresse : ……….

Fournisseur d'électricité : ………………………………… Numéro client : ………………………………….

Fournisseur de gaz : …………………………………………. Numéro client : ………………………………….

Madame, Monsieur,

Avec votre consentement préalable, vos données personnelles seront collectées et utilisées dans le cadre d'une étude réalisée au sein du laboratoire d'architecture durable de l'université de Liège qui vise à caractériser de manière précise la consommation énergétique des bâtiments quatre façades en Belgique.

Nous serons susceptibles de traiter et collecter les données suivantes :

- Votre nom
- Votre prénom
- Votre adresse
- Votre consommation ainsi que le montant de votre facture d'électricité mensuels, saisonniers, annuels des 5 dernières années
- Votre consommation ainsi que le montant de votre facture de gaz mensuels, saisonniers, annuels des 5 dernières années

L'université de Liège s'engage à ne traiter que les données personnelles vous concernant qui sont adéquates, pertinentes et non excessives au regard des finalités pour lesquelles elles sont collectées. Conformément à la loi Informatique et Libertés du 6 janvier 1978, vous pouvez, pour des motifs légitimes vous opposer au traitement de vos données vous concernant et vous pouvez retirer à tout moment votre consentement sur simple demande.

Les données seront conservées pour une durée de 5 ans à compter de la date de la signature.

Les données seront recueillies auprès de votre fournisseur d'électricité et de gaz. Elles ne seront communiquées qu'au destinataire suivant : Shady ATTIA et ne seront pas partagée avec des tiers.

Monsieur Shady ATTIA, directeur du laboratoire sustainable building design de l'université de Liège est responsable de vos données. Vous pouvez le contacter par voie postale à l'adresse suivante : Quartier Polytech 1, Allée de la Découverte 13A, 4000 Liège, Belgique ou par courrier électronique à l'adresse suivante : shady.attia@uliege.be

Veuillez confirmer votre accord, en apposant votre signature sur cette page et en nous renvoyant ce document, de préférence sous format électronique à l'adresse mail suivante : shady.attia@uliege.be

Signature ……………………………………… Date ………………………………….

Appendix 6: Field survey Dutch version

Huis Nr.*   Hectare N°   F / W / B   Datum :

*Dit nummer is niet gerelateerd aan uw postadres maar aan onze database, gebruik dit nummer om het formulier in te vullen

Adres :   Leeftijd :

0 Audit

Vraag 1. Uw bent : eigenaar ☐ vruchtgebruiker ☐ huurder ☐

Dak :

Vraag 2. Oppervlakte:

Vraag 3. Dakoriëntatie : Plat ☐ Helling ☐

Vraag 4. Dakbedekking : Leisteen ☐ Dakpannen ☐ Bitumen / EPDM ☐

kunstleien ☐ Anders____________

Gevel :

Vraag 5. Oppervlakte :

Vraag 6. Gevel Bekleding : Crépi ☐ Mortel ☐ Baksteen ☐

Bekleding en Hout ☐ Steen ☐ Composite ☐ Anders________

Vraag 6.b. Gevelkleur (indien crépi of baksteen): ________

Verdiepingen :

Vraag 7. Aantal : 1 ☐ 2 ☐ 3 ☐

Vraag 8. Zolder : Ja ☐ Nee ☐

Raam + Raamkozijn :

Vraag 9. Oppervlakte : ________

Vraag 10. Type beglazing Enkel ☐ Dubbel ☐ Triple ☐

Vraag 11. Ventilatierooster in Raamkozijn: Ja ☐ Nee ☐

Vraag 12. Materiaal Raamkozijnen: Hout ☐ Aluminium ☐ PVC ☐

Vraag 13 Zonwering: Ja ☐ Nee ☐

Vraag 13.b. Rolluiken: Ja ☐ Nee ☐

Vraag 13.c. Gordijnen : Ja ☐ Nee ☐

Vraag 13.d. Ander systeem :

Schoorsteen :

Vraag 14. Schoorsteen : Ja ☐ Nee ☐

Vraag 15. Type : Steen ☐ Inox ☐

Foto :

Vraag 16. Foto : Ja ☐ Nee ☐

Vraag 17. Zonnepanelen : Ja ☐ Nee ☐

Vraag 17.b. Zo ja, oppervlakte (in m2): ________

Vraag 18. Zonwering : Ja ☐ Nee ☐

Vraag 18.b. Zo ja, oppervlakte (in m2): ________

Vraag 19. VELUX: Ja ☐ Nee ☐

Vraag 20. Mazout voeding: Ja ☐ Nee ☐

Geometrie :

- **Garage**

Vraag 21. Garage: Ja ☐ Nee ☐

Vraag 21.b. Zo ja, locatie van de garage:

Ondergronds ☐ Onderdeel van het bouwvolume ☐

Vrijstaand ☐ Carport ☐

Vraag 21.c. Zo ja, oppervlakte van de garage (in m2): ________

- **Veranda**

Vraag 22. Veranda: Ja ☐ Nee ☐

Vraag 22.b. Zo ja, veranda oppervlak: Ja ☐ Nee ☐

- **Uitbreiding**

Vraag 23. Uitbreiding: Ja ☐ Nee ☐

Zo ja, soort uitbreiding:

Vraag 23.b. Etage: Ja ☐ Nee ☐

Vraag 23.c. Toevoeging van een nieuw onderdeel: Ja ☐ Nee ☐

Vraag 23.d. Uitbreiding van een bestaand deel: Ja ☐ Nee ☐

- **Kelder**

Vraag 24. Kelder: Ja ☐ Nee ☐

1 Algemene Karakteristieken

Vraag 25. Gasleverancier: ___________

Vraag 26. Elektriciteitsbedrijf: ___________

Heb je een slimme meter? Ja ☐ Nee ☐

Zo ja, sinds wanneer? ___________

Type verwarmingssysteem :

Vraag 27. Brandstof ☐ Gas ☐ Elektriciteit ☐ Hout ☐ Biomassa ☐

Thermische zonnesystem ☐ Onbekend ☐ ☐ Anders___________

Vraag 27.b. Soort gas: Rijkelijk ☐ Gebrekkig ☐

Vraag 27.c. Wat is uw verwarmingssysteem ?

Radiator ☐ Vloerverwarmingssysteem ☐ Elektrische verwarming ☐

Warmtepomp ☐ Kachel ☐

Brandstof Warmwater Systeem:

Vraag 28. Brandstof ☐ Gas ☐ Elektriciteit ☐ Hout ☐

Thermische zonnepanelen ☐ Onbekend ☐ Anders___________

Ventilatie:

Vraag 29. Wat is uw ventilatiesysteem?

Systeem A ☐ Systeem B☐ Systeem C ☐ Systeem D ☐

PEB :

Vraag 30. Het Energie label (EPB) van uw woning is momenteel:

A B C D E F G Onbekend

Oppervlakte :

Vraag 31. Totale oppervlakte van de woning: ________

Elektriciteitsrekening:

Vraag 32. De elektriciteitsrekening van het huishouden bedraagt :

- minder dan 500€
- Tussen 500€ en 1000€
- Meer dan 1000€
- ___________€
- Weet ik niet
- Wenst geen commentaar te geven

Verwarmingsrekening:

Vraag 33. De verwarmingskosten van het huishouden bedragen (per jaar):

- Minder dan 1000 €
- Tussen 1000 € en 2000 €
- ________€________L
- Weet ik niet
- Wenst geen commentaar te geven

- Meer dan 2000 €

Inkomensbereik

Vraag 34. Inkomensbereik(/maand):

- 0 à 1000 €
- 1000 à 2000 €
- 2000 € à 3000 €
- 3000 à 4000 €
- 4000 à 5000 €
- + 5000 €
- Wenst geen commentaar te geven

Aantal bewoners :

Vraag 35. Aantal bewoners van het huis : 1☐ 2☐ 3☐ 4☐ 5☐ 6☐

2 Renovatie

Vraag 36. Gerenoveerd gebouw: Licht (systeem) ☐ Ingrijpend energetische (gevel)☐

Vraag 37. Aankoopdatum Verwarmingssysteem: ___________ Onbekend ☐

Vraag 38. Aankoopdatum Warmwater Systeem: __________ Onbekend ☐

Vraag 39. Ventilatie: enkele stroom ☐ dubbele stroom ☐ Geen ☐

Vraag 40. Datum vervanging raamkozijnen: ________ niet vervangen ☐ Onbekend ☐

- **Dak**

Vraag 41. Datum dak isolatie: ________ Niet afgezonderd ☐ Onbekend ☐

Vraag 41.b. Dakisolatie dikte: ________ Onbekend ☐

- **Vloer**

Vraag 42. Datum vloer isolatie: ________ Niet geïsoleerd ☐ Onbekend ☐

Vraag 42.b. Dakisolatie Vloer: ________ Onbekend ☐

- **Muur**

Vraag 43. Datum isolatie Muur: ________ Niet geïsoleerd ☐

Vraag 43.b. Dakisolatie Vloer: ________ Onbekend ☐

3 Aanwezigheid bewoners

Vraag 44. Hoeveel kamers verwarmd u in uw woning: ________

Weekdagen :

Vraag 45. Aantal inwoners aanwezig gedurende de dag: ________

Vraag 46. Wat is de vertrektijd en terugkom tijd van de inwoners die gedurende de dag afwezig zijn: ________

Vraag 47. Zijn deze tijden wisselend gedurende de weekdagen?

Ja ☐ Nee ☐

Weekend :

Vraag 48. Aantal inwoners aanwezig gedurende de dag: ________

Vraag 49. Wat is de vertrektijd en terugkom tijd van de inwoners die (een deel van) de dag afwezig zijn: ________

4 Elektrische apparatuur en Verlichting

Vraag 50. Wasdroger: Ja ☐ Nee ☐

Vraag 51. Friteuse: Ja ☐ Nee ☐

Vraag 52. Extra verwarming system Ja ☐ Nee ☐

Vraag 53. Verlichtingstype: LED ☐ Compacte tl-lamp ☐ Halogeen ☐

Neon ☐ Gloeilamp ☐

Vraag 53.b. Gemiddeld aantal Watt verlichting: ________

25 W ☐ 50 W ☐ 75 W ☐ 100 W ☐ 125 W ☐ 150 W ☐

Vraag 53.c. Hoeveel uur zijn de lichten gemiddeld aan?

Woonkamer: _____________

Eetkamer: _____________

Huis: _____________

5 Comfort

Het doel van de enquête in deze sectie is het verzamelen van de realtime meting van thermische comfortparameters en thermische comfortreacties van de bewoners van de natuurlijk geventileerde, mixed-mode en ruimtegeconditioneerde woongebouwen, volgens de CEN16798 en ASHRAE 55-2020 klasse II-protocol.

5A. Sociaal-demografische details
1. Leeftijd: _ Onder 18 _ 18-29 _ 30-39 _ 40-49 _ 50-59 _ 60-69 _ 70 en hoger
2. Geslacht: _ Vrouw _ Man _ Transgender _ Zeg ik liever niet
3. Hoogte (cm): _____________
4. Gewicht (kg): ____________________
5. BMI (kg/m2): ___________
6 Onderwijs:_ Secundair _ Senior Secundair_ Afstuderen _ Na afstuderen _ Doctoraat _ Diploma _ Overige:_________
7 Inkomensgroep: Laag _ Lager midden _ Midden _ Hoger midden _ Hoog

Temperatuur in de woning:

Vraag 54. Welke temperatuur stelt u in voor de woonkamer tijdens de winter: ______

Vraag 55. Welke temperatuur stelt u in voor de slaapkamer tijdens de winter: ______

Vraag 56. Hoe lang is de verwarmingsperiode in maanden : ______

Vraag 57. Hoeveel uuren verwarmt u uw huis per dag (gemiddeld)?

Woonkamer: _____________

Eetkamer: _____________

Huis: _____________

Vraag 58. Is de temperatuur in uw huis gecontroleerd:

- ☐ Nee, ik kan de temperatuur binnenshuis niet controleren.
- ☐ Ja, via een manuele thermostaat
- ☐ Ja, via een programmeerbare thermostaat
- ☐ Ja, via een buitenvoeler zonder thermostaat
- ☐ Ja, via een buitenvoeler en een thermostaat

Vraag 59. Airconditioning: Ja ☐ Nee ☐

Vraag 59.b. Zo ja, aantal airconditioners: _______________

Vraag 59.c. Zo niet, wilt u dan een airconditioningsysteem installeren? Ja ☐ Nee ☐

Vraag 59.d. Zo niet, wat houdt je dan tegen? _______________

Vraag 59.e. Zo ja, heeft u om een schatting gevraagd? Ja ☐ Nee ☐

Vraag 60. Buitenzonwering? Ja ☐ Nee ☐

Vraag 60.b. Zo niet, wilt u dan zonwering installeren? Ja ☐ Nee ☐

Vraag 60.c. Zo niet, wat houdt je dan tegen? _______________

Vraag 60.d. Zo ja, heb je om een schatting gevraagd? Ja ☐ Nee ☐

Vraag 61. Voelt u zich oncomfortabel tijdens de zomer? Ja ☐ Nee ☐

Vraag 62. Voelt u zich oncomfortabel tijdens de winter? Ja ☐ Nee ☐

<u>Ventilatie & Luchtkwaliteit:</u>

Vraag 63. Ruikt u onaangename geuren bij u in de woning? Ja ☐ Nee ☐

Vraag 64. Voelt u een hoge luchtvochtigheid in uw woning? Ja ☐ Nee ☐

Vraag 65. Heeft u schimmelproblemen in uw huis? Ja ☐ Nee ☐

Vraag 66. Heeft u condensatie aan de binnenkant van de ramen? Ja ☐ Nee ☐

Vraag 67. Zijn de vloeren koud in de winter? Ja ☐ Nee ☐

5B. Subjectief Thermisch Comfort in het Winter

Hoe beoordeelt u in het algemeen het thermisch comfort van het gebouw in de winter?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Winter seizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de woonkamer in de winter?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Winter seizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de slaapkamer in de winter?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Winter seizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de keuken in de winter?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Winter seizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de badkamer in de winter?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Winter seizoen							

5C. Subjectief Thermisch Comfort in het Zomer

Hoe beoordeelt u in het algemeen het thermisch comfort van het gebouw in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van het gebouw in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de woonkamer in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de slaapkamer in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de keuken in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

Hoe beoordeelt u in het algemeen het thermisch comfort van de badkamer in de zomer?

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Zomerseizoen							

5D. Subjectief Thermisch Comfort in het Winter

Op basis van de 'temperatuur' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'luchtbeweging' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van de 'vochtigheid' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van de 'temperatuur' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'luchtbeweging' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'vocht' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

5E. Subjectief Thermisch Comfort in het Zomer

Op basis van de 'temperatuur' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'luchtbeweging' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van de 'vochtigheid' in mijn slaapkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud

Ochtend							
Middag							
Avond							
Nacht							

Op basis van de 'temperatuur' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'luchtbeweging' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

Op basis van 'vocht' in mijn woonkamer op dit moment voel ik:

	Heet	Warm	Enigszins warm	Neutraal	Enigszins koel	Koel	Koud
Ochtend							
Middag							
Avond							
Nacht							

5F. Persoonlijke comfortvariabelen

Kleding: Ik draag de volgende kleding in de winter.

	T-Shirt	Shirt met korte mouwen	Shirt met lange mouwen	Katoenen blouse	Polyester Blouse	Wollen Jas	Trui/ Pullover	Thermal Top	Thermal Lower	Pyjama	Jeans	Shorts/ Short Rok	Trouser/ Long Rok	Sjaal/ Wollen Pet	Sandalen/ Pantoffels	Sokken/ Schoenen	Overige
Ochtend																	
Middag																	
Avond																	
Nacht																	

Kleding: Ik draag de volgende kledingstukken in de zomer.

	Singlet	T-Shirt	Shirt met korte mouwen	Katoenen blouse	Polyester Blouse	Pyjama	Jeans	Shorts/ Short Rok	Broek/ Lang Rok	Sandalen/ Pantoffels	Sokken/ Schoenen	Overige
Ochtend												
Middag												
Avond												
Nacht												

Metabolische activiteit: Ik doe de volgende activiteiten in de winter.

	Slapen	Zittend (actief werk)	Zittend (passief werk)	Staan Ontspannen	Staand Werken	Lopen Binnen	Buiten wandelen	Anderen (specificeren)
Ochtend								
Middag								
Avond								
Nacht								

Metabolische activiteit: Ik doe de volgende activiteiten in de zomer.

	Slapen	Zittend (actief werk)	Zittend (passief werk)	Staan Ontspannen	Staand Werken	Lopen Binnen	Buiten wandelen	Anderen (specificeren)
Ochtend								
Middag								
Avond								
Nacht								

Heeft u tijdens de winter warme/koude delen in uw lichaam? (schrijf 'H' voor warm en 'C' voor koud)

	Gezicht	Nek	Handen	Armen	Rug	Borst	Benen	Voeten
Ochtend								
Middag								
Avond								
Nacht								

Heeft u in de zomer warme/koude delen in uw lichaam? (schrijf 'H' voor warm en 'C' voor koud)

	Gezicht	Nek	Handen	Armen	Rug	Borst	Benen	Voeten
Ochtend								
Middag								
Avond								
Nacht								

Hoe ril jij in de winter? (schrijf 'H' voor rillen)

	Geen rillingen	Een beetje rillen	Matig rillen	Overvloedig rillen
Ochtend				
Middag				
Avond				
Nacht				

Hoe wordt uw productiviteit beïnvloed door de omgevingsomstandigheden?

	Veel hoger	Iets hoger	Geen verandering	Iets lager	Veel lager
Ochtend					
Middag					
Avond					
Nacht					

Hoe zweet jij in de zomer? (schrijf 'W' voor zweten)

	Niet zweten	Een beetje zweten	Matig zweten	Overmatig zweten
Ochtend				
Middag				
Avond				
Nacht				

Hoe wordt uw productiviteit beïnvloed door de omgevingsomstandigheden?

	Veel hoger	Iets hoger	Geen verandering	Iets lager	Veel lager
Ochtend					
Middag					
Avond					
Nacht					

5G. Omgevingscontrolevariabelen

Welke adaptieve acties had u nu kunnen ondernemen als u het warm of koud had?

	Rusten	Dingen minder doen krachtig	van houding veranderen	Binnen/weg blijven van luchtige plaatsen	Direct vermijden zonlicht	Wegblijven uit warme gebieden	Direct vermijden zonlicht	Handventilator gebruiken	Verwijderen/Toevoegen kledinglagen	Haar opbinden	Warm/koud drinken dranken	Handspoeling en gezicht	Warm blijven plaatsen	Dichtbij verhuizen direct zonlicht	Kleding Wisselen	Wandelen binnen	Wandelen buiten	Overige
Ochtend																		
Middag																		
Avond																		
Nacht																		

Gebruikt u de volgende natuurlijke ventilatieregelingen?

_ Ramen _ Buitendeuren _ Balkondeuren _ Jaloezieën/gordijnen

Zijn deze nu "open" of "dicht"?

	Ramen	Buitendeuren	Balkondeuren	Jaloezieën/ Gordijnen
Ochtend				
Middag				
Avond				
Nacht				

Welke problemen ondervindt u bij het gebruik van deze natuurlijke ventilatieregelingen? (vink aan wat van toepassing is)

	Ramen	Buiten deuren	Balkondeuren	Jaloezieën/ Gordijnen
Buitenluchtkwaliteit				
Stof				

Lawaai				
Slechte geur				
Verlies van privacy				
Beveiliging				
Muggen				
Regenwater komt naar binnen				
Niet-beschikbaarheid van controle				
anderen				

Gebruikt u de volgende omgevingscontroles?

_ Plafondventilatoren _ Verdampingskoelers _ Staande ventilatoren _ Kamerverwarming_Kamerkoeling _ Luchtzuiveringssysteem

Zijn deze nu "aan" of "uit"?

	Plafondventilatore n	Verdampingskoelin g	Staande ventilatore n	Kamerverwarmin g	Kamerkoelin g	Luchtzuiveringssystee m
Ochten d						
Middag						
Avond						
Nacht						

Appendix 7: Field survey French version

Maison N°*   Hectare N°   F / W / B   Date:

*ce numéro n'est pas en lien avec votre adresse postale mais avec notre base de données, svp utilisez ce numéro pour remplir le formulaire

Adresse :   Age :

0 Audit

Question 1. Vous êtes : Propriétaire ☐ Usufruitier ☐ Locataire ☐

Toiture :

Question 2. Surface : __________

Question 3. Orientation toiture : Plat ☐ Pente ☐

Question 4. Revêtement toiture :

Ardoise ☐ Tuile ☐ Tuile de roofing ☐ Ardoise artificielle ☐ Autre__________

Enveloppe :

Question 5. Surface : __________

Question 6. Revêtement : Crépi ☐ Enduit ☐ Brique ☐
Bardage en bois ☐ Pierre ☐ Composite ☐ Autre_________

Question 6.b. Couleur façade (si crépi ou brique) : _________

Etage :

Question 7. Nombre : 1 ☐ 2 ☐ 3 ☐

Question 8. Etage sous-comble : Oui ☐ Non ☐

Châssis + store :

Question 9. Surface : __________

Question 10. Type de vitrage : Simple ☐ Double ☐ Triple ☐

Question 11. Châssis ventilé : Oui ☐ Non ☐

Question 12. Matériau du châssis : Bois ☐ Aluminium ☐ PVC ☐

Question 13. Store : Oui ☐ Non ☐

Question 13.b. Volet : Oui ☐ Non ☐

Question 13.c. Rideau : Oui ☐ Non ☐

Question 13.d. Autre système : _____________

Cheminée :

Question 14. Cheminée : Oui ☐ Non ☐

Question 15. Type : Pierre ☐ Inox ☐

Photo :

Question 16. Photo : Oui ☐ Non ☐

Question 17. Photovoltaïque : Oui ☐ Non ☐

Question 17.b. Si oui, surface (en m2) : _________

Question 18. Panneaux solaires thermiques : Oui ☐ Non ☐

Question 18.b. Si oui, surface (en m2) : _________

Question 19. Velux : Oui ☐ Non ☐

Question 20. Alimentation mazout : Oui ☐ Non ☐

<u>Géométrie :</u>

- **Garage**

Question 21. Garage : Oui ☐ Non ☐

Question 21.b Si oui, emplacement du garage :

Sous-sol ☐ Mitoyen (« collé à l'habitat ») ☐ Indépendant ☐ Carport ☐

Question 21.c Si oui, surface du garage (en m2): _________

- **Véranda**

Question 22. Véranda : Oui ☐ Non ☐

Question 22.b. Si oui, surface véranda (en m2) : _________

- **Extension**

Question 23. Extension : Oui ☐ Non ☐

Si oui, type d'extension :

Question 23.b. Etage Oui ☐ Non ☐

Question 23.c. Ajout d'une nouvelle pièce Oui ☐ Non ☐

Question 23.d. Allongement d'une pièce existante Oui ☐ Non ☐

- **Cave**

Question 24. Cave : Oui ☐ Non ☐

1 Caractéristiques Générales

Question 25. Fournisseur de gaz : ___________

Question 26. Fournisseur d'électricité : ___________

Disposez-vous d'un compteur intelligent ? Oui ☐ Non ☐

Si oui, depuis quand ? ___________

Type d'énergie chauffage :

Question 27. Fuel ☐ Gaz ☐ Electricité ☐ Bois ☐ Biomasse ☐

Solaire Thermique ☐ Inconnu ☐ Autre___________

Question 27.b. Nature du gaz : Riche ☐ Pauvre ☐

Question 27.c. Quel est votre système de chauffage ?

Radiateur ☐ Chauffage au sol ☐ Chauffage électrique ☐

Pompe à chaleur ☐ Poêle ☐

Type d'énergie ECS :

Question 28. Fuel ☐ Gaz ☐ Electricité ☐ Bois

Solaire Thermique ☐ Inconnu ☐ Autre___________

Ventilation

Question 29. Quel est votre système de ventilation :

Système A ☐ Système B ☐ Système C ☐ Système D ☐

PEB :

Question 30. Le label PEB de votre logement est actuellement de :

A B C D E F G Inconnu

Surface :

Question 31. Superficie totale du logement : ____________

Facture électricité :

Question 32. A combien s'élève la facture d'électricité du ménage :

- Moins de 500€
- Entre 500€ et 1000€
- Plus de 1000€
- ________€
- Ne sait pas
- Ne souhaite pas se prononcer

Facture chauffage :

Question 33. A combien s'élève la facture de chauffage du ménage :

- Moins de 1000 €
- Entre 1000 € et 2000 €
- Plus de 2000 €
- ________€________L
- Ne sait pas
- Ne souhaite pas se prononcer

Gamme de revenu

Question 34. Gamme de revenu (/mois):

- 0 à 1000 €
- 1000 à 2000 €
- 2000 à 3000 €
- 3000 à 4000 €
- 4000 à 5000 €
- + 5000 €

Nombres d'occupants :

Question 35. Nombre d'occupant dans la maison : 1☐ 2☐ 3☐ 4☐ 5☐ 6☐

2 Rénovation

Question 36. Bâtiment rénové : Légèrement (système) ☐ Approfondie (enveloppe) ☐

Question 37. Date achat système Chauffage : ____________ ☐ Inconnu

Question 38. Date achat système Chauffage ECS : ___________ ☐ Inconnu

Question 39. Ventilation : Simple flux ☐ Double flux ☐ Aucune ☐

Question 40. Date rénovation châssis des fenêtres : Pas isolé ☐ Inconnu ☐

- **Toiture**

Question 41. Date isolation Toiture : ____________ Pas isolé ☐ Inconnu ☐

Question 41.b. Epaisseur isolation Toiture : _________ Inconnu ☐

- **Sol**

Question 42. Date isolation sol : ____________ Pas isolé ☐ Inconnu ☐

Question 42.b. Epaisseur isolation sol : __________ Inconnu ☐

- **Mur**

Question 43. Date isolation Mur : ____________ Pas isolé ☐ Inconnu ☐

Question 43.b. Epaisseur isolation Mur : __________ Inconnu ☐

3 Occupation

Question 44. Nombre de pièce non chauffée dans votre logement : __________

Semaine :

Question 45. Nombre d'occupant présent toute la journée : __________

Question 46. Horaire de départ et retour des occupants absents une partie de la journée : __________

Question 47. Ces horaires sont-elles valables tous les jours de la semaine ?

Oui ☐ Non ☐

Weekend :

Question 48. Nombre d'occupant présent toute la journée : __________

Question 49. Horaire de départ et retour des occupants absents une partie de la journée :

____

4 Appareils électriques & éclairage

Question 50. Sèche-linge : Oui ☐ Non ☐

Question 51. Friteuse : Oui ☐ Non ☐

Question 52. Chauffage d'appoint : Oui ☐ Non ☐

Question 53. Type d'éclairage : LED ☐ Lampe fluorescente compact ☐ Néon ☐ Halogène ☐ Lampe à incandescence ☐

Question 53.b. Puissance moyenne des ampoules :

25 W ☐ 50 W ☐ 75 W ☐ 100 W ☐ 125 W ☐ 150 W ☐

Question 53.c. Combien d'heures les lampes sont-elles allumées ?

Living-room: _________

Salle à manger: _________

Chambre: _________

5 Confort

Le but des questions de cette section est de rassembler la mesure en temps réel des paramètres de confort thermique et des réponses de confort thermique des occupants des bâtiments résidentiels à ventilation naturelle, à mode mixte et climatisés, conformément aux normes CEN16798 et ASHRAE 55-2020. protocole de classe II.

5A. Détails socio-démographiques
1. Âge: _ Moins de 18 ans _ 18≤29 _ 30≤39 _ 40≤49 _ 50≤59 _ 60≤69 _ 70 et plus
2. Sexe: _ Féminin _ Masculin _ Transgenre _ Préfère ne pas dire
3. Taille (cm): _____________
4. Poids (kg):_____________________
5. IMC (kg/m2): ___________
6 Éducation :
_ Secondaire _ Secondaire supérieur
_ Diplôme _ Post diplôme
_ Doctorat _ Diplôme _ Autres :_________
7 Groupe de revenu : Faible _ Intermédiaire inférieur _ Intermédiaire _ Intermédiaire supérieur _ Élevé

Température :

Question 54. Quelle température essayez-vous de maintenir dans votre salon en hiver : _

Question 55. Quelle température essayez-vous de maintenir dans votre chambre en hiver : _

Question 56. Quelle est la durée de la période de chauffage en mois : _

Question 57. Combien d'heure chauffez-vous votre logement ?

Living room : __________

Chambre : __________

Salle à manger : __________

Question 58. Est-ce que la température de votre logement est contrôlée :

- ☐ Non, je ne peux pas contrôler la température intérieure
- ☐ Oui, via un thermostat manuel
- ☐ Oui, via un thermostat programmable
- ☐ Oui, via une sonde extérieure sans thermostat
- ☐ Oui, via une sonde extérieure et un thermostat

Question 59. Air conditionné : Oui ☐ Non ☐

Question 59.b. Si oui, nombre d'unité de climatisation intérieure : __________

Question 59.c. Si non, souhaitez-vous installer un système d'air conditionné ?

Oui ☐ Non ☐

Question 59.d. Si non, qu'est-ce qui vous en empêche ? ________________

Question 59.e. Si oui, avez-vous demandé un devis ? Oui ☐ Non ☐

Question 60. Protection solaire extérieure ? Oui ☐ Non ☐

Question 60.b. Si non, souhaitez-vous installer un système de protection solaire ?

Oui ☐ Non ☐

Question 60.c. Si non, qu'est-ce qui vous empêche ? ________________

Question 60.d. Si oui, avez-vous demandé un devis ? Oui ☐ Non ☐

Question 61. Ressentez-vous un inconfort de température en été ? Oui ☐ Non ☐

Question 62. Ressentez-vous un inconfort de température en hiver ? Oui ☐ Non ☐

<u>Ventilation & Qualité de l'air :</u>

Question 63. Ressentez-vous des odeurs désagréables chez vous ? Oui ☐ Non ☐

Question 64. Ressentez-vous trop d'humidité chez vous ? Oui ☐ Non ☐

Question 65. Avez-vous des problèmes de moisissure dans votre maison ? Oui ☐ Non ☐

Question 66. Avez-vous de la condensation à l'intérieur des fenêtres ? Oui ☐ Non ☐

Question 67. Les sols sont-ils froids en hiver ? Oui ☐ Non ☐

5B. Confort thermique subjectif en hiver

Globalement, comment jugez-vous le confort thermique du bâtiment en hiver?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'hiver							

Globalement, comment jugez-vous le confort thermique du séjour en hiver?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'hiver							

Globalement, comment évaluez-vous le confort thermique de la chambre à coucher en hiver?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'hiver							

Globalement, comment jugez-vous le confort thermique de la cuisine en hiver?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'hiver							

Globalement, comment jugez-vous le confort thermique de la salle de bain en hiver?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'hiver							

5C. Confort thermique subjectif en été

Globalement, comment jugez-vous le confort thermique du bâtiment en été?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'été							

Globalement, comment jugez-vous le confort thermique du séjour en été?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'été							

Globalement, comment évaluez-vous le confort thermique de la chambre à coucher en été?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'été							

Globalement, comment jugez-vous le confort thermique de la cuisine en été?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'été							

Globalement, comment jugez-vous le confort thermique de la salle de bain en été?

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Saison d'été							

5D. Confort thermique subjectif en hiver

D'après la « température » dans ma chambre à coucher actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après le "mouvement d'air" dans ma chambre à coucher actuellement, je ressens:

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après "l'humidité" dans ma chambre à coucher actuellement, je ressens:

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après la "température" de mon salon actuellement, je ressens:

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après le "mouvement d'air" dans mon salon actuellement, je ressens:

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

Sur la base de "l'humidité" dans mon salon actuellement, je ressens:

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

5E. Confort thermique subjectif en été

D'après la « température » dans ma chambre à coucher actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après le "mouvement d'air" dans ma chambre à coucher actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après "l'humidité" dans ma chambre à coucher actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après la "température" de mon salon actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

D'après le "mouvement d'air" dans mon salon actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

Sur la base de "l'humidité" dans mon salon actuellement, je ressens :

	Chaud	tiède	légèrement tiède	Neutre	légèrement frais	frais	froid
Matin							
Après midi							
Soirée							
Nuit							

5F. Variables de confort personnel

Vêtements : Je porte les vêtements suivants en hiver.

	T-Shirt	Chemise à manches courtes	Chemise à manches longues	Coton Chemisier	Polyester Chemisier	Veste en laine	Pull/Pullover	Haut Thermique	Bas Thermique	Pyjama	Jeans	Shorts/ Short Jupe	Pantalon/ Longue Jupe	Echarpe/ Laine Casquette	Sandales/ Chaussons	Chaussettes/ Chaussures	Autres
Matin																	
Après midi																	
Soirée																	
Nuit																	

Vêtements : Je porte les vêtements suivants pendant l'été.

	Débardeur	T-Shirt	Chemise à manches courtes	Coton Chemisier	Polyester Chemisier	Pyjama	Jeans	Shorts/ Short Jupe	Pantalon/ Longue Jupe	Sandales/ Chaussons	Chaussettes/ Chaussures	Autres
Matin												
Après midi												
Soirée												
Nuit												

Activité métabolique : Je fais les activités suivantes pendant l'hiver.

	Dormir	Assis (travail actif)	Assis (travail passif)	Debout Détendu	Debout Travail	Marcher a l'intérieur	Marcher Extérieur	Autres (précisez)
Matin								

Après midi								
Soirée								
Nuit								

Activité métabolique : Je fais les activités suivantes pendant l'été.

	Dormir	Assis (travail actif)	Assis (travail passif)	Debout Détendu	Debout Travail	Marcher a l'intérieur	Marcher Extérieur	Autres (précisez)
Matin								
Après midi								
Soirée								
Nuit								

Avez-vous des parties chaudes/froides dans votre corps pendant l'hiver ? (écrivez 'H' pour chaud et 'C' pour froid)

	Visage	Cou	Mains	Bras	Dos	Poitrine	Jambes	Pieds
Matin								
Après midi								
Soirée								
Nuit								

Avez-vous des parties chaudes/froides dans votre corps pendant l'été ? (écrivez 'H' pour chaud et 'C' pour froid)

	Visage	Cou	Mains	Bras	Dos	Poitrine	Jambes	Pieds
Matin								
Après midi								
Soirée								
Nuit								

Comment frissonnez-vous en hiver ? (écrivez 'H' pour frissonner)

	Pas de frissons	Frissonnant légèrement	Frissonnant modérément	Frissonnant abondamment
Matin				
Après midi				
Soirée				
Nuit				

Comment votre productivité est-elle affectée par les conditions environnementales environnantes ? (cochez la case appropriée)

	Bien plus haut	Légèrement supérieur	Pas de changement	Légèrement plus bas	Beaucoup plus bas
Matin					
Après midi					
Soirée					
Nuit					

Comment transpirez-vous pendant l'été ? (écrivez 'W' pour la transpiration)

	Pas de	Transpiration	Transpiration	Transpiration

	transpiration	légère	modérée	abondante
Matin				
Après midi				
Soirée				
Nuit				

Comment votre productivité est-elle affectée par les conditions environnementales environnantes ? (cochez la case appropriée)

	Bien plus haut	Légèrement supérieur	Pas de changement	Légèrement plus bas	Beaucoup plus bas
Matin					
Après midi					
Soirée					
Nuit					

5G. Variables de contrôle environnemental

Quelles actions d'adaptation auriez-vous pu entreprendre maintenant lorsque vous vous sentiez chaud ou froid ? (cocher si applicable)

	Repos	Faire moins les choses vigoureusement	Changer de posture	Rester à l'intérieur / à l'écart des endroits aérés	Éviter les lumière du soleil	Rester à l'écart des zones chaudes	Éviter les lumière du soleil	Utilisation d'un ventilateur à main	Supprimer/Ajouter couches de vêtements	Boire chaud/froid breuvages	Rinçage des mains et visage	Rester au chaud des endroits	Se déplacer près de lumière directe du soleil	Changement de vêtements	Marcher à l'intérieur	Marcher en plein air	Les autres
Matin																	
Après midi																	
Soirée																	
Nuit																	

Utilisez-vous les commandes de ventilation naturelle suivantes ?
_ Fenêtres _ Portes extérieures _ Portes de balcon _ Stores/rideaux

Sont-ils "ouverts" ou "fermés" en ce moment ? (cocher si ouvert)

	les fenêtres	portes extérieures	portes de balcon	Stores/ Rideaux
Matin				
Après midi				
Soirée				
Nuit				

Quels problèmes rencontrez-vous lors de l'utilisation de ces commandes de ventilation naturelle ? (cocher si applicable)

	les fenêtres	portes extérieures	portes de balcon	Stores/ Rideaux

Outside Air Quality				
Dust				
Noise				
Bad Odor				
Loss of Privacy				
Security				
Mosquitoes				
Rainwater coming inside				
Non-availability of control				
Others				

Utilisez-vous les contrôles environnementaux suivants ? (cochez si oui)
_ Ventilateurs de plafond _ Refroidisseurs par évaporation _ Ventilateurs sur pied _ Chauffage de pièce_Refroidissement de pièce _ Système de purification d'air

Sont-ils "activés" ou "désactivés" en ce moment ? (cocher si activé)

	Ventilateurs de plafond	Le refroidissement par évaporation	Ventilateurs debout	Chauffage d'appoint	Systeme de Refroidissement	Système de purification d'air
Matin						
Après midi						
Soirée						
Nuit						

Appendix 8: Occupancy schedule

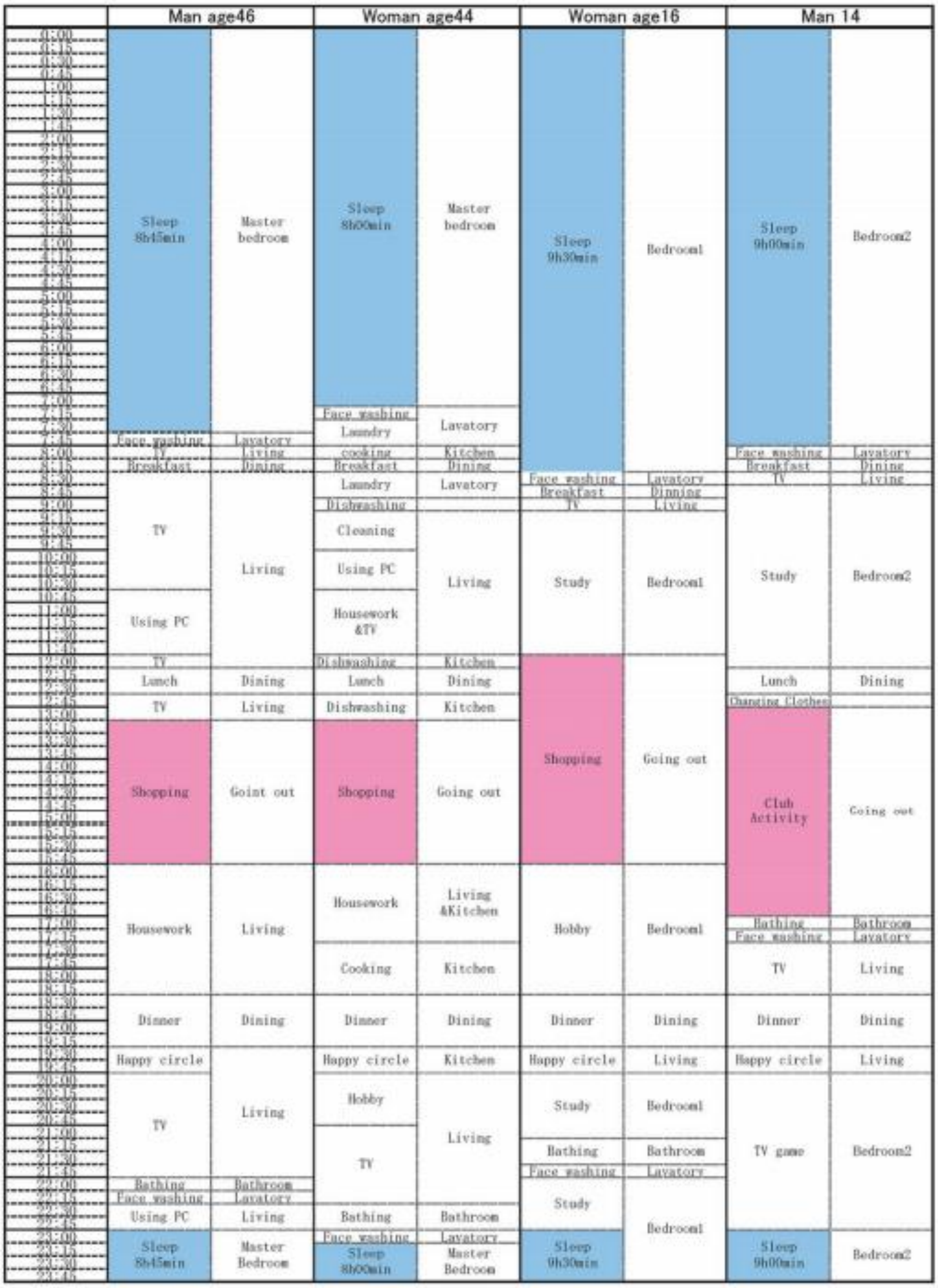


Figure A.2 – Time use for weekend

Appendix 9 : Database

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Code	N°mais	N°hect	F/W/B	Date	Age	Adresse	Propriétaire	Usufruitier	Locataire	Surface toiture	Toiture : plat	Toiture : pente	Toiture Ardoise	Toiture Tuile	Toiture Tuile de roofing (asphalte)	Toiture Ardoise artificielle	Autre revêtement toiture
2	22a0	510	22a	F	03/07/2020	1961	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
3	22a0	506	22a	F	03/07/2020	1952	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	0	1	0	
4	22a0	513	22a	F	03/07/2020	1956	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
5	22a0	500	22a	F	03/07/2020	1962	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
6	22a0	511	22a	F	03/07/2020	1961	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
7	22a0	508	22a	F	03/07/2020	1951	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
8	22a0	501	22a	F	03/07/2020	1960	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	0	1	0	
9	22a0	509	22a	F	03/07/2020	1965	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
10	22a0	507	22a	F	03/07/2020	1967	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	0	1	0	
11	22a1	512	22a	F	03/07/2020	1967	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	0	1	0	
12	22a1	505	22a	F	03/07/2020	1966	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
13	22a1	502	22a	F	03/07/2020	1967	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	1	0	0	
14	22a1	503	22a	F	03/07/2020	1966	Schoonderbeuk enweg 24-64, 3202 Aarschot					0	1	0	0	1	0	
15																		
16	23a0	348	23a	F	19/12/2018	1966	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	
17	23a0	355	23a	F	19/12/2018	1966	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	
18	23a0	347	23a	F	19/12/2018	1965	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	
19	23a0	349	23a	F	19/12/2018	1967	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	
20	23a0	343	23a	F	19/12/2018	1969	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	0	1	0	0	
21	23a0	342	23a	F	19/12/2018	1967	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	
22	23a0	352	23a	F	19/12/2018	1967	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	0	1	0	0	
23	23a0	354	23a	F	19/12/2018	1966	Pastoor Breemanslaan 15, 3621 Lanaken					0	1	1	0	0	0	

	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Enveloppe Crépi	Enveloppe Enduit	Enveloppe Brique	Enveloppe Bardage en bois	Enveloppe Pierre	Enveloppe Composite	Autres revêtement	Couleur façade blanc	Couleur façade rouge	Couleur façade gris	Couleur façade beige	1 étage	2 étages	3 étages	Etage sous comble	Surface châssis + store	Simple vitrage	Double vitrage	Triple vitrage	Chassis ventilé	Châssis Bois	Châssis Aluminium	Châssis PVC	Store	Volet	Rideau	Cheminée Pierre	Cheminée Inox	Photovoltaique	Surface Photovoltaique	Panneaux solaires thermiques	Surface Panneaux solaires thermiques
2	0	0	1	0	0	0						0	1	0	1		0	1	0	0	1	0	0	1	1	1	1	0	0			
3	0	0	1	0	0	0						0	1	0	1		0	1	0	0	1	0	0	1	1	1	1	0	0			
4	1	0	0	0	0	0						0	1	0	1		0	1	0		0	0	1	1	1	1	1	0	0			
5	0	0	1	0	0	0						0	1	0	1		0	1	0	0	1	0	0	1	1	1	1	0	0			
6	0	0	1	0	0	0						0	1	0	1		0	1	0		0	1	0	1	1	1	1	0	0			
7	0	0	1	0	0	0						0	1	0	1		0	1	0	0	1	0	0	1	1	1	1	0	0			
8	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	1	0	1	1	1	1	0	0			
9	0	0	1	0	0	0						0	1	0	1		0	1	0	0	1	0	0	0	0	1	1	0	0			
10	0	0	1	0	0	0						1	0	0	0		0	1	0	0	0	1	0	0	0	1	1	0	0			
11	0	0	1	0	0	0						1	0	0	1		0	1	0	0	0	1	0	0	0	1	0	1	0			
12	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
13	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
14	0	0	1	0	0	0						1	0	0	1		0	1	0	0	1	0	0	1	1	1	1	0	0			
15																																
16	0	0	1	0	0	0						1	0	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
17	0	0	1	0	0	0						0	1	0	1		1	0	0	0	1	0	0	1	1	1	1	0	0			
18	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
19	0	0	1	0	0	0						0	1	0	1		1	0	0	0	1	0	0	1	1	1	1	0	0			
20	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	0	0	1	1	0	0			
21	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
22	0	0	1	0	0	0						0	1	0	1		0	1	0	0	0	0	1	1	1	1	1	0	0			
23	0	0	1	0	0	0						0	1	0	1		0	1	0		0	0	1	1	1	1	0	1	0			

	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW
1	Velux	Alimentation mazout	Garage	Garage sous-sol	Garage mitoyen	Garage indépendant	Carport	Surface Garage	Véranda	Surface Véranda	Extension	Extension Etage	Extension Nouvelle pièce	Extension Allongement pièce	Cave	Fournisseur gaz	Gaz riche	Gaz pauvre	Fournisseur électricité	Energie chauffage : Fuel	Energie chauffage : Gaz	Energie chauffage : Electricité	Energie chauffage : Bois	Energie chauffage : Biomasse	Energie chauffage : Solaire thermique
2	0	1	0																	1	0	0	0	0	0
3	0	1	0																	1	0	0	0	0	0
4	0	1	0																	1	0	0	0	0	0
5	0	1	0																	1	0	0	0	0	0
6	0	1	0																	1	0	0	0	0	0
7	0	1	1																	1	0	0	0	0	0
8	0	1	1																	1	0	0	0	0	0
9	0	1	1																	1	0	0	0	0	0
10	0	1	1																	1	0	0	0	0	0
11	0	1	1																	1	0	0	0	0	0
12	0	0	0																	0	1	0	0	0	0
13	0	0	0																	0	1	0	0	0	0
14	0	1	1																	1	0	0	0	0	0
15																									
16	1	0	1																	0	1	0	0	0	0
17	1	0	1																	0	1	0	0	0	0
18	1	0	1																	0	1	0	0	0	0
19	0	0	1																	0	1	0	0	0	0
20	0	0	0																	0	1	0	0	0	0
21	0	0	1																	0	1	0	0	0	0
22	0	0	0																	0	1	0	0	0	0
23	0	1	0																	1	0	0	0	0	0

BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY
Radiateur	Chauffage au sol	Chauffage électrique	Pompe à chaleur	Poêle	Energie ECS : Fuel	Energie ECS : Gaz	Energie ECS : Electricité	Energie ECS : Bois	Energie ECS : Solaire thermique	Ventilation : Système A	Ventilation : Système B	Ventilation : Système C (simple flux)	Ventilation : Système D (double flux)	Aucune ventilation	Label PEB	Superficie totale	Facture d'électricité (€/mois)	Facture chauffage (€/an)	Revenu	1 occupant	2 occupants	3 occupants	4 occupants	5 occupants	6 occupants	Bâtiment rénové : légerement	Bâtiment rénové : approfondie
					1	0	0	0	0					1	F	220	65	2000		0	0	0	0	0	1		
					1	0	0	0	0					1	G	260	45	1400		1	0	0	0	0	0		
					1	0	0	0	0						D		25	1200		0	1	0	0	0	0	Rénové	
					1	0	0	0	0					1	F	240	45	1600		0	1	0	0	0	0		
					1	0	0	0	0					1	F		45	1300		1	0	0	0	0	0		
					1	0	0	0	0					1	F	220	55	1800		0	0	0	1	0	0		
					1	0	0	0	0					1	F	200	35	1400		1	0	0	0	0	0		
					1	0	0	0	0					1	F	195	35	1400		1	0	0	0	0	0		
					1	0	0	0	0					1	F	150	55	1800		0	0	1	0	0	0		
					1	0	0	0	0						F	120	55	1200		1	0	0	0	0	0		
					0	1	0	0	0					1	E		45	1600		0	0	0	1	0	0	Rénové	
					0	1	0	0	0					1	F	200	55	1200		1	0	0	0	0	0	Rénové	
					1	0	0	0	0					1	G	120	40	1600		0	1	0	0	0	0		
					0	1	0	0	0					1	F		50	1500		1	0	0	0	0	0		
					0	1	0	0	0					1	F		50	1500		1	0	0	0	0	0		
					0	1	0	0	0					1			60	1500		1	0	0	0	0	0		
					0	1	0	0	0					1			70	2000		1	0	0	0	0	0		
					0	1	0	0	0					1			60	2500		1	0	0	0	0	0		
					0	1	0	0	0					1	E		80	2000		0	0	1	0	0	0		
					0	1	0	0	0																		
					1	0	0	0	0					1			70	2500		1	0	0	0	0	0		

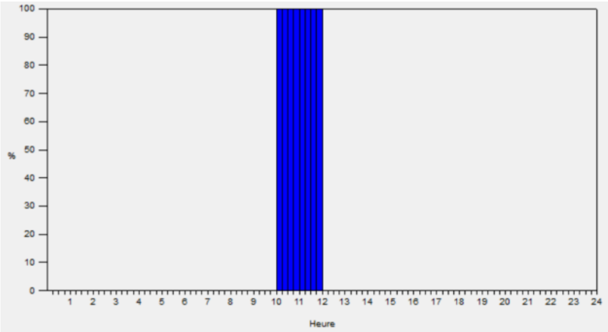
CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY
Data achat système chauffage	Date achat système chauffage ECS	Date rénovation châssis fenêtres	Date isolation toiture	Toiture pas isolée	Date isolation sol	Sol pas isolée	Date isolation mur	Mur pas isolée	Nbr pièces non chauffées	Nbr occupant présent toute la journée (semaine)	Horaire départ et retour occupant (semaine)	Horaires valables tous les jours ?	Nbr occupant présent toute la journée (week-end)	Horaire départ et retour occupant (week-end)	Sèche-linge ?	Friteuse ?	Chauffage d'appoint ?	Type d'éclairage : LED	Type d'éclairage : Lampe fluorescente compact	Type d'éclairage : Néon	Type d'éclairage : Halogène	Type d'éclairage : Lampe à incandescence	Nbr d'heure lampes allumées living room (/jour)	Nbr d'heure lampes allumées salle à manger (/jour)	Nbr d'heure lampes allumées chambre (/jour)
2000	2000		2015			1		1	0				6		1		0	1		1	0				
2000	2000					1		1		1			1		1		0	1		1	0				
2017	2017	2017	2017			1	2017			0			2		1		0	1		1	0				
2000	2000					1		1		2			2		1		0	1		1	0				
2000	2000					1		1		1			1		1		0	1		1	0				
2010	2010					1		1		1			4		1		0	1		1	0				
2001	2001					1		1		1			1		1		0	1		1	0				
2001	2001					1		1		1			1		1		0	1		1	0				
1999	1999					1		1		2			3		1		0	1		1	0				
1995	1995					1		1		1			1		1		0	1		1	0				
2017	2017					1		1	4	0			4		1		0	1		1	0				
2013	2013					1		1	2	1			1		1		0	1		1	0				
2010	2010					1		1		0			2		1		0	1		1	0				
1990	1990	2000			1995			1	3	1			1		1		0	0		1	0				
1990	1990	2000			1995			1	4	1			1		1		0	0		1	0				
1995	1995	2000			1995			1	3	1			1		1		0	0		1	0				
2000	2005					1		1	4	1	pension	pension	1		1		0	0		1	0				
2000	2005					1		1	3	1	pension	pension	1		1		0	0		1	0				
2000	2005					1		1	5	0	8h-18h	pension	2		1		0	0		1	0				
									5	0	8h-17h		3		1		0	0		1	0				
									4	1			1		1		0	0		1	0				

DZ	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM	EN	EO	EP	EQ	ER	ES	ET	EU	EV
Temp maintenu salon hiver	Temp maintenu chambre hiver	Durée période de chauffage en mois	Nbr d'heure de chauffage living room (/jour)	Nbr d'heure de chauffage chambre (/jour)	Nbr d'heure de chauffage salle à manger (/jour)	Pas contrôle de la température	Contrôle température : thermostat manuel	Contrôle température : thermostat programmable	Contrôle température : sonde exterieure sans thermosta	Contrôle température : sonde exterieure avec thermosta	Air conditionné	Nbr d'unité de climatisation intérieure	Volonté d'installer un système d'air conditionné	Protection solaire exterieure	Volonté d'installer un système de protection solaire	Inconfort de température en été	Inconfort de température en hiver	Odeurs désagreables	Humidité	Moisissure	Condensation	Sols froids
																1	0	0	0			
																0	0	0	0			
																0	0	0	0			
																0	0	0	0			
																0	0	0	0			
																1	0	0	0			
																0	0	0	0			
																0	0	0	0			
																1	0	0	0			
																0	0	0	0			
																0	0	0	0			
																0	0	0	0			
											1					1	0	0	0			
22	18															0	0	0	0			
23	16															0	0	0	0			
23	18															0	0	0	0			
23	16															0	0	0	0			
23	16															0	0	0	0			
22	16															0	0	0	0			
23	16															0	0	0	0			
23	16															0	0	0	1			

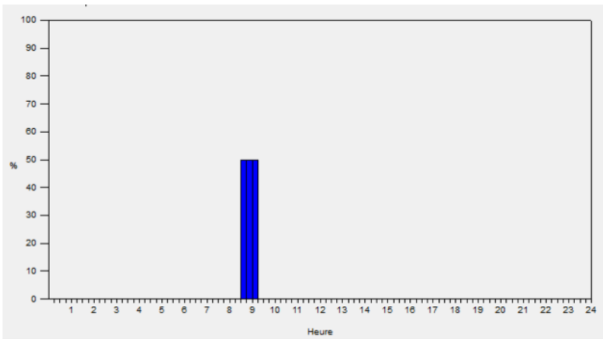
Appendix 10: Template Design Builder typology A

ACTIVITY TEMPLATE	
Template	Common circulation area
Sector	Residential space
Zone Multiplier	Default : 1
Include zone in thermal calculations	Yes
Include zone in Radiance daylighting calculations	Yes
FLOOR AREAS AND VOLUMES	
Occupied Floor Area (m2)	200,7
Occupied Volume (m3)	544,3
Unoccupied Floor Area (m2)	120,8
Unoccupied Volume (m3)	230,1
OCCUPANCY	
Density (people/m2)	0,01
Schedule	Off 24/7 (specify at room scale)
METABOLIC	
Activity	Standing relaxed
Factor	0,93
CO2 Generation Rate (m3/s-W)	3,82E-08
CLOTHING	
Winter Clothing (clo)	1- Generic summer and winter clothing
Summer Clothing (clo)	0,5
GENERIC CONTAMINANT GENERATION	
Contaminant Simulation Method	
GENERATION	
Design Generation Rate (m3/s)	
Schedule	
REMOVAL	
Design Removal Rate (m3/s)	
Schedule	
HOLIDAYS	
Holidays per Year	36
Holiday Schedule	Project Holidays Schedule
DOMESTIC HOT WATER	
Consumption Rate (l/m2-day)	0,35
ENVIRONMENTAL CONTROL	
HEATING SETPOINT TEMPERATURES	
Heating (°C)	21
Heating Set Back (°C)	0
COOLING SETPOINT TEMPERATURES	

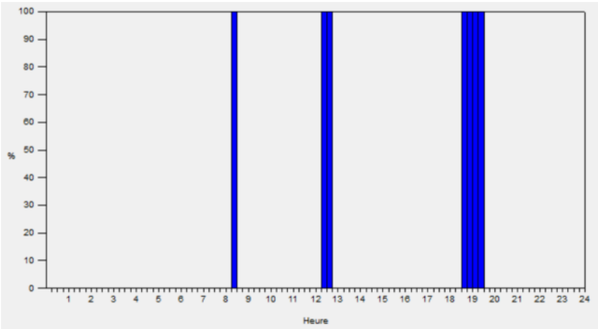
Cooling (°C)	
Cooling Set Back (°C)	
HUMIDITY CONTROL	
RH Humidification Setpoint (%)	
RH Dehumidification Setpoint (%	
NATURAL VENTILATION	
Indoor Min Temperature Definition	Yes
Min Temperature (°C)	22
Indoor Max Temperature Definition	Yes
Max Temperature (°C)	26
MINUMUM FRESH AIR	
Fresh Air (l/s-person)	
Mech Vent per area (l/s-m2)	
LIGHTING	
Target Illuminance (lux)	300
Default Display Lighting Density (W/m2)	0
COMPUTERS	
Gain (W/m2)	14,3
Schedule	OFF 24/7 (specify at room scale)
Radiant Fraction	0,22
OFFICE EQUIPEMENT	
Gain (W/m2)	
Schedule	
Radiant Fraction	
MISCELLANEOUS	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	
Radiant Fraction	
CATERING	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	
Radiant Fraction	
PROCESS	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	



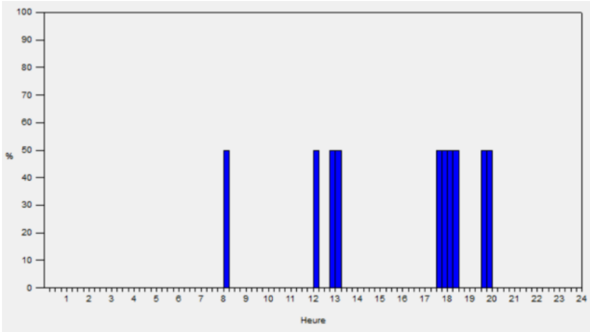
Office Equip Typ A



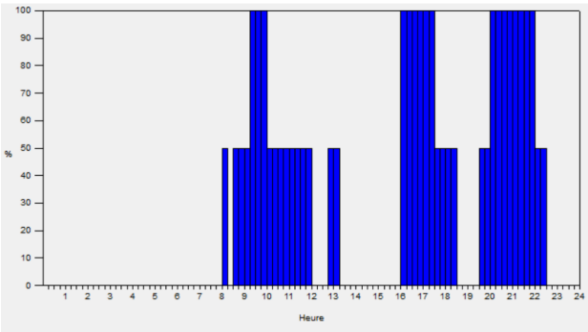
Circulation Occ Typ A



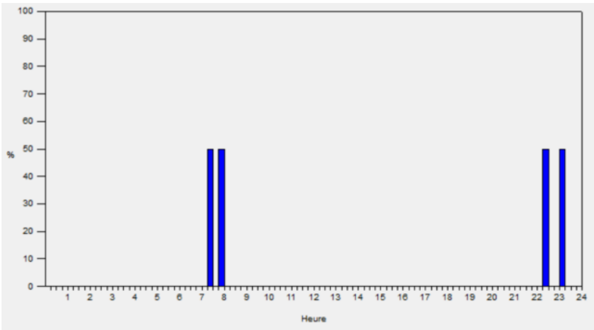
Diningroom Occ Typ A



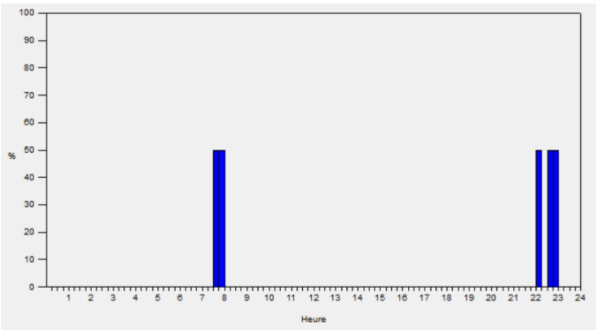
Kitchen Occ Typ A



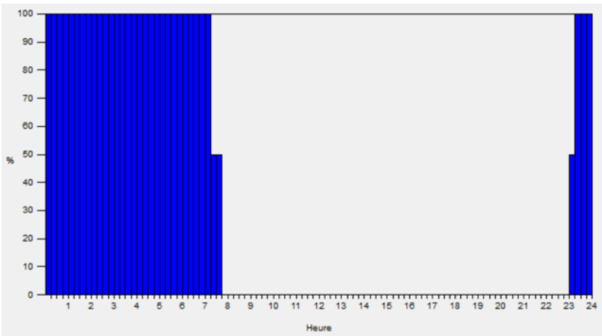
Livingroom Occ Typ A



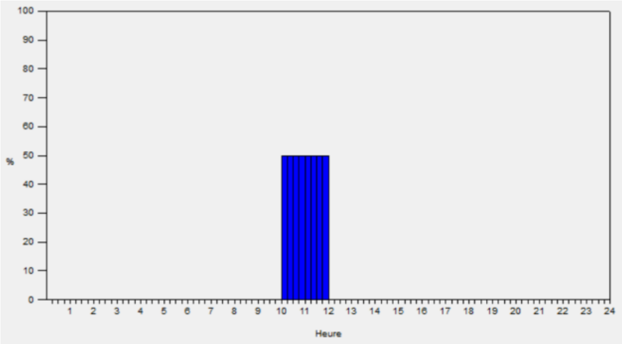
WC Occ Typ A



Bathroom Occ Typ A



Bedroom Occ Typ A



Office Occ Typ A

CONSTRUCTION	
CARACHTERISTICS	
External Walls	External Wall
Below Grade Walls	Project below grade wall
Flat Roof	Project flat Roof
Pitched Roof (occupied)	Unoccupied Roof
Pitched Roof (unoccupied)	Unoccupied Roof
Internal Partitions	Internal Wall
SEMI EXPOSED	
Semi Exposed Walls	Project semi-exposed wall
Semi Exposed Ceiling	Project semi-exposed ceiling
Semi Exposed Floor	Project semi-exposed floor
FLOORS	
Ground Floor	Ground Floor
External Floor	Project external floor
Internal Floor	Internal Floor
Internal	Project internal wall sub-surface construction
Roof	Project roof sub surface construction
Extermal Door	Project external door
Internal Door	Project internal door
INTERNAL THERMAL MASS	
Construction	Project internal mass
Zone Capacitance Multiplier	1,0
SHADES AND REFLECTS	
Level	
Material	
Maximum Transmittance	
GEOMETRY, AREAS AND VOLUMES	
Geoometry Convention Template	External measurements
Zone Geometry and Surface Areas	2-Outer
Zone Volume Calculation Method	1-Inner

Zone Floor Area Calculation Method	1-Inner
FIXED SURFACE THICKNESS	
External Wall Thickness (m)	
Below Grade Wall Thickness (m)	
Internal Partition Thickness (m)	
Ground Floor Thickness (m)	0,0
Basement Ground Floor Thickness (m)	0,0
External Floor Thickness (m)	
Internal Floor Thickness (m)	
Semi-exposed Wall Thickness (m)	
Semi-exposed Floor Thickness (m)	
Semi-exposed Ceiling Thickness (m)	
Flat Roof Thickness (m)	
Pitched Roof Thickness (m)	
VOID DEPTHS	
Ceiling Void Depth (m)	0,0
Floor Void Depth (m)	0
SURFACE CONVECTION	
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
LINEAR THERMAL BRIDGING AT JUNCTION	
PSI VALUES INVOLVING METAL CLADDING	
Roof-Wall (W/m-K)	
Wall-Ground Floor (W/m-K)	
Wall-Wall (corner) (W/m-K)	
Wall-Floor (Int - not ground floor) (W/m-K)	
Wall-Floor (Ext - not ground floor) (W/m-K)	
Lintel above window or door (W/m-K)	
Jamb at window or door (W/m-K)	
PSI VALUES NOT INVOLVING METAL CLADDING	
Roof-Wall (W/m-K)	
Wall-Ground Floor (W/m-K)	
Wall-Wall (corner) (W/m-K)	
Wall-Floor (Int - not ground floor) (W/m-K)	
Wall-Floor (Ext - not ground floor) (W/m-K)	
Lintel above window or door (W/m-K)	
Jamb at window or door (W/m-K)	
AIRTIGHTNESS	
Constant Rate (ac/h)	18
Schedule	ON 24/7
DELTA T AND WIND SPEED COEFFICIENT	

Constant	1,0
Temperature	0,0
Velocity	0,0
Velocity Squared	0,0
COST	
Sub structure cost (GBP/m2 GIFA)	
Structural Frame Type	
COST OF INTERNAL FINISHES	
Walls (GPB/m2)	
Floors /GBP/m2)	
Ceilings (GBP/m2)	

External Wall

	Brick Typology A calibration	2010 NCM Cavity unventilated typologie A	Concrete, cast - mediumweight
General			
Thickness (m)	0,100	0,070	0,140
Category	Brick and Cinderblock	Gaz	Concrete
Material layer thickness			
Force thickness	-	-	-
Thermal Properties			
	Detailled	Detailled	Detailled
Conductivity (W/m-K)	-	-	0,8
Specific heat (J/kg-K)	-	-	840
Densité	-	-	1300
Thermic resistance (m^2K/W)	0,11	0,13	-
Vapour Resistance			
Vapour Resistance def.	2-Resistivity	1- Factor	2-Resistivity
Vapour factor	150	1	150
Vapour resistivity(MNs/g.m)	50	10	60
Moisture Transfer	Oui	Non	Oui
	Generic Brick	-	Generic concrete
Surface properties			
Th. abs. (emissivity)	0,9	0,9	0,9
Solar abs.	0,6	0,7	0,6
Visible abs.	0,6	0,7	0,6
Roughness	Rough	Rough	Rough
Radiance Daylighting			
Specularity	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic

Ground Floor				
	Concrete, Reinforced (with 2% steel) ground typologie A	Spray-On R-12 InsulationPolyurethane foam (low density)(roof) ground typologie A	Cement/plaster/mortar - cement screed ground typologie A	Ceramic/clay tiles - ceramic floor tiles Dry ground typologie A
General				
Thickness (m)	0,120	0,050	0,010	0,005
Category	Concrete	Insulating materials	Screed and plaster	Tiles
Material layer thickness				
Force thickness	-	-		-
Thermal Properties				
	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	2,500	0,026	1	1,2
Specific heat (J/kg-K)	1000	1400	1000	1000
Conductivity (W/m-K)	24000	40	1700	2000
Thermic resistance (m²K/W)	-	-	-	-
Vapour Resistance				
Vapour Resistance def.	1- Factor	1- Factor	1- Factor	2-Resistivity
Vapour factor	130	150	20	150
Vapour resistivity(MNs/g.m)	10	10	10	4000
Moisture Transfer	Oui	Non	Oui	Non
	-	-	-	
Surface properties				
Th. abs. (emissivity)	0,9	0,9	0,9	0,9
Solar abs.	0,6	0,7	0,6	0,6
Visible abs.	0,6	0,7	0,6	0,6
Roughness	Rough	Rough	Rough	Rough
Radiance Daylighting				
Specularity	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic

Internal Floor						
	Perlite Plastering	2010 NCM Air layer unventilated-floor	Concrete, Reinforced (with 2% steel) typologie A	Sandstone floor typologie A	2010 NCM Cement Bonded particle board	Timber Flooring typologie A
General						
Thickness (m)	0,015	0,020	0,120	0,02	0,01	0,015
Category	Plaster	Gaz	Concrete	Sand, stone	Other	Wood
Material layer thickness						
Force thickness	-	-	-	-	-	-
Thermal Properties						

	Detailled	Detailled	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,080	-	2,5	1,3	0,23	0,13
Specific heat (J/kg-K)	837	-	1000	712	1000	600
Conductivity (W/m-K)	400	-	2400	2200	1100	2000
Thermic resistance (m²K/W)	-	0,21	-	-	-	
Vapour Resistance						
Vapour Resistance def.	1- Factor	1- Factor	1- Factor	2-Resistivity	2-Resistivity	2-Resistivity
Vapour factor	5	1	130	150	150	150
Vapour resistivity(MNs/g.m)	10	10	10	300	50	50
Moisture Transfer	Non	Non	Oui	Non	Non	Non
	-	-	-			
Surface properties						
Th. abs. (emissivity)	0,9	0,9	0,9	0,9	0,9	0,9
Solar abs.	0,5	0,7	0,6	0,6	0,7	0,78
Visible abs.	0,5	0,7	0,6	0,6	0,7	0,78
Roughness	Rough	Rough	Rough	Rough	Rough	Rough
Radiance Daylighting						
Specularity	0	0	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic	1-Plastic	1-Plastic

Internal Wall			
	Gypsum Plasterboard	**Cast Concrete typologie A**	**Gypsum Plasterboard**
General			
Thickness (m)	0,005	0,140	0,005
Category	Plaster	Concrete	Plaster
Material layer thickness			
Force thickness	-	-	-
Thermal Properties			
	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,250	0,570	0,250
Specific heat (J/kg-K)	1000	1000	1000
Conductivity (W/m-K)	900	2000	900
Thermic resistance (m²K/W)	-	-	-
Vapour Resistance			
Vapour Resistance def.	1- Factor	2-Resistivity	1- Factor
Vapour factor	10	150	10
Vapour resistivity(MNs/g.m)	10	120	10
Moisture Transfer	Oui	Oui	Oui
	Generic gypsum	Generic concrete	Generic gypsum
Surface properties			
Th. abs. (emissivity)	0,9	0,9	0,9
Solar abs.	0,5	0,6	0,5
Visible abs.	0,5	0,6	0,5
Roughness	Rough	Rough	Rough
Radiance Daylighting			
Specularity	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic

Attic Floor				
	Timber Flooring Attic Typology A	**2010 NCM Cavity unventilated Attic Typology A**	**MW Stone Wool (rolls) Attic Typology A**	**Timber Flooring Attic Typology A**
General				
Thickness (m)	0,020	0,090	0,090	0,02
Category	Wood	Gaz	Insulating materials	Tiles
Material layer thickness				
Force thickness	-	-		-
Thermal Properties				
	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,180	-	0,04	0,180
Specific heat (J/kg-K)	1600	-	840	1600
Conductivity (W/m-K)	800	-	30	800
Thermic resistance (m²K/W)	-	0,13	-	-
Vapour Resistance				
Vapour Resistance def.	2-Resistivity	1- Factor	2-Resistivity	2-Resistivity
Vapour factor	150	1	150	150
Vapour resistivity(MNs/g.m)	50	10	6	50
Moisture Transfer	Oui	Non	Non	Oui
	Generic wood	-	-	Generic wood
Surface properties				
Th. abs. (emissivity)	0,9	0,9	0,9	0,9
Solar abs.	0,78	0,7	0,6	0,78
Visible abs.	0,78	0,7	0,6	0,78
Roughness	Rough	Rough	Rough	Rough
Radiance Daylighting				
Specularity	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic

EXTERNAL WINDOWS	
Glazing template	Glazing template
Glazing Type	External Window
Layout	Preferred height 1,5m, 30% glazed
DIMENSION	
Type	0-None
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	

Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
WINDOW SHADING	
Type	Shade roll - medium opaque
Position	Outside
Control type	Schedule
Operation	Blind schedule
LOCAL SHADING	
Type	
AIRFLOW CONTROL WINDOWS	
Source	
Destination	
Max Flow Rate (m3/s-m)	
FREE APERTURE	
Opening Position	1-Top
% Glazing Area Opens	5
INTERNAL WINDOWS	
Glazing Type	
Layout	
DIMENSION	
Type	
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	
Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
FREE APERTURE	
Opening Position	
% Glazing Area Opens	
SLOPED ROOF WINDOWS/SKYLIGHTS	
Glazing Type	
Layout	

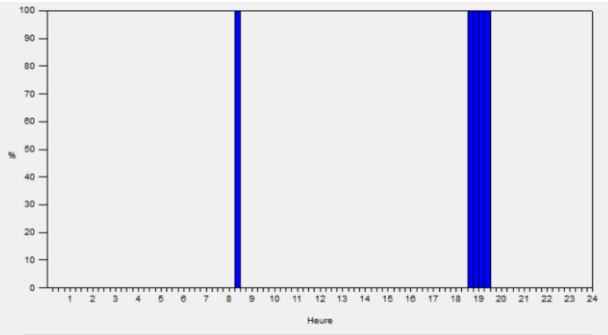
DIMENSION	
Type	
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	
Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
WINDOW SHADING	
Type	
Position	
Control type	
FREE APERTURE	
Opening Position	
% Glazing Area Opens	
DOORS	
EXTERNAL	
% Area Door Opens	50
Opening position	3-Right
INTERNAL	
% Area Door Opens	50
% Time door is open	5
Opening position	3-Right
Operation schedule	Off 24/7
VENTS	
Vent type	Grille, small, lights slats
Control option	1- Control by schedule
Operation schedule	Off 24/7

External Window			
	VERRE Typ A	**AIR 12MM Typ A**	**VERRE Typ A**
General			
Category	**Clear glass**	**Air**	**Clear glass**
Data type			
Data type	1-Broadband	2-personalised	1-Broadband
Thermal properties			

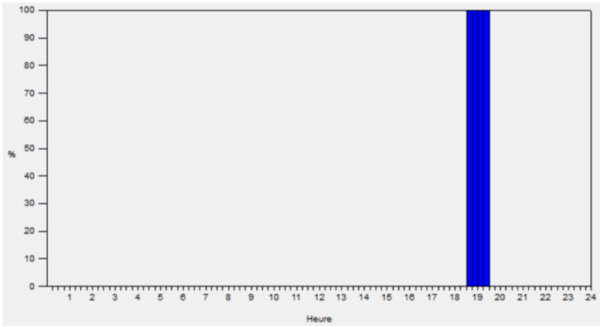
Thickness (mm)	4	12	4
Conductivity (W/m-K)	1,1	-	1,1
Solar Properties			
Solar transmittance	0,816	-	0,816
Outside solar reflectance	0,075	-	0,075
Inside solar reflectance	0,075	-	0,075
Visible Properties			
Visible transmittance	0,892	-	0,892
Outside visible reflectance	0,081	-	0,081
inside visible reflectance	0,081	-	0,081
Infra-red properties			
Infra-red transmittance	0	-	0
Outside emissivity	0,84	-	0,84
Inside emissivity	0,84	-	0,84
Personnalised			
Conductivity coefficient A (W/m-K)	-	0,006073	-
Conductivity coefficient B (W/m-K2)	-	0,0000996	-
Conductivity coefficient C (W/m-K3)	-	0	-
Viscosity coefficient A (kg/m-s)	-	0,000003723	-
Viscosity coefficient B (kg/m-s-K)	-	4,94E-08	-
Viscosity coefficient C (kg/m-s-K2)	-	0	-
Specific heat coefficient A (J/kg-K)	-	1002,74	-
Specific heat coefficient B (J/kg-K2)	-	0,012324	-
Specific heat coefficient C (J/kg-K3)	-	0	-
Molecular weight (kg/kmol)	-	28,97	-
Specific heat ratio	-	1,5	-

GENERAL LIGHTING	
Template	<None>
Lighting power density (W/m2)	5
Schedule	OFF 24/7 (specify at room scale)
Luminar type	1-Suspendu
Radiant fraction	0,42
Visible fraction	0,18
LIGHTING CONTROL	
Working plane height (m)	
Control type	
Min output fraction	
Min output power fraction	
GLARE	
Maximum allowable glare index	
View angle relative to y-axis (°)	
LIGHTING AREA 1	
% zone covered by lightning area 1	
LIGHTING AREA 2	
Target illuminance (lux)	
% zone covered by lightning area 2	

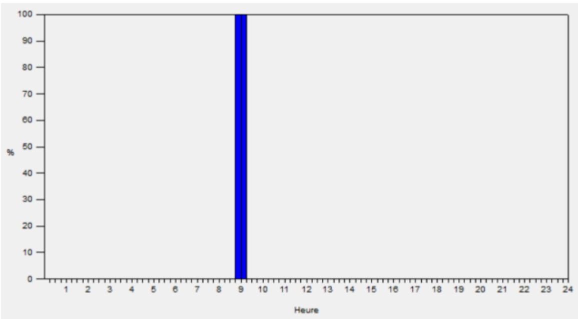
TASK AND DISPLAY LIGHTNING	
Gain (W/m2)	
Schedule	
EXTERIOR LIGHTING	
Design level (W)	
Schedule	
Control option	
COST	
Cost per area (GBP/m2 GIFA)	0



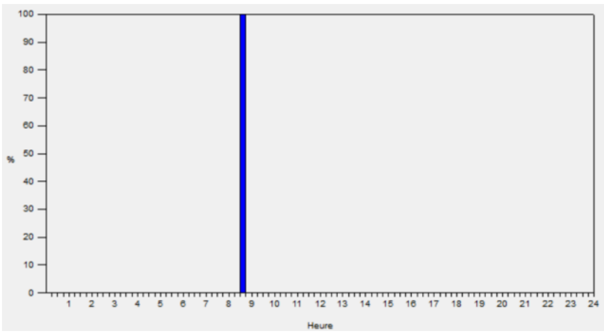
Diningroom Lighting Typ A Calibration (winter time)



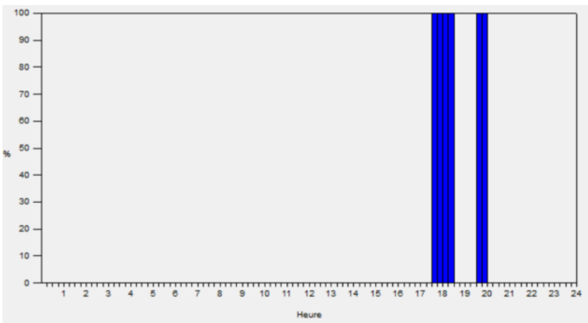
Diningroom Lighting Typ A Calibration (summer time)



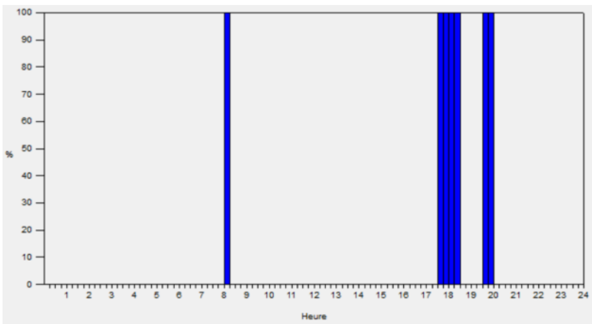
Circulation Lighting Typ A



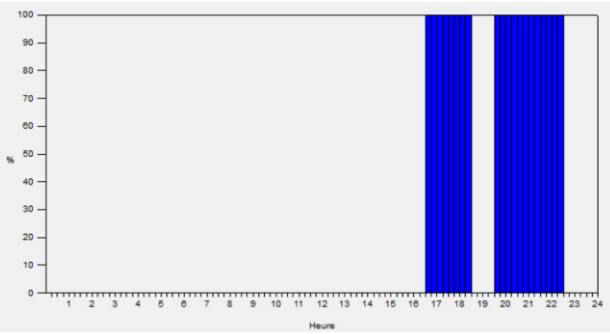
Cellar Lighting Typ A



Kitchen Lighting Typ A Calibration

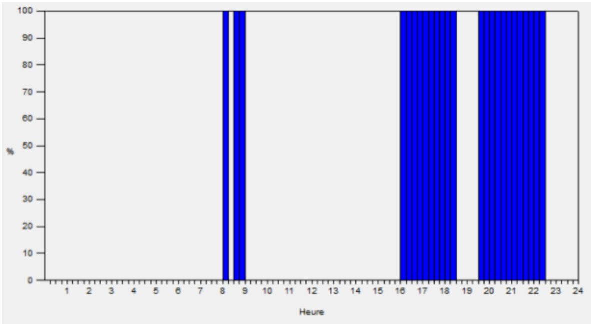


Kitchen Lighting Typ A Calibration

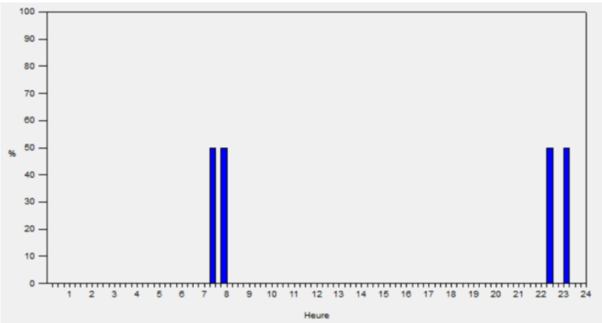


Livingroom Lighting Typ A Calibration

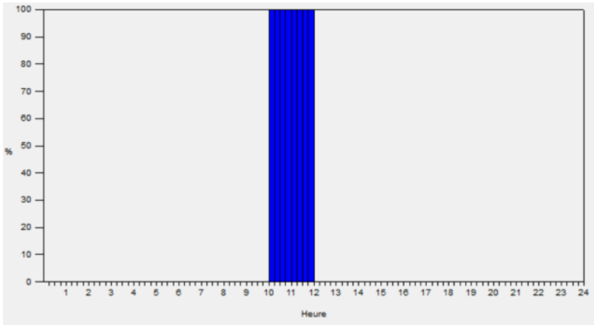
(summer time)



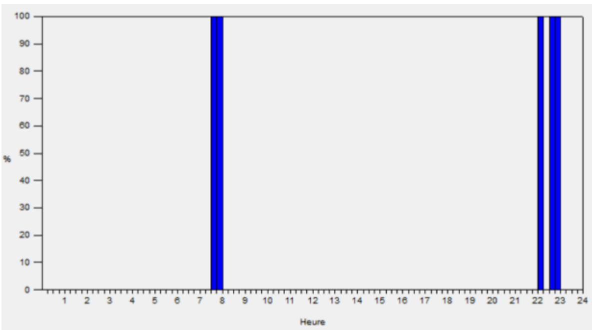
Livingroom Lighting Typ A Calibration



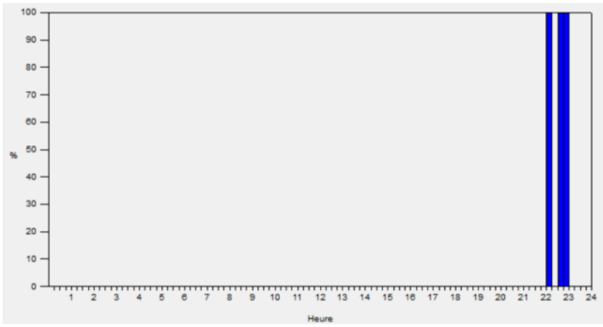
WC Lighting Typ A



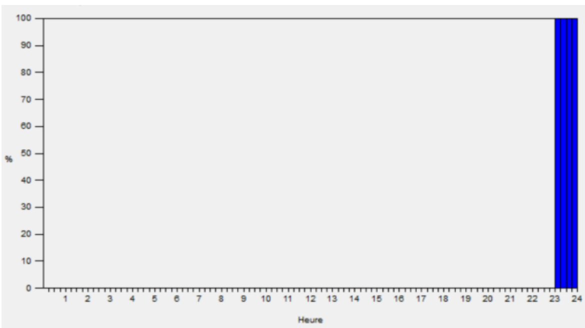
Office Lighting Typ A



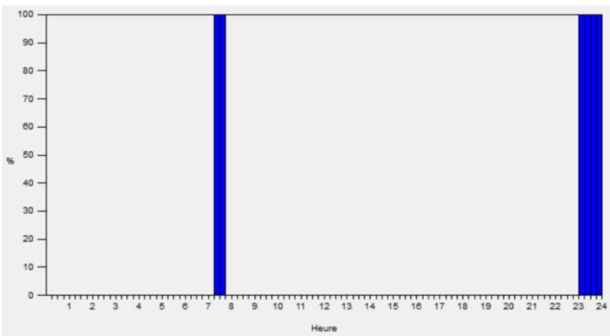
Bathroom Lighting Typ A
Calibration (winter time)



Bathroom Lighting Typ A
Calibration (summer time)



Bedroom Lighting Typ A Calibration
(summer time)

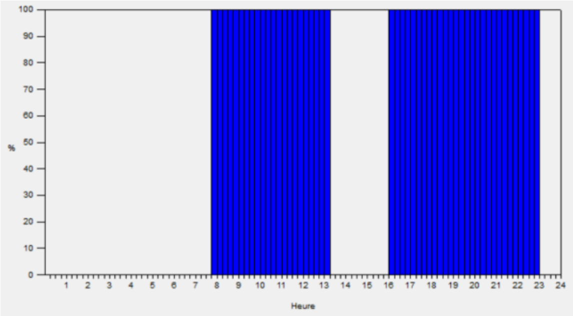


Bedroom Lighting Typ A Calibration
(winter time)

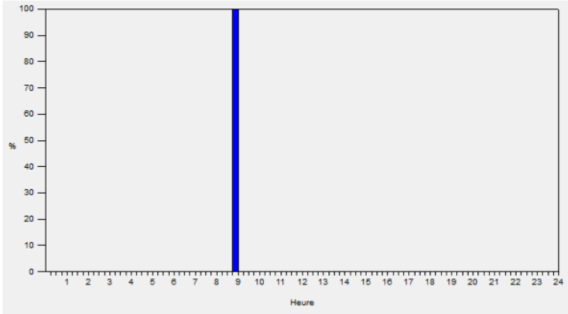
HVAC	
Template	<None>
MECHANICAL VENTILATION	
Outside air definition method	
Outside air (ac/h)	
Schedule	
ECONOMISER (FREE COOLING)	
Type	
Max outdoor air rate when economiser operates (ac/h)	
HEAT RECOVERY	
Heat recovery type	
Sensible heat recovery effectiveness	
Latent heat recovery effectiveness	
HEATING	
Fuel	2- Natural gas
Heating system seasonal CoP	0,85
SUPPLY AIR CONDITION	
Maximum supply air temperature (°C)	35
Maximum supply air humidity (g/g)	0,0156
Heating limit type	2- Limit capacity
Schedule	ON 24/7 (specify at room scale)
COOLING	
Cooling system	
Fuel	
Cooling system seasonal CoP	
SUPPLY AIR CONDITION	
Minimum supply air temperature (°C)	
Minimum supply air humidity (g/g)	
Schedule	
HUMIDITY CONTROL	
Humidification control type	
Dehumidification control type	

DOMESTIC HOT WATER	
DHW Template	DHW Template
Type	4- Instantaneous hot water only
DHW Cop	0,85
Fuel	2-Natural Gas
WATER TEMPERATURES	
Delivery temperature (°C)	60
Mains supply temperature (°C)	10
Schedule	OFF 24/7 (specify at room scale)
NATURAL VENTILATION	
Outside air definition method	1- By zone
Outside air (ac/h)	5
Schedule	ON 24/7 (speecify at room scale)
OUTDOOR TEMPERATURE LIMITS	
Min temperature definition	1-By value
Min temprature (°C)	10
Max temperature definition	1-By value
Max temperature (°C)	30
DELTA T LIMITS	
Delta T definition	1-By value
Delta T (deltaC)	0
DELTA T AND WIND SPEED COEFFICIENTS	
Constant	1
Temperature	0
Velocity	0
Velocity squared	0
MIXED MODE ZONE EQUIPEMENT	
Min outdoor temperature (°C)	
Max outdoor temperature (°C)	
Min outdoor enthaplpy (J/kg)	
Max outdoor enthalpy (J/kg)	
Min outdoor dew point temperature (°C)	
Max outdoor dew point temperature (°C)	
EARTH TUBE	
Outside air definition method	
Schedule	

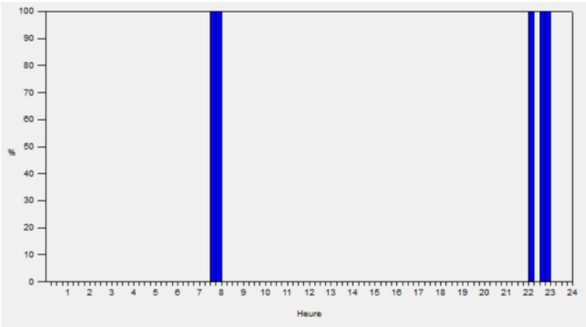
CONTROL	
Minimum zone temperature when cooling (°C)	
Maximum zone temperature when heating (°C)	
Delta temperature (deltaC)	
FAN ELECTRIC CONSUMPTION CONFIGURATION	
Earth tube type	
PIPE SPECIFICATIONS	
Pipe radius (m)	
Pipe thickness (m)	
Pipe lenght (m)	
Pipe thermal conductivity (W/m-K)	
Pipe depth under ground surface (m)	
SOIL HEAT TRANSFER CALCULATIONS	
Soil condition	
Average soil surface temperature (°C)	
Amplitude of soil surface temperature (deltaC)	
Phase constant of soil surface temperature	
TERM FLOW COEFFICIENTS	
Constant	
Temperature	
Velocity	
Velocity squared	
AIR TEMPERATURE DISTRIBUTION	
Distribution mode	1-Mixed
COST	
HVAC cost (GBP/m2 GIFA)	
Other services costs (GBP/m2 GIFA)	



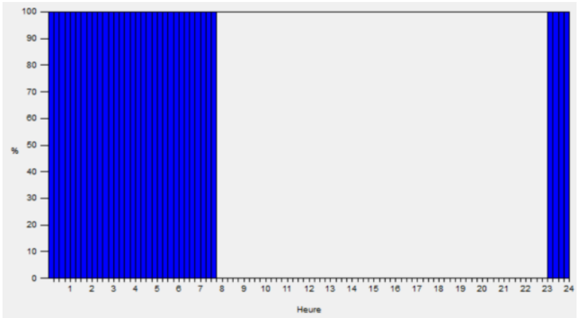
Livingroom+Diningroom+Kitchen +Office Heating Hours Typ A



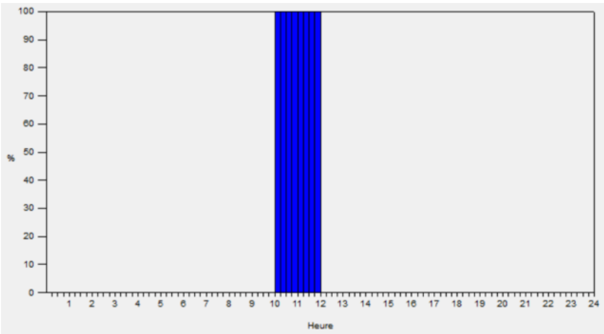
Circulation Heating Typ A



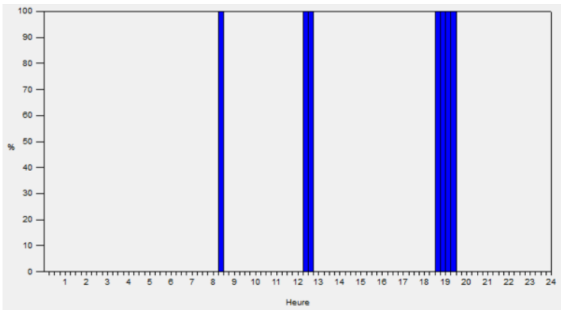
Bathroom Heating Typ A



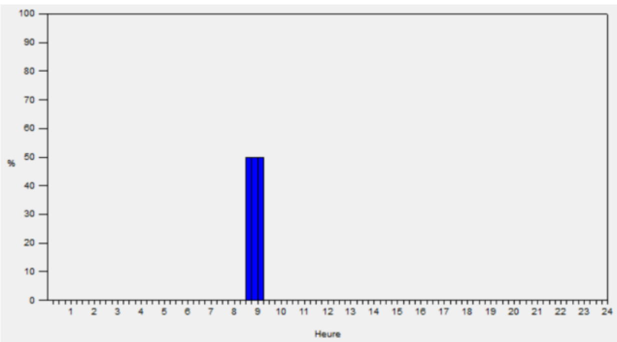
Bedroom Heating Typ A



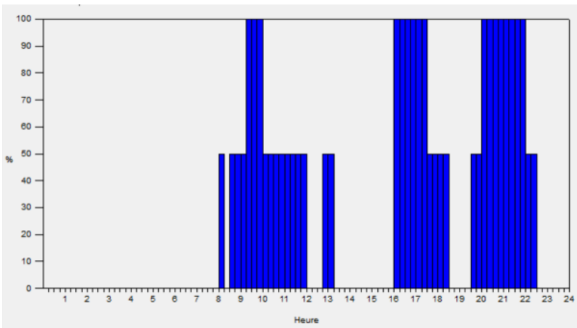
Office Heating Typ A



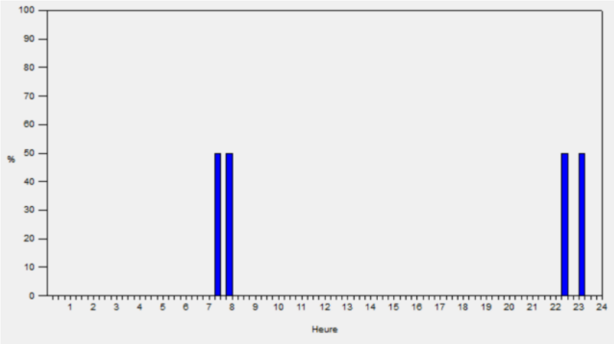
Diningroom Ventilation Typ A



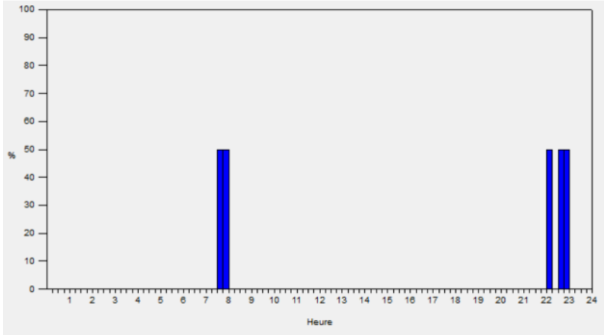
Kitchen Ventilation Typ A



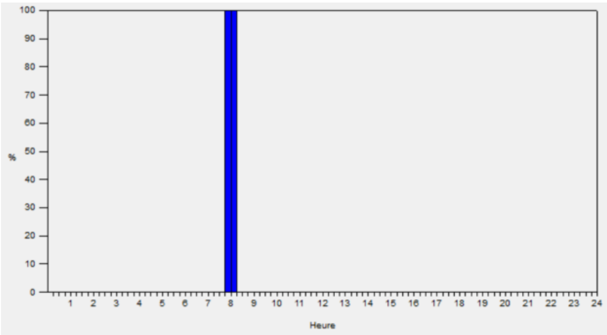
Livingroom Ventilation Typ A



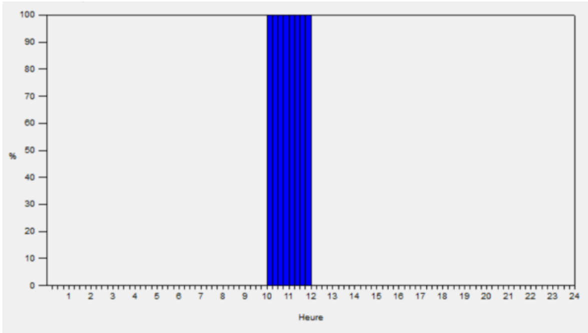
WC ventilation Typ A



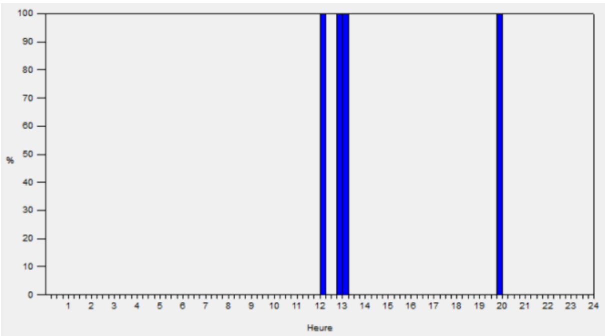
Bathroom Ventilation Typ A



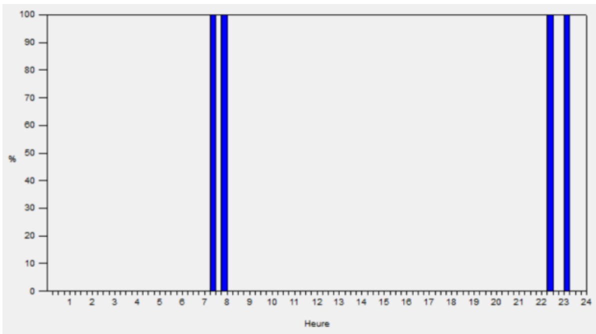
Bedroom Ventilation Typ A



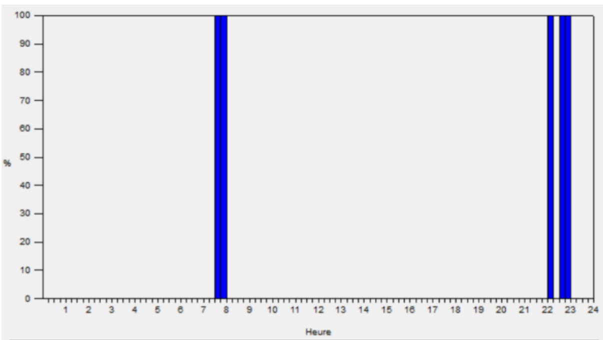
Office Ventilation Typ A



Kitchen DHW Typ A



WC DHW Typ A

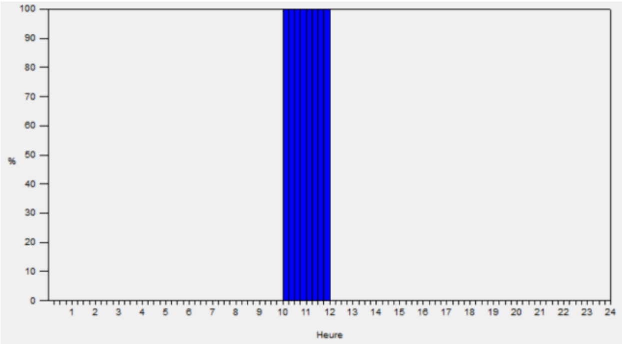


Bathroom DHW Typ A

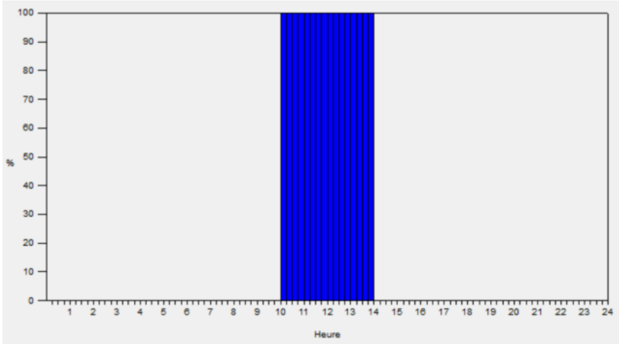
Appendix 11: Template Design Builder typology B

ACTIVITY TEMPLATE	
Template	Common circulation area
Sector	Residential space
Zone Multiplier	Default : 1
Include zone in thermal calculations	Yes
Include zone in Radiance daylighting calculations	Yes
FLOOR AREAS AND VOLUMES	
Occupied Floor Area (m2)	173,2
Occupied Volume (m3)	519,5
Unoccupied Floor Area (m2)	207,8
Unoccupied Volume (m3)	323,6
OCCUPANCY	
Density (people/m2)	0,01
Schedule	Off 24/7 (specify at room scale)
METABOLIC	
Activity	Standing relaxed
Factor	0,93
CO2 Generation Rate (m3/s-W)	3,82E-08
CLOTHING	
Winter Clothing (clo)	1- Generic summer and winter clothing
Summer Clothing (clo)	0,5
GENERIC CONTAMINANT GENERATION	
Contaminant Simulation Method	
GENERATION	
Design Generation Rate (m3/s)	
Schedule	
REMOVAL	
Design Removal Rate (m3/s)	
Schedule	
HOLIDAYS	
Holidays per Year	36
Holiday Schedule	Project Holidays Schedule
DOMESTIC HOT WATER	
Consumption Rate (l/m2-day)	1,44
ENVIRONMENTAL CONTROL	
HEATING SETPOINT TEMPERATURES	
Heating (°C)	21,5
Heating Set Back (°C)	0
COOLING SETPOINT TEMPERATURES	

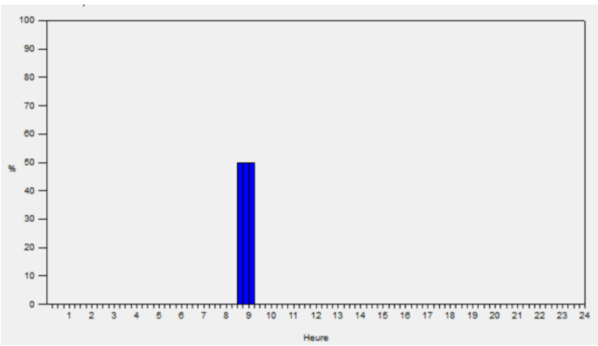
Cooling (°C)	
Cooling Set Back (°C)	
HUMIDITY CONTROL	
RH Humidification Setpoint (%)	
RH Dehumidification Setpoint (%	
NATURAL VENTILATION	
Indoor Min Temperature Definition	Yes
Min Temperature (°C)	24
Indoor Max Temperature Definition	Yes
Max Temperature (°C)	26
MINUMUM FRESH AIR	
Fresh Air (l/s-person)	
Mech Vent per area (l/s-m2)	
LIGHTING	
Target Illuminance (lux)	300
Default Display Lighting Density (W/m2)	0
COMPUTERS	
Gain (W/m2)	35,1
Schedule	OFF 24/7 (specify at room scale)
Radiant Fraction	0,22
OFFICE EQUIPEMENT	
Gain (W/m2)	
Schedule	
Radiant Fraction	
MISCELLANEOUS	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	
Radiant Fraction	
CATERING	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	
Radiant Fraction	
PROCESS	
Gain (W/m2)	
Schedule	
Fuel	
Fraction Lost	
Latent Fraction	
Radiant Fraction	



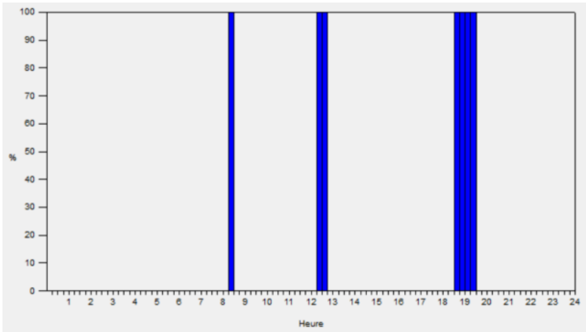
Office Equip Typ B



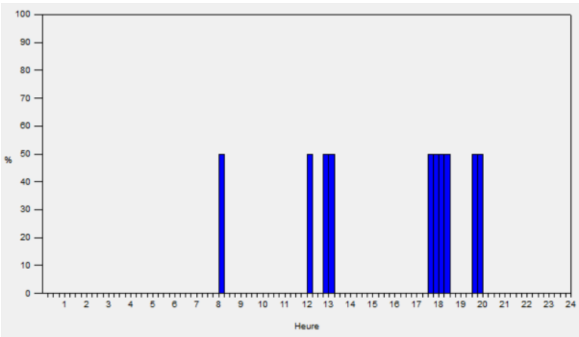
Office Equip Typ B



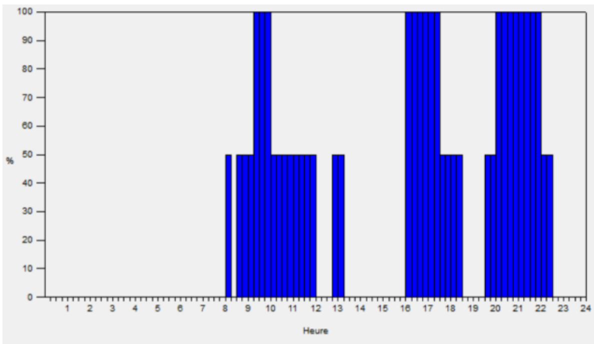
Circulation Occ Typ B



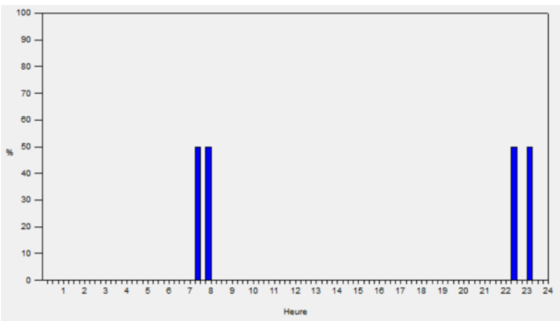
Diningroom Occ Typ



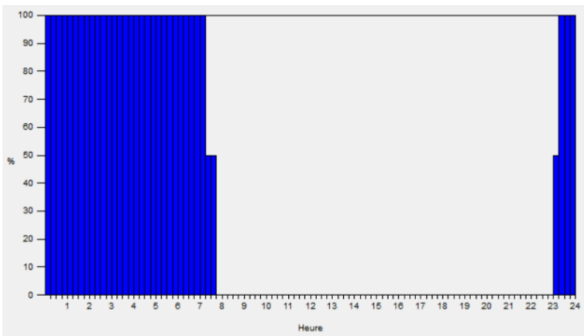
Kitchen Occ Typ B



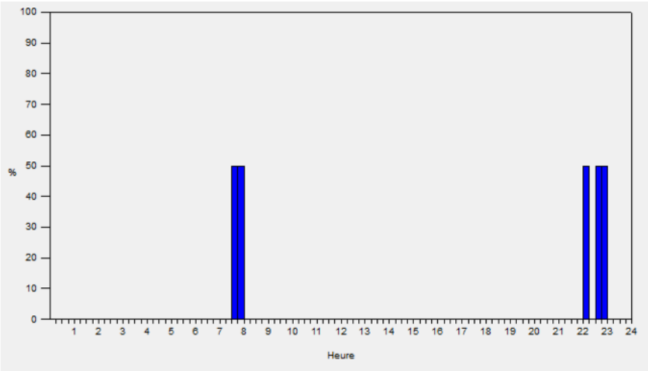
Livingroom Occ Typ B



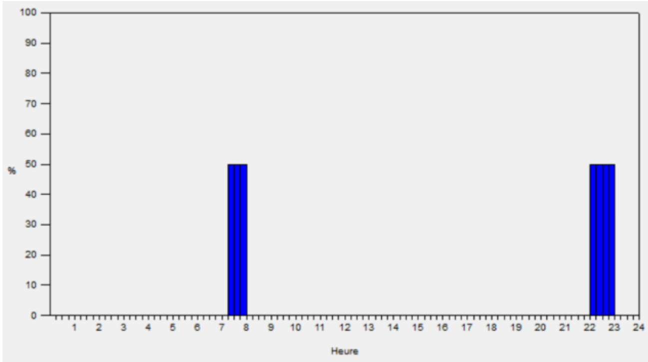
WC Occ Typ B



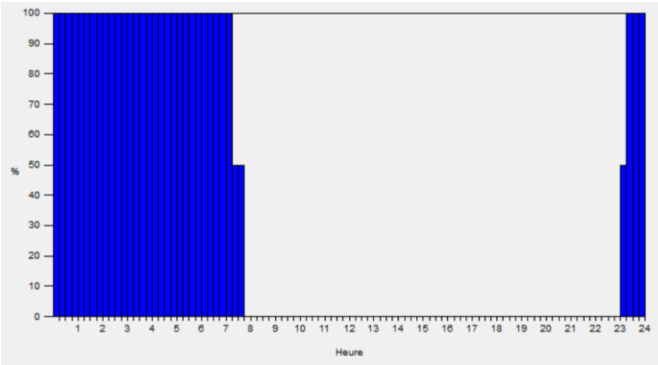
Bedroom Occ Typ B



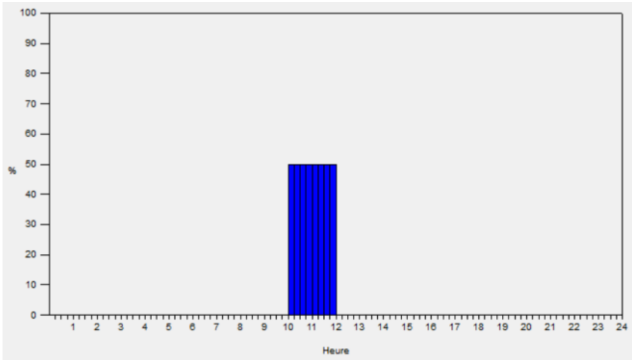
Bathroom Occ Typ B



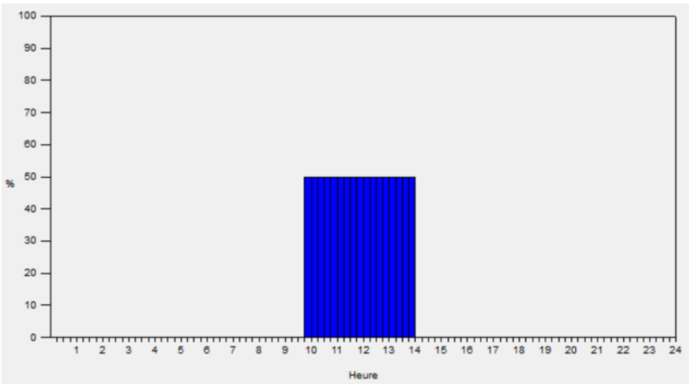
Bathroom Occ Typ B



Bedroom 2 Occ Typ B



Office Occ Typ B Calibration WE (weekday)



Office Occ Typ B Calibration WE (weekend)

CONSTRUCTION	
CARACHTERISTICS	
External Walls	External Wall Calibration B
Below Grade Walls	Project below grade wall
Flat Roof	Project flat Roof
Pitched Roof (occupied)	Unoccupied Roof
Pitched Roof (unoccupied)	Unoccupied Roof
Internal Partitions	Internal Wall
SEMI EXPOSED	
Semi Exposed Walls	Project semi-exposed wall
Semi Exposed Ceiling	Project semi-exposed ceiling
Semi Exposed Floor	Project semi-exposed floor
FLOORS	
Ground Floor	Ground Floor
External Floor	Project external floor
Internal Floor	Internal Floor
Internal	Project internal wall sub-surface construction
Roof	Project roof sub surface construction
Extermal Door	Project external door
Internal Door	Project internal door
INTERNAL THERMAL MASS	
Construction	Project internal mass
Zone Capacitance Multiplier	1,0
SHADES AND REFLECTS	
Level	
Material	
Maximum Transmittance	
GEOMETRY, AREAS AND VOLUMES	
Geoometry Convention Template	External measurements
Zone Geometry and Surface Areas	2-Outer
Zone Volume Calculation Method	1-Inner
Zone Floor Area Calculation Method	1-Inner
FIXED SURFACE THICKNESS	
External Wall Thickness (m)	
Below Grade Wall Thickness (m)	
Internal Partition Thickness (m)	
Ground Floor Thickness (m)	0,0
Basement Ground Floor Thickness (m)	0,0
External Floor Thickness (m)	
Internal Floor Thickness (m)	

Semi-exposed Wall Thickness (m)	
Semi-exposed Floor Thickness (m)	
Semi-exposed Ceiling Thickness (m)	
Flat Roof Thickness (m)	
Pitched Roof Thickness (m)	
VOID DEPTHS	
Ceiling Void Depth (m)	0,0
Floor Void Depth (m)	0
SURFACE CONVECTION	
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
HEATING DESIGN	
Inside Convection Algorithm	6-TARP
Outside Convection Algorithm	6-DOE-2
LINEAR THERMAL BRIDGING AT JUNCTION	
PSI VALUES INVOLVING METAL CLADDING	
Roof-Wall (W/m-K)	
Wall-Ground Floor (W/m-K)	
Wall-Wall (corner) (W/m-K)	
Wall-Floor (Int - not ground floor) (W/m-K)	
Wall-Floor (Ext - not ground floor) (W/m-K)	
Lintel above window or door (W/m-K)	
Jamb at window or door (W/m-K)	
PSI VALUES NOT INVOLVING METAL CLADDING	
Roof-Wall (W/m-K)	
Wall-Ground Floor (W/m-K)	
Wall-Wall (corner) (W/m-K)	
Wall-Floor (Int - not ground floor) (W/m-K)	
Wall-Floor (Ext - not ground floor) (W/m-K)	
Lintel above window or door (W/m-K)	
Jamb at window or door (W/m-K)	
AIRTIGHTNESS	
Constant Rate (ac/h)	17,1
Schedule	ON 24/7
DELTA T AND WIND SPEED COEFFICIENT	
Constant	1,0
Temperature	0,0
Velocity	0,0
Velocity Squared	0,0
COST	
Sub structure cost (GBP/m2 GIFA)	
Structural Frame Type	
COST OF INTERNAL FINISHES	
Walls (GPB/m2)	
Floors /GBP/m2)	
Ceilings (GBP/m2)	

External Wall Calibration B			
	Brick Typology B calibration	**2010 NCM Cavity unventilated typologie B**	**Concrete, cast - mediumweight**
General			
Thickness (m)	0,100	0,070	0,140
Category	Brick and Cinderblock	Gaz	Concrete
Material layer thickness			
Force thickness	-	-	-
Thermal Properties			
	Detailled	Detailled	Detailled
Conductivity (W/m-K)	-	-	0,8
Specific heat (J/kg-K)	-	-	840
Densité	-	-	1300
Thermic resistance (m²K/W)	0,11	0,13	-
Vapour Resistance			
Vapour Resistance def.	2-Resistivity	1- Factor	2-Resistivity
Vapour factor	150	1	150
Vapour resistivity(MNs/g.m)	50	10	60
Moisture Transfer	Oui	Non	Oui
	Generic Brick	-	Generic concrete
Surface properties			
Th. abs. (emissivity)	0,9	0,9	0,9
Solar abs.	0,6	0,7	0,6
Visible abs.	0,6	0,7	0,6
Roughness	Rough	Rough	Rough
Radiance Daylighting			
Specularity	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic

Unoccupied Roof			
	Clay Tile (roofing)	**Air gap**	**Wood derivatives - wood shingle roof Typologie B**
General			
Thickness (m)	0,025	0,020	0,090
Category	Tiles	Gaz	Asphalt and others
Material layer thickness			
Force thickness	-	-	-
Thermal Properties			
	Detailled	Detailled	Detailled
Conductivity (W/m-K)	1,000	-	0,180
Specific heat (J/kg-K)	800	-	1600
Conductivity (W/m-K)	2000	-	800
Thermic resistance (m²K/W)	-	0,15	-
Vapour Resistance			
Vapour Resistance def.	2-Resistivity	1- Factor	2-Resistivity
Vapour factor	150	1	150
Vapour resistivity(MNs/g.m)	1000	10	50
Moisture Transfer	Non	Non	Oui
	-	-	-
Surface properties			
Th. abs. (emissivity)	0,9	0,9	0,9
Solar abs.	0,7	0,7	0,6
Visible abs.	0,7	0,7	0,6
Roughness	Rough	Rough	Rough
Radiance Daylighting			
Specularity	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic

Ground Floor				
	Concrete, Reinforced (with 2% steel) ground typologie B	**Spray-On R-12 InsulationPolyurethane foam (low density)(roof) ground typologie B**	**Cement/plaster/mortar - cement screed ground typologie B**	**Ceramic/clay tiles - ceramic floor tiles Dry ground typologie B**
General				
Thickness (m)	0,120	0,050	0,010	0,005
Category	Concrete	Insulating materials	Screed and plaster	Tiles
Material layer thickness				
Force thickness	-	-		-
Thermal Properties				
	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	2,500	0,026	1	1,2
Specific heat (J/kg-K)	1000	1400	1000	1000
Conductivity (W/m-K)	24000	40	1700	2000
Thermic resistance (m²K/W)	-	-	-	-
Vapour Resistance				
Vapour Resistance def.	1- Factor	1- Factor	1- Factor	2-Resistivity

Vapour factor	130	150	20	150
Vapour resistivity(MNs/g.m)	10	10	10	4000
Moisture Transfer	Oui	Non	Oui	Non
	-	-	-	
Surface properties				
Th. abs. (emissivity)	0,9	0,9	0,9	0,9
Solar abs.	0,6	0,7	0,6	0,6
Visible abs.	0,6	0,7	0,6	0,6
Roughness	Rough	Rough	Rough	Rough
Radiance Daylighting				
Specularity	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic

Internal Floor						
	Perlite Plastering	**2010 NCM Air layer unventilated-floor**	**Concrete, Reinforced (with 2% steel) typologie B**	**Sandstone floor typologie B**	**2010 NCM Cement Bonded particle board**	**Timber Flooring typologie B**
General						
Thickness (m)	0,015	0,020	0,120	0,02	0,01	0,015
Category	Plaster	Gaz	Concrete	Sand, stone	Other	Wood
Material layer thickness						
Force thickness	-	-	-	-	-	-
Thermal Properties						
	Detailled	Detailled	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,080	-	2,5	1,3	0,23	0,13
Specific heat (J/kg-K)	837	-	1000	712	1000	600
Conductivity (W/m-K)	400	-	2400	2200	1100	2000
Thermic resistance (m²K/W)	-	0,21	-	-	-	
Vapour Resistance						
Vapour Resistance def.	1- Factor	1- Factor	1- Factor	2-Resistivity	2-Resistivity	2-Resistivity
Vapour factor	5	1	130	150	150	150
Vapour resistivity(MNs/g.m)	10	10	10	300	50	50
Moisture Transfer	Non	Non	Oui	Non	Non	Non
	-	-	-			
Surface properties						
Th. abs. (emissivity)	0,9	0,9	0,9	0,9	0,9	0,9
Solar abs.	0,5	0,7	0,6	0,6	0,7	0,78
Visible abs.	0,5	0,7	0,6	0,6	0,7	0,78
Roughness	Rough	Rough	Rough	Rough	Rough	Rough
Radiance Daylighting						
Specularity	0	0	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic	1-Plastic	1-Plastic

Internal Wall			
	Gypsum Plasterboard	**Cast Concrete typologie B**	**Gypsum Plasterboard**
	General		
Thickness (m)	0,005	0,140	0,005
Category	Plaster	Concrete	Plaster
	Material layer thickness		
Force thickness	-	-	-
	Thermal Properties		
	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,250	0,570	0,250
Specific heat (J/kg-K)	1000	1000	1000
Conductivity (W/m-K)	900	2000	900
Thermic resistance (m²K/W)	-	-	-
	Vapour Resistance		
Vapour Resistance def.	1- Factor	2-Resistivity	1- Factor
Vapour factor	10	150	10
Vapour resistivity(MNs/g.m)	10	120	10
Moisture Transfer	Oui	Oui	Oui
	Generic gypsum	Generic concrete	Generic gypsum
Surface properties			
Th. abs. (emissivity)	0,9	0,9	0,9
Solar abs.	0,5	0,6	0,5
Visible abs.	0,5	0,6	0,5
Roughness	Rough	Rough	Rough
Radiance Daylighting			
Specularity	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic

Attic Floor				
	Timber Flooring Attic Typology B	**2010 NCM Cavity unventilated Attic Typology B**	**MW Stone Wool (rolls) Attic Typology B**	**Timber Flooring Attic Typology B**
	General			
Thickness (m)	0,020	0,090	0,090	0,02
Category	Wood	Gaz	Insulating materials	Tiles
	Material layer thickness			
Force thickness	-	-		-
	Thermal Properties			
	Detailled	Detailled	Detailled	Detailled
Conductivity (W/m-K)	0,180	-	0,04	0,180
Specific heat (J/kg-K)	1600	-	840	1600
Conductivity (W/m-K)	800	-	30	800
Thermic resistance (m²K/W)	-	0,13	-	-
	Vapour Resistance			
Vapour Resistance def.	2-Resistivity	1- Factor	2-Resistivity	2-Resistivity
Vapour factor	150	1	150	150
Vapour resistivity(MNs/g.m)	50	10	6	50
Moisture Transfer	Oui	Non	Non	Oui
	Generic wood	-	-	Generic wood

Surface properties				
Th. abs. (emissivity)	0,9	0,9	0,9	0,9
Solar abs.	0,78	0,7	0,6	0,78
Visible abs.	0,78	0,7	0,6	0,78
Roughness	Rough	Rough	Rough	Rough
Radiance Daylighting				
Specularity	0	0	0	0
Material class	1-Plastic	1-Plastic	1-Plastic	1-Plastic

EXTERNAL WINDOWS	
Glazing template	Glazing template
Glazing Type	External Window Typology B
Layout	No glazing
DIMENSION	
Type	0-None
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	
Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
WINDOW SHADING	
Type	Shade roll - medium opaque
Position	Outside
Control type	Schedule
Operation	Blind schedule
LOCAL SHADING	
Type	
AIRFLOW CONTROL WINDOWS	
Source	
Destination	
Max Flow Rate (m3/s-m)	
FREE APERTURE	
Opening Position	1-Top
% Glazing Area Opens	5
INTERNAL WINDOWS	
Glazing Type	

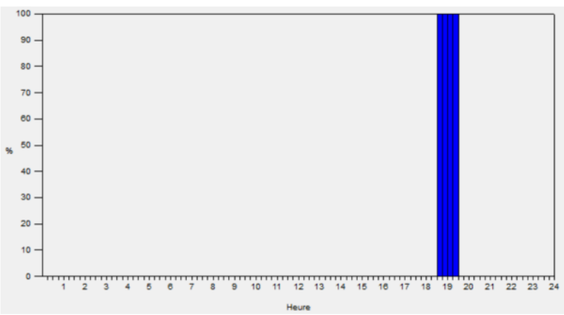
Layout	
DIMENSION	
Type	
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	
Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
FREE APERTURE	
Opening Position	
% Glazing Area Opens	
SLOPED ROOF WINDOWS/SKYLIGHTS	
Glazing Type	
Layout	
DIMENSION	
Type	
Window to Wall %	
Window Height (m)	
Window Spacing (m)	
Sill Height (m)	
DIVIDERS	
Type	
Width (m)	
Horizontal Dividers	
Vertical Dividers	
Outside Projection (m)	
Inside Projection	
Glass edge-centre conduction ratio	
FRAME	
Frame Width (m)	
Frame inside Projection (m)	
Frame outside projection (m)	
Glass edge-centre conduction ratio	
WINDOW SHADING	
Type	
Position	
Control type	

FREE APERTURE	
Opening Position	
% Glazing Area Opens	
DOORS	
EXTERNAL	
% Area Door Opens	
Opening position	
INTERNAL	
% Area Door Opens	
% Time door is open	
Opening position	
Operation schedule	
VENTS	
Vent type	
Control option	
Operation schedule	

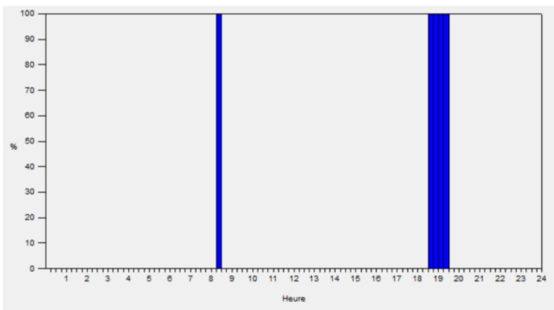
External Window Typology B			
	VERRE Typ B	**AIR 12MM Typ B**	**VERRE Typ B**
General			
Category	**Clear glass**	**Air**	**Clear glass**
Data type			
Data type	1-Broadband	2-personalised	1-Broadband
Thermal properties			
Thickness (mm)	4	12	4
Conductivity (W/m-K)	1	-	1
Solar Properties			
Solar transmittance	0,816	-	0,816
Outside solar reflectance	0,075	-	0,075
Inside solar reflectance	0,075	-	0,075
Visible Properties			
Visible transmittance	0,892	-	0,892
Outside visible reflectance	0,081	-	0,081
inside visible reflectance	0,081	-	0,081
Infra-red properties			
Infra-red transmittance	0	-	0
Outside emissivity	0,84	-	0,84
Inside emissivity	0,84	-	0,84
Personnalised			
Conductivity coefficient A (W/m-K)	-	0,004073	-
Conductivity coefficient B (W/m-K2)	-	0,0000797	-
Conductivity coefficient C (W/m-K3)	-	0	-
Viscosity coefficient A (kg/m-s)	-	0,000003723	-
Viscosity coefficient B (kg/m-s-K)	-	4,94E-08	-
Viscosity coefficient C (kg/m-s-K2)	-	0	-
Specific heat coefficient A (J/kg-K)	-	1002,74	-
Specific heat coefficient B (J/kg-K2)	-	0,012324	-
Specific heat coefficient C (J/kg-K3)	-	0	-
Molecular weight (kg/kmol)	-	28,97	-

Specific heat ratio	-	1,5	-

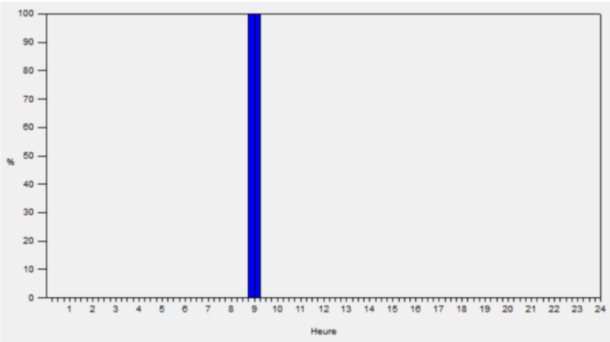
GENERAL LIGHTING	
Template	<None>
Lighting power density (W/m2)	5
Schedule	OFF 24/7 (specify at room scale)
Luminar type	1-Suspendu
Radiant fraction	0,42
Visible fraction	0,18
LIGHTING CONTROL	
Working plane height (m)	
Control type	
Min output fraction	
Min output power fraction	
GLARE	
Maximum allowable glare index	
View angle relative to y-axis (°)	
LIGHTING AREA 1	
% zone covered by lightning area 1	
LIGHTING AREA 2	
Target illuminance (lux)	
% zone covered by lightning area 2	
TASK AND DISPLAY LIGHTNING	
Gain (W/m2)	
Schedule	
EXTERIOR LIGHTING	
Design level (W)	
Schedule	
Control option	
COST	
Cost per area (GBP/m2 GIFA)	0



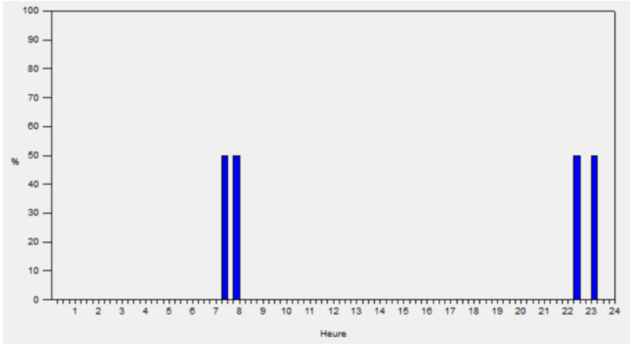
Diningroom Lighting Typ B Calibration (summer time)



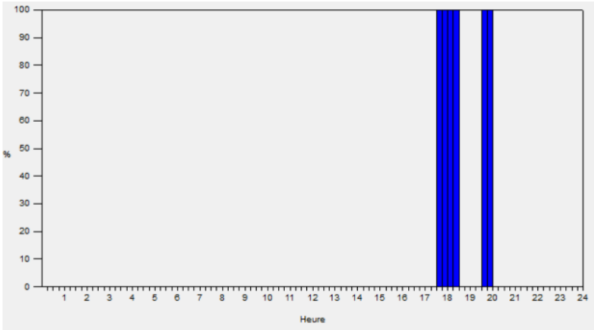
Diningroom Lighting Typ A Calibration (winter time)



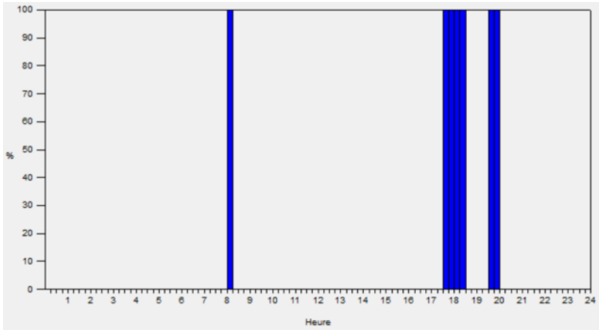
Circulation Lighting Hours Typ B



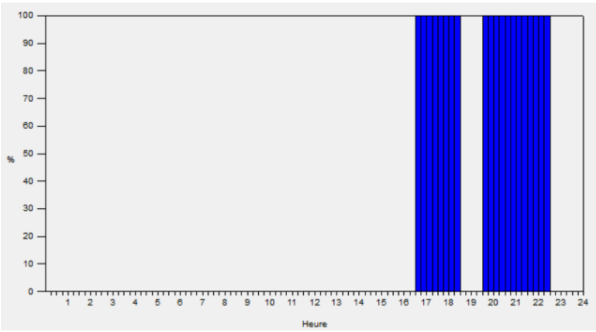
WC Lighting Typ B



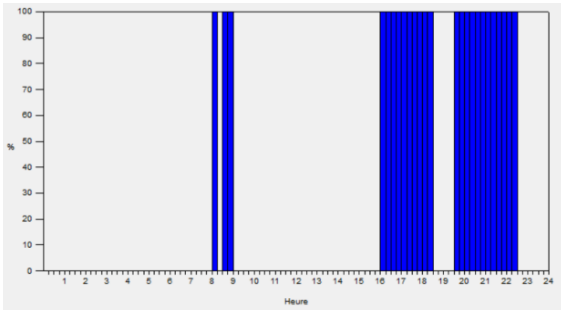
Kitchen Lighting Typ B Calibration



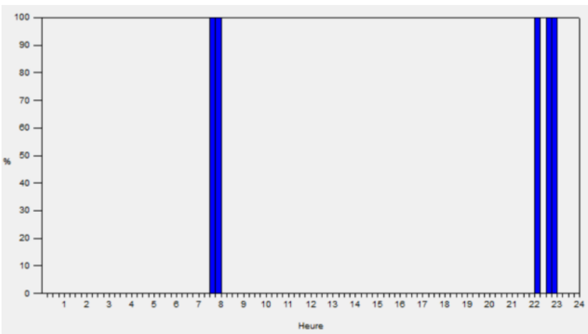
Kitchen Lighting Typ B Calibration (winter time)



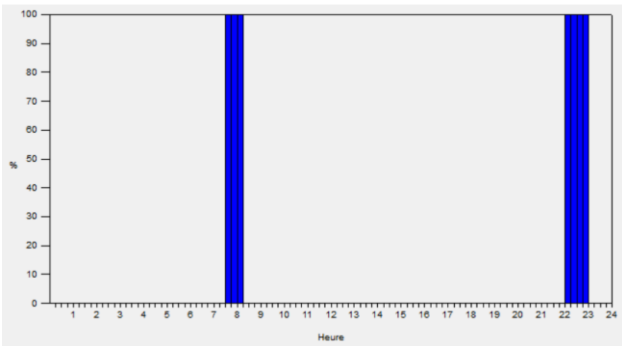
Livingroom Lighting Typ B Calibration



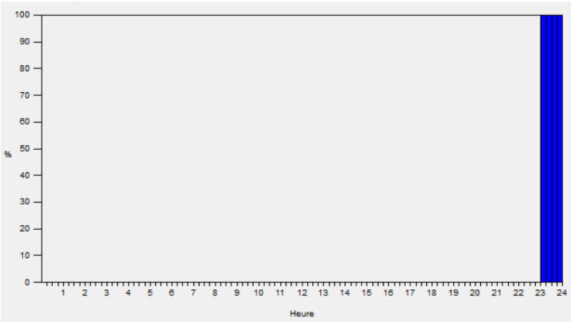
Livingroom Lighting Typ B Calibration



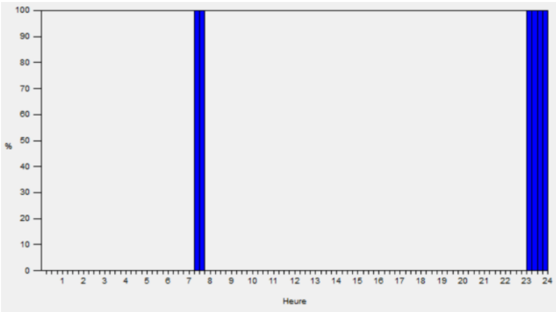
Bathroom Lighting Typ B Calibration WE (weekday)



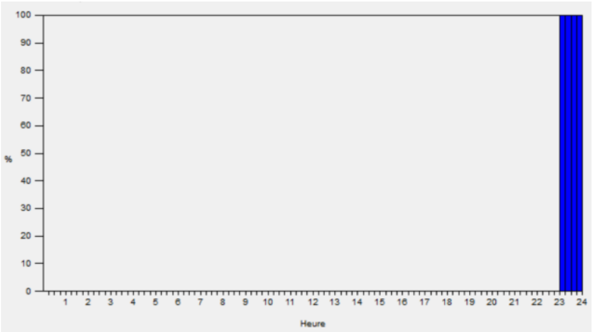
Bathroom Lighting Typ B Calibration WE (weekend)



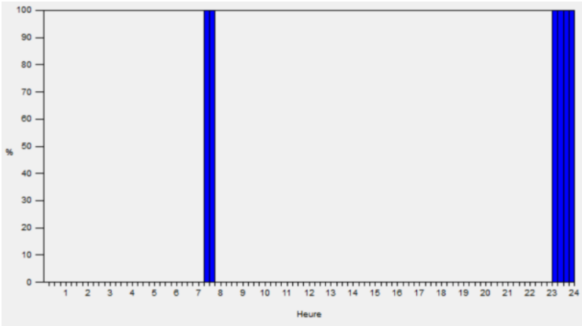
Bedroom Lighting Typ B Calibration (summer time)



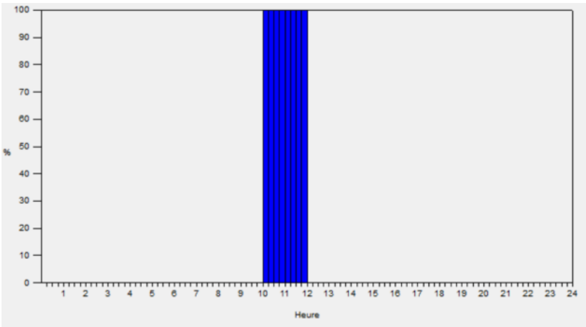
Bedroom Lighting Typ B Calibration (winter time)



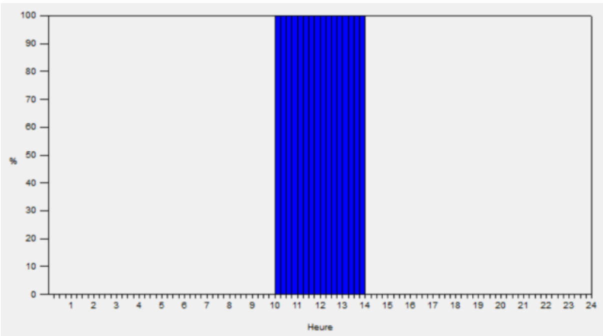
Bedroom 2 Lighting Typ B Calibration (only the weekend, summer time)



Bedroom 2 Lighting Typ B Calibration (only the weekend, winter time)



Office Lighting Typ B Calibration WE (weekday)

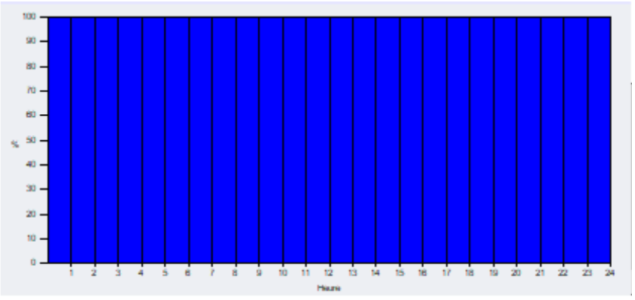


Office Lighting Typ B Calibration WE

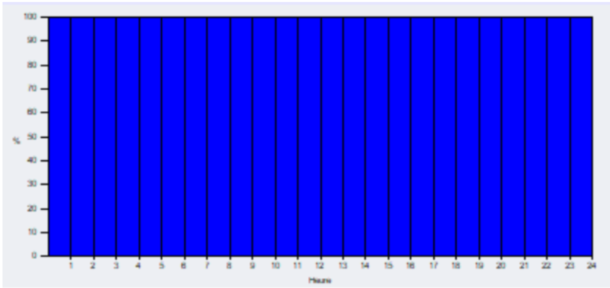
HVAC	
Template	<None>
MECHANICAL VENTILATION	
Outside air definition method	
Outside air (ac/h)	
Schedule	
ECONOMISER (FREE COOLING)	
Type	
Max outdoor air rate when economiser operates (ac/h)	
HEAT RECOVERY	
Heat recovery type	
Sensible heat recovery effectiveness	
Latent heat recovery effectiveness	
HEATING	
Fuel	2- Natural gas
Heating system seasonal CoP	0,87
SUPPLY AIR CONDITION	
Maximum supply air temperature (°C)	35
Maximum supply air humidity (g/g)	0,0156
Heating limit type	2- Limit capacity
Schedule	ON 24/7 (specify at room scale)
COOLING	
Cooling system	
Fuel	
Cooling system seasonal CoP	
SUPPLY AIR CONDITION	
Minimum supply air temperature (°C)	
Minimum supply air humidity (g/g)	
Schedule	
HUMIDITY CONTROL	
Humidification control type	
Dehumidification control type	

DOMESTIC HOT WATER	
DHW Template	DHW Template
Type	4- Instantaneous hot water only
DHW Cop	0,85
Fuel	2-Natural Gas
WATER TEMPERATURES	
Delivery temperature (°C)	60
Mains supply temperature (°C)	10
Schedule	OFF 24/7 (specify at room scale)
NATURAL VENTILATION	
Outside air definition method	1- By zone
Outside air (ac/h)	5
Schedule	ON 24/7 (specify at room scale)
OUTDOOR TEMPERATURE LIMITS	
Min temperature definition	1-By value
Min temprature (°C)	10
Max temperature definition	1-By value
Max temperature (°C)	30
DELTA T LIMITS	
Delta T definition	1-By value
Delta T (deltaC)	0
DELTA T AND WIND SPEED COEFFICIENTS	
Constant	1
Temperature	0
Velocity	0
Velocity squared	0
MIXED MODE ZONE EQUIPEMENT	
Min outdoor temperature (°C)	
Max outdoor temperature (°C)	
Min outdoor enthaplpy (J/kg)	
Max outdoor enthalpy (J/kg)	
Min outdoor dew point temperature (°C)	
Max outdoor dew point temperature (°C)	
EARTH TUBE	

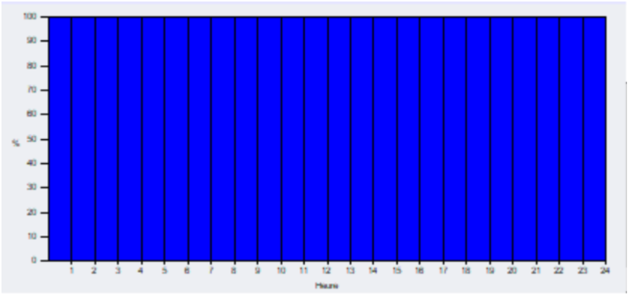
Outside air definition method	
Schedule	
CONTROL	
Minimum zone temperature when cooling (°C)	
Maximum zone temperature when heating (°C)	
Delta temperature (deltaC)	
FAN ELECTRIC CONSUMPTION CONFIGURATION	
Earth tube type	
PIPE SPECIFICATIONS	
Pipe radius (m)	
Pipe thickness (m)	
Pipe lenght (m)	
Pipe thermal conductivity (W/m-K)	
Pipe depth under ground surface (m)	
SOIL HEAT TRANSFER CALCULATIONS	
Soil condition	
Average soil surface temperature (°C)	
Amplitude of soil surface temperature (deltaC)	
Phase constant of soil surface temperature	
TERM FLOW COEFFICIENTS	
Constant	
Temperature	
Velocity	
Velocity squared	
AIR TEMPERATURE DISTRIBUTION	
Distribution mode	1-Mixed
COST	
HVAC cost (GBP/m2 GIFA)	
Other services costs (GBP/m2 GIFA)	



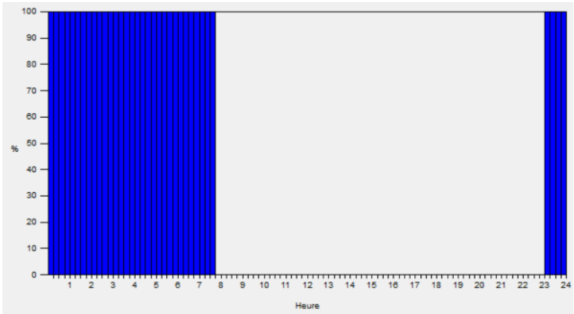
Livingroom+Diningroom+Kitchen+ Office Heating All Typ B Calibration



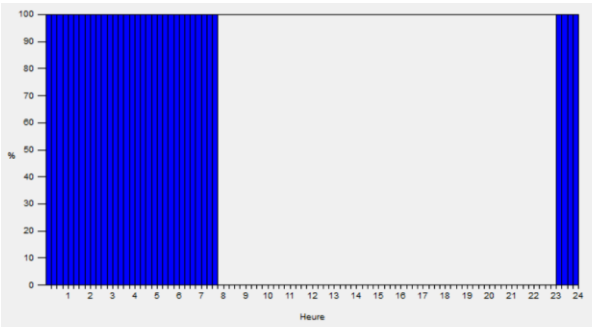
Circulation Heating All Typ B



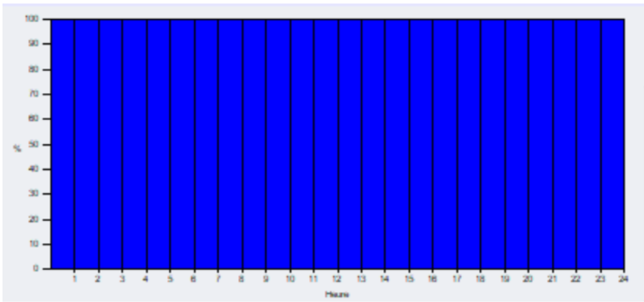
Bathroom Heating All Typ B



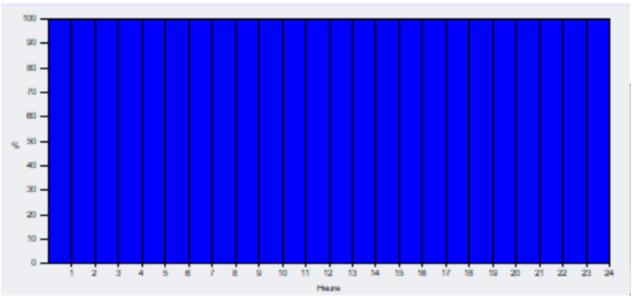
Bedroom Heating Typ B



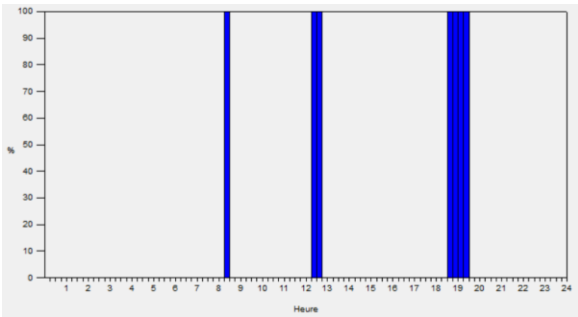
Bedroom 2 Heating Typ B Calibration



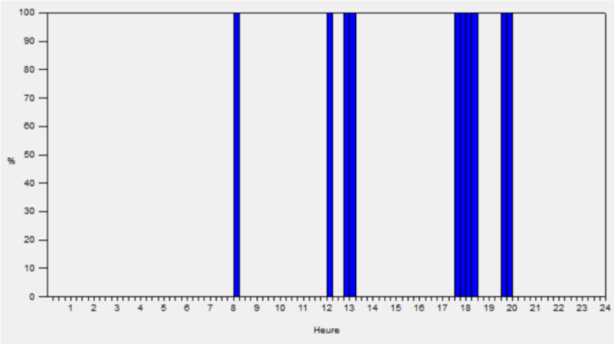
Office Heating All Typ B Calibration



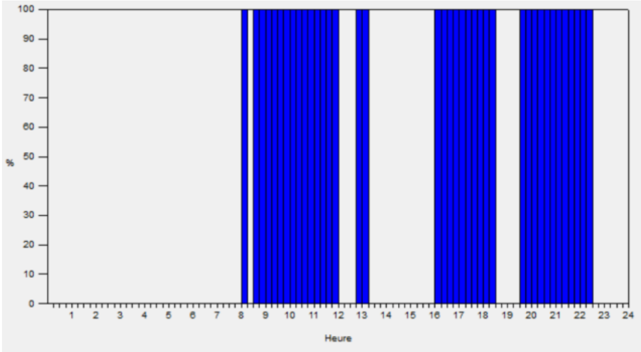
WC Heating All Typ B Calibration



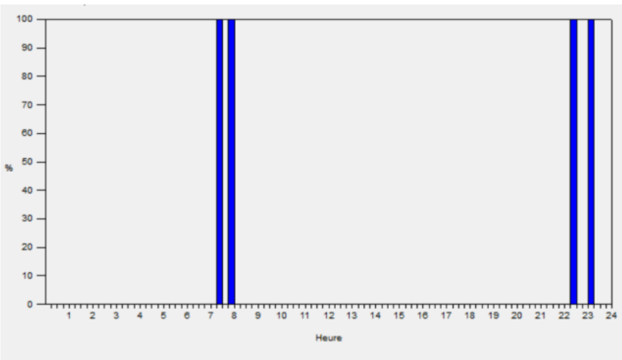
Diningroom Ventilation Typ B



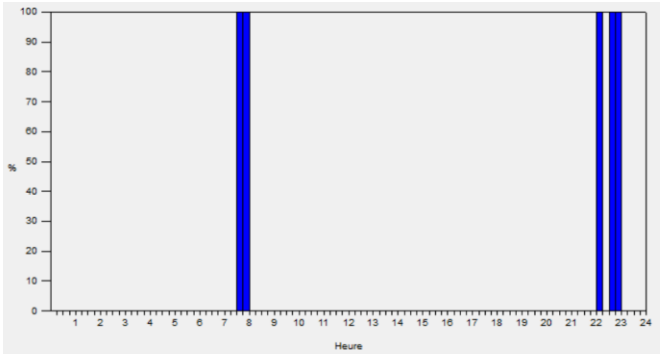
Kitchen Ventilation Typ B



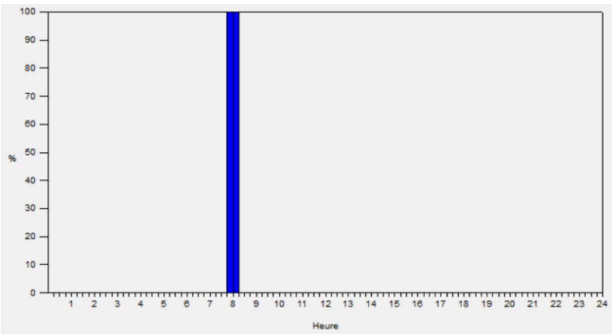
Livingroom Ventilation Typ B



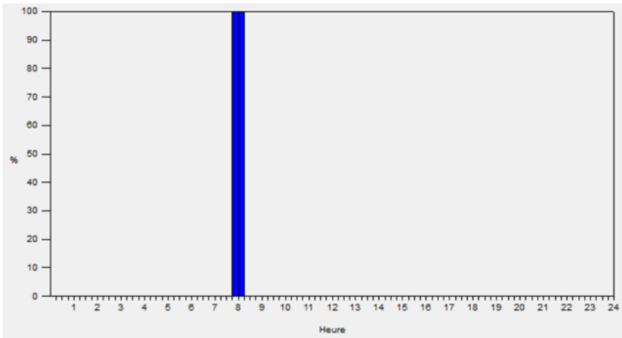
WC ventilation Typ B



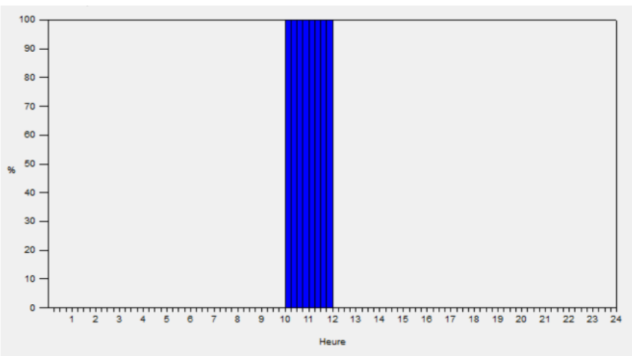
Bathroom Ventilation Typ B



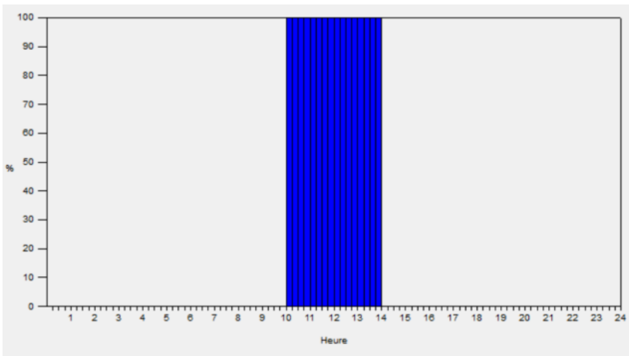
Bedroom Ventilation Typ B



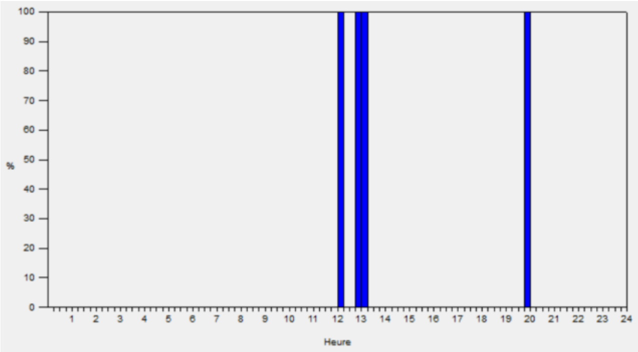
Bedroom 2 Ventilation Typ B
Calibration (only on the weekend)



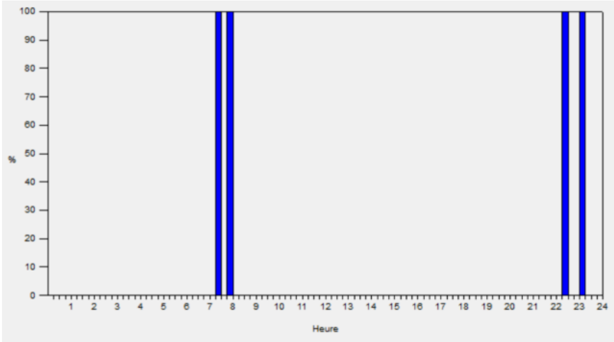
Office Ventilation Typ B Calibration
WE (weekday)



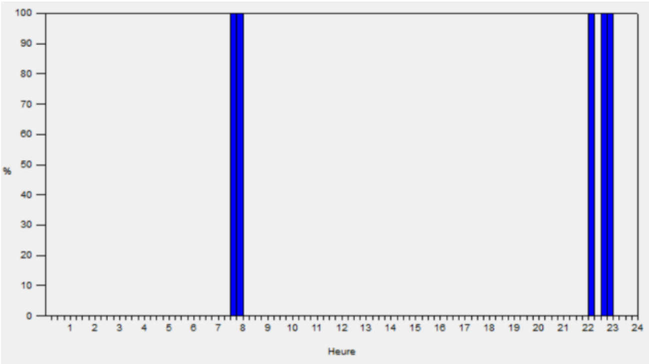
Office Ventilation Typ B



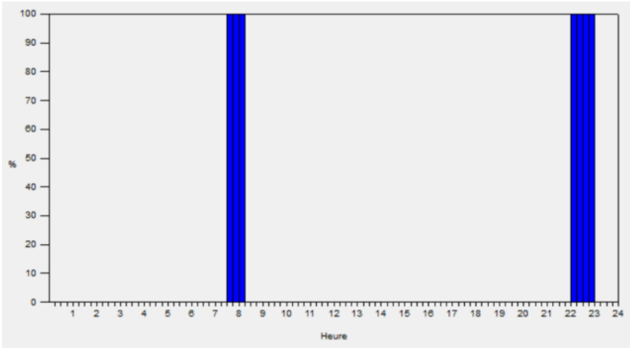
Kitchen DHW Typ B



WC DHW Typ B



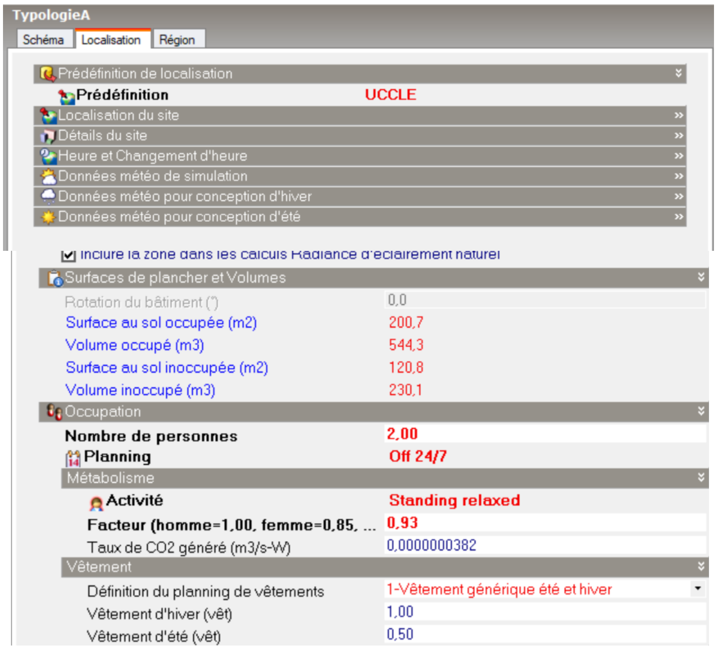
Bathroom DHW Typ B Calibration WE (weekday)

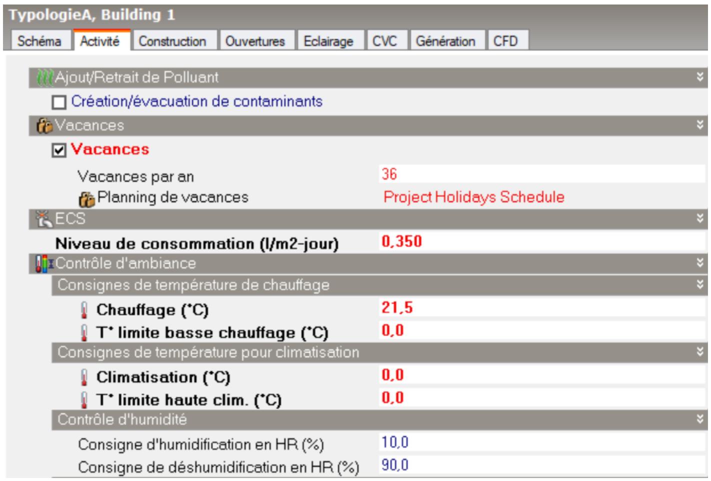


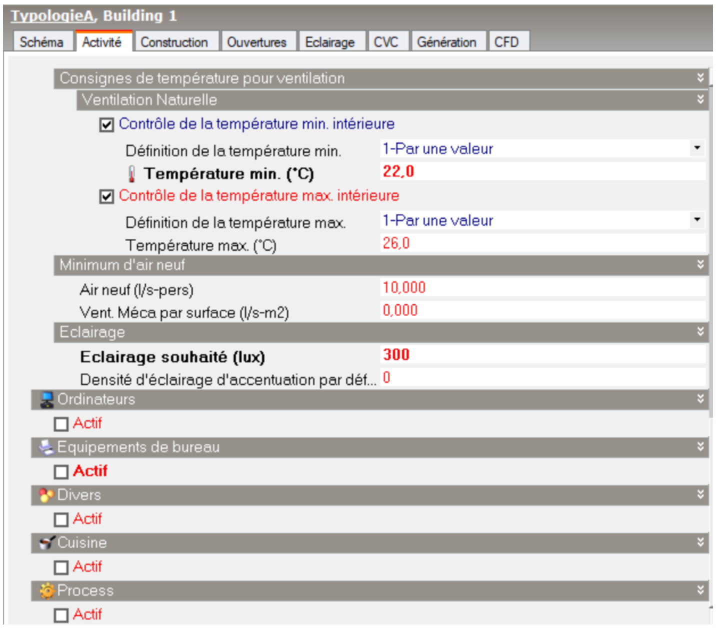
Bathroom DHW Typ B Calibration WE (weekend)

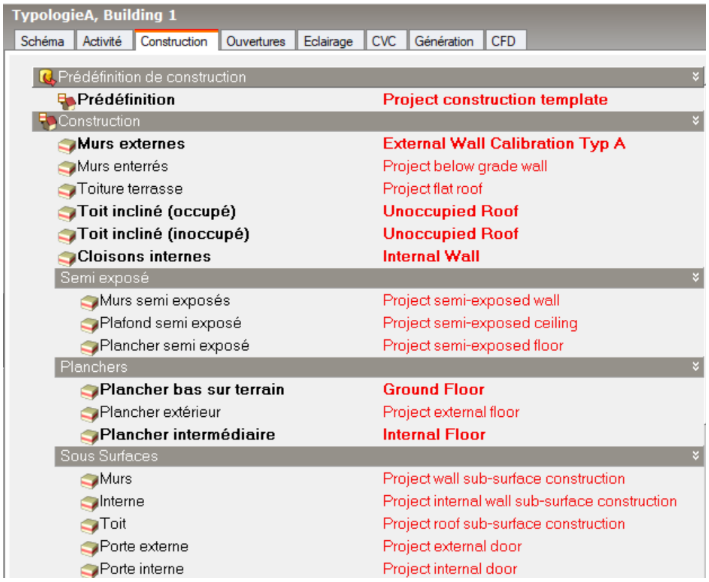
Appendix 12: Input Data Design Builder typology A

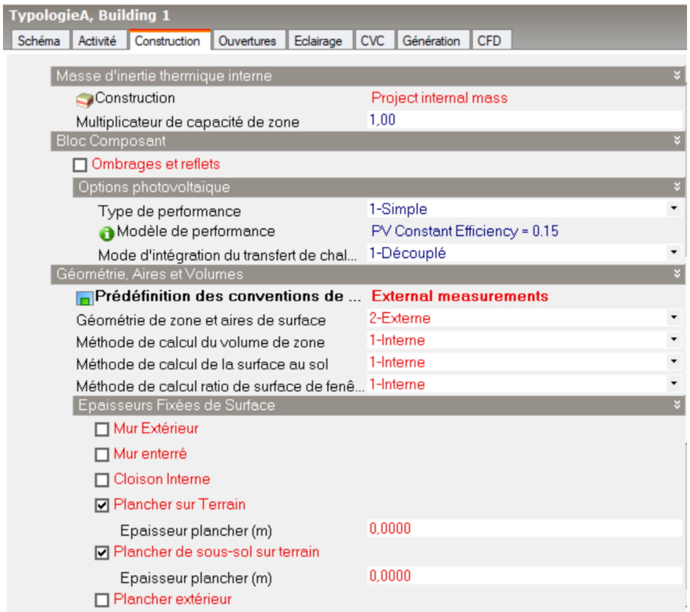
Screenshot only at the scale of the buildings not for each zone (schedule OFF at the scale of the building but ON in the zones)

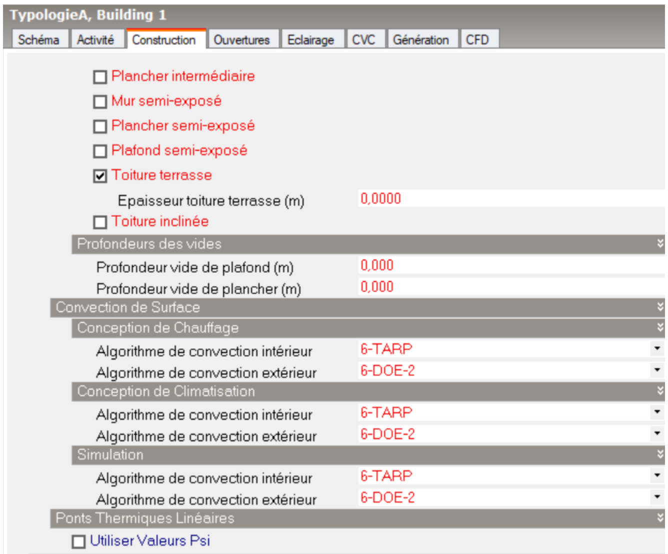


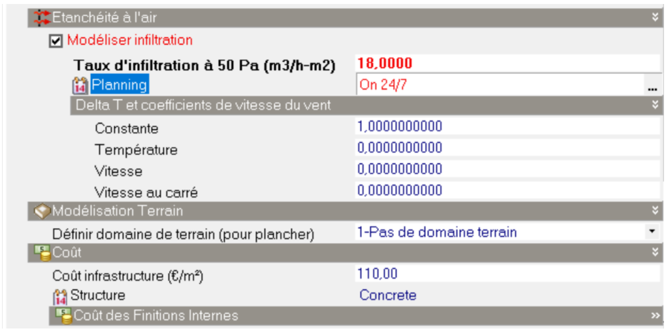


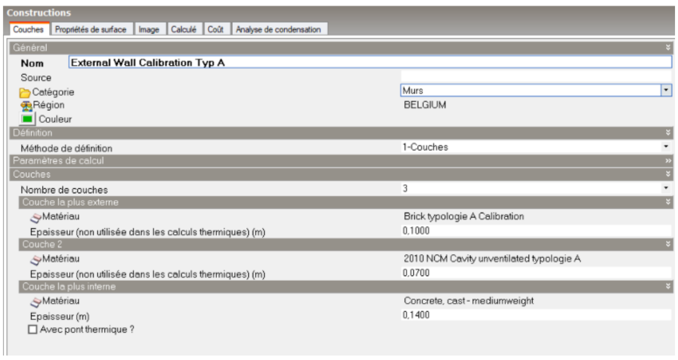

TypologieA, Building 1
Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Consignes de température pour ventilation
Ventilation Naturelle
Contrôle de la température min. intérieure
Définition de la température min. 1-Par une valeur
Température min. (°C) 22,0
Contrôle de la température max. intérieure
Définition de la température max. 1-Par une valeur
Température max. (°C) 26,0
Minimum d'air neuf
Air neuf (l/s-pers) 10,000
Vent. Méca par surface (l/s-m2) 0,000
Eclairage
Eclairage souhaité (lux) 300
Densité d'éclairage d'accentuation par déf... 0
Ordinateurs
Actif
Equipements de bureau
Actif
Divers
Actif
Cuisine
Actif
Process
Actif

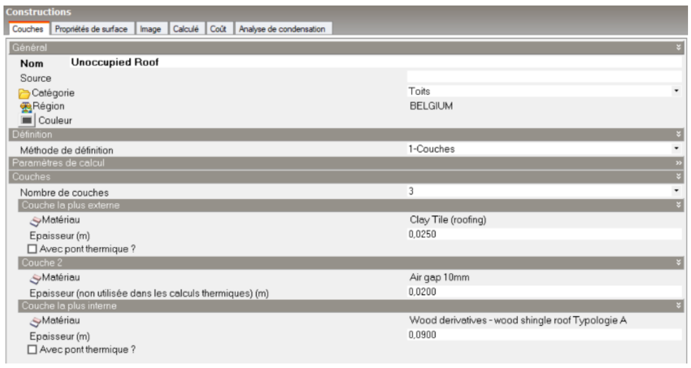

TypologieA, Building 1
Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Prédéfinition de construction
Prédéfinition Project construction template
Construction
Murs externes External Wall Calibration Typ A
Murs enterrés Project below grade wall
Toiture terrasse Project flat roof
Toit incliné (occupé) Unoccupied Roof
Toit incliné (inoccupé) Unoccupied Roof
Cloisons internes Internal Wall
Semi exposé
Murs semi exposés Project semi-exposed wall
Plafond semi exposé Project semi-exposed ceiling
Plancher semi exposé Project semi-exposed floor
Planchers
Plancher bas sur terrain Ground Floor
Plancher extérieur Project external floor
Plancher intermédiaire Internal Floor
Sous Surfaces
Murs Project wall sub-surface construction
Interne Project internal wall sub-surface construction
Toit Project roof sub-surface construction
Porte externe Project external door
Porte interne Project internal door

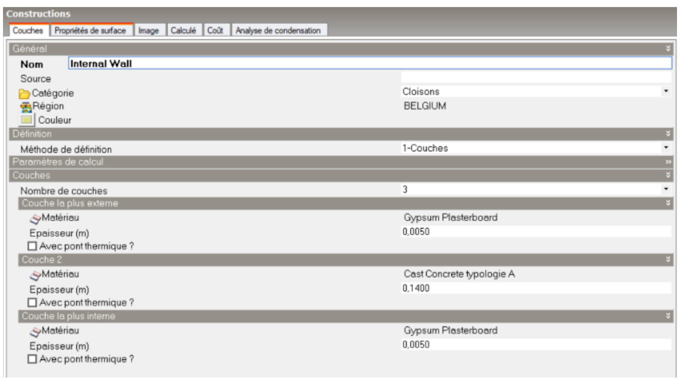

TypologieA, Building 1
Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Masse d'inertie thermique interne
Construction Project internal mass
Multiplicateur de capacité de zone 1,00
Bloc Composant
Ombrages et reflets
Options photovoltaïque
Type de performance 1-Simple
Modèle de performance PV Constant Efficiency = 0.15
Mode d'intégration du transfert de chal... 1-Découplé
Géométrie, Aires et Volumes
Prédéfinition des conventions de ... External measurements
Géométrie de zone et aires de surface 2-Externe
Méthode de calcul du volume de zone 1-Interne
Méthode de calcul de la surface au sol 1-Interne
Méthode de calcul ratio de surface de fenê... 1-Interne
Epaisseurs Fixées de Surface
Mur Extérieur
Mur enterré
Cloison Interne
Plancher sur Terrain
Epaisseur plancher (m) 0,0000
Plancher de sous-sol sur terrain
Epaisseur plancher (m) 0,0000
Plancher extérieur

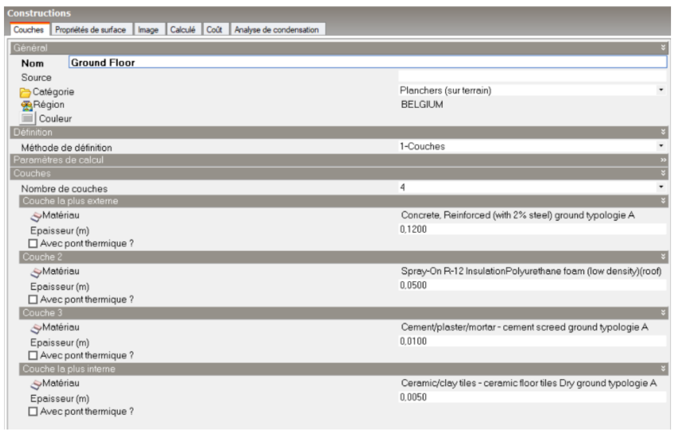

TypologieA, Building 1
Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Plancher intermédiaire
Mur semi-exposé
Plancher semi-exposé
Plafond semi-exposé
Toiture terrasse
Epaisseur toiture terrasse (m) 0,0000
Toiture inclinée
Profondeurs des vides
Profondeur vide de plafond (m) 0,000
Profondeur vide de plancher (m) 0,000
Convection de Surface
Conception de Chauffage
Algorithme de convection intérieur 6-TARP
Algorithme de convection extérieur 6-DOE-2
Conception de Climatisation
Algorithme de convection intérieur 6-TARP
Algorithme de convection extérieur 6-DOE-2
Simulation
Algorithme de convection intérieur 6-TARP
Algorithme de convection extérieur 6-DOE-2
Ponts Thermiques Linéaires
Utiliser Valeurs Psi

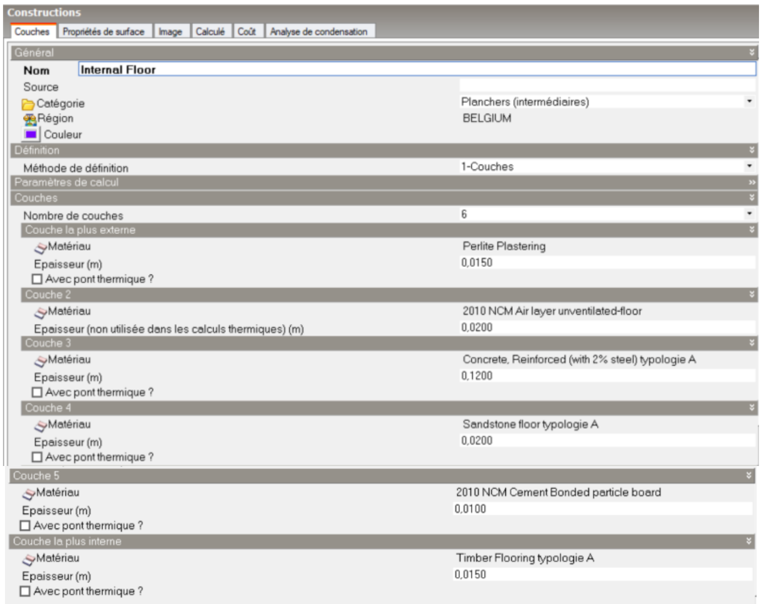

Etanchéité à l'air
Modéliser infiltration
Taux d'infiltration à 50 Pa (m3/h-m2) 18,0000
Planning On 24/7
Delta T et coefficients de vitesse du vent
Constante 1,0000000000
Température 0,0000000000
Vitesse 0,0000000000
Vitesse au carré 0,0000000000
Modélisation Terrain
Définir domaine de terrain (pour plancher) 1-Pas de domaine terrain
Coût
Coût infrastructure (€/m²) 110,00
Structure Concrete
Coût des Finitions Internes

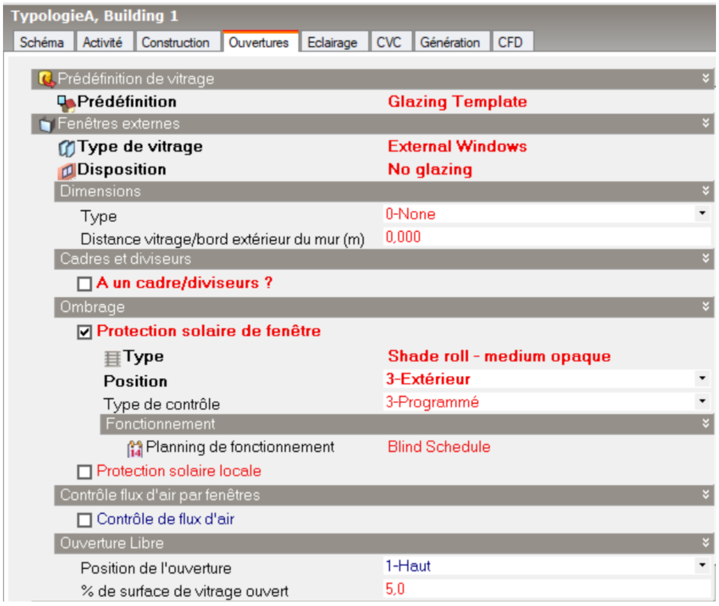

Constructions
Couches
Propriétés de surface
Image
Calculé
Coût
Analyse de condensation
Général
Nom External Wall Calibration Typ A
Source
Catégorie Murs
Région BELGIUM
Couleur
Définition
Méthode de définition 1-Couches
Paramètres de calcul
Couches
Nombre de couches 3
Couche la plus externe
Matériau Brick typologie A Calibration
Epaisseur (non utilisée dans les calculs thermiques) (m) 0,1000
Couche 2
Matériau 2010 NCM Cavity unventilated typologie A
Epaisseur (non utilisée dans les calculs thermiques) (m) 0,0700
Couche la plus interne
Matériau Concrete, cast - mediumweight
Epaisseur (m) 0,1400
Avec pont thermique ?

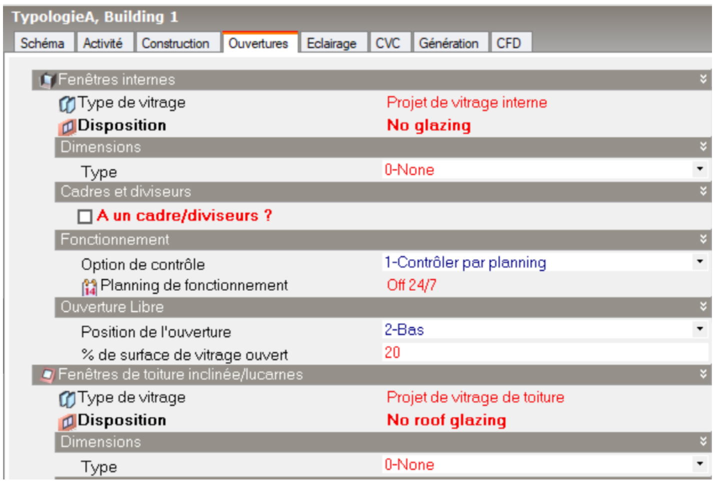

Constructions
Couches
Propriétés de surface
Image
Calculé
Coût
Analyse de condensation
Général
Nom Unoccupied Roof
Source
Catégorie Toits
Région BELGIUM
Couleur
Définition
Méthode de définition 1-Couches
Paramètres de calcul
Couches
Nombre de couches 3
Couche la plus externe
Matériau Clay Tile (roofing)
Epaisseur (m) 0,0250
Avec pont thermique ?
Couche 2
Matériau Air gap 10mm
Epaisseur (non utilisée dans les calculs thermiques) (m) 0,0200
Couche la plus interne
Matériau Wood derivatives - wood shingle roof Typologie A
Epaisseur (m) 0,0900
Avec pont thermique ?

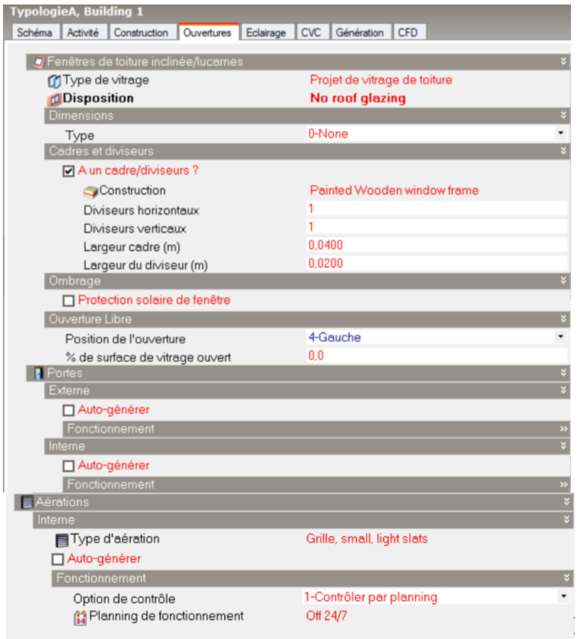

Constructions
Couches
Propriétés de surface
Image
Calculé
Coût
Analyse de condensation
Général
Nom Internal Wall
Source
Catégorie Cloisons
Région BELGIUM
Couleur
Définition
Méthode de définition 1-Couches
Paramètres de calcul
Couches
Nombre de couches 3
Couche la plus externe
Matériau Gypsum Plasterboard
Epaisseur (m) 0,0050
Avec pont thermique ?
Couche 2
Matériau Cast Concrete typologie A
Epaisseur (m) 0,1400
Avec pont thermique ?
Couche la plus interne
Matériau Gypsum Plasterboard
Epaisseur (m) 0,0050
Avec pont thermique ?

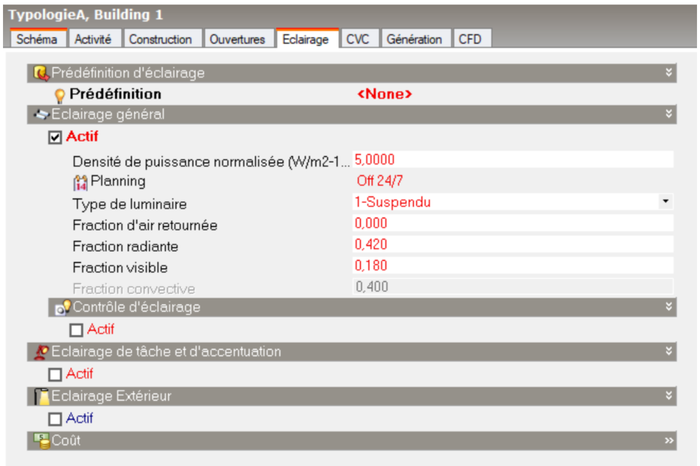

Constructions
Couches
Propriétés de surface
Image
Calculé
Coût
Analyse de condensation
Général
Nom Ground Floor
Source
Catégorie Planchers (sur terrain)
Région BELGIUM
Couleur
Définition
Méthode de définition 1-Couches
Paramètres de calcul
Couches
Nombre de couches 4
Couche la plus externe
Matériau Concrete, Reinforced (with 2% steel) ground typologie A
Epaisseur (m) 0,1200
Avec pont thermique ?
Couche 2
Matériau Spray-On R-12 InsulationPolyurethane foam (low density)(roof)
Epaisseur (m) 0,0500
Avec pont thermique ?
Couche 3
Matériau Cement/plaster/mortar - cement screed ground typologie A
Epaisseur (m) 0,0100
Avec pont thermique ?
Couche la plus interne
Matériau Ceramic/clay tiles - ceramic floor tiles Dry ground typologie A
Epaisseur (m) 0,0050
Avec pont thermique ?

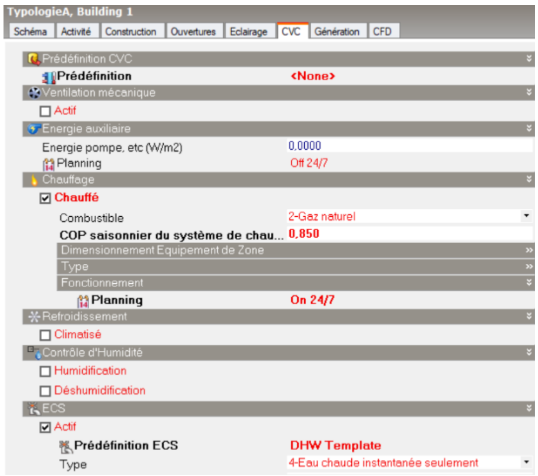

Constructions
Couches | Propriétés de surface | Image | Calculé | Coût | Analyse de condensation
Général
Nom: Internal Floor
Source
Catégorie: Planchers (intermédiaires)
Région: BELGIUM
Couleur
Définition
Méthode de définition: 1-Couches
Paramètres de calcul
Couches
Nombre de couches: 6
Couche la plus externe
Matériau: Perlite Plastering
Epaisseur (m): 0,0150
Avec pont thermique ?
Couche 2
Matériau: 2010 NCM Air layer unventilated-floor
Epaisseur (non utilisée dans les calculs thermiques) (m): 0,0200
Couche 3
Matériau: Concrete, Reinforced (with 2% steel) typologie A
Epaisseur (m): 0,1200
Avec pont thermique ?
Couche 4
Matériau: Sandstone floor typologie A
Epaisseur (m): 0,0200
Avec pont thermique ?
Couche 5
Matériau: 2010 NCM Cement Bonded particle board
Epaisseur (m): 0,0100
Avec pont thermique ?
Couche la plus interne
Matériau: Timber Flooring typologie A
Epaisseur (m): 0,0150
Avec pont thermique ?

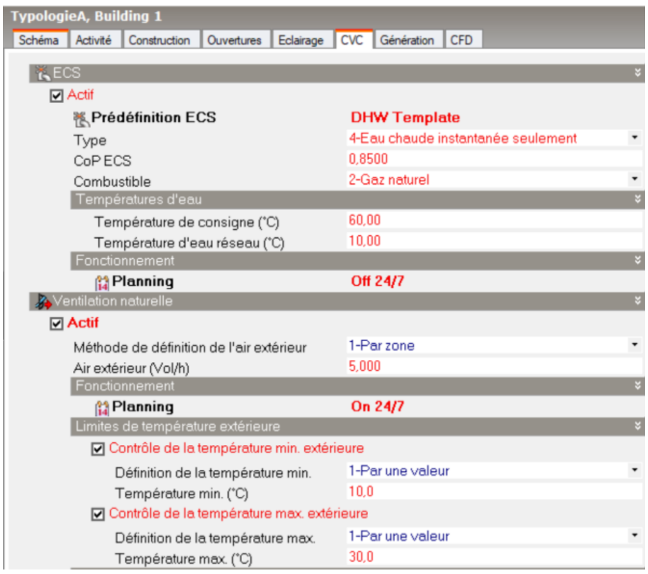

TypologieA, Building 1
Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Prédéfinition de vitrage
Prédéfinition: Glazing Template
Fenêtres externes
Type de vitrage: External Windows
Disposition: No glazing
Dimensions
Type: 0-None
Distance vitrage/bord extérieur du mur (m): 0,000
Cadres et diviseurs
A un cadre/diviseurs ?
Ombrage
Protection solaire de fenêtre
Type: Shade roll - medium opaque
Position: 3-Extérieur
Type de contrôle: 3-Programmé
Fonctionnement
Planning de fonctionnement: Blind Schedule
Protection solaire locale
Contrôle flux d'air par fenêtres
Contrôle de flux d'air
Ouverture Libre
Position de l'ouverture: 1-Haut
% de surface de vitrage ouvert: 5,0

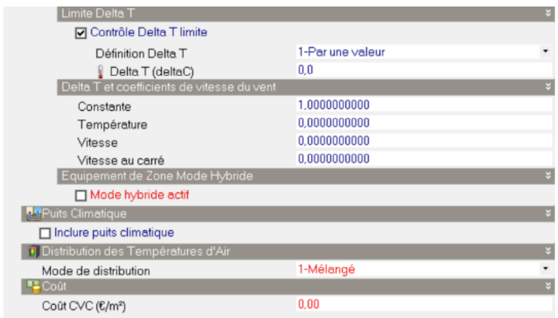

TypologieA, Building 1
Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Fenêtres internes
Type de vitrage: Projet de vitrage interne
Disposition: No glazing
Dimensions
Type: 0-None
Cadres et diviseurs
A un cadre/diviseurs ?
Fonctionnement
Option de contrôle: 1-Contrôler par planning
Planning de fonctionnement: Off 24/7
Ouverture Libre
Position de l'ouverture: 2-Bas
% de surface de vitrage ouvert: 20
Fenêtres de toiture inclinée/lucarnes
Type de vitrage: Projet de vitrage de toiture
Disposition: No roof glazing
Dimensions
Type: 0-None


TypologieA, Building 1
Schéma Activité Construction Ouvertures Eclairage CVC Génération CFD
Fenêtres de toiture inclinée/lucarnes
Type de vitrage Projet de vitrage de toiture
Disposition No roof glazing
Dimensions
Type 0-None
Cadres et diviseurs
A un cadre/diviseurs ?
Construction Painted Wooden window frame
Diviseurs horizontaux 1
Diviseurs verticaux 1
Largeur cadre (m) 0,0400
Largeur du diviseur (m) 0,0200
Ombrage
Protection solaire de fenêtre
Ouverture Libre
Position de l'ouverture 4-Gauche
% de surface de vitrage ouvert 0,0
Portes
Externe
Auto-générer
Fonctionnement
Interne
Auto-générer
Fonctionnement
Aérations
Interne
Type d'aération Grille, small, light slats
Auto-générer
Fonctionnement
Option de contrôle 1-Contrôler par planning
Planning de fonctionnement Off 24/7


TypologieA, Building 1
Schéma Activité Construction Ouvertures Eclairage CVC Génération CFD
Prédéfinition d'éclairage
Prédéfinition <None>
Eclairage général
Actif
Densité de puissance normalisée (W/m2-1... 5,0000
Planning Off 24/7
Type de luminaire 1-Suspendu
Fraction d'air retournée 0,000
Fraction radiante 0,420
Fraction visible 0,180
Fraction convective 0,400
Contrôle d'éclairage
Actif
Eclairage de tâche et d'accentuation
Actif
Eclairage Extérieur
Actif
Coût

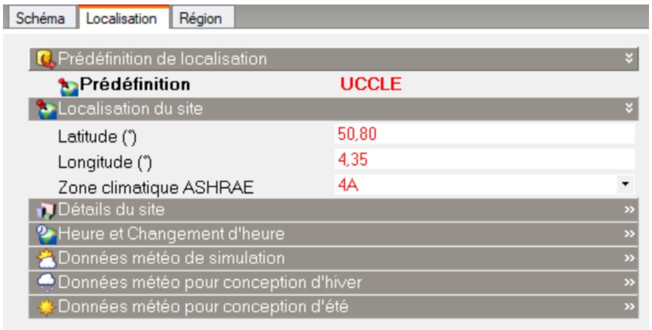

TypologieA, Building 1
Schéma Activité Construction Ouvertures Eclairage CVC Génération CFD
Prédéfinition CVC
Prédéfinition <None>
Ventilation mécanique
Actif
Energie auxiliaire
Energie pompe, etc (W/m2) 0,0000
Planning Off 24/7
Chauffage
Chauffé
Combustible 2-Gaz naturel
COP saisonnier du système de chau... 0,850
Dimensionnement Equipement de Zone
Type
Fonctionnement
Planning On 24/7
Refroidissement
Climatisé
Contrôle d'Humidité
Humidification
Déshumidification
ECS
Actif
Prédéfinition ECS DHW Template
Type 4-Eau chaude instantanée seulement

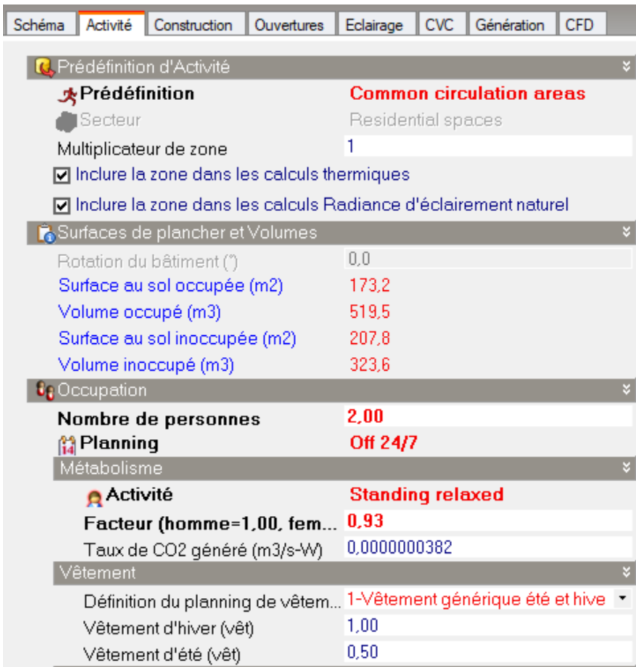

TypologieA, Building 1
Schéma Activité Construction Ouvertures Eclairage CVC Génération CFD
ECS
Actif
Prédéfinition ECS DHW Template
Type 4-Eau chaude instantanée seulement
CoP ECS 0,8500
Combustible 2-Gaz naturel
Températures d'eau
Température de consigne (°C) 60,00
Température d'eau réseau (°C) 10,00
Fonctionnement
Planning Off 24/7
Ventilation naturelle
Actif
Méthode de définition de l'air extérieur 1-Par zone
Air extérieur (Vol/h) 5,000
Fonctionnement
Planning On 24/7
Limites de température extérieure
Contrôle de la température min. extérieure
Définition de la température min. 1-Par une valeur
Température min. (°C) 10,0
Contrôle de la température max. extérieure
Définition de la température max. 1-Par une valeur
Température max. (°C) 30,0

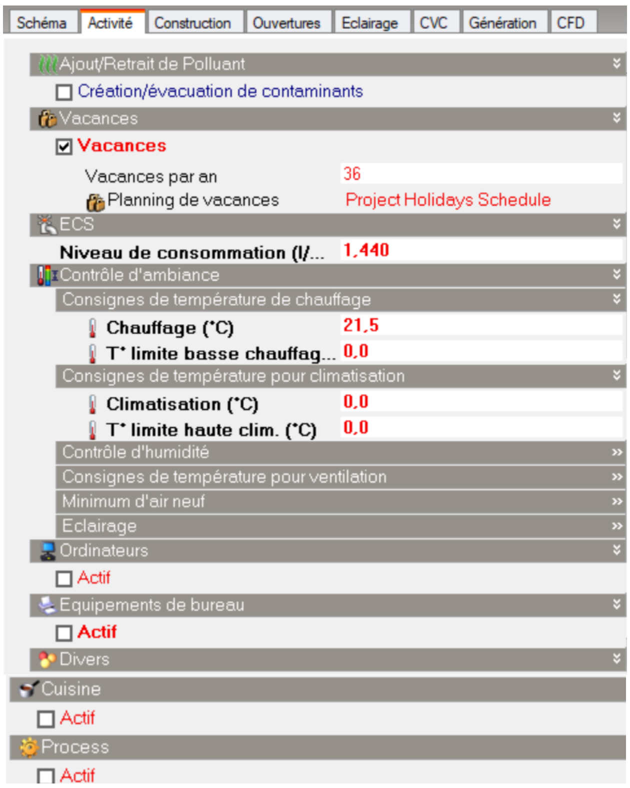

Limite Delta T
Contrôle Delta T limite
Définition Delta T 1-Par une valeur
Delta T (deltaC) 0,0
Delta T et coefficients de vitesse du vent
Constante 1,0000000000
Température 0,0000000000
Vitesse 0,0000000000
Vitesse au carré 0,0000000000
Equipement de Zone Mode Hybride
Mode hybride actif
Puits Climatique
Inclure puits climatique
Distribution des Températures d'Air
Mode de distribution 1-Mélangé
Coût
Coût CVC (€/m²) 0,00

Appendix 13: Input Data Design Builder typology B

Screenshot only at the scale of the buildings not for each zone (schedule OFF at the scale of the building but ON in the zones)







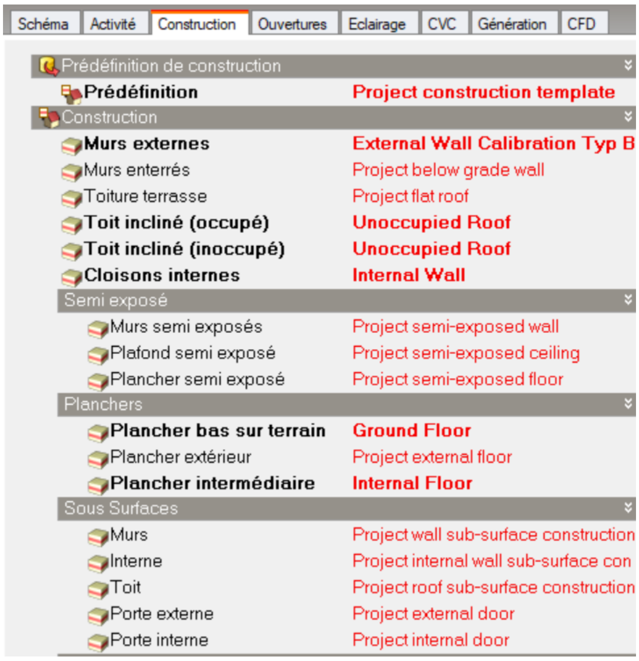


Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Prédéfinition de construction
Prédéfinition
Project construction template
Construction
Murs externes
External Wall Calibration Typ B
Murs enterrés
Project below grade wall
Toiture terrasse
Project flat roof
Toit incliné (occupé)
Unoccupied Roof
Toit incliné (inoccupé)
Unoccupied Roof
Cloisons internes
Internal Wall
Semi exposé
Murs semi exposés
Project semi-exposed wall
Plafond semi exposé
Project semi-exposed ceiling
Plancher semi exposé
Project semi-exposed floor
Planchers
Plancher bas sur terrain
Ground Floor
Plancher extérieur
Project external floor
Plancher intermédiaire
Internal Floor
Sous Surfaces
Murs
Project wall sub-surface construction
Interne
Project internal wall sub-surface con
Toit
Project roof sub-surface construction
Porte externe
Project external door
Porte interne
Project internal door

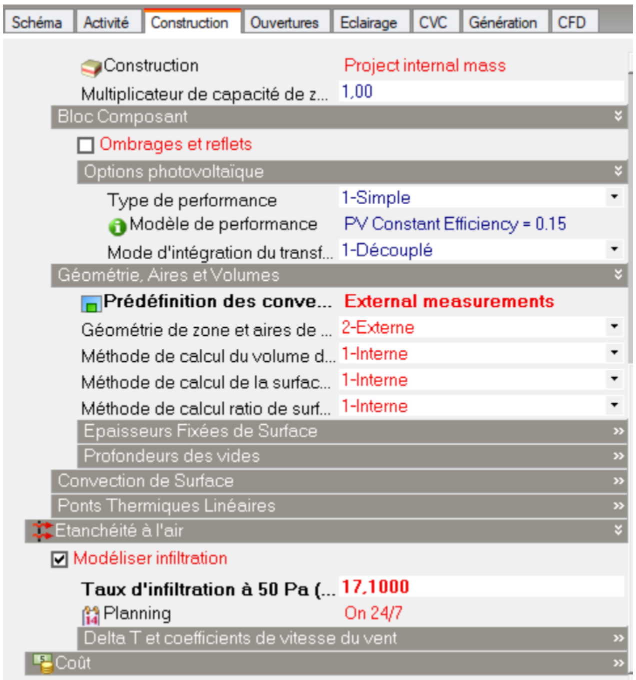
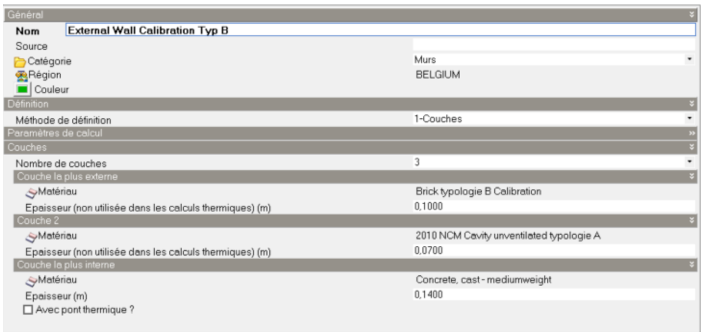
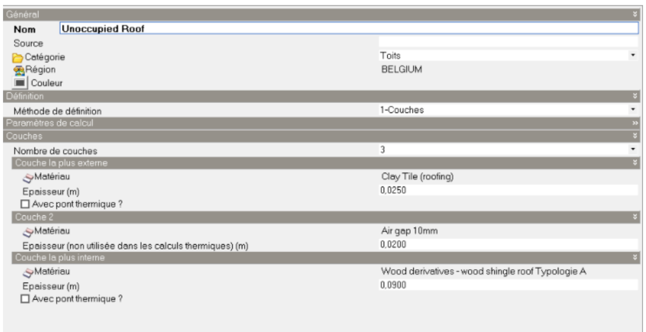


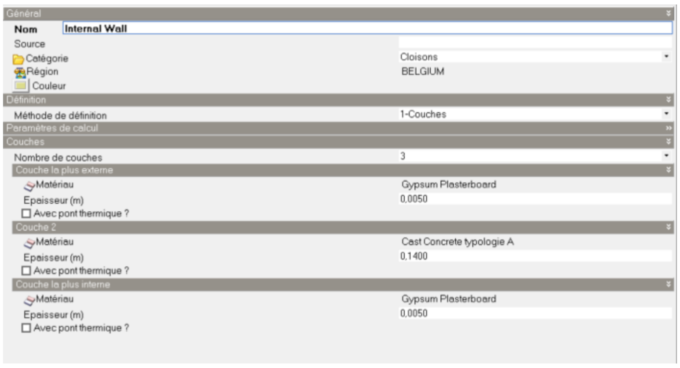
Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Construction
Project internal mass
Multiplicateur de capacité de z...
1,00
Bloc Composant
Ombrages et reflets
Options photovoltaïque
Type de performance
1-Simple
Modèle de performance
PV Constant Efficiency = 0.15
Mode d'intégration du transf...
1-Découplé
Géométrie, Aires et Volumes
Prédéfinition des conve...
External measurements
Géométrie de zone et aires de ...
2-Externe
Méthode de calcul du volume d...
1-Interne
Méthode de calcul de la surfac...
1-Interne
Méthode de calcul ratio de surf...
1-Interne
Epaisseurs Fixées de Surface
Profondeurs des vides
Convection de Surface
Ponts Thermiques Linéaires
Etanchéité à l'air
Modéliser infiltration
Taux d'infiltration à 50 Pa (...
17,1000
Planning
On 24/7
Delta T et coefficients de vitesse du vent
Coût

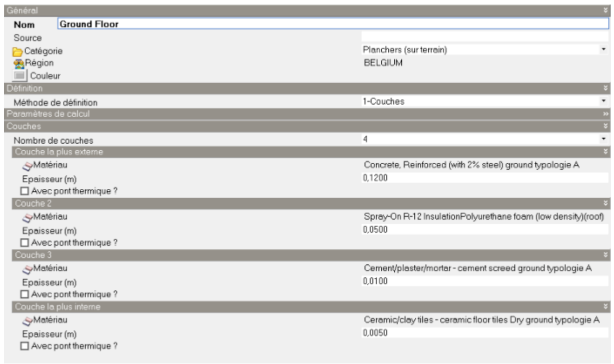


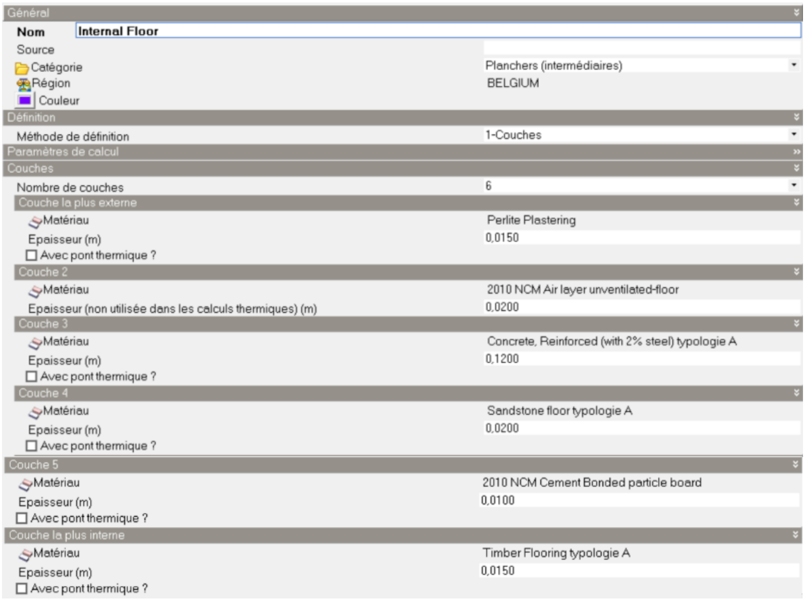
Général
Nom
External Wall Calibration Typ B
Source
Catégorie
Murs
Région
BELGIUM
Couleur
Définition
Méthode de définition
1-Couches
Paramètres de calcul
Couches
Nombre de couches
3
Couche la plus externe
Matériau
Brick typologie B Calibration
Epaisseur (non utilisée dans les calculs thermiques) (m)
0,1000
Couche 2
Matériau
2010 NCM Cavity unventilated typologie A
Epaisseur (non utilisée dans les calculs thermiques) (m)
0,0700
Couche la plus interne
Matériau
Concrete, cast - mediumweight
Epaisseur (m)
0,1400
Avec pont thermique ?



Général
Nom
Unoccupied Roof
Source
Catégorie
Toits
Région
BELGIUM
Couleur
Définition
Méthode de définition
1-Couches
Paramètres de calcul
Couches
Nombre de couches
3
Couche la plus externe
Matériau
Clay Tile (roofing)
Epaisseur (m)
0,0250
Avec pont thermique ?
Couche 2
Matériau
Air gap 10mm
Epaisseur (non utilisée dans les calculs thermiques) (m)
0,0200
Couche la plus interne
Matériau
Wood derivatives - wood shingle roof Typologie A
Epaisseur (m)
0,0900
Avec pont thermique ?


Général
Nom
Internal Wall
Source
Catégorie
Cloisons
Région
BELGIUM
Couleur
Définition
Méthode de définition
1-Couches
Paramètres de calcul
Couches
Nombre de couches
3
Couche la plus externe
Matériau
Gypsum Plasterboard
Epaisseur (m)
0,0050
Avec pont thermique ?
Couche 2
Matériau
Cast Concrete typologie A
Epaisseur (m)
0,1400
Avec pont thermique ?
Couche la plus interne
Matériau
Gypsum Plasterboard
Epaisseur (m)
0,0050
Avec pont thermique ?


Général
Nom
Ground Floor
Source
Catégorie
Planchers (sur terrain)
Région
BELGIUM
Couleur
Définition
Méthode de définition
1-Couches
Paramètres de calcul
Couches
Nombre de couches
4
Couche la plus externe
Matériau
Concrete, Reinforced (with 2% steel) ground typologie A
Epaisseur (m)
0,1200
Avec pont thermique ?
Couche 2
Matériau
Spray-On R-12 InsulationPolyurethane foam (low density)(roof)
Epaisseur (m)
0,0500
Avec pont thermique ?
Couche 3
Matériau
Cement/plaster/mortar - cement screed ground typologie A
Epaisseur (m)
0,0100
Avec pont thermique ?
Couche la plus interne
Matériau
Ceramic/clay tiles - ceramic floor tiles Dry ground typologie A
Epaisseur (m)
0,0050
Avec pont thermique ?


Général
Nom
Internal Floor
Source
Catégorie
Planchers (intermédiaires)
Région
BELGIUM
Couleur
Définition
Méthode de définition
1-Couches
Paramètres de calcul
Couches
Nombre de couches
6
Couche la plus externe
Matériau
Perlite Plastering
Epaisseur (m)
0,0150
Avec pont thermique ?
Couche 2
Matériau
2010 NCM Air layer unventilated-floor
Epaisseur (non utilisée dans les calculs thermiques) (m)
0,0200
Couche 3
Matériau
Concrete, Reinforced (with 2% steel) typologie A
Epaisseur (m)
0,1200
Avec pont thermique ?
Couche 4
Matériau
Sandstone floor typologie A
Epaisseur (m)
0,0200
Avec pont thermique ?
Couche 5
Matériau
2010 NCM Cement Bonded particle board
Epaisseur (m)
0,0100
Avec pont thermique ?
Couche la plus interne
Matériau
Timber Flooring typologie A
Epaisseur (m)
0,0150
Avec pont thermique ?

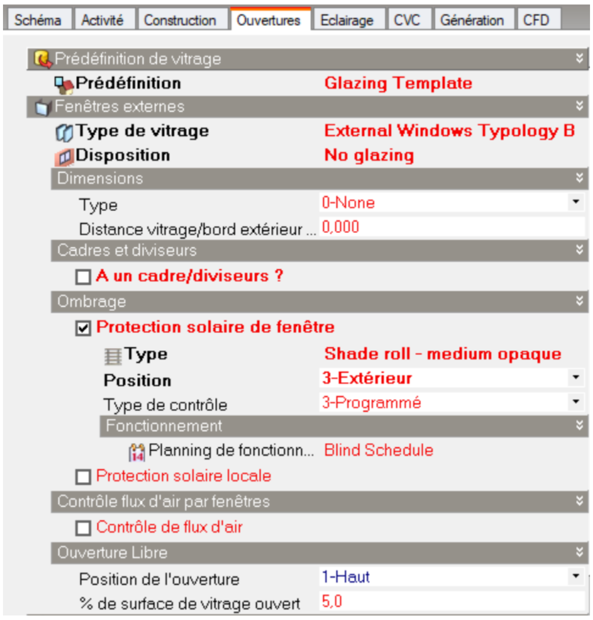


Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Prédéfinition de vitrage
Prédéfinition
Glazing Template
Fenêtres externes
Type de vitrage
External Windows Typology B
Disposition
No glazing
Dimensions
Type
0-None
Distance vitrage/bord extérieur ...
0,000
Cadres et diviseurs
A un cadre/diviseurs ?
Ombrage
Protection solaire de fenêtre
Type
Shade roll - medium opaque
Position
3-Extérieur
Type de contrôle
3-Programmé
Fonctionnement
Planning de fonctionn...
Blind Schedule
Protection solaire locale
Contrôle flux d'air par fenêtres
Contrôle de flux d'air
Ouverture Libre
Position de l'ouverture
1-Haut
% de surface de vitrage ouvert
5,0

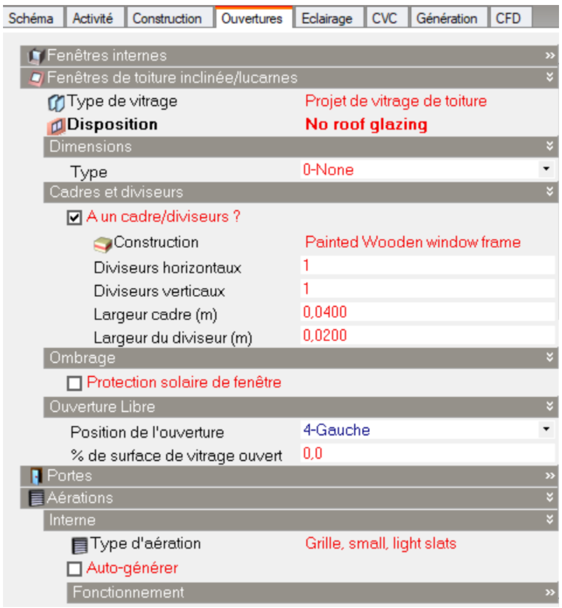
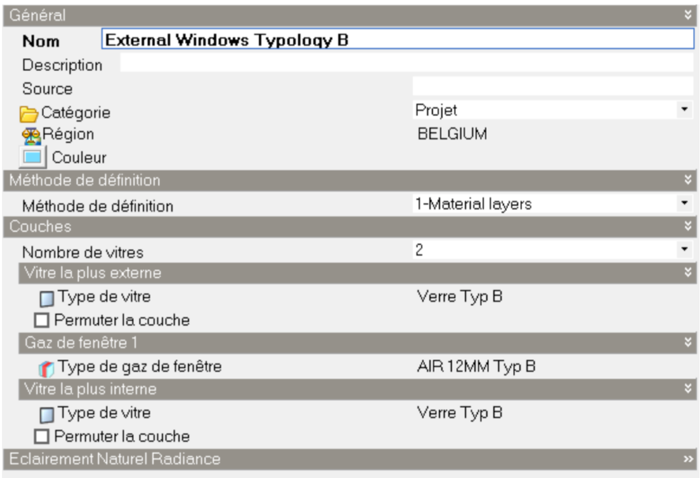


Schéma | Activité | Construction | Ouvertures | Eclairage | CVC | Génération | CFD
Fenêtres internes
Fenêtres de toiture inclinée/lucarnes
Type de vitrage
Projet de vitrage de toiture
Disposition
No roof glazing
Dimensions
Type
0-None
Cadres et diviseurs
A un cadre/diviseurs ?
Construction
Painted Wooden window frame
Diviseurs horizontaux
1
Diviseurs verticaux
1
Largeur cadre (m)
0,0400
Largeur du diviseur (m)
0,0200
Ombrage
Protection solaire de fenêtre
Ouverture Libre
Position de l'ouverture
4-Gauche
% de surface de vitrage ouvert
0,0
Portes
Aérations
Interne
Type d'aération
Grille, small, light slats
Auto-générer
Fonctionnement


Général
Nom External Windows Typology B
Description
Source
Catégorie Projet
Région BELGIUM
Couleur
Méthode de définition
Méthode de définition 1-Material layers
Couches
Nombre de vitres 2
Vitre la plus externe
Type de vitre Verre Typ B
Permuter la couche
Gaz de fenêtre 1
Type de gaz de fenêtre AIR 12MM Typ B
Vitre la plus interne
Type de vitre Verre Typ B
Permuter la couche
Eclairement Naturel Radiance

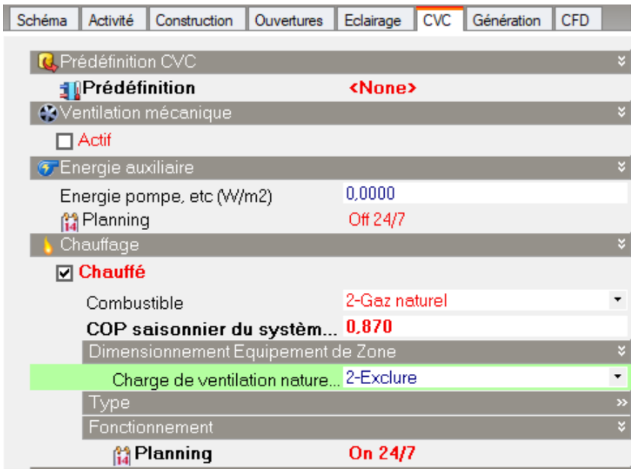


Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Prédéfinition CVC
Prédéfinition <None>
Ventilation mécanique
Actif
Energie auxiliaire
Energie pompe, etc (W/m2) 0,0000
Planning Off 24/7
Chauffage
Chauffé
Combustible 2-Gaz naturel
COP saisonnier du systèm... 0,870
Dimensionnement Equipement de Zone
Charge de ventilation nature... 2-Exclure
Type
Fonctionnement
Planning On 24/7

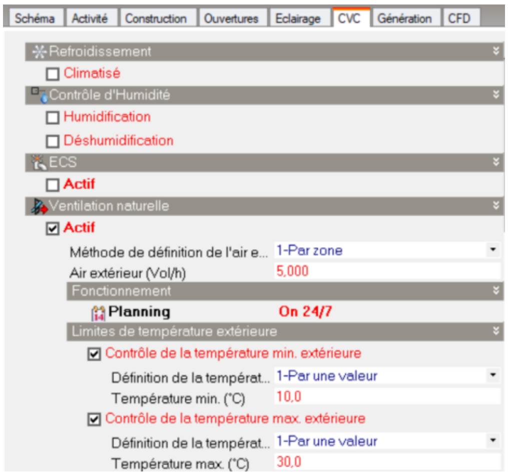


Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Refroidissement
Climatisé
Contrôle d'Humidité
Humidification
Déshumidification
ECS
Actif
Ventilation naturelle
Actif
Méthode de définition de l'air e... 1-Par zone
Air extérieur (Vol/h) 5,000
Fonctionnement
Planning On 24/7
Limites de température extérieure
Contrôle de la température min. extérieure
Définition de la températ... 1-Par une valeur
Température min. (°C) 10,0
Contrôle de la température max. extérieure
Définition de la températ... 1-Par une valeur
Température max. (°C) 30,0

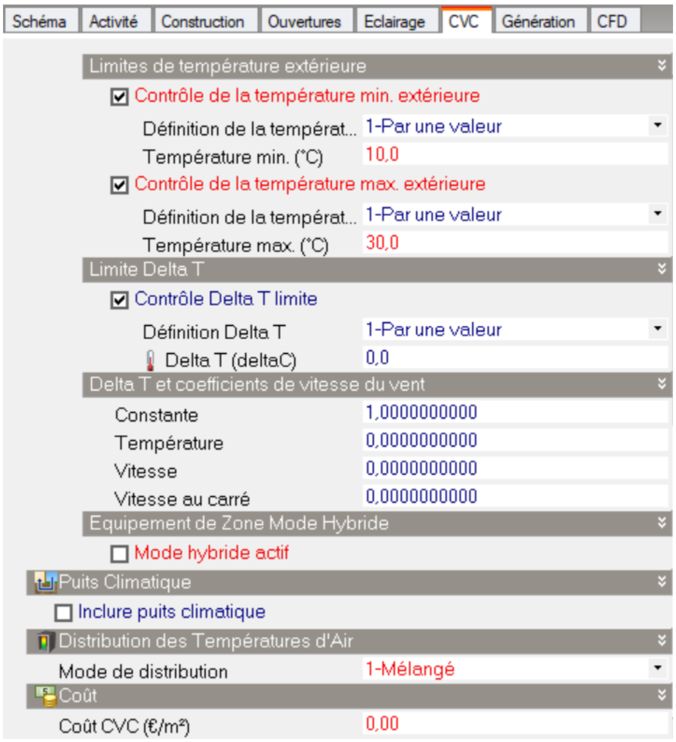


Schéma
Activité
Construction
Ouvertures
Eclairage
CVC
Génération
CFD
Limites de température extérieure
Contrôle de la température min. extérieure
Définition de la températ... 1-Par une valeur
Température min. (°C) 10,0
Contrôle de la température max. extérieure
Définition de la températ... 1-Par une valeur
Température max. (°C) 30,0
Limite Delta T
Contrôle Delta T limite
Définition Delta T 1-Par une valeur
Delta T (deltaC) 0,0
Delta T et coefficients de vitesse du vent
Constante 1,0000000000
Température 0,0000000000
Vitesse 0,0000000000
Vitesse au carré 0,0000000000
Equipement de Zone Mode Hybride
Mode hybride actif
Puits Climatique
Inclure puits climatique
Distribution des Températures d'Air
Mode de distribution 1-Mélangé
Coût
Coût CVC (€/m²) 0,00

References

[1] « Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings », p. 23.

[2] S. P. Corgnati, E. Fabrizio, M. Filippi, et V. Monetti, « Reference buildings for cost optimal analysis: Method of definition and application », *Appl. Energy*, vol. 102, p. 983-993, févr. 2013, doi: 10.1016/j.apenergy.2012.06.001.

[3] « Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elementsText with EEA relevance », p. 19.

[4] « Émissions par secteur », *Klimaat | Climat*. https://climat.be/en-belgique/climat-et-emissions/emissions-des-gaz-a-effet-de-serre/emissions-par-secteur (consulté le déc. 08, 2020).

[5] « cozeb-rapport-final.pdf ». Consulté le: déc. 08, 2020. [En ligne]. Disponible sur: https://energie.wallonie.be/servlet/Repository/cozeb-rapport-final.pdf?ID=28472.

[6] S. Attia, A. Evrard, et E. Gratia, « Development of benchmark models for the Egyptian residential buildings sector », *Appl. Energy*, vol. 94, p. 270-284, juin 2012, doi: 10.1016/j.apenergy.2012.01.065.

[7] A. Tereci, S. T. E. Ozkan, et U. Eicker, « Energy benchmarking for residential buildings », *Energy Build.*, vol. 60, p. 92-99, mai 2013, doi: 10.1016/j.enbuild.2012.12.004.

[8] M. Ghajarkhosravi, Y. Huang, A. S. Fung, R. Kumar, et V. Straka, « Energy benchmarking analysis of multi-unit residential buildings (MURBs) in Toronto, Canada », *J. Build. Eng.*, vol. 27, p. 100981, janv. 2020, doi: 10.1016/j.jobe.2019.100981.