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Determination of the Insulation Solution that Leads to Lower CO_2 Emissions during the Construction Phase of a Building

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Abstract: The characteristics of the envelope of a building determine, together with other factors, its consumption of energy. Additionally, the climate zone and insulation material may vary the minimum insulation thickness of walls and roofs, making it different, according to cooling down or warming up the home. Spanish legislation establishes different maximum values for energy demand according to different climate area both for heating and for cooling. This paper presents the results of a study that determines the influence of many variables as the climate zone or the orientation, among others, in the optimization of thickness insulation in residential homes in Spain to reduce the CO_2 emissions embodied. To do that, 12 representative cities in Spain corresponding to different climate zones, four orientations, two constructive solutions, and four different configurations of the same house have been combined, for three different hypotheses and four insulation materials, resulting in 4608 cases of study. The results show that, under equal conditions on energy demand, the optimal insulation requirements are determined by heating necessities more than by cooling ones. In addition, a higher insulation thickness need does not necessarily mean more CO_2 emissions, since it can be compensated with a lower Global Warming Potential characterization factor that is associated to the insulation material. The findings of this study can serve to designers and architects to establish the better combination of the variables that are involved in order to minimize the CO_2 emissions embodied during the construction phase of a building, making it more energy efficient.

Keywords: energy demand analysis; insulation materials; climate zones; envelope; CO_2 emissions

1. Introduction

Urban growth following the central years of the "real estate bubble 1998–2007" [1] has produced significant change in Spain in terms of building densities, which fell to substantially below 35 dwellings per hectare [2]. Current legislation, far from restricting the expansion of the urban by occupation of the rural space, promotes it by deregulating the use of undeveloped land [3]. Lower urban densities, high losses of non-urban land covers, the depopulation of metropolitan inner cores, and the expansion of transportation infrastructures confirm the generalization of the dispersed urban model, in which the importance of single housings is highlighted [4,5].

The upward trend in energy prices is growing [6], parallel to this disproportionate development of urban society, which makes it necessary to implement measures that are aimed at optimizing demand and promoting energy saving and efficiency [7]. In this respect, dwellings, like all other buildings,

face the challenge of achieving an energy management that allows them to contribute to economic growth, social welfare and sustainability of non-renewable resources, and preservation of the natural environment [8].

Buildings are big consumers of energy and materials and important producers of waste and emissions. Prefabrication presents an opportunity to reduce impacts in the building sector [9]. Among the advantages and benefits that are offered by the prefabricated building systems when compared to conventional construction methods, reductions in cost and time, improved quality, safety, and accuracy in manufacture, speed of installation on-site, and even dismantling and reuse are provided [10,11], as well as customization [12].

Energy consumption in the building sector is gaining increasing interest, as it is directly related to energy economics and sustainable development. The design and the choice of building materials, as well as the energy and thermal systems, evolve very rapidly. In the energy challenge, the building is among the largest consumers of energy in the European Union area [13]. The efficiency and optimization of energy systems remain among the main items that are studied in order to reduce energy consumption and increase system performance. In the area of housing, the cost and optimization of space are the two main reasons that require the decrease of the thickness of walls in new constructions; however, this reduction greatly affects the thermal inertia of the frame and makes it insufficient to effectively damp the oscillations due to the outdoor temperature variation [14]. Under these conditions, the optimization of the thickness insulation plays an important role in reaching a workable compromise between the comfort, the cost of the building, and the consumption of energy (and its corresponding cost during their lifetime).

Spain has generated an intense development of new regulations seeking for better energy performance in buildings in recent years. Thus, it is noteworthy that, as a result of the transposition of Directive 2002/91/CE [15], the Technical Building Code (CTE) is enacted [16], as well as a procedure for energy Certification for Buildings [17] (transposition of Directive 2010/31/EU [18]) and a new Regulation for Thermal Installations in Buildings [19] (transposition of Directive 2012/27/EU [20]).

Many of the potential effects of climate change on the building sector are not well studied, as climate change one of the most important social and environmental concern [21]. At the European level, about 36% of CO_2 emissions are related to buildings. For this reason, the European Union (EU) has identified the building sector as one key area for achieving its objectives for greenhouse gas emission reductions [22].

The EU Directive on the Energy Performance of Buildings [18] specifies that, by the end of 2020, all new buildings shall be nearly Zero Energy Building (nZEB). Directive 2012/27/EU establishes a specific mandatory for member states to draw up national plans to increase the number of nZEB. These plans must include the detailed definition of the nZEB concept in such a way that their national, regional, or local conditions are reflected, and a numerical indicator of the primary energy use must be included and expressed in kWh/m^2 per year.

The Basic Document of Energy Saving (DB-HE) of the CTE [23] is the second revision of the original one dated on 2006 in terms of energy saving (the first revision is dated on 2013). The method of calculation of the characteristic parameters of the elements that compose the thermal envelope of the models is carried out according to the Directives of DB-HE of the CTE. This method consists of the calculation of the thermal transmittance of these elements: enclosures that are in contact with external air, enclosures in contact with the ground, interior partitions in contact with non-habitable spaces and hollows, and skylights considering their modified solar factor.

Usually, the lifetime of the buildings easily reach between 50 and 100 years, so the buildings constructed today need to be resilient to future climates, than can be largely different than the one that we experience today [22]. Pérez-Andreau et al. [24] studied the impacts of climate change on heating and cooling energy demand in a residential building in a Mediterranean climate with two different Global Circulation Models for 2050 and 2100. The authors concluded that climate change has a direct

effect on energy demand in homes, and suggested that thermal insulation will have great effect on total energy demand.

Previous studies have analyzed the environmental impact of using different insulation materials [25–30], fixing the rest of parameters (orientation, climate zone, compactness, or constructive solution). This is the case of Braulio-Gonzalo and Bovea [25], which compares eleven insulation materials alternatives for a single-family house that was located in the climate zone B3, with a given orientation, and fixing the envelope description and thermal resistance, in order to see the influence of the insulation material and the thickness on energy demand, to accomplish the Spanish Technical Code. On the other hand, Hill et al. [26] make a review of the different insulation materials environmental information published, with the aim of comparing both the embodied energy and the environmental impact in terms of CO_2 emissions, independently of the rest of variables or the insulation needs. Additionally, Pargana et al. [27] compare the different insulation materials in order to evaluate their environmental impacts, and the consumption of energy on their production. Again, the authors do not consider the needs of insulation materials or the possibility that, although one type of insulation may have a higher environmental impact during its production, this can be compensated with lower insulation thickness needs, resulting in lower CO_2 emissions once placed into the building during its construction phase. Sierra-Pérez et al. [28] analyse different façade-building systems and thermal insulation materials for different climatic conditions, in order to determine their environmental impact. These authors consider five insulation materials, three façade systems, but, as in [25], just consider one climate zone (D), although they perform a sensitivity analysis varying the climate zone, but without varying orientation, compactness, or constructive solutions, variables that also influence the envelope and the insulation thickness needs. The same authors indicate, as one of the weaknesses of their research, that they just consider a unique building façade system in isolation and not as part of an entire building. Asdrubali et al. [29], in line with that indicated for [27], present a report of the state-of-the-art of insulation materials, without going into embodied energy or CO_2 emissions that are associated to its construction, or in the different insulation thickness needs according to variables as orientation, climate zone, and so on. Finally, Schiavoni et al. [30] make a review of the different insulation materials that were used for the building sector, presenting a comparative life cycle assessment between the different insulation materials for four different typical configurations of external walls, in order to compare both the embodied energy and global warming potential in terms of CO_2 emissions, for the same functional unit. Again, the authors do not consider different insulation thickness needs, depending on the climate zone, the orientation of the building, the constructive solution, and the building model, among others, apart from the insulation material.

In addition, different authors have studied the influence of different electricity-to-emissions conversion factors for three different insulation materials into the calculation of lifecycle emissions [13]. Apart from that, other studies [31] have investigated the building energy demand under different climates, or even including variables, such as the configuration of walls [32], but none of them have considered the influence of all the parameters, taken together.

This paper presents the results of a study that determines the influence of different parameters as the climate zone, the compactness of the building and the orientation, as well as the insulation material and the constructive solution in the optimization of thickness insulation in residential prefabricated houses in order to minimize the CO_2 emissions that were embodied during their construction phase.

A series of cases of a single-family semi-detached house is proposed to develop the study. In total, 4608 cases of study have been analyzed, while considering 12 locations according to DB-HE climate zones, four main orientations, two constructive solutions, and four compactnesses, all of them for four insulation materials, under three hypotheses of demand limitation.

The results of this study can help professionals that are involved in the building sector (designers, builders, architects, engineers, and even legislators) to establish the better conditions for minimizing the CO_2 emissions from the insulation during the construction phase for an energy demand fixed for cooling and heating in the use phase. Variables that have been taken into account are the climatic zone,

the orientation, the constructive solution for façade and roof, and the compactness of the building, as well as the insulation material and its thickness.

The originality of the research that is presented in this paper consists in the fact that we have considered different variables that have a substantial influence on the determination of the envelope of the building (climate zone, orientation, compactness, constructive solution, insulation material, and energy demand), in order to determine the insulation thickness needs for each case. This way, for a given climate zone, the builders and designers can select the best combination of the variables in order to minimize the embodied CO_2 emissions of the building during its construction phase. Economical aspects are not to be left out of the considerations, since they may affect the final decision. Nevertheless, the difference in cost of implementing the most effective solution in terms of reducing CO_2 emissions and its possible compensation with the savings derived from a minor energy consumption during the use phase of the building is out of the scope of this study and it will be the subject of subsequent research. In addition, the energy requirements for the use phase of the building and the possibility to satisfy them with renewable energies (solar thermal and photovoltaic energies, for example) will also be the subject of further researches.

The paper is structured, as follows. Section 2 presents the method used, establishing the three calculation hypotheses and describing the software used, choosing the location from the climate zones and their orientation, defining the characteristics of the building (compactness and constructive solutions), and selecting the insulation material. Section 3 shows the main results that were obtained of the study, including the thickness of the insulation for each climatic zone, orientation, compactness, constructive solution, and demand hypotheses, as well as their emissions. The major findings are also highlighted and contextualized, discussing them with the literature review made. Section 4 concludes the paper, summarizes the contributions, and proposes further research continuations.

2. Method

2.1. Calculation Procedure and Software Used

The unified tool LIDER-CALENER (HULC) is used in order to assess the energy demand [33]. HULC is the official energy certification tool in Spain, although other homologated tools can also be employed. This tool includes a graphical interface for a three-dimensional (3D) representation of buildings and it performs an hourly simulation considering a transitional regime, while taking into account thermal coupling between adjacent zones and thermal inertia, thanks to its calculation engine, called S3PAS, following the procedure from the ISO 52016-1:2017 standard [34].

There are three demand hypotheses that have been established for each situation (1536 scenarios from 12 climate zones, four orientations, two constructive solutions, and four compactness), making a total of 4608 case studies:

- H1: Compliance with the minimum legal requirements derived from the DB-HE of the CTE.
- H2: Joint (summing heating and cooling up) demand ≤ 30 kWh/m^2 per year.
- H3: Heating demand ≤ 15 kWh/m^2 per year and cooling demand ≤ 15 kWh/m^2 per year.

Hypothesis 1, as shown in Table 1, establishes four different heating demands (a basis of 15 kWh/m^2 per year for climate zones A and B, almost 30 kWh/m^2 for climate zone C, and slightly above 40 and 60 kWh/m^2 for climate zones D and E, respectively, as explained in the next section). Regarding cooling demand, only two requirements are stated (15 kWh/m^2 per year for climate zones 1, 2, and 3, and 20 kWh/m^2 for climate zone 4, as explained in the next section).

Table 1. Maximum heating and cooling demand per climate zone for legal compliance.

Climate Zone	Heating Demand	Cooling Demand
A3	15	15
A4	15	20
B3	15	15
B4	15	20
C1	26.8	15
C2	26.8	15
C3	26.8	15
C4	26.8	20
D1	40.6	15
D2	40.6	15
D3	40.6	15
E1	60.4	15

Units in kilowatts hour per square meter per year (kWh/m^{2}y).

Spanish legal requirements, which fix the maximum energy demand, generate a gap in energy consumption that is faced by final users from some climate zones, especially D and E ones. On the contrary, the hypothesis 3, which is based on the requirements of the Passivhaus standard [35], limits the heating and cooling demand to 15 kWh/m^2 per year each. Given the fact that letter indicates the severity of the winter, whereas the number indicates the severity of summer, for the same winter severity (as explained in the next section), this constraint is detrimental to users in moderate summers as compared to colder ones. Hypothesis 2 is proposed to mitigate this, while considering a joint demand for heating and cooling, aggregating them up to a limit of 30 kWh/m^2 per year.

The procedure has been the following: starting with an initial insulation thickness of 0 mm (both for the façade and for the roof and the ground floor), the energy demand has been calculated and compared to the limits by hypothesis. If the energy demand is under the limits, then an increase in insulation thickness of 5 mm is considered and the process is repeated again. The process continues with an incremental insulation thickness of 5 mm until the limits for each of the hypotheses considered are reached. The incremental insulation thickness of 5 mm has been chosen according to the commercial availability on the market. Other parameters must be taken into account once the insulation thickness for each of the hypotheses considered is fixed, and before the energy demand is determined, according to the characteristics of the building (compactness and constructive solutions), and the other variables considered (orientation, climate zones, block shadows, and so on).

The gains and losses are considered by HULC according to the detailed method of the ISO 52000-1:2017 standard [36], and depend on the type and thickness of insulation, infiltration, orientation, and climate zone, among other variable elements. They also depend on the fenestration, thermal bridges, and ventilation, which remain invariable in this study. Besides, both thermal bridges and ventilation are calculated by the DB-HE of the CTE [22]. Ensuring continuity in the insulation of the constructive elements union solves thermal bridges. In the case of ventilation, the minimum required flow rate is 33 liters per second (intake and extraction), which means 0.27 renovations per hour.

2.2. Climate Zones

The Köppen Climate Classification is chosen in order to identify the climate zones within mainland Spain. This classification, published in 1900, is still one of the most widely classifications systems used for climate studies in the world. According to this, based on the average monthly values for precipitation and air temperature, the climate zones are characterized by a combination of a letter by the climate severity of winter and a number by the climate severity of summer.

For this study, 12 provinces (represented by their capitals) in mainland Spain have been chosen, whose selection is due to its representativeness from their climate zones by their population. Table 2

shows the selected provinces for the study, as well as the climate zone, the altitude of their capitals, their population, and their percentage over the total population of mainland Spain.

Table 2. Characteristics of the cities object of the study [37].

City	Climate Zone	Altitude (m.a.s.l.)	Population [1]	% over Total in Mainland Spain
Cádiz	A3	0	1,238,714	2.86%
Almería	A4	0	709,340	1.64%
Valencia	B3	8	2,547,986	5.89%
Sevilla	B4	9	1,939,887	4.48%
La Coruña	C1	0	1,119,351	2.59%
Barcelona	C2	1	5,609,350	12.96%
Granada	C3	754	912,075	2.11%
Cáceres	C4	385	396,487	0.92%
San Sebastián	D1	5	720,592	1.66%
Gerona	D2	143	761,947	1.76%
Madrid	D3	589	6,578,079	15.19%
Burgos	E1	861	357,070	0.82%

[1] Data at 01/01/2018.

Figure 1 shows the distribution of climate zones for mainland Spain, according to Köppen Climate Classification:

Figure 1. Distribution of climate zones in Spain.

2.3. Orientation

Orientation influences the energy consumption of a building, and the election of an accurate orientation, together with the correct location and landscaping changes, may decrease its energy consumption [38]. For this study, in order to consider different advantage of solar power depending on the orientation of the building due to different shadow, and also to analyze the influence of this parameter on the results of insulation thickness needs, the four cardinal orientations have been selected, following the wind rose: North (N), East (E), South (S), and West (W).

2.4. Characteristics of the Building

All of the buildings considered for this study belong to the category of semidetached houses, joined in a dwelling unit. Each semidetached building consists of three different floors (ground floor, first floor, and roof floor). It can be noted that the same housing units compose all of the studied

models). At the ground floor, we can find the dining room, the kitchen, the living room, one bath, and the pantry, apart from the entrance to the house and the ground floor stairs. At the first floor, we can find three bedrooms, two bathrooms, and the first floor stairs. Finally, at the roof floor, there are the roof floor stairs and the access to the deck. Each dwelling unit is made up of three shared median walls and a façade one limiting with the public domain. The block presents a number multiple of four houses. For example, Figure 2 shows a 3D simulation for the models considered, in which the block configuration can be observed.

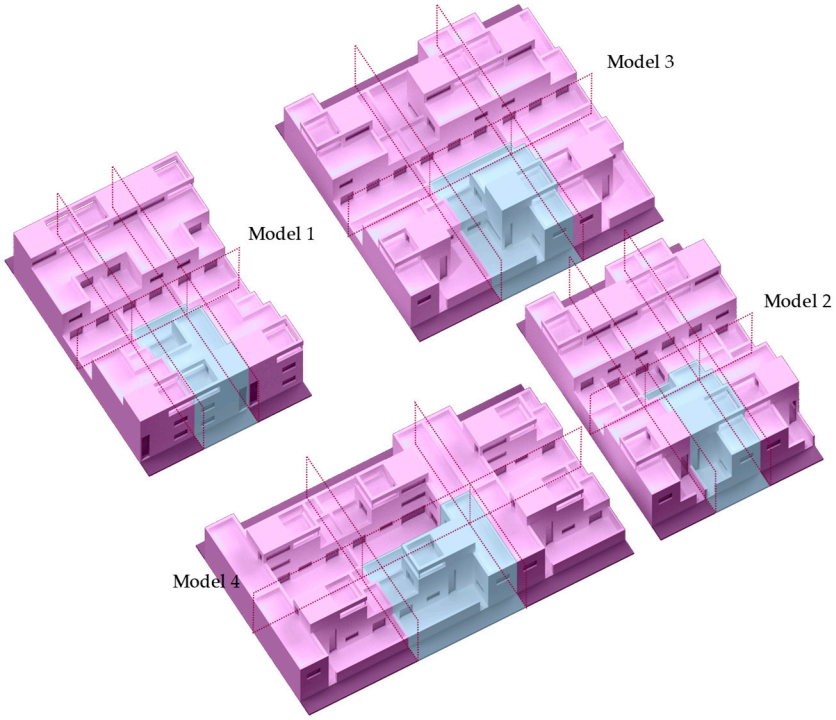


Figure 2. Three-dimensional (3D) Simulation of the block configuration from the dwelling unit for Models 1–4.

Four different building configurations are considered in order to determine the influence of the compactness of the building. For the four models involved, the degree of compactness vary from 1.5 for Model 4 to 2.2 to Model 1. The configurations of the four models studied are shown in Figure 3a–d, in which the green color corresponds to the garden zones (from the ground floor) and the blue color to walkable terraces (from the first and the roof floor).

In addition, the surface of the building is the same (insofar as all the models are made up of the exactly same housing units), but its compactness, which establishes the relationship between the outer shell of the building and its volume, changes. Independent of the orientation, climate zone, and configuration of the elements, the four models studied have the same building characteristics regarding their volume, their built area, their roof, and ground area, but with small differences regarding their opaque façade surface area and their glazed façade surface area, which makes its compactness vary, as can be seen in Table 3.

Figure 3. (**a**) Configuration of the Model 1; (**b**) Configuration of the Model 2; (**c**) Configuration of the Model 3; and, (**d**) Configuration of the Model 4.

Table 3. Characteristics of the building for different models analyzed.

Characteristics	Model 1	Model 2	Model 3	Model 4
Volume (m^3)	441.00	441.00	441.00	441.00
Built area (m^2)	147.00	147.00	147.00	147.00
Roof area (m^2)	73.50	73.50	73.50	73.50
Ground area(m^2)	73.50	73.50	73.50	73.50
Total façade surface area (m^2)	126.00	136.50	199.50	220.50
Opaque façade surface area (m^2)	99.00	107.00	161.50	178.50
Glazed façade surface area (m^2)	27.00	29.50	38.00	42.00
Glazing ratio (%)	21.50	21.50	19.00	19.00
Total insulation surface area (m^2)	246.00	254.00	308.50	325.50
Compactness *	2.20	2.10	1.60	1.50

* Compactness is defined as the 'volume divided by the area exposed to outside air (roof and façades)' ratio.

2.5. Selection of the Insulation Material

The correct choice of the insulation material is relevant when improving the energy-efficiency of the buildings. Different materials can be used to provide similar functions in buildings but the related energy-use and emissions could vary widely [39]. Most commonly used insulation materials in building industry are fiberglass, stone wool (also known as mineral wool or rock wool), glass wool, cellulose fiber, expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanurate (PIR), and polyurethane (PUR) [39,40].

For this study, the four commonly insulation materials used have been chosen. The choice has been made according to the state-of-the-art review, where four types of insulation materials have been identified as the most commercialized for building: derived from petroleum (for example, PUR and PIR), polystyrenes (XPS and EPS), minerals (stone wool, glass wool, etcetera), and natural or ecological ones (expanded cork, wood fibreboard, etcetera). According to this, one insulation material of each type has been chosen for this study: Extruded Polystyrene (XPS), Polyurethane foam (PUR), Stone Wool (SW), and Expanded Cork (EC). Table 4 shows the characteristics of insulation materials considered, from Environmental Product Declarations that will be used to determine CO_2 emissions according to their insulation thickness needs.

Table 4. Characteristics of the insulation materials.

Characteristic	XPS Board [41]	PUR Foam [42]	SW Board [43]	EC Board [44]
Thermal conductivity [1]	0.025	0.028	0.031	0.040
Density [2]	32	31	30	115
Global Warming Potential factor [3]	127.35	89.90	64.80	33.30

[1] Data in W/mK. [2] Data in kg/m^3. [3] Data in kg CO_2/m^3 insulation.

As stated before, two different constructive solutions have been considered for the roof and for the façade wall, whereas the intermediate floor, ground floor, medium walls, and partition walls are the same for both cases. The details for their components and layers are shown in Appendix A, Figures A1–A6.

Table 5 includes the data for thermal transmittance (U-value) of the constructive elements detailed. Some of them have a fixed part (because they are invariable) and the others, a variable part, depending on the thickness and the insulation material, as shown in the Figures A7–A9, located in Appendix A.

Table 5. Thermal transmittance (U-value) of different constructive elements.

Elements	Thermal Transmittance (U in W/m^{2}K)
Roof - 1 *	0.77-0.11
Roof - 2 *	0.86-0.11
Intermediate floor	0.45
Ground floor *	0.90-0.11
Façade wall - 1 *	1.45-0.11
Façade wall - 2 *	1.51-0.11
Dry median wall	0.25
Wet median wall	0.27
Dry partition	0.50
Wet/Dry partition	0.51
Wet partition	0.52
Fenestration (windows and exterior doors): Frame: PVC 3 chambers Glass: Low-emissivity double glazing 4/20/4 mm	1.50

* Variable transmittance according to thickness and insulation material.

3. Results and Discussion

Sections 3.1–3.5 present the main results of CO_2 embodied emissions resulting from different insulation requirement needs according to different variable studied: climate zone, insulation material, orientation, constructive solution, and compactness, for the hypotheses H1, H2, and H3, respectively. Finally, a discussion is made in Section 3.6.

Appendix B includes all the results for calculations of different insulation requirement needs for each of the 4608 cases of study in order to reduce the amount of data and extract just the main results obtained from the study, making it more readable and understandable for the reader.

This way, Tables 6–10 show differences between CO_2 emissions in relation to the best possible value for each sequence, according to different variables, in a colour scale varying from blue to red. For each of the hypotheses considered two combinations of different variables have been taken into account: the set up that leads to the lowest CO_2 emissions possible, and the set up that leads to the higher CO_2 emissions possible, in order to analyse the results from both points of view.

Each sequence will be composed by different options, depending on the variable studied. For example, in the case of insulation materials, the options will be EC, SW, PUR, and XPS (as well as for the orientation will be the wind rose, for the compactness will be the four model studied and for the constructive solution will be the two referred in Appendix A). Besides, there will be as sequences as climate zones, set ups, and hypotheses.

For all of the tables, blue colour means situations where no insulation is needed (and consequently no CO_2 emissions derived from insulation is generated). On the other side, grey colour means situations where is not possible to realize this combination of variables due to constructive reasons (and, due to this, the calculation of CO_2 emissions is not applicable). Cells with no background colour indicate the reference value of CO_2 emissions for each sequence, and the rest of the cells will have a different colour, varying from green to red, depending on their difference with the reference value. In this way, the closer the colour of the cell is to light green, the lesser the difference regarding the minimum value of CO_2 emissions; on the other hand, the closer the colour of the cell to dark red, the higher the difference regarding the minimum value of CO_2 emissions.

3.1. Influence of the Climate Zone on CO_2 Emissions

The differences in the insulation needs depend first of all on the climate zone, as can be seen in Table A1a,b, Table A2a,b and Table A3a,b, in Appendix B. The results were shown to correspond to the minimum insulation thicknesses needed (in increments of 5 millimeters, from 0 to 200) to satisfy the energy demands defined in the hypotheses H1, H2, and H3, according to the rest of the variables considered. As the optimal insulation thickness needs are determined more by the needs of heating than for cooling, climate zones where winters are not severe (letters A and B), will need less insulation than climate zones where the winters are colder (letters C, D, and E).

While analyzing the results from the point of view of insulation thickness needs, we can observe that, for a given climate zone (this is the case of someone who wants to build a house in a determined place), XPS material results always in minor insulation material thicknesses than for the rest of materials considered, but in major insulation material emissions, as explained in the next section. These differences between insulation materials needs considerably increase with the degree of compactness, being the lesser compactness the higher differences among the insulation thickness needs. Nevertheless, although these needs also depend on the rest of variables (orientation and constructive solution), analyzing the results from the point of view of CO_2 emissions, the climatic zone is the main factor to be taken into account, as can be understood when analyzing Table 6, which shows that the emissions increased in cold areas, especially for Hypotheses 2 and 3.

In Appendix B, Table A4a–c, Tables A5a–c and A6a–c present the results of CO_2 emissions for Hypotheses H1, H2, and H3, respectively. Expression "n.a" meaning: "not applicable" refers to the situations where the minimum insulation thickness to satisfy energy demand is not possible due to constructive restrictions and, therefore, calculations of CO_2 emissions have no sense.

Table 6. Increase of emissions according to the climatic zone for the best and worst set ups.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	Best	**Worst**	**Best**	**Worst**	**Best**	**Worst**
A3	0.00E+00	8.29E+03	0.00E+00	8.29E+03	0.00E+00	8.29E+03
A4	0.00E+00	+25.45%	0.00E+00	+25.45%	0.00E+00	+25.45%
B3	1.23E+03	+175.03%	1.23E+03	+175.03%	1.23E+03	+175.03%
B4	0.00%	+175.03%	0.00%	+175.03%	0.00%	+175.03%
C1	+100.00%	+224.49%	+100.00%	+224.49%	+365.85%	n.a.
C2	+33.33%	+224.49%	+33.33%	+324.61%	+365.85%	n.a.
C3	+33.33%	+200.36%	+133.33%	+475.39%	+332.52%	+725.09%
C4	+33.33%	+224.49%	+233.33%	+750.42%	+332.52%	+799.88%
D1	+100.00%	+275.15%	+332.52%	+900.00%	n.a.	n.a.
D2	+100.00%	+275.15%	+365.85%	n.a.	n.a.	n.a.
D3	+100.00%	+224.49%	+465.85%	n.a.	+1135.77%	n.a.
E1	+33.33%	+149.70%	+665.85%	n.a.	n.a.	n.a.

0	n.a.	+0%	1–25%	26–50%	51–75%	76–100%	101–125%	126–150%	151–175%	176–200%	>200%

3.2. Influence of the Insulation Material on CO_2 Emissions

If we analyze the results in terms of CO_2 emissions, we can observe how, although the recommendations for orientation, compactness, and constructive solution are the same (that is to say, always the combination of North orientation, constructive solution 1, and building Model 1 will result in lower CO_2 emissions; on the other side, the combination of West orientation, constructive solution 2, and building Model 4 will result in more CO_2 emissions, under equal conditions for the rest of variables), the recommendation for the insulation material changes.

The higher insulation thickness that is required to satisfy an energy demand fixed in the case of expanded cork (instead of the minimum thickness need from the extruded polystyrene), as observed in Table A1a,b, Table A2a,b and Table A3a,b, is compensated with its lower Global Warming Potential (GWP) factor, as a result, giving appreciably less CO_2 emissions. This difference increase with the needs of insulation material, so, in order to reduce CO_2 emissions during the construction phase, expanded cork is always preferable, if possible.

Table 7 shows the increase of CO_2 emissions according to the insulation material, for the different climate zones and hypotheses that were considered. The insulation material that generates lower emissions is always the expanded cork. The second one is the stone wool and the third, the polyurethane. The worst is always the extruded polystyrene. However, thanks to its lower thickness needs, it is the most applicable in the cases in which other materials cannot satisfy the demands that are required.

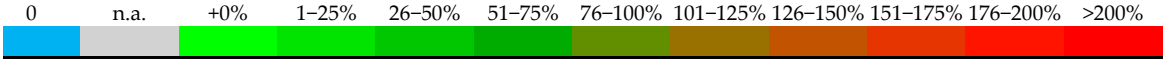
3.3. Influence of the Orientation on CO_2 Emissions

Regarding the orientation, Table A1a,b, Table A2a,b and Table A3a,b in Appendix B show that West orientation is always the most insulation demanding independent of the climate zone, the compactness, the constructive solution, and the insulation material, being the needs higher as long as the compactness of the building decreases. At the same time, the North orientation is also the least insulation demanding.

Table 8 shows the increase of CO_2 emissions according to the orientation, for the different climate zones and hypotheses considered. The orientation that generates lower emissions is always the North. The second one is the East and the third, the South. The worst is always the West orientation. It implies that the North orientation is the most applicable and the West is the orientation in which more cases are not possible. However, sometimes the North and East tie, as well as South and West, due to being included in the same step thickness.

Table 7. Increase of emissions according to the insulation material for the best and worst set ups.

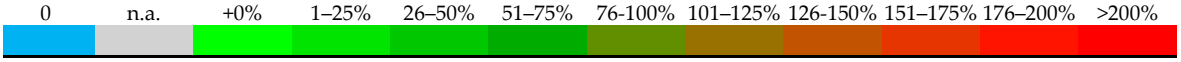
CZ	Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
		Best	Worst	Best	Worst	Best	Worst
A3	EC	0.00E+00	4.88E+03	0.00E+00	4.88E+03	0.00E+00	4.88E+03
	SW	0.00E+00	+51.23%	0.00E+00	+51.23%	0.00E+00	+51.23%
	PUR	0.00E+00	+79.92%	0.00E+00	+79.92%	0.00E+00	+79.92%
	XPS	0.00E+00	+113.11%	0.00E+00	+113.11%	0.00E+00	+113.11%
A4	EC	0.00E+00	3.25E+03	0.00E+00	3.25E+03	0.00E+00	3.25E+03
	SW	0.00E+00	+29.85%	0.00E+00	+29.85%	0.00E+00	+29.85%
	PUR	0.00E+00	+80.00%	0.00E+00	+80.00%	0.00E+00	+80.00%
	XPS	0.00E+00	+155.08%	0.00E+00	+155.08%	0.00E+00	+155.08%
B3	EC	1.23E+03	9.21E+03	1.23E+03	9.21E+03	1.23E+03	9.21E+03
	SW	+29.27%	+48.75%	+29.27%	+48.75%	+29.27%	+48.75%
	PUR	+79.67%	+91.10%	+79.67%	+91.10%	+79.67%	+91.10%
	XPS	+154.47%	+147.56%	+154.47%	+147.56%	+154.47%	+147.56%
B4	EC	1.23E+03	9.21E+03	1.23E+03	9.21E+03	1.23E+03	9.21E+03
	SW	+29.27%	+48.75%	+29.27%	+48.75%	+29.27%	+48.75%
	PUR	+79.67%	+91.10%	+79.67%	+91.10%	+79.67%	+91.10%
	XPS	+154.47%	+147.56%	+154.47%	+147.56%	+154.47%	+147.56%
C1	EC	2.46E+03	1.14E+04	2.46E+03	1.14E+04	5.73E+03	n.a.
	SW	+29.67%	+57.02%	+29.67%	+57.02%	+53.05%	n.a.
	PUR	+79.67%	+92.11%	+79.67%	+92.11%	+93.72%	n.a.
	XPS	+154.88%	+135.96%	+154.88%	+135.96%	+146.07%	n.a.
C2	EC	1.64E+03	1.14E+04	1.64E+03	1.46E+04	5.73E+03	n.a.
	SW	45.73%	+57.02%	+45.73%	+51.37%	+53.05%	n.a.
	PUR	102.44%	+92.11%	+102.44%	+90.41%	+93.72%	n.a.
	XPS	186.59%	+135.96%	+186.59%	+141.10%	+146.07%	n.a.
C3	EC	1.64E+03	1.03E+04	2.87E+03	2.01E+04	5.32E+03	n.a.
	SW	+45.73%	+43.69%	+66.55%	+52.24%	+49.81%	n.a.
	PUR	102.44%	+84.47%	+92.68%	+89.05%	+87.03%	5.41E+04
	XPS	186.59%	+141.75%	+118.47%	+137.31%	+134.96%	+26.43%
C4	EC	1.64E+03	1.08E+04	4.10E+03	n.a.	5.32E+03	n.a.
	SW	+45.73%	+56.48%	+55.61%	n.a.	+49.81%	n.a.
	PUR	+102.44%	+89.81%	+88.78%	5.56E+04	+87.03%	5.85E+04
	XPS	186.59%	+149.07%	+129.27%	+26.80%	+134.96%	+27.52%
D1	EC	2.46E+03	1.30E+04	5.32E+03	n.a.	n.a.	n.a.
	SW	+29.67%	+53.85%	+49.81%	n.a.	2.63E+04	n.a.
	PUR	+79.67%	+91.54%	+87.03%	n.a.	+26.24%	n.a.
	XPS	+154.88%	+139.23%	+134.96%	8.29E+04	+60.84%	n.a.
D2	EC	2.46E+03	1.30E+04	5.73E+03	n.a.	n.a.	n.a.
	SW	+29.67%	+53.85%	+53.05%	n.a.	2.55E+04	n.a.
	PUR	+79.67%	+91.54%	+93.72%	n.a.	+25.88%	n.a.
	XPS	+154.88%	+139.23%	+146.07%	n.a.	+59.61%	n.a.
D3	EC	2.46E+03	1.14E+04	6.96E+03	n.a.	1.52E+04	n.a.
	SW	+29.67%	+57.02%	+49.43%	n.a.	+51.97%	n.a.
	PUR	+79.67%	+92.11%	+91.09%	n.a.	+89.47%	n.a.
	XPS	+154.88%	+135.96%	+147.13%	n.a.	+136.84%	n.a.
E1	EC	1.64E+03	8.67E+03	9.42E+03	n.a.	n.a.	n.a.
	SW	+45.73%	+46.48%	+51.80%	n.a.	n.a.	n.a.
	PUR	+102.44%	+85.70%	+87.90%	n.a.	n.a.	n.a.
	XPS	+186.59%	+138.75%	+132.48%	n.a.	n.a.	n.a.



Best set up: N (Orientation), Model 1 (Compactness), S1 (Constructive Solution). Worst set up: W (Orientation), Model 4 (Compactness), S2 (Constructive Solution).

Table 8. Increase of emissions according to the orientation for the best and worst set ups.

CZ	Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
		Best	Worst	Best	Worst	Best	Worst
A3	N	0.00E+00	8.29E+03	0.00E+00	8.29E+03	0.00E+00	8.29E+03
	E	4.10E+02	0.00%	4.10E+02	0.00%	4.10E+02	0.00%
	S	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	W	0.00%	25.45%	0.00%	25.45%	0.00%	25.45%
A4	N	0.00E+00	8.29E+03	0.00E+00	8.29E+03	0.00E+00	8.29E+03
	E	4.10E+02	0.00%	4.10E+02	0.00%	4.10E+02	0.00%
	S	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	W	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
B3	N	1.23E+03	1.45E+04	1.23E+03	1.45E+04	1.23E+03	1.45E+04
	E	+33.33%	0.00%	+33.33%	0.00%	+33.33%	0.00%
	S	+33.33%	+14.48%	+33.33%	+14.48%	+33.33%	+14.48%
	W	+33.33%	+57.24%	+33.33%	+57.24%	+33.33%	+57.24%
B4	N	1.23E+03	1.45E+04	1.23E+03	1.45E+04	1.23E+03	1.45E+04
	E	+33.33%	0.00%	+33.33%	0.00%	+33.33%	0.00%
	S	+33.33%	+14.48%	+33.33%	+14.48%	+33.33%	+14.48%
	W	+33.33%	+57.24%	+33.33%	+57.24%	+33.33%	+57.24%
C1	N	2.46E+03	2.28E+04	2.46E+03	2.28E+04	5.73E+03	6.01E+04
	E	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	S	0.00%	+9.21%	0.00%	+9.21%	+14.31%	+10.32%
	W	+16.67%	+17.98%	+16.67%	+17.98%	+21.47%	n.a.
C2	N	1.64E+03	2.07E+04	1.64E+03	2.69E+04	5.32E+03	4.56E+04
	E	+50.00%	0.00%	+50.00%	0.00%	+7.71%	0.00%
	S	+50.00%	+10.14%	+50.00%	+7.81%	+7.71%	+13.60%
	W	+50.00%	+29.95%	+50.00%	+30.86%	+23.12%	+50.00%
C3	N	1.64E+03	1.87E+04	2.87E+03	3.32E+04	5.32E+03	5.39E+04
	E	0.00%	0.00%	0.00%	+6.02%	+7.71%	0.00%
	S	0.00%	+10.70%	+28.57%	+12.35%	+7.71%	+11.50%
	W	+50.00%	+33.16%	+28.57%	+43.67%	+23.12%	+38.40%
C4	N	1.64E+03	2.07E+04	4.10E+03	4.97E+04	n.a.	n.a.
	E	0.00%	0.00%	+10.00%	+8.45%	n.a.	n.a.
	S	0.00%	+10.14%	+29.76%	+12.68%	n.a.	n.a.
	W	+50.00%	+29.95%	+39.76%	+41.85%	n.a.	n.a.
D1	N	2.46E+03	2.69E+04	5.32E+03	7.05E+04	n.a.	n.a.
	E	0.00%	0.00%	0.00%	0.00%	n.a.	n.a.
	S	+16.67%	0.00%	+7.71%	0.00%	n.a.	n.a.
	W	+16.67%	+15.61%	+7.71%	+17.59%	n.a.	n.a.
D2	N	2.46E+03	2.49E+04	5.73E+03	8.29E+04	n.a.	n.a.
	E	0.00%	+8.03%	+14.31%	n.a.	n.a.	n.a.
	S	+16.67%	+8.03%	+21.47%	n.a.	n.a.	n.a.
	W	+16.67%	+24.90%	+35.78%	n.a.	n.a.	n.a.
D3	N	2.46E+03	2.28E+04	6.96E+03	n.a.	1.52E+04	n.a.
	E	0.00%	0.00%	+11.78%	n.a.	+5.26%	n.a.
	S	0.00%	+9.21%	+17.67%	n.a.	+7.89%	n.a.
	W	0.00%	+17.98%	+23.56%	n.a.	n.a.	n.a.
E1	N	1.64E+03	1.87E+04	9.42E+03	n.a.	n.a.	n.a.
	E	0.00%	0.00%	+4.35%	n.a.	n.a.	n.a.
	S	0.00%	+10.70%	+12.53%	n.a.	n.a.	n.a.
	W	0.00%	+10.70%	+17.83%	n.a.	n.a.	n.a.



Best set up: Model 1 (Compactness), Expanded Cork (EC) (Insulation Material), S1 (Constructive Solution). Worst set up: Model 4 (Compactness), Extruded Polystyrene (XPS) (Insulation Material), S2 (Constructive Solution).

3.4. Influence of the Constructive Solution on CO_2 Emissions

Constructive solution for the roof and façade wall also has an influence on the CO_2 emissions, always being preferable the constructive solution 1, under equal conditions of the rest of variables, since the needs of insulation are lower. It can be noted that the constructive solution 1, as can be checked in the Figures A1a and A4a, presents a more modern solution both for the façade and for the roof (ventilated façade and floating roof) than the traditional ones that are represented in the constructive solution 2 (as shown in Figures A1b and A4b). Table 9 shows the increase of CO_2 emissions, according to the constructive solution, for the different climate zones and hypotheses considered.

Table 9. Increase of emissions due to the constructive solution for the best and worst set ups.

CZ	Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
		Best	Worst	Best	Worst	Best	Worst
A3	S1	0.00E+00	8.29E+03	0.00E+00	8.29E+03	0.00E+00	8.29E+03
	S2	4.10E+02	+25.45%	4.10E+02	+25.45%	4.10E+02	+25.45%
A4	S1	0.00E+00	8.29E+03	0.00E+00	8.29E+03	0.00E+00	8.29E+03
	S2	4.10E+02	0.00%	4.10E+02	0.00%	4.10E+02	0.00%
B3	S1	1.23E+03	2.07E+04	1.23E+03	2.07E+04	1.23E+03	2.07E+04
	S2	+33.33%	+10.14%	+33.33%	+10.14%	+33.33%	+10.14%
B4	S1	1.23E+03	2.07E+04	1.23E+03	2.07E+04	1.23E+03	2.07E+04
	S2	+33.33%	+10.14%	+33.33%	+10.14%	+33.33%	+10.14%
C1	S1	2.46E+03	2.49E+04	2.46E+03	2.49E+04	5.73E+03	7.05E+04
	S2	+16.67%	+8.03%	+16.67%	+8.03%	+21.47%	0.00%
C2	S1	1.64E+03	2.69E+04	1.64E+03	3.32E+04	5.73E+03	7.05E+04
	S2	+75.00%	0.00%	+75.00%	+6.02%	+21.47%	0.00%
C3	S1	1.64E+03	2.07E+04	2.87E+03	4.35E+04	5.32E+03	5.60E+04
	S2	+50.00%	+20.29%	+28.57%	+9.66%	+7.71%	+22.14%
C4	S1	1.64E+03	2.28E+04	4.10E+03	6.01E+04	5.32E+03	6.01E+04
	S2	+50.00%	+17.98%	+29.76%	+17.30%	+23.12%	+24.13%
D1	S1	2.46E+03	2.69E+04	5.32E+03	6.63E+04	n.a.	n.a.
	S2	+16.67%	+15.61%	+7.71%	+25.04%	n.a.	n.a.
D2	S1	2.46E+03	2.69E+04	5.73E+03	n.a.	n.a.	n.a.
	S2	+16.67%	+15.61%	+14.31%	n.a.	n.a.	n.a.
D3	S1	2.46E+03	2.69E+04	6.96E+03	n.a.	1.52E+04	n.a.
	S2	+16.67%	0.00%	+17.67%	n.a.	+7.89%	n.a.
E1	S1	1.64E+03	2.07E+04	9.42E+03	n.a.	n.a.	n.a.
	S2	+50.00%	0.00%	+12.53%	n.a.	n.a.	n.a.

0 n.a. +0% 1–25% 26–50% 51–75% 76–100% 101–125% 126–150% 151–175% 176–200% >200%

Best set up: N (Orientation), Model 1 (Compactness), EC (Insulation Material). Worst set up: W (Orientation), Model 4 (Compactness), XPS (Insulation Material).

3.5. Influence of the Compactness on CO_2 Emissions

As observed in Table A2a,b and Table A3a,b in Appendix B, as the compactness of the building diminish, and, depending of the hypotheses considered, it could be possible that the maximum insulation thickness cannot be enough to satisfy the energy demand in those climate zones where the winter is extreme. The situation arrives to that point that, for the hypotheses 3 (Passivhauss Standard), it is not possible to satisfy energy demand in any of the 128 cases that were analyzed for the climate zone E1.

Table 10 shows the increase of CO_2 emissions according to the compactness, for the different climate zones and hypotheses considered. Model 1 generates, in all of the climate zones and for the three hypotheses considered, lower emissions than the other configuration models. This can be noted, since it is the reference base to calculate the differences with the rest of the models, except in those cases where it is not possible to build that configuration due to constructive reasons.

Table 10. Increase of emissions due to the compactness for the best and worst set ups.

CZ	Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
		Best	Worst	Best	Worst	Best	Worst
A3	Model 1	0.00E+00	3.13E+03	0.00E+00	3.13E+03	0.00E+00	3.13E+03
	Model 2	0.00E+00	+3.19%	0.00E+00	+3.19%	0.00E+00	+3.19%
	Model 3	0.00E+00	+151.12%	0.00E+00	+151.12%	0.00E+00	+151.12%
	Model 4	0.00E+00	+232.27%	0.00E+00	+232.27%	0.00E+00	+232.27%
A4	Model 1	0.00E+00	3.13E+03	0.00E+00	3.13E+03	0.00E+00	3.13E+03
	Model 2	0.00E+00	+3.19%	0.00E+00	+3.19%	0.00E+00	+3.19%
	Model 3	0.00E+00	+151.12%	0.00E+00	+151.12%	0.00E+00	+151.12%
	Model 4	0.00E+00	+164.86%	0.00E+00	+164.86%	0.00E+00	+164.86%
B3	Model 1	1.23E+03	6.27E+03	1.23E+03	6.27E+03	1.23E+03	6.27E+03
	Model 2	+37.40%	+3.19%	+37.40%	+3.19%	+37.40%	+3.19%
	Model 3	+275.61%	+182.30%	+275.61%	+182.30%	+275.61%	+182.30%
	Model 4	+340.65%	+263.64%	+340.65%	+263.64%	+340.65%	+263.64%
B4	Model 1	1.23E+03	9.21E+03	1.23E+03	9.21E+03	1.23E+03	9.21E+03
	Model 2	+37.40%	+3.19%	+37.40%	+3.19%	+37.40%	+3.19%
	Model 3	+275.61%	+182.30%	+275.61%	+182.30%	+275.61%	+182.30%
	Model 4	+340.65%	+263.64%	+340.65%	+263.64%	+340.65%	+263.64%
C1	Model 1	2.46E+03	7.83E+03	2.46E+03	7.83E+03	5.73E+03	2.04E+04
	Model 2	+20.33%	+3.32%	+20.33%	+3.32%	+25.48%	+10.78%
	Model 3	+171.54%	+201.40%	+171.54%	+201.40%	+196.68%	+188.73%
	Model 4	+252.44%	+243.55%	+252.44%	+243.55%	n.a.	n.a.
C2	Model 1	1.64E+03	6.27E+03	1.64E+03	6.27E+03	5.73E+03	2.04E+04
	Model 2	+54.88%	+29.03%	+80.49%	+54.70%	+25.48%	+2.94%
	Model 3	+307.32%	+244.50%	+338.41%	+306.70%	+196.68%	+188.73%
	Model 4	+362.80%	+329.03%	+528.05%	+461.40%	n.a.	n.a.
C3	Model 1	1.64E+03	6.27E+03	2.87E+03	1.10E+04	5.32E+03	+1.72E+04
	Model 2	+54.88%	+3.19%	+32.75%	+2.73%	+11.28%	+12.79%
	Model 3	+244.51%	+212.60%	+240.07%	+203.64%	+161.28%	+185.47%
	Model 4	+329.88%	+297.13%	+408.71%	+333.64%	+245.86%	+297.67%
C4	Model 1	1.64E+03	6.27E+03	4.10E+03	1.72E+04	5.32E+03	1.88E+04
	Model 2	+54.88%	+29.03%	+34.15%	+12.79%	+11.28%	+11.70%
	Model 3	+244.51%	+212.60%	+200.00%	+151.16%	+161.28%	+181.91%
	Model 4	+329.88%	+329.03%	+375.61%	+309.88%	+266.54%	+296.81%
D1	Model 1	2.46E+03	7.83E+03	5.32E+03	1.72E+04	n.a.	n.a.
	Model 2	+20.33%	+23.88%	+11.28%	+12.79%	n.a.	n.a.
	Model 3	+192.28%	+225.67%	+189.47%	+219.77%	n.a.	n.a.
	Model 4	+274.39%	+297.19%	n.a.	+381.98%	n.a.	n.a.
D2	Model 1	2.46E+03	7.83E+03	5.73E+03	2.04E+04	n.a.	n.a.
	Model 2	+20.33%	+23.88%	+25.48%	10.78%	n.a.	n.a.
	Model 3	+192.28%	+201.40%	+249.04%	n.a.	n.a.	n.a.
	Model 4	+274.39%	+297.19%	n.a.	n.a.	n.a.	n.a.
D3	Model 1	2.46E+03	6.27E+03	6.96E+03	2.66E+04	1.52E+04	5.17E+04
	Model 2	+3.25%	+29.03%	+21.55%	+9.40%	+11.18%	+6.38%
	Model 3	+171.54%	+244.50%	n.a.	n.a.	n.a.	n.a.
	Model 4	+252.44%	+329.03%	n.a.	n.a.	n.a.	n.a.
E1	Model 1	1.64E+03	6.27E+03	9.42E+03	3.13E+04	n.a.	n.a.
	Model 2	+54.88%	+3.19%	+16.77%	+8.63%	n.a.	n.a.
	Model 3	+244.51%	+150.40%	n.a.	n.a.	n.a.	n.a.
	Model 4	+329.88%	+230.14%	n.a.	n.a.	n.a.	n.a.

0	n.a.	+0%	1–25%	26–50%	51–75%	76–100%	101–125%	126–150%	151–175%	176–200%	>200%

Best set up: N (Orientation), EC (Insulation Material), S1 (Constructive Solution). Worst set up: W (Orientation), XPS (Insulation Material), S2 (Constructive Solution).

3.6. Discussion

It is useful to present an overview of buildings' thermal balance with respect to energy gains and losses, checking ventilation and infiltration, heat gains, and transmission through the envelope before discussing the results of insulation thicknesses and CO_2 emissions. Among the 4608 study cases, two from 4008 applicable cases are shown in Tables 11 and 12 as an example (600 of them are not possible due to constructive limitations in which insulation thicknesses are not enough), corresponding to the Hypothesis 2, from Madrid (D3) and Barcelona (C2).

Table 11. Thermal balance. Example 1: Hypothesis 2, Model 1, Constructive solution 1, Climate Zone D3, Orientation North. Thickness 85mm, Insulation Material Expanded Cork.

Elements	Heating *				Cooling *			
	Losses		Gains		Losses		Gains	
Façade	−13.04	20.88%	0.01	0.02%	−0.83	04.27%	1.55	5.72%
Fenestration (windows and doors)	−11.64	18.64%	1.48	3.69%	−1.14	05.86%	3.60	13.27%
Roof	−9.10	14.57%	0.01	0.02%	−0.92	04.73%	0.91	3.36%
Ground floor	−4.30	6.89%	0.08	0.20%	−2.95	15.17%	0.97	3.58%
Thermal bridges	−0.62	1.00%	0.01	0.02%	−0.26	01.34%	0.52	1.92%
Solar heat gains			13.47	33.57%			5.12	18.88%
Internal heat gains			25.07	62.46%			12.80	47.20%
Ventilation and infiltration	−23.74	38.02%	0.01	0.02%	−13.34	68.62%	1.65	6.08%
Sum	−62.44	100%	40.14	100%	−19.44	100%	27.12	100%
Total demand	−22.30						7.68	

* Units in kilowatts hour per square meter per year (kWh/m^{2}y).

Table 12. Thermal balance. Example 2: Hypothesis 2, Model 4, Constructive solution 2, Climate Zone C2, Orientation West. Thickness 80mm, Insulation Material XPS.

Elements	Heating *				Cooling *			
	Losses		Gains		Losses		Gains	
Façade	−15.37	22.63%	0.01	0.02%	−2.53	9.88%	1.06	3.31%
Fenestration (windows and doors)	−15.74	23.17%	0.17	0.38%	−1.58	6.17%	3.87	12.10%
Roof	−5.87	8.64%	0.01	0.02%	−0.73	2.85%	1.04	3.25%
Ground floor	−3.98	5.86%	0.13	0.29%	−2.42	9.45%	0.85	2.66%
Thermal bridges	−0.87	1.28%	0.02	0.02%	−0.37	1.45%	0.74	2.31%
Solar heat gains			18.79	42.33%			10.49	32.79%
Internal heat gains			25.24	56.86%			12.60	39.39%
Ventilation and infiltration	−26.09	38.41%	0.02	0.02%	−17.97	70.20%	1.34	4.19%
Sum	−67.92	100%	44.39	100%	−25.60	100%	31.99	100%
Total demand	−23.53						6.39	

* Units in kilowatts hour per square meter per year (kWh/m^{2}y).

In total, we have analyzed 4608 cases of study (1536 cases by hypothesis), corresponding to 12 climatic zones, four main orientations, four models of construction, two constructive solutions, four insulation materials, and three energy demand limitation hypothesis. The results show that just 4008 case studies could really run, from the constructive point of view, given that the 600 remaining cases would require thickness insulation that is incompatible with the constructive characteristics of the building. All of the 600 cases where it was not possible to meet energy demand requirements correspond to the hypothesis H2 (162), and especially to hypothesis H3 (438 cases). However, in many of those cases it would be enough with a small adjustment that allowed a few extra millimeters of insulation in certain cases, in order to achieve compliance with the requirements.

Table 6 has shown the variability of the emissions that were generated to satisfy a specific heating and cooling demand (hypotheses H1–H3), according to the climate zone in which the building is

located. For the H1 scenario, these emissions are doubled in the best scenario and tripled in the worst scenario. However, for hypotheses H2 and H3, the differences increase a lot (almost multiplied by ten times). Subsequently, Tables 7–10 show the contribution of the other factors, once a location is fixed. The compactness and the insulation material also have a major influence on the amount of emissions generated. Next, orientation and the constructive solution for the envelope exert a minor but significance influence.

4. Conclusions

In general, it is concluded that the optimal insulation thickness are determined more by the needs of heating than for cooling, even in the most severe summer climates needs. On the demand for energy, in the case of H1, values established by CTE result in similar thicknesses independently of the climate zone, and therefore the costs due to insulation during the construction phase are similar. Nevertheless, this will increase the costs of energy during the use phase of the building, punishing the inhabitants of cold spots due to its higher energy demand for heating. On the contrary, while considering the H3, the users of temperate zones are penalized, given that energy demand for cooling in cold areas is very low. Here follows that the intermediate hypothesis, H2, which tries to balance the joint demand during the phase of use of the building, may be the most optimal when regular energy demand limitations, given that these, and therefore, consumption (and their associated costs), they are similar, both in temperate and in cold-zones. For this case, it would be interesting to determine the satisfaction of the energy demand exclusively with renewable energies.

With regard to CO_2 emissions, and analyzing the results according to the compactness of the building primarily, it is observed that the model 1, regardless of the climatic zone, the orientation and the scenario, always generates less emissions than the rest of the models, for all cases. In terms of the influence of the orientation, regardless of the climatic zone, compactness of the building, constructive solution, and scenario, the orientation W is always that generates a greater number of emissions. These differences can reach up to 57% for the same climatic zone. This can be taken into account by the designers and builders in order to minimize the emissions from the stages of design and construction of the buildings due to the insulation of the envelope. Additionally, the material has influence on the amount of CO_2 emissions, since, as stated before, using expanded cork instead of XPS can reduce the total amount of CO_2 emissions during the construction phase of the building, although the needs for this material are higher, due to its lower GWP factor.

It must be recalled that increased consumption means, not only an increase in CO_2 emissions during the phase of use of the building, but also an increase of the costs for the users of the same, due to the increase in their electric bills. From this point of view, other future research can be done in order to incorporate a cost analysis to determine the influence of the different variables that are considered into the final cost of the electricity, with the aim of minimizing it. It will be also interesting to analyze, from an eco-efficiency point of view, the costs of fabrication, installation, and maintenance for different materials, which will be material for further research. Other research include the extension of the scope in order to include lighting requirements, and the inclusion of active measures, such as the use of photovoltaic and/or solar thermal energy.

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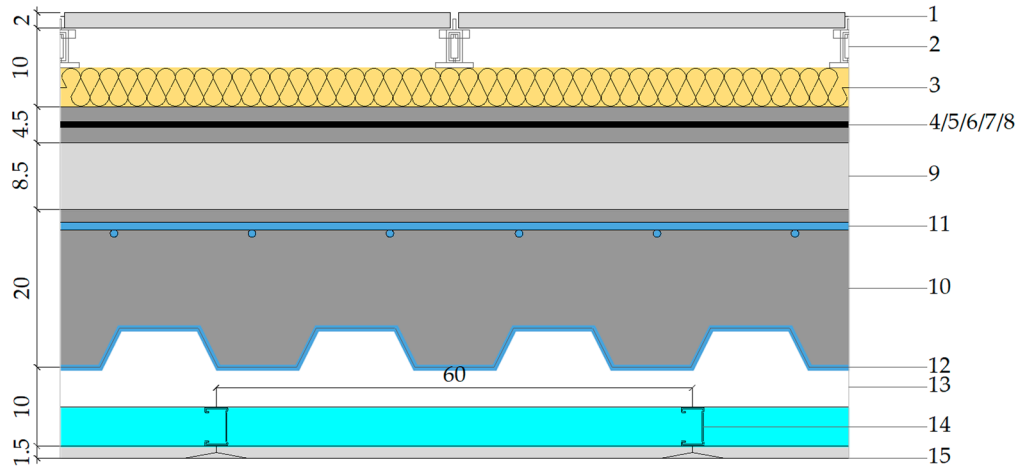
Conflicts of Interest: The authors declare no conflict of interest.

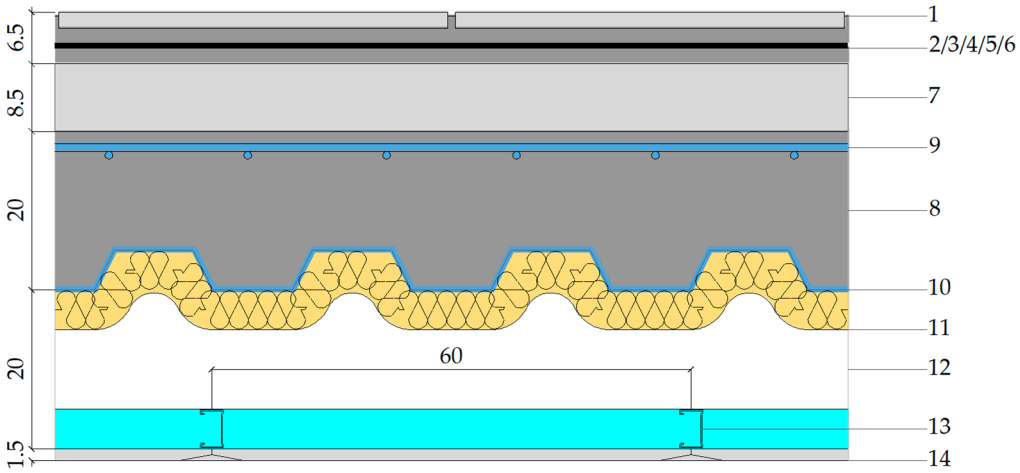
Appendix A

Appendix A includes the constructive description of the different solutions, both variable and permanent, for roofs, ground and intermediate floors, façades, median walls and partitions. The end of the appendix present the thermal transmittance of the variable elements.



1. Non-slip cement tile
2. Floating deck system
3. Insulation 0-100 mm
4. Cement mortar
5. Non-woven polyester geotextile
6. Asphalt primer
7. Cement mortar
8. Elastomer-modified bitumen sheet
9. Lightweight concrete with expanded clay
10. Concrete slab
11. Reinforced steel
12. Trapezoidal corrugated metal sheet
13. Slightly ventilated air chamber
14. Omega-shape steel profile + Insulation 100-200 mm
15. Plasterboard

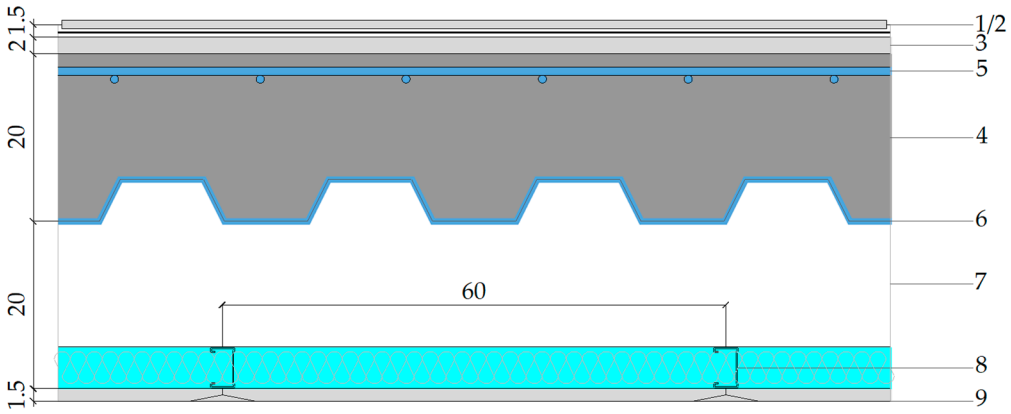
(**a**)



1. Non-slip cement tile
2. Cement mortar
3. Non-woven polyester geotextile
4. Asphalt primer
5. Cement mortar
6. Elastomer-modified bitumen sheet
7. Lightweight concrete with expanded clay
8. Concrete slab
9. Reinforced steel
10. Trapezoidal corrugated metal sheet
11. Insulation 0-150 mm
12. Slightly ventilated air chamber
13. Omega-shape steel profile + Isulation 150-200 mm
14. Plasterboard

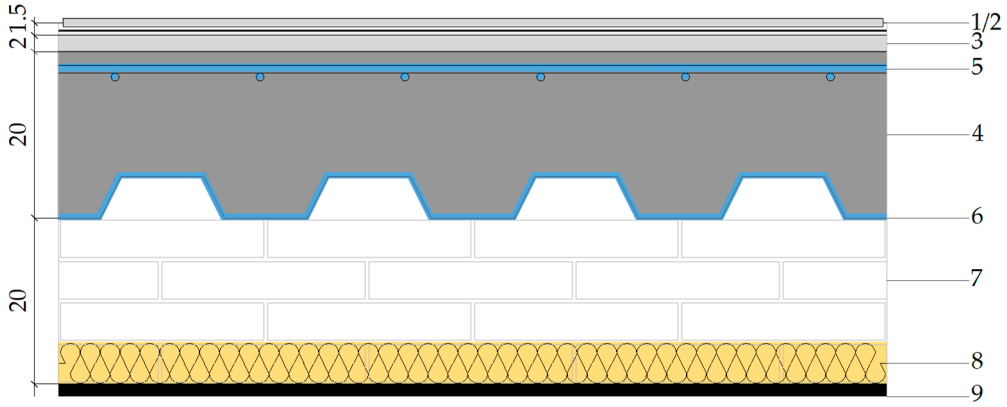
(**b**)

Figure A1. (**a**) Roof floor components detail for constructive solution 1. (**b**) Roof floor components detail for constructive solution 2.



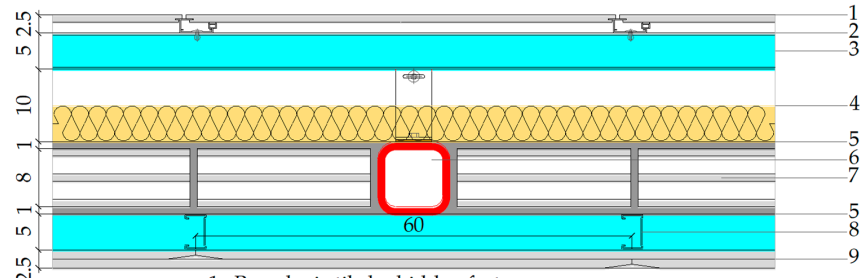
1. Floating laminate floor
2. Foam underlayment
3. Self-leveling mortar
4. Concrete slab
5. Reinforced steel
6. Trapezoidal corrugated metal sheet
7. Slightly ventilated air chamber
8. Omega-shape steel profile + Glass Wool (acoustic insulation)
9. Laminated plasterboard

Figure A2. Intermediate floor components detail.



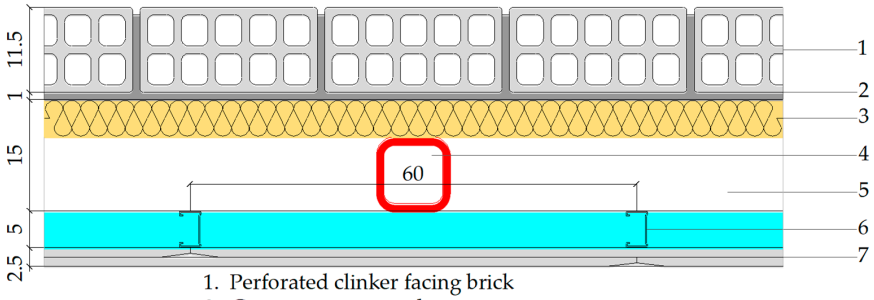
1. Floating laminate floor
2. Foam underlayment
3. Self-leveling mortar
4. Concrete slab
5. Reinforced steel
6. Trapezoidal corrugated metal sheet
7. Slightly ventilated air chamber + Perimeter wall
8. Insulation 0-200mm
9. Insitu foundation

Figure A3. Ground floor components detail.



1. Porcelanic tile by hidden fastener
2. Slightly ventilated air chamber
3. Self-supporting tube-shape aluminium profile
4. Insulation 0-150 mm
5. Cement mortar rendering
6. Structural steel column
7. Double hollow brick
8. Self-supporting omega-shape steel profile + Insulation 150-200 mm
9. Double plasterboard

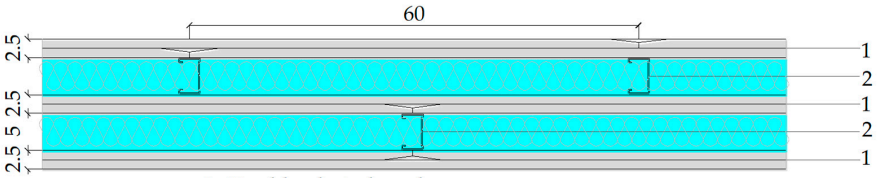
(**a**)



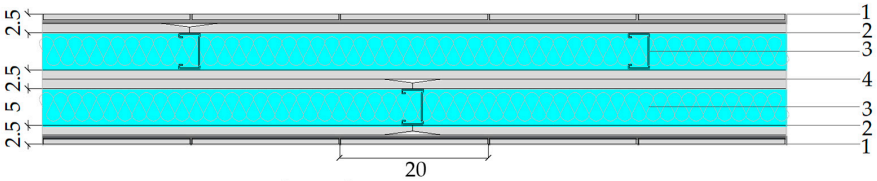
1. Perforated clinker facing brick
2. Cement mortar rendering
3. Insulation 0-150 mm
4. Structural steel column
5. Slightly ventilated air chamber
6. Self-supporting omega-shape steel profile + Insulation 150-200 mm
7. Double plasterboard

(**b**)

Figure A4. (**a**) Façade wall components detail for constructive solution 1. (**b**) Façade wall components detail for constructive solution 2.



1. Double plasterboard
2. Self-supporting omega-shape steel profile + Glass Wool (acoustic insulation)



1. Porcelanic tile
2. Laminated plasterboard
3. Self-supporting omega-shape steel profile + Glass Wool (acoustic insulation)
4. Double laminated plasterboard

Figure A5. Median walls components detail.

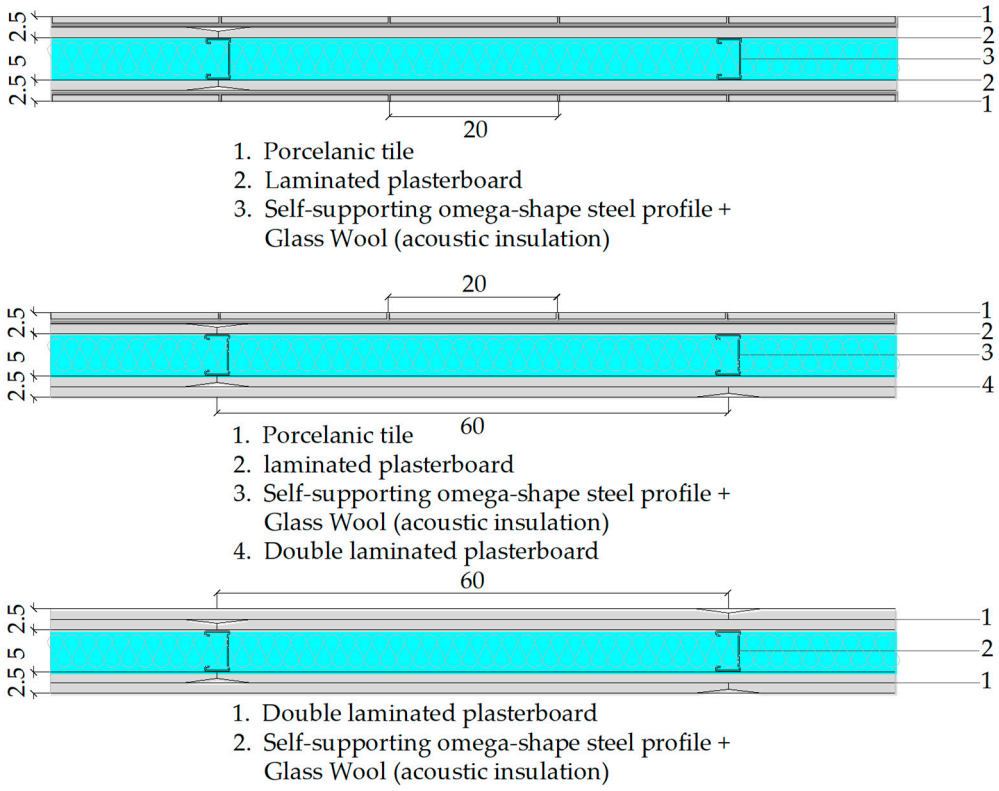


Figure A6. Partition walls component details.

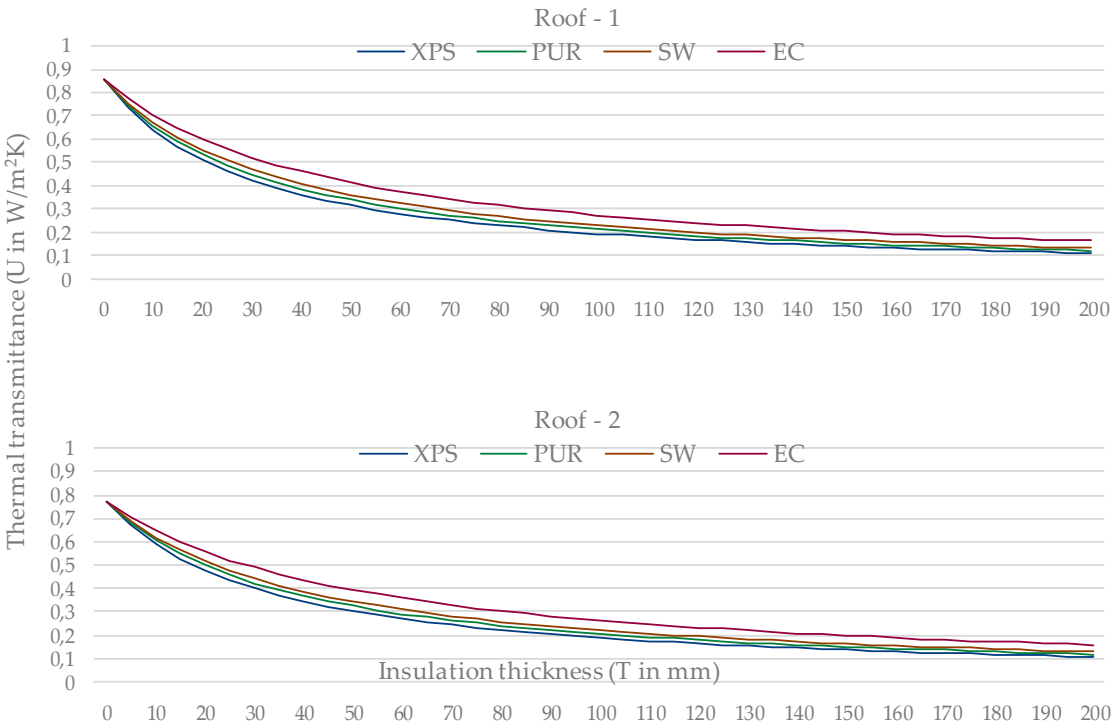


Figure A7. Thermal transmittance (U-value) according to insulation thickness, for roofs.

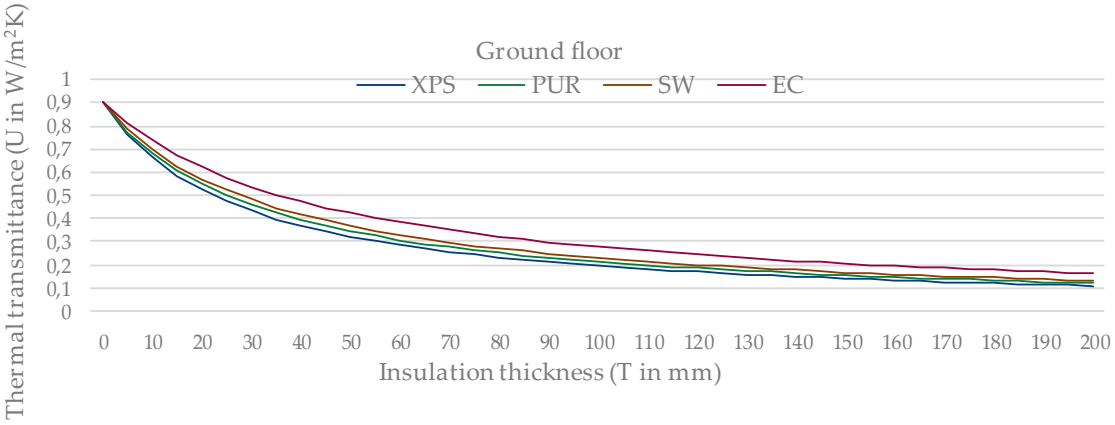


Figure A8. Thermal transmittance (U-value) according to insulation thickness, for ground floor.

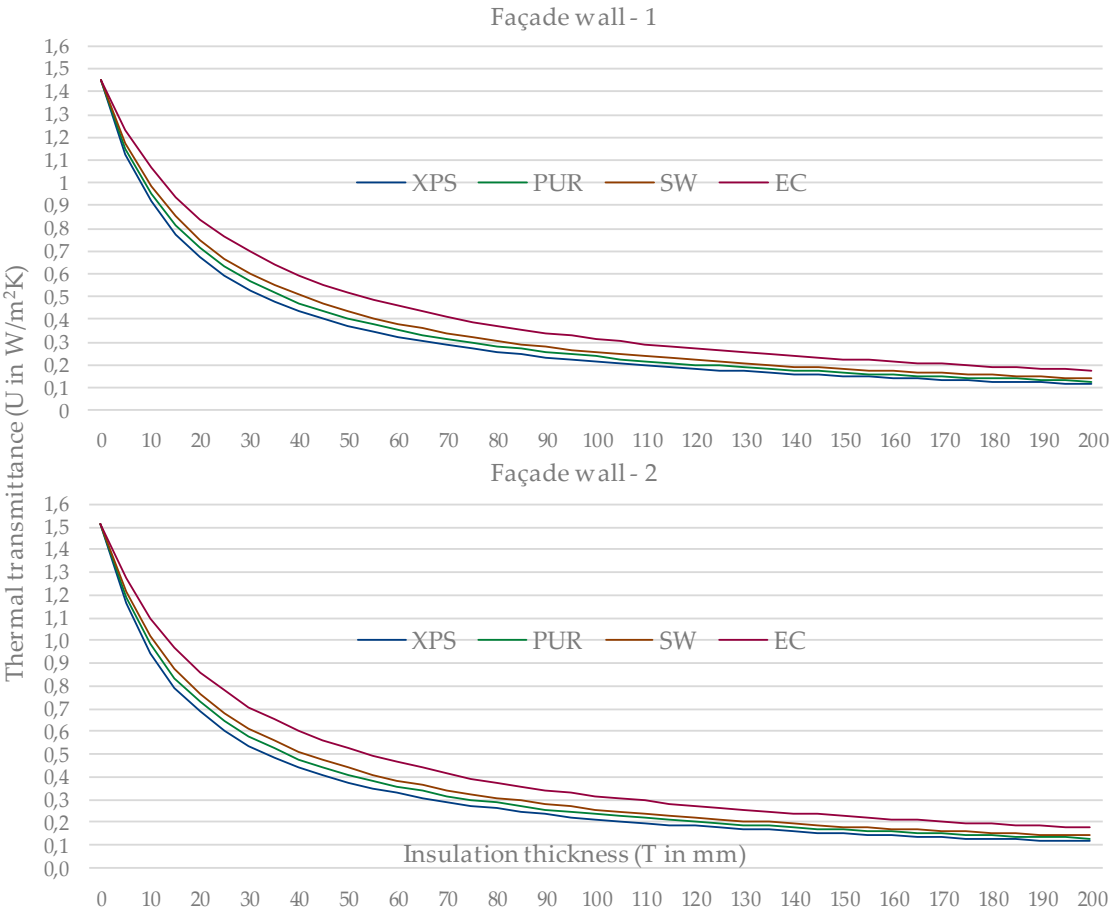


Figure A9. Thermal transmittance (U-value) according to insulation thickness, for façade walls.

Appendix B

Appendix B includes all the results from the 4608 cases studied, both for insulation thickness requirements and for embodied CO_2 emissions.

Table A1. Insulation thicknesses (in mm), for Hypothesis 1: Legal Minimum Compliance.

(a)

CZ	O	S	Model 1				Model 2				Model 3				Model 4			
			XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC
A3	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	20	20	20	30
A4	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	25	30	35	45
B3	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	35	40	45	55
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	40	45	50	65	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
B4	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	40	45	50	65
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	35	40	45	55	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
C1	N	S1	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
		S2	20	25	30	35	20	25	30	35	45	50	55	70	55	60	65	85
	E	S1	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
		S2	20	25	30	35	25	30	35	45	45	50	55	70	55	60	65	85
	S	S1	20	20	20	30	20	25	30	35	50	55	60	80	55	60	65	85
		S2	20	25	30	35	25	30	35	45	55	60	65	85	60	65	70	95
	W	S1	20	25	30	35	20	25	30	35	55	60	65	85	60	65	70	95
		S2	25	30	35	45	25	30	35	45	60	65	70	95	65	75	85	105
C2	N	S1	15	15	15	20	20	20	20	30	40	45	50	65	45	50	55	70
		S2	20	25	30	35	20	25	30	35	45	50	55	70	50	55	60	80
	E	S1	20	20	20	30	20	25	30	35	40	45	50	65	45	50	55	70
		S2	20	25	30	35	25	30	35	45	45	50	55	70	50	55	60	80
	S	S1	20	20	20	30	20	25	30	35	45	50	55	70	50	55	60	80
		S2	20	25	30	35	25	30	35	45	50	55	60	80	55	60	65	85
	W	S1	20	20	20	30	20	25	30	35	50	55	60	80	65	70	80	100
		S2	20	25	30	35	25	30	35	45	55	60	65	85	65	75	85	105

Table A1. *Cont.*

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**
C3	N	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	25	30	35	40	45	50	65	45	50	55	70
	E	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	25	30	35	40	45	50	65	45	50	55	70
	S	S1	15	15	15	20	20	20	20	30	40	45	50	65	45	50	55	70
		S2	20	20	20	30	20	25	30	35	45	50	55	70	50	55	60	80
	W	S1	20	20	20	30	20	25	30	35	45	50	55	70	50	55	60	80
		S2	20	25	30	35	20	25	30	35	50	55	60	80	60	65	70	95
C4	N	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
	E	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
	S	S1	15	15	15	20	20	20	20	30	40	45	50	65	45	50	55	70
		S2	20	25	30	35	20	25	30	35	45	50	55	70	55	60	65	85
	W	S1	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
		S2	20	25	30	35	25	30	35	45	50	55	60	80	65	70	80	100
D1	N	S1	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
		S2	20	25	30	35	25	30	35	45	50	55	60	80	65	70	80	100
	E	S1	20	20	20	30	25	30	35	45	45	50	55	70	55	60	65	85
		S2	20	25	30	35	25	30	35	45	50	55	60	80	65	70	80	100
	S	S1	20	25	30	35	25	30	35	45	55	60	65	85	60	65	70	95
		S2	25	30	35	45	30	35	40	50	60	65	70	95	65	75	85	105
	W	S1	20	25	30	35	25	30	35	45	60	65	70	95	65	75	85	105
		S2	25	30	35	45	30	35	40	50	65	70	80	100	75	85	95	120
D2	N	S1	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
		S2	20	25	30	35	25	30	35	45	50	55	60	80	65	70	80	100
	E	S1	20	20	20	30	20	25	30	35	45	50	55	70	50	55	60	80
		S2	20	25	30	35	25	30	35	45	50	55	60	80	60	65	70	95
	S	S1	20	25	30	35	25	30	35	45	50	55	60	80	55	60	65	85
		S2	20	25	30	35	30	35	40	50	55	60	65	85	65	70	80	100
	W	S1	20	25	30	35	25	30	35	45	55	60	65	85	65	75	85	105
		S2	25	30	35	45	30	35	40	50	60	65	70	95	75	85	95	120
D3	N	S1	20	20	20	30	20	20	20	30	40	45	50	65	50	55	60	80
		S2	20	25	30	35	20	25	30	35	45	50	55	70	55	60	65	85
	E	S1	20	20	20	30	20	25	30	35	40	45	50	65	45	50	55	70
		S2	20	25	30	35	25	30	35	45	45	50	55	70	55	60	65	85
	S	S1	20	20	20	30	20	25	30	35	45	50	55	70	50	55	60	80
		S2	20	25	30	35	25	30	35	45	50	55	60	80	60	65	70	95
	W	S1	20	20	20	30	20	25	30	35	50	55	60	80	65	70	80	100
		S2	20	25	30	35	25	30	35	45	55	60	65	85	65	75	85	105
E1	N	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	20	20	30	35	40	45	55	45	50	55	70
	E	S1	15	15	15	20	20	20	20	30	35	40	45	55	40	45	50	65
		S2	20	20	20	30	20	25	30	35	40	45	50	65	45	50	55	70
	S	S1	15	15	15	20	20	20	20	30	40	45	50	65	45	50	55	70
		S2	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
	W	S1	15	15	15	20	20	20	20	30	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80

CZ (Climate Zone); O (Orientation); S (Constructive Solution).

Table A2. Insulation thicknesses (in mm), for Hypothesis 2: Joint (heating + cooling) demand ≤ 30.

(a)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**
A3	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	25	30	35	45
A4	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	20	20	20	30
B3	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	35	40	45	55
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	40	45	50	65	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
B4	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	40	45	50	65
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	35	40	45	55	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
C1	N	S1	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
		S2	20	25	30	35	20	25	30	35	45	50	55	70	55	60	65	85
	E	S1	20	20	20	30	20	25	30	35	40	45	50	65	50	55	60	80
		S2	20	25	30	35	25	30	35	45	45	50	55	70	55	60	65	85
	S	S1	20	20	20	30	20	25	30	35	50	55	60	80	55	60	65	85
		S2	20	25	30	35	25	30	35	45	55	60	65	85	60	65	70	95
	W	S1	20	25	30	35	20	25	30	35	55	60	65	85	60	65	70	95
		S2	25	30	35	45	25	30	35	45	60	65	70	95	65	75	85	105
C2	N	S1	15	15	15	20	20	25	30	35	45	50	55	70	60	65	70	95
		S2	20	25	30	35	25	30	35	45	50	55	60	80	65	70	80	100
	E	S1	20	20	20	30	20	25	30	35	55	60	65	85	65	70	80	100
		S2	20	25	30	35	25	30	35	45	60	65	70	95	65	75	85	105
	S	S1	20	20	20	30	20	25	30	35	55	60	65	85	65	70	80	100
		S2	20	25	30	35	25	30	35	45	60	65	70	95	70	80	90	115
	W	S1	20	20	20	30	20	25	30	35	60	65	70	95	80	90	100	130
		S2	20	25	30	35	30	35	40	50	65	70	80	100	85	95	105	135

Table A2. *Cont.*

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**	**XPS**	**PUR**	**SW**	**EC**
C3	N	S1	20	25	30	35	25	30	35	45	60	65	70	95	85	95	105	135
		S2	25	30	35	45	35	40	45	55	65	70	80	100	80	90	100	130
	E	S1	20	25	30	35	25	30	35	45	65	75	85	105	85	95	105	135
		S2	25	30	35	45	35	40	45	55	70	80	90	115	85	95	105	135
	S	S1	25	30	35	45	30	35	40	50	65	75	85	105	90	100	110	145
		S2	35	40	45	55	35	40	45	55	70	80	90	115	90	100	110	145
	W	S1	25	30	35	45	30	35	40	50	80	90	100	130	105	120	135	170
		S2	35	40	45	55	35	40	45	55	85	95	105	135	115	130	145	185
C4	N	S1	30	35	40	50	40	45	50	65	75	85	95	120	110	125	140	180
		S2	40	45	50	65	45	50	55	70	80	90	100	130	120	135	150	195
	E	S1	35	40	45	55	40	45	50	65	90	100	110	145	110	125	140	180
		S2	40	45	50	65	50	55	60	80	95	105	115	150	130	145	160	-
	S	S1	40	45	50	65	45	50	55	70	95	105	115	150	130	145	160	-
		S2	55	60	65	85	55	60	65	85	100	110	120	155	135	150	165	-
	W	S1	45	50	55	70	45	50	55	70	105	120	135	170	145	160	175	-
		S2	55	60	65	85	60	65	70	95	110	125	140	180	170	190	-	-
D1	N	S1	40	45	50	65	45	50	55	70	95	105	115	150	130	145	160	-
		S2	45	50	55	70	50	55	60	80	100	110	120	155	170	190	-	-
	E	S1	40	45	50	65	50	55	60	80	105	120	135	170	135	150	165	-
		S2	45	50	55	70	55	60	65	85	110	125	140	180	170	190	-	-
	S	S1	45	50	55	70	50	55	60	80	120	135	150	195	145	160	175	-
		S2	50	55	60	80	55	60	65	85	125	140	155	200	170	190	-	-
	W	S1	45	50	55	70	55	60	65	85	135	150	165	-	160	180	200	-
		S2	55	60	65	85	60	65	70	95	140	155	170	-	200	-	-	-
D2	N	S1	45	50	55	70	55	60	65	85	120	135	150	195	145	160	175	-
		S2	50	55	60	80	60	65	70	95	125	140	155	200	200	-	-	-
	E	S1	50	55	60	80	60	65	70	95	140	155	170	-	150	170	190	-
		S2	50	55	60	80	65	75	85	105	150	170	190	-	-	-	-	-
	S	S1	55	60	65	85	60	65	70	95	145	160	175	-	160	180	200	-
		S2	65	70	80	100	65	75	85	105	150	170	190	-	-	-	-	-
	W	S1	60	65	70	95	65	70	80	100	145	160	175	-	-	-	-	-
		S2	65	70	80	100	70	80	90	115	-	-	-	-	-	-	-	-
D3	N	S1	55	60	65	85	65	70	80	100	145	160	175	-	-	-	-	-
		S2	65	70	80	100	70	80	90	115	160	180	-	-	-	-	-	-
	E	S1	60	65	70	95	70	80	90	115	150	170	190	-	-	-	-	-
		S2	65	70	80	100	75	85	95	120	-	-	-	-	-	-	-	-
	S	S1	65	70	80	100	70	80	90	115	165	185	-	-	-	-	-	-
		S2	80	90	100	130	80	90	100	130	-	-	-	-	-	-	-	-
	W	S1	65	75	85	105	80	90	100	130	-	-	-	-	-	-	-	-
		S2	85	95	105	135	90	100	110	145	-	-	-	-	-	-	-	-
E1	N	S1	70	80	90	115	80	90	100	130	145	165	185	-	-	-	-	-
		S2	80	90	100	130	90	100	110	145	200	-	-	-	-	-	-	-
	E	S1	75	85	95	120	90	100	110	145	170	190	-	-	-	-	-	-
		S2	80	90	100	130	100	110	120	155	-	-	-	-	-	-	-	-
	S	S1	80	90	100	130	90	100	110	145	200	-	-	-	-	-	-	-
		S2	90	100	110	145	105	115	125	165	-	-	-	-	-	-	-	-
	W	S1	85	95	105	135	100	110	120	155	200	-	-	-	-	-	-	-
		S2	100	110	120	155	105	120	135	170	-	-	-	-	-	-	-	-

CZ (Climate Zone); O (Orientation); S (Constructive Solution); - Thickness not enough to satisfy demand.

Table A3. Insulation thicknesses (in mm), for Hypothesis 3: Both heating and cooling demand ≤ 15.

(a)

CZ	O	S	Model 1				Model 2				Model 3				Model 4			
			XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC
A3	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	25	30	35	45
A4	N	S1	0	0	0	0	0	0	0	0	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	E	S1	5	5	5	5	5	5	5	5	10	10	10	15	10	10	10	15
		S2	5	5	5	5	10	10	10	15	15	15	15	20	20	20	20	30
	S	S1	5	5	5	5	5	5	5	5	15	15	15	20	10	10	10	15
		S2	5	5	5	5	10	10	10	15	20	20	20	30	20	20	20	30
	W	S1	5	5	5	5	5	5	5	5	15	15	15	20	20	25	30	35
		S2	10	10	10	15	10	10	10	15	20	25	30	35	20	20	20	30
B3	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	35	40	45	55
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	40	45	50	65	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
B4	N	S1	10	10	10	15	15	15	15	20	25	30	35	45	30	35	40	50
		S2	15	15	15	20	20	20	20	30	30	35	40	50	35	40	45	55
	E	S1	15	15	15	20	15	15	15	20	30	35	40	50	30	35	40	50
		S2	20	20	20	30	20	25	30	35	30	35	40	50	40	45	50	65
	S	S1	15	15	15	20	15	15	15	20	35	40	45	55	35	40	45	55
		S2	20	20	20	30	20	25	30	35	35	40	45	55	40	45	50	65
	W	S1	15	15	15	20	15	15	15	20	40	45	50	65	50	55	60	80
		S2	20	20	20	30	20	25	30	35	45	50	55	70	55	60	65	85
C1	N	S1	45	50	55	70	55	60	65	85	105	115	125	165	135	150	165	-
		S2	55	60	65	85	65	70	80	100	105	120	135	170	145	165	185	-
	E	S1	50	55	60	80	60	65	70	95	110	125	140	180	135	150	165	-
		S2	60	65	70	95	65	75	85	105	115	130	145	185	145	160	175	-
	S	S1	60	65	70	95	65	70	80	100	135	150	165	215	145	160	175	-
		S2	60	65	70	95	65	75	85	105	140	155	170	220	165	185	-	-
	W	S1	60	65	70	95	65	70	80	100	145	165	185	235	170	190	-	-
		S2	65	75	85	105	70	80	90	115	150	170	190	245	-	-	-	-
C2	N	S1	45	50	55	70	55	60	65	85	105	115	125	165	135	150	165	-
		S2	55	60	65	85	60	65	70	95	105	120	135	170	145	160	175	-
	E	S1	50	55	60	80	60	65	70	95	105	120	135	170	135	150	165	-
		S2	60	65	70	95	65	75	85	105	110	125	140	180	145	160	175	-
	S	S1	45	50	55	70	60	65	70	95	130	145	160	205	135	150	165	-
		S2	60	65	70	95	65	75	85	105	135	150	165	-	160	180	200	-
	W	S1	55	60	65	85	65	70	80	100	145	165	185	235	170	190	-	-
		S2	65	70	80	100	65	75	85	105	150	170	190	-	-	-	-	-

Table A3. *Cont.*

(b)

CZ	O	S	Model 1				Model 2				Model 3				Model 4			
			XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC
C3	N	S1	40	45	50	65	45	50	55	70	85	95	105	135	105	120	135	170
		S2	45	50	55	70	55	60	65	85	90	100	110	145	110	125	140	180
	E	S1	45	50	55	70	50	55	60	80	90	100	110	145	105	120	135	170
		S2	50	55	60	80	60	65	70	95	95	105	115	150	110	125	140	180
	S	S1	45	50	55	70	50	55	60	80	105	120	135	170	115	130	145	185
		S2	50	55	60	80	60	65	70	95	110	125	140	180	125	140	155	200
	W	S1	50	55	60	80	55	60	65	85	120	135	150	195	135	150	165	-
		S2	55	60	65	85	60	65	70	95	125	140	155	200	165	185	-	-
C4	N	S1	40	45	50	65	45	50	55	70	85	95	105	135	110	125	140	180
		S2	50	55	60	80	55	60	65	85	95	105	115	150	130	145	160	-
	E	S1	45	50	55	70	50	55	60	80	90	100	110	145	110	125	140	180
		S2	50	55	60	80	60	65	70	95	105	115	125	165	130	145	160	-
	S	S1	45	50	55	70	55	60	65	85	105	115	125	165	130	145	160	-
		S2	55	60	65	85	60	65	70	95	115	130	145	185	145	165	185	-
	W	S1	50	55	60	80	55	60	65	85	115	130	145	185	145	160	175	-
		S2	60	65	70	95	65	70	80	100	135	150	165	–	180	200	-	-
D1	N	S1	135	150	165	-	145	160	175	-	-	-	-	-	-	-	-	-
		S2	160	180	200	-	175	195	-	-	-	-	-	-	-	-	-	-
	E	S1	140	155	170	-	165	185	-	-	-	-	-	-	-	-	-	-
		S2	165	185	-	-	200	-	-	-	-	-	-	-	-	-	-	-
	S	S1	140	155	170	-	190	-	-	-	-	-	-	-	-	-	-	-
		S2	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	W	S1	150	170	190	-	195	-	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D2	N	S1	130	145	160	-	145	160	175	-	-	-	-	-	-	-	-	-
		S2	150	170	190	-	165	185	-	-	-	-	-	-	-	-	-	-
	E	S1	135	150	165	-	160	180	200	-	-	-	-	-	-	-	-	-
		S2	155	175	195	-	200	-	-	-	-	-	-	-	-	-	-	-
	S	S1	145	160	175	-	165	185	-	-	-	-	-	-	-	-	-	-
		S2	180	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	W	S1	155	175	195	-	180	200	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D3	N	S1	115	130	145	185	125	140	155	200	-	-	-	-	-	-	-	-
		S2	125	140	155	200	135	150	165	-	-	-	-	-	-	-	-	-
	E	S1	120	135	150	195	135	150	165	-	-	-	-	-	-	-	-	-
		S2	135	150	165	-	150	170	190	-	-	-	-	-	-	-	-	-
	S	S1	125	140	155	200	145	160	175	-	-	-	-	-	-	-	-	-
		S2	145	165	185	-	160	180	200	-	-	-	-	-	-	-	-	-
	W	S1	140	155	170	-	150	170	190	-	-	-	-	-	-	-	-	-
		S2	165	185	-	-	170	190	-	-	-	-	-	-	-	-	-	-
E1	N	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	W	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CZ (Climate Zone); O (Orientation); S (Constructive Solution); - Thickness not enough to satisfy demand.

Table A4. Emissions of CO_2 according to climate zone (CZ), orientation (O), constructive solution (S), building model and insulation material model (in Kg CO_2), for H1.

(a)

CZ	O	S	Model 1				Model 2				Model 3				Model 4			
			XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC	XPS	PUR	SW	EC
A3	N	S1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	E	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	S	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	5.55E+03	4.00E+03	3.08E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	W	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	7.32E+03	6.33E+03	3.79E+03
		S2	3.13E+03	2.21E+03	1.59E+03	1.23E+03	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	6.93E+03	6.00E+03	3.60E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
A4	N	S1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	E	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	S	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	5.55E+03	4.00E+03	3.08E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	W	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	7.32E+03	6.33E+03	3.79E+03
		S2	3.13E+03	2.21E+03	1.59E+03	1.23E+03	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	6.93E+03	6.00E+03	3.60E+03	1.04E+04	8.78E+03	7.38E+03	4.88E+03
B3	N	S1	3.13E+03	2.21E+03	1.59E+03	1.23E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	9.82E+03	8.32E+03	7.00E+03	4.62E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	W	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
B4	N	S1	3.13E+03	2.21E+03	1.59E+03	1.23E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	9.82E+03	8.32E+03	7.00E+03	4.62E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	W	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+0f3	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03

Table A4. *Cont.*

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
C1	N	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	S	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
	W	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
C2	N	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	S	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	W	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
C3	N	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	W	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
C4	N	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	W	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04

Table A4. *Cont.*

(c)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
D1	N	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
	S	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
	W	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.55E+04	1.94E+04	1.60E+04	1.03E+04	3.11E+04	2.49E+04	2.00E+04	1.30E+04
D2	N	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
	S	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
	W	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	3.11E+04	2.49E+04	2.00E+04	1.30E+04
D3	N	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	S	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
	W	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
E1	N	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.87E+04	1.46E+04	1.16E+04	7.59E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
	W	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03

Table A5. Emissions of CO_2 according to climate zone (CZ), orientation (O), constructive solution (S), building model and insulation material model (in Kg CO_2), for H2.

(a)

CZ	O	S	Model 1				Model 2				Model 3				Model 4			
			XPS	PUR	SW	EC				XPS	PUR	SW	EC				XPS	PUR
A3	N	S1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	E	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	S	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	5.55E+03	4.00E+03	3.08E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	W	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	7.32E+03	6.33E+03	3.79E+03
		S2	3.13E+03	2.21E+03	1.59E+03	1.23E+03	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	6.93E+03	6.00E+03	3.60E+03	1.04E+04	8.78E+03	7.38E+03	4.88E+03
A4	N	S1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	E	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	3.93E+03	2.77E+03	2.00E+03	1.54E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	S	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	4.15E+03	2.93E+03	2.11E+03	1.63E+03
		S2	1.57E+03	1.11E+03	7.97E+02	4.10E+02	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	5.55E+03	4.00E+03	3.08E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
	W	S1	1.57E+03	1.11E+03	7.97E+02	4.10E+02	1.62E+03	1.14E+03	8.23E+02	4.23E+02	5.89E+03	4.16E+03	3.00E+03	2.05E+03	8.29E+03	7.32E+03	6.33E+03	3.79E+03
		S2	3.13E+03	2.21E+03	1.59E+03	1.23E+03	3.23E+03	2.28E+03	1.65E+03	1.27E+03	7.86E+03	6.93E+03	6.00E+03	3.60E+03	8.29E+03	5.85E+03	4.22E+03	3.25E+03
B3	N	S1	3.13E+03	2.21E+03	1.59E+03	1.23E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	9.82E+03	8.32E+03	7.00E+03	4.62E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	W	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
B4	N	S1	3.13E+03	2.21E+03	1.59E+03	1.23E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	9.82E+03	8.32E+03	7.00E+03	4.62E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	4.57E+03	3.29E+03	2.54E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
	E	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.24E+04	1.02E+04	8.44E+03	5.42E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.18E+04	9.71E+03	8.00E+03	5.14E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	S	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.45E+04	1.17E+04	9.49E+03	5.96E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.38E+04	1.11E+04	9.00E+03	5.65E+03	1.66E+04	1.32E+04	1.05E+04	7.05E+03
	W	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	4.85E+03	3.43E+03	2.47E+03	1.69E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03

Table A5. *Cont.*

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
C1	N	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.57E+04	1.25E+04	1.00E+04	6.68E+03	2.07E+04	1.61E+04	1.27E+04	8.67E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
	S	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.28E+04	1.76E+04	1.37E+04	9.21E+03
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
	W	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
C2	N	S1	4.70E+03	3.32E+03	2.39E+03	1.64E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	1.77E+04	1.39E+04	1.10E+04	7.19E+03	2.49E+04	1.90E+04	1.48E+04	1.03E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	1.96E+04	1.53E+04	1.20E+04	8.22E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
	E	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.69E+04	2.19E+04	1.79E+04	1.14E+04
	S	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	2.16E+04	1.66E+04	1.30E+04	8.73E+03	2.69E+04	2.05E+04	1.69E+04	1.08E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	2.90E+04	2.34E+04	1.90E+04	1.25E+04
	W	S1	6.27E+03	4.42E+03	3.19E+03	2.46E+03	6.47E+03	5.71E+03	4.94E+03	2.96E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	3.32E+04	2.63E+04	2.11E+04	1.41E+04
		S2	6.27E+03	5.53E+03	4.78E+03	2.87E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.55E+04	1.94E+04	1.60E+04	1.03E+04	3.52E+04	2.78E+04	2.21E+04	1.46E+04
C3	N	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.36E+04	1.80E+04	1.40E+04	9.76E+03	3.52E+04	2.78E+04	2.21E+04	1.46E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	1.13E+04	9.13E+03	7.41E+03	4.65E+03	2.55E+04	1.94E+04	1.60E+04	1.03E+04	3.32E+04	2.63E+04	2.11E+04	1.41E+04
	E	S1	6.27E+03	5.53E+03	4.78E+03	2.87E+03	8.09E+03	6.85E+03	5.76E+03	3.81E+03	2.55E+04	2.08E+04	1.70E+04	1.08E+04	3.52E+04	2.78E+04	2.21E+04	1.46E+04
		S2	7.83E+03	6.63E+03	5.58E+03	3.69E+03	1.13E+04	9.13E+03	7.41E+03	4.65E+03	2.75E+04	2.22E+04	1.80E+04	1.18E+04	3.52E+04	2.78E+04	2.21E+04	1.46E+04
	S	S1	7.83E+03	6.63E+03	5.58E+03	3.69E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	2.55E+04	2.08E+04	1.70E+04	1.08E+04	3.73E+04	2.93E+04	2.32E+04	1.57E+04
		S2	1.10E+04	8.85E+03	7.17E+03	4.51E+03	1.13E+04	9.13E+03	7.41E+03	4.65E+03	2.75E+04	2.22E+04	1.80E+04	1.18E+04	3.73E+04	2.93E+04	2.32E+04	1.57E+04
	W	S1	7.83E+03	6.63E+03	5.58E+03	3.69E+03	9.70E+03	7.99E+03	6.58E+03	4.23E+03	3.14E+04	2.50E+04	2.00E+04	1.34E+04	4.35E+04	3.51E+04	2.85E+04	1.84E+04
		S2	1.10E+04	8.85E+03	7.17E+03	4.51E+03	1.13E+04	9.13E+03	7.41E+03	4.65E+03	3.34E+04	2.63E+04	2.10E+04	1.39E+04	4.77E+04	3.80E+04	3.06E+04	2.01E+04
C4	N	S1	9.40E+03	7.74E+03	6.38E+03	4.10E+03	1.29E+04	1.03E+04	8.23E+03	5.50E+03	2.95E+04	2.36E+04	1.90E+04	1.23E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.14E+04	2.50E+04	2.00E+04	1.34E+04	4.97E+04	3.95E+04	3.16E+04	2.11E+04
	E	S1	1.10E+04	8.85E+03	7.17E+03	4.51E+03	1.29E+04	1.03E+04	8.23E+03	5.50E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
	S	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	3.93E+04	3.05E+04	2.40E+04	1.59E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
	W	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	7.05E+04	5.56E+04	n.a.	n.a.

Table A5. *Cont.*

(c)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
D1	N	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
		S2	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.93E+04	3.05E+04	2.40E+04	1.59E+04	7.05E+04	5.56E+04	n.a.	n.a.
	E	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	7.05E+04	5.56E+04	n.a.	n.a.
	S	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	4.71E+04	3.74E+04	3.00E+04	2.00E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.91E+04	3.88E+04	3.10E+04	2.05E+04	7.05E+04	5.56E+04	n.a.	n.a.
	W	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	5.30E+04	4.16E+04	3.30E+04	n.a.	6.63E+04	5.27E+04	4.22E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	5.50E+04	4.30E+04	3.40E+04	n.a.	8.29E+04	n.a.	n.a.	n.a.
D2	N	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.71E+04	3.74E+04	3.00E+04	2.00E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.91E+04	3.88E+04	3.10E+04	2.05E+04	8.29E+04	n.a.	n.a.	n.a.
	E	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	5.50E+04	4.30E+04	3.40E+04	n.a.	6.22E+04	4.97E+04	4.01E+04	n.a.
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.89E+04	4.71E+04	3.80E+04	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	5.70E+04	4.44E+04	3.50E+04	n.a.	6.63E+04	5.27E+04	4.22E+04	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.89E+04	4.71E+04	3.80E+04	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.44E+04	3.50E+04	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D3	N	S1	1.72E+04	1.33E+04	1.04E+04	6.96E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.44E+04	3.50E+04	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	6.29E+04	4.99E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	5.89E+04	4.71E+04	3.80E+04	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.43E+04	1.94E+04	1.56E+04	1.01E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	6.48E+04	5.13E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.51E+04	1.99E+04	1.59E+04	1.06E+04	2.59E+04	2.06E+04	1.65E+04	1.10E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	2.04E+04	1.66E+04	1.35E+04	8.60E+03	2.59E+04	2.06E+04	1.65E+04	1.10E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.66E+04	2.10E+04	1.67E+04	1.11E+04	2.91E+04	2.28E+04	1.81E+04	1.23E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
E1	N	S1	2.19E+04	1.77E+04	1.43E+04	9.42E+03	2.59E+04	2.06E+04	1.65E+04	1.10E+04	5.70E+04	4.58E+04	3.70E+04	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.51E+04	1.99E+04	1.59E+04	1.06E+04	2.91E+04	2.28E+04	1.81E+04	1.23E+04	7.86E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	2.35E+04	1.88E+04	1.51E+04	9.83E+03	2.91E+04	2.28E+04	1.81E+04	1.23E+04	6.68E+04	5.27E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.51E+04	1.99E+04	1.59E+04	1.06E+04	3.23E+04	2.51E+04	1.98E+04	1.31E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	2.51E+04	1.99E+04	1.59E+04	1.06E+04	2.91E+04	2.28E+04	1.81E+04	1.23E+04	7.86E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	2.82E+04	2.21E+04	1.75E+04	1.19E+04	3.40E+04	2.63E+04	2.06E+04	1.40E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	2.66E+04	2.10E+04	1.67E+04	1.11E+04	3.23E+04	2.51E+04	1.98E+04	1.31E+04	7.86E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	3.13E+04	2.43E+04	1.91E+04	1.27E+04	3.40E+04	2.74E+04	2.22E+04	1.44E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table A6. Emissions of CO_2 according to climate zone (CZ), orientation (O), constructive solution (S), building model and insulation material model (in Kg CO_2), for H3.

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
C1	N	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	6.01E+04	4.83E+04	3.90E+04	n.a.
	E	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	S	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.30E+04	4.16E+04	3.30E+04	2.21E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.50E+04	4.30E+04	3.40E+04	2.26E+04	6.84E+04	5.41E+04	n.a.	n.a.
	W	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.58E+04	3.70E+04	2.41E+04	7.05E+04	5.56E+04	n.a.	n.a.
		S2	2.04E+04	1.66E+04	1.35E+04	8.60E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	5.89E+04	4.71E+04	3.80E+04	2.52E+04	n.a.	n.a.	n.a.	n.a.
C2	N	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	S	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	5.11E+04	4.02E+04	3.20E+04	2.11E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.30E+04	4.16E+04	3.30E+04	n.a.	6.63E+04	5.27E+04	4.22E+04	n.a.
	W	S1	1.72E+04	1.33E+04	1.04E+04	6.96E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.58E+04	3.70E+04	2.41E+04	7.05E+04	5.56E+04	n.a.	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.89E+04	4.71E+04	3.80E+04	n.a.	n.a.	n.a.	n.a.	n.a.
C3	N	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.34E+04	2.63E+04	2.10E+04	1.39E+04	4.35E+04	3.51E+04	2.85E+04	1.84E+04
		S2	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.35E+04	3.51E+04	2.85E+04	1.84E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
	S	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	4.77E+04	3.80E+04	3.06E+04	2.01E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	5.18E+04	4.10E+04	3.27E+04	2.17E+04
	W	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.71E+04	3.74E+04	3.00E+04	2.00E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.91E+04	3.88E+04	3.10E+04	2.05E+04	6.84E+04	5.41E+04	n.a.	n.a.
C4	N	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.34E+04	2.63E+04	2.10E+04	1.39E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
	S	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.83E+04	3.90E+04	n.a.
	W	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.30E+04	4.16E+04	3.30E+04	n.a.	7.46E+04	5.85E+04	n.a.	n.a.

Table A6. *Cont.*

(b)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
C1	N	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	6.01E+04	4.83E+04	3.90E+04	n.a.
	E	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	S	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.30E+04	4.16E+04	3.30E+04	2.21E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.50E+04	4.30E+04	3.40E+04	2.26E+04	6.84E+04	5.41E+04	n.a.	n.a.
	W	S1	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.58E+04	3.70E+04	2.41E+04	7.05E+04	5.56E+04	n.a.	n.a.
		S2	2.04E+04	1.66E+04	1.35E+04	8.60E+03	2.26E+04	1.83E+04	1.48E+04	9.73E+03	5.89E+04	4.71E+04	3.80E+04	2.52E+04	n.a.	n.a.	n.a.	n.a.
C2	N	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
	S	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	5.11E+04	4.02E+04	3.20E+04	2.11E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.30E+04	4.16E+04	3.30E+04	n.a.	6.63E+04	5.27E+04	4.22E+04	n.a.
	W	S1	1.72E+04	1.33E+04	1.04E+04	6.96E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.70E+04	4.58E+04	3.70E+04	2.41E+04	7.05E+04	5.56E+04	n.a.	n.a.
		S2	2.04E+04	1.55E+04	1.28E+04	8.19E+03	2.10E+04	1.71E+04	1.40E+04	8.88E+03	5.89E+04	4.71E+04	3.80E+04	n.a.	n.a.	n.a.	n.a.	n.a.
C3	N	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.34E+04	2.63E+04	2.10E+04	1.39E+04	4.35E+04	3.51E+04	2.85E+04	1.84E+04
		S2	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.35E+04	3.51E+04	2.85E+04	1.84E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
	S	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	4.13E+04	3.33E+04	2.70E+04	1.75E+04	4.77E+04	3.80E+04	3.06E+04	2.01E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.32E+04	3.47E+04	2.80E+04	1.85E+04	5.18E+04	4.10E+04	3.27E+04	2.17E+04
	W	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.71E+04	3.74E+04	3.00E+04	2.00E+04	5.60E+04	4.39E+04	3.48E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.91E+04	3.88E+04	3.10E+04	2.05E+04	6.84E+04	5.41E+04	n.a.	n.a.
C4	N	S1	1.25E+04	9.95E+03	7.97E+03	5.32E+03	1.46E+04	1.14E+04	9.05E+03	5.92E+03	3.34E+04	2.63E+04	2.10E+04	1.39E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	3.73E+04	2.91E+04	2.30E+04	1.54E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
	E	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.62E+04	1.26E+04	9.88E+03	6.77E+03	3.54E+04	2.77E+04	2.20E+04	1.49E+04	4.56E+04	3.66E+04	2.95E+04	1.95E+04
		S2	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
	S	S1	1.41E+04	1.11E+04	8.77E+03	5.73E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.13E+04	3.19E+04	2.50E+04	1.70E+04	5.39E+04	4.24E+04	3.37E+04	n.a.
		S2	1.72E+04	1.33E+04	1.04E+04	6.96E+03	1.94E+04	1.48E+04	1.15E+04	8.04E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.83E+04	3.90E+04	n.a.
	W	S1	1.57E+04	1.22E+04	9.56E+03	6.55E+03	1.78E+04	1.37E+04	1.07E+04	7.19E+03	4.52E+04	3.61E+04	2.90E+04	1.90E+04	6.01E+04	4.68E+04	3.69E+04	n.a.
		S2	1.88E+04	1.44E+04	1.12E+04	7.78E+03	2.10E+04	1.60E+04	1.32E+04	8.46E+03	5.30E+04	4.16E+04	3.30E+04	n.a.	7.46E+04	5.85E+04	n.a.	n.a.

Table A6. *Cont.*

(c)																		
CZ	**O**	**S**	**Model 1**				**Model 2**				**Model 3**				**Model 4**			
			XPS	**PUR**	**SW**	**EC**				**XPS**	**PUR**	**SW**	**EC**				**XPS**	**PUR**
D1	N	S1	4.23E+04	3.32E+04	2.63E+04	n.a.	4.69E+04	3.65E+04	2.88E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	5.01E+04	3.98E+04	3.19E+04	n.a.	5.66E+04	4.45E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	4.39E+04	3.43E+04	2.71E+04	n.a.	5.34E+04	4.22E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	5.17E+04	4.09E+04	n.a.	n.a.	6.47E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	4.39E+04	3.43E+04	2.71E+04	n.a.	6.15E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	5.95E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	4.70E+04	3.76E+04	3.03E+04	n.a.	6.31E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D2	N	S1	4.07E+04	3.21E+04	2.55E+04	n.a.	4.69E+04	3.65E+04	2.88E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	4.70E+04	3.76E+04	3.03E+04	n.a.	5.34E+04	4.22E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	4.23E+04	3.32E+04	2.63E+04	n.a.	5.18E+04	4.11E+04	3.29E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	4.86E+04	3.87E+04	3.11E+04	n.a.	6.47E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	4.54E+04	3.54E+04	2.79E+04	n.a.	5.34E+04	4.22E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	5.64E+04	4.42E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	4.86E+04	3.87E+04	3.11E+04	n.a.	5.82E+04	4.57E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D3	N	S1	3.60E+04	2.88E+04	2.31E+04	1.52E+04	4.04E+04	3.20E+04	2.55E+04	1.69E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	3.92E+04	3.10E+04	2.47E+04	1.64E+04	4.37E+04	3.43E+04	2.72E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	3.76E+04	2.99E+04	2.39E+04	1.60E+04	4.37E+04	3.43E+04	2.72E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	4.23E+04	3.32E+04	2.63E+04	n.a.	4.85E+04	3.88E+04	3.13E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	3.92E+04	3.10E+04	2.47E+04	1.64E+04	4.69E+04	3.65E+04	2.88E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	4.54E+04	3.65E+04	2.95E+04	n.a.	5.18E+04	4.11E+04	3.29E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	4.39E+04	3.43E+04	2.71E+04	n.a.	4.85E+04	3.88E+04	3.13E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	5.17E+04	4.09E+04	n.a.	n.a.	5.50E+04	4.34E+04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
E1	N	S1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	E	S1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	S	S1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	W	S1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		S2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

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