Renobel - Technical Report

Renobel is a model designed to calculate the profitability of energy renovation investments using data from the 2023 Woonsurvey[1], a large-scale housing survey carried out across Flanders, in Belgium. The profitability of investments in Renobel is computed using households' actual energy consumption, under the assumption that their chosen indoor temperature would remain unchanged after renovation. In general, theoretical energy consumption tends to significantly overestimate actual consumption. To address this, we use the theoretical energy consumption before and after the potential renovation to calculate the expected reduction in energy needs, and we apply this same rate of reduction to the observed energy consumption. This technical report presents the structure of the data and how we impute missing values (NA's and omitted variables) (see section 1), the methodology and the assumptions used to construct the theoretical energy consumption of each dwelling (see section 2) and to estimate the costs of energy renovations (see section 3). Assumptions are highlighted in blue.

1 Woonsurvey

Woonsurvey 2023 is a particularly rich source of microdata for our analysis, as it provides detailed information on household socio-demographic characteristics, dwelling attributes relevant for computing theoretical energy consumption, and actual energy bills. In this section, we explain how we derive the dwellings' energy performance (U-values) and how we impute missing information such as envelope surfaces and solar panel areas.

1.1 The U-Values

The U-value measures how effectively a building component insulates: the lower the U-value, the better the insulation. The Woonsurvey provides information on the year of construction and on the insulation level of each component (bad, intermediate, good). For dwellings with a missing construction period, we randomly assign one of the three oldest construction-period

[1] Data have been made available by Agentschap Wonen in Vlaanderen and collected by Steunpunt Wonen.

categories, using a fixed seed for reproducibility. Missing insulation information for roofs, floors, walls and pipes is assigned to the poor-insulation category. Missing window-insulation information is also assigned to the poor-insulation category; when windows are reported as insulated but the glazing type is missing, the glazing type is assigned to the poor-insulation category. These imputations allow us to assign U-values while keeping these observations in the EPC calculation. For the windows we have four levels of information concerning the insulation of the glass (triple glazing, high-efficiency double glazing, other double glazing and single glass). We construct U-values based on Gendebien et al. (2014), who distinguish five main construction periods and two insulation levels (bad, good). Since the Woonsurvey reports an additional insulation level (intermediate), we assume that its U-value corresponds to the average of the bad and good scenarios. For buildings constructed since 1990, we adjust the "bad" insulation scenario from Gendebien et al. (2014) to comply with the maximum U-values imposed by the Flemish Region (Vlaamse Overheid, 1991, 2018). For windows we do not differentiate between years of construction as the type of glazing does not depend on its year of installation.

Table 1 presents the U-values associated with each insulation quality level (bad, intermediate, good) for the different components of the building envelope, as a function of the dwelling's year of construction.

Table 1: U-Values

YOC*	**Wall**			**Windows**				**Roof**			**Floor**		
	Bad	Int.	Good	VB†	Bad	Int.	Good	Bad	Int.	Good	Bad	Int.	Good
< 1945	2.25	1.42	0.59	5	4	3	2	4.15	2.3	0.44	3.38	2	0.77
1945–69	1.56	1	0.53	5	4	3	2	3.33	1.9	0.43	3.38	2	0.77
1970–89	0.98	0.71	0.44	5	4	3	2	0.77	0.5	0.30	1.14	0.8	0.43
1990–2010	0.60	0.5	0.40	5	4	3	2	0.60	0.45	0.30	0.60	0.5	0.40
> 2010	0.24	0.24	0.24	2	2	2	2	0.24	0.24	0.24	0.24	0.24	0.24

* YOC: Year of Construction

† VB: Very bad

Source: Own calculations based on Gendebien et al. (2014) and Flemish regional norms (Vlaamse Overheid, 1991).

1.2 Areas of the envelope's components

The surfaces of the envelope's components are not provided in Woonsurvey, except for the ground floor area (A_{floor}). We make the following assumptions regarding the components' surfaces. The roof surface (A_{roof}) is assumed to equal the ground floor area for flats and is multiplied by $\sqrt{2}$ for houses to account for 45° inclined roofs:

$$A_{roof} = \begin{cases} 1.44 \times A_{\text{floor}} & \text{if house} \\ A_{\text{floor}} & \text{if flat} \end{cases}$$

The vertical surface (A_{vert}), which serves as the basis for wall and window areas (A_{wall} and A_{win} respectively), is estimated by assuming a rectangular building with a floor-to-floor height of 3 meters and a ground footprint twice as long as it is wide. Here, n_{floor} denotes the number of floors of the dwelling, so that the vertical surface is calculated as:

$$A_{\text{vert}} = 9 \times n_{\text{floor}} \times \sqrt{2 \times A_{\text{floor}}}$$

The surface of shared walls ($A_{\text{wall,ter}}$), is modeled using a terraced correction coefficient C_{ter}, which represents the fraction of vertical surface in contact with adjacent dwellings. Its values depend on the housing type: Studio/Room: 5/6, Flat: 2/3, Terraced house: 2/3, Semi-detached house: 1/3, and Detached house: 0.

$$A_{\text{walls,ter}} = A_{\text{vert}} \times C_{\text{ter}}$$

The window share of the exposed vertical surface, denoted s_{win}, varies by dwelling type. The shares are calibrated from own calculations combining the VEKA geometry and dwelling-characteristics datasets (Vlaams Energie- en Klimaatagentschap, 2026a, 2026b).[2] The calibrated shares are 22% for detached houses, 20% for semi-detached houses, 32% for terraced houses, and 50% for flats, studios and rooms. Other dwelling types retain a 30% assumption:

[2] Window surface (`VENSTER_OPPERVLAKTE`) from `AG_OVERZICHT_GEOMETRIE_DETAIL` was linked by `AANGIFTE_ID` to `AG_DIMENSIES`. In that dataset, `TYPE_WONING` distinguishes flats from single-family houses, while `BOUWVORM` distinguishes detached, semi-detached and terraced houses. Mean window area was then calculated for each dwelling category and used to calibrate s_{win}.

$$s_{\text{win}} = \begin{cases} 0.22 & \text{if detached house} \\ 0.20 & \text{if semi-detached house} \\ 0.32 & \text{if terraced house} \\ 0.50 & \text{if flat, studio or room} \\ 0.30 & \text{otherwise} \end{cases}$$

Window area is calculated from the exposed vertical surface, and the exposed opaque wall area is the residual after subtracting windows:

$$\begin{cases} A_{\text{win}} = A_{\text{vert}} \cdot (1 - C_{\text{ter}}) \cdot s_{\text{win}} \\ A_{\text{walls,ext}} = A_{\text{vert}} \cdot (1 - C_{\text{ter}}) \cdot (1 - s_{\text{win}}) \end{cases}$$

1.3 Photovoltaic and solar thermal panels

Woonsurvey reports whether a dwelling is equipped with photovoltaic panels; however, the total panel surface area is missing. We assume that $A_{\text{PV}} = \frac{A_{\text{roof}}}{6}$ if photovoltaic panels are present [3]. For solar thermal panels, the current model assigns a fixed collector area of 1 m^2 to dwellings equipped with a solar boiler, and 0 otherwise.

2 Theoretical Energy consumption

The theoretical energy consumption of buildings in Europe is determined within the framework of the *Energy Performance of Buildings Directive* (EPBD), which requires that national calculation methods rely on the European framework standard ISO 52000-1 (International Organization for Standardization, 2017). This directive has been transposed by each member state – and, in Belgium, by each region. Our analysis relies on the Flemish methodology (Vlaamse Overheid, 2022). This section presents the methodology, together with the additional resources used to compute the theoretical energy consumption. The elements shown in blue indicate the supplementary assumptions or parameter values that we may use for simplicity.

The EPC score is expressed in kWh/m^2.year and is defined as the theoretical primary energy consumption ($E_{th,primary}$) divided by the heated surface of the dwelling in square meter (A) times the conversion factor 3.6 to convert MJ in kWh. A is computed as $A_{floor}(1+0.7(n_{floor}-1))$ (Cellar and attic are excluded from the area).

[3] This corresponds to a mean A_{PV} of 27 m^2, in line with evidence from Energuide (2026).

$$EPC_{score} = \frac{E_{th,primary}}{3.6 \cdot A} \tag{2.0.1}$$

where the theoretical primary energy consumption is the sum of the theoretical energy consumption from electricity ($E_{th,elec)}$) penalized by a factor 2,5[4] and the theoretical energy consumption from other fossil fuels ($E_{th,other}$).

$$E_{th,primary} = 2.5 \times E_{th,elec} + E_{th,fossil} \tag{2.0.2}$$

where the theoretical energy consumption from electricity ($E_{th,elec}$) is the sum of the energy needed for electric heating (E_{heat}, Section 2.1), for electric domestic hot water heating (E_{DHW}, Section 2.2), for auxiliary equipment (E_{aux}, Section 2.3) and cooling (E_{cool}), from which we substract the energy produced by photovoltaic panels (E_{PV}, Section 2.4):

$$E_{th,elec} = E_{heat,elec} + E_{DHW,elec} + E_{aux} + E_{cool} - E_{PV} \tag{2.0.3}$$

The theoretical energy consumption from fossil fuels ($E_{th,fossil}$) is the sum of the fossil energy needed for heating (E_{heat}, Section 2.1), fossil energy for domestic hot water (E_{DHW}, Section 2.2):

$$E_{th,fossil} = E_{heat,fossil} + E_{DHW,fossil} \tag{2.0.4}$$

The Renobel model does not include space cooling (E_{cool}), as we do not have any information about potential cooling installations in Woonsurvey. According to Eurostat estimates for 2023 (Eurostat, 2025), space cooling accounts for only 0.6% of residential energy consumption in EU households.

2.1 Heating

The energy consumption for heating is the ratio between the energy need for heating ($E_{heat,need}$, Section 2.1.1), and the efficiency of the heating system (η_{heat}, Section 2.1.2).

$$E_{heat} = \frac{E_{heat,need}}{\eta_{heat}} \tag{2.1.1}$$

[4] Electricity is multiplied by 2.5 because producing and delivering 1 unit of electricity typically requires about 2.5 units of primary energy due to generation and grid losses.

2.1.1 Heating need

The yearly energy need for heating is the summation over the twelve months of the difference between monthly energy losses ($E_{loss,m}$) and heat gains ($E_{int,m} + E_{sol,m}$) for which a utilisation factor is applied (ϕ_m).

$$E_{\text{heat,need}} = \sum_{m=1}^{12} \left[E_{\text{loss},m} - \phi_m (E_{\text{int},m} + E_{\text{sol},m}) \right]. \tag{2.1.2}$$

2.1.1.1 Energy Losses. Monthly energy losses, denoted $E_{\text{loss},m}$, represent the amount of heat that a dwelling must compensate through its heating system to maintain a comfortable indoor temperature. These losses arise from three main sources. The first component, $E_{\text{loss,tr}}$, captures transmission losses through the building envelope, including walls, windows, the roof, and the floor; these losses depend on the thermal properties (U-values) and surface areas of each component. The second component, $E_{\text{loss,air}}$, reflects heat losses due to air exchange, combining both uncontrolled infiltration and controlled mechanical ventilation. The third component, $E_{\text{loss,tb}}$, corresponds to thermal bridge losses, which occur at junctions where insulation is reduced or interrupted. Their sum defines the total heat-loss coefficient H (in W/K):

$$H = E_{\text{loss,tr}} + E_{\text{loss,air}} + E_{\text{loss,tb}}.$$

This coefficient is converted into monthly energy losses through multiplication by the indoor–outdoor temperature difference and the monthly duration (D_m, see Table 8). The indoor temperature T_{int} is conventionally fixed at 18°C, while the monthly outdoor temperatures in Flanders ($T_{e,m}$) are retrieved from Table 8.

$$E_{\text{loss},m} = H \times (T_{\text{int}} - T_{e,m}) \times D_m.$$

Transmission heat losses. Transmission heat losses are calculated as the sum over all components of the product of each component's U-value (U) (see Table 1) , its surface area (A), and an exposure correction factor (b). $b = 2/3$ for houses' ground floors in contact with a basement and 1/3 for flats' ground floors and roofs.

$$E_{\text{loss,tr}} = U_{win} \times A_{win} + U_{roof} \times A_{roof} \times b_{roof} + U_{wall} \times A_{walls,ext} + U_{floor} \times A_{floor} \times b_{floor} \tag{2.1.3}$$

Air exchange losses. Air exchange losses are computed based on the total air renewal rate, which includes either infiltration losses for old, non-renovated buildings, or ventilation losses for renovated or new buildings. The formula for air exchange heat loss is

$$E_{\text{loss,air}} = 0.34 \times Q_{\text{air,age}}, \tag{2.1.4}$$

where 0.34 is the volumetric heat capacity of air and $Q_{\text{air,age}}$ is the total air flow rate, which is computed differently for buildings constructed before 2010 and after 2010.

For buildings constructed before 2010, only infiltration is considered. In this case, the total air flow is calculated as :

$$Q_{\text{air,old}} = \left(\frac{2}{50}\right)^{0.66} \times q_{50} \times A, \tag{2.1.5}$$

where $\left(\frac{2}{50}\right)^{0.66}$ is a conversion factor from 50 Pa to natural pressure (approximately 2 Pa). We assume the standard exponent of 0.66 for Belgian dwellings, following Gendebien et al. (2014). The parameter q_{50} denotes the air leakage rate at 50 Pa ((in $m^3/h/m^2$). In the absence of surveyed leakage measurements, we follow Gendebien et al. (2014) and use the values they report, depending on the year of construction and dwelling type. These are summarized in Table 2.

Table 2: Infiltration rate at 50 Pa per time period and type of dwelling

YOC	**Initial walls**				**Insulated walls**
	Apt.	Terraced	Semi	Free	if ins=good
<1971	14.9	14.9	18	18	6
1971–1990	14.1	14.1	16.3	17.1	6
1991–2007	10	10	12	12	6
2008–2010	6	6	6.3	6.1	6

YOC: Year of Construction. Apt. = Apartment, Semi = Semi-detached house, Free = Freestanding house.
Source: Gendebien et al. (2014).

For dwellings constructed after 2010, mechanical ventilation is considered instead of infiltration. The corresponding net airflow is:

$$Q_{\text{air,new}} = 0,6 \times (1 - \kappa) \times V, \tag{2.1.6}$$

where the air change rate is set to $0,6$ is the air change rate (Gendebien et al., 2014). The internal volume V is computed as $3A$, assuming an average storey height of 3 m. Since we only consider new or renovated dwellings in this case, we follow Gendebien et al. (2014) and assume a heat-recovery efficiency of $\kappa = 0.8$ (80%) for all buildings equipped with mechanical ventilation.

Thermal bridging losses. Thermal bridging losses are computed as

$$E_{\text{loss,tb}} = \left(A_{\text{floor}} + A_{\text{vert}} + A_{\text{roof}}\right) \times U_{\text{sup}},$$

where U_{sup} is an additional U-value representing the contribution of linear thermal bridges. Following Gendebien et al. (2014), we use the U_{sup} values they provide for different dwelling configurations.

The envelope area used in this calculation is the sum of the floor, vertical wall, and roof areas, an approximation that treats thermal bridges as proportional to the overall envelope surface rather than relying on detailed junction-by-junction lengths. The corresponding U_{sup} values are reported in Table 3.

Table 3: Supplementary U-values (W/(m^2 K))

YOC	Insulation Walls	Apartment	Terraced	Semi	Free
<1970	Bad	/	/	/	/
<1970	Inter./Good	0.15	0.10	0.08	0.07
1971–2009	All	0.15	0.10	0.08	0.07
>2010	Good	0.04	0.02	0.01	0.005

Source: Own hypotheses based on Gendebien et al. (2014)

2.1.1.2 Internal gains. Internal gains, such as body heating, electric appliances and lighting contribute to heating. Monthly internal gains are computed by multiplying a fixed base load of 220 W, supplemented by a volume-dependent component of 0.67 W per cubic metre of the internal volume ($V = 3 \cdot A_{floor} \cdot n_{floor}$), by the monthly duration D_m (see Table 8):

$$E_{int,m} = (220 + 0,67 \cdot V)D_m \quad (2.1.7)$$

2.1.1.3 Solar gains. Solar gains represent the monthly heat contribution from incident solar radiation transmitted through the glazed surfaces of the dwelling. They are computed by multiplying a reduction factor of 0.513 (accounting for incindence-angle correction, dirt and shading) by the glazed area (A_{win}), the monthly solar irradiance for an angle of 90° ($I_{so,m}$, see table 10), and the solar factor at normal incidence of the selected glazing type (g_{win}, see Table 9). We assume that all the windows are vertical to the ground and that no solar protection is installed. Furthermore, as we don't know the orientation of the dwelling, we take the average of the different orientations for $I_{so,m}$.

$$E_{\mathrm{sol},m} = 0.513\, A_{win}\, I_{so,m}\, g_{win} \tag{2.1.8}$$

2.1.1.4 Correction factor. The monthly gain utilisation factor (ϕ_m) represents the fraction of internal and solar heat gains that can actually be used to offset heating needs. Because gains do not always coincide with periods of heat demand, only part of them is effectively useful. It is calculated as

$$\phi_m = \frac{1-\gamma_m^a}{1-\gamma_m^{a+1}}. \tag{2.1.9}$$

where γ_m is the monthly gain–loss ratio:

$$\gamma_m = \frac{E_{\mathrm{int},m} + E_{\mathrm{sol},m}}{E_{\mathrm{loss},m}}, \tag{2.1.10}$$

and a is a dimensionless parameter representing the thermal inertia of the dwelling:

$$a = 1 + \frac{\tau}{54000}, \tag{2.1.11}$$

where 54 000 seconds correspond to a reference time constant of 15 hours. The building time constant τ, expressed in seconds, is defined as

$$\tau = \frac{CV}{H}. \tag{2.1.12}$$

Here, C is the effective thermal capacity per unit of heated volume (in J/(K m^3)), V is the heated volume defined in Section 2.1.1.2 (in m^3), and H is the total heat-loss coefficient defined in Section 2.1.1.1 (in W/K). The EPC formula structure distinguishes light, medium/semi-heavy and heavy buildings, with respective values of C equal to 37 000, 71 000 and 123 000 J/(K m^3) (Vlaamse Overheid, 2022). As Woonsurvey does not provide sufficient information to identify the thermal-mass class of each dwelling, we assume the medium/semi-heavy value $C = 71\,000$ J/(K m^3) for all dwellings.

Following the EPC convention, the monthly heating need is set directly to zero when $\gamma_m \geq$

2.5, when $\gamma_m < 0$, or when $E_{\text{loss},m} = 0$.

2.1.2 Efficiency of the heating system

The Efficiency (η_{heat}) of the heating system represents the number of kWh of useful heating obtained from 1 kWh of energy. This is represented in Table 4 for the different heating systems. The explanation for the efficiency factors of heat pumps is provided in Appendix 4. We consider that the heating systems have been installed after 2005.

Table 4: Heating systems and associated efficiencies

Heating system	η_{heat}
Fuel oil (standard boiler)	0,81
Fuel oil (condensing boiler)	0,92
Natural gas (standard boiler)	0,75
Natural gas (condensing boiler)	0,92
Pellets (standard)	0,84
Pellets (condensing)	0,91
Wood (standard)	0,69
Wood (condensing)	0,81
Heat pump (dwelling built after 2010)	4,2
Heat pump (good insulation)	3,4
Heat pump (medium insulation)	2,9

Source: Own estimations based on Vlaamse Overheid (2022) and Appendix 4.

2.2 Domestic Hot Water

The energy consumption for domestic hot water (E_{DHW}) represents the energy used for household purposes (kitchen and bathroom). It is computed as the sum of the monthly domestic hot water energy use,

$$E_{\text{DHW}} = \sum_{m=1}^{12} E_{\text{DHW},m} \tag{2.2.1}$$

where the monthly domestic hot water energy is the sum of the energy need for domestic hot water ($E_{\text{DHW,need},m}$, see 2.2.1) and the storage losses ($E_{storage,m}$, see 2.2.2) from which we retire the gains from the solar thermal panels ($E_{so,m}$, see 2.2.3). This is then divided by the efficiency of the domestic hot water system (η_{DHW}, see 2.2.4). Whenever the calculated monthly domestic hot water energy is negative, it is set to 0.

$$E_{\text{DHW,m}} = \frac{E_{\text{DHW,need,m}} + E_{storage,m} - E_{so,m}}{\eta_{\text{DHW}}} \tag{2.2.2}$$

2.2.1 Need of domestic hot water

The need for domestic hot water is computed as the sum of the domestic hot water need for the kitchen and for the bathrooms, divided by the distribution efficiency (η_{pipes}) :

$$E_{\text{DHW,need},m} = \frac{E_{\text{DHW,kitchen},m} + E_{\text{DHW,bathroom},m}}{\eta_{\text{pipes}}} \tag{2.2.3}$$

Where we assume that the distribution efficiency is based on the insulation of the pipes, which we retrieve from Woonsurvey (Bad=0.16; Intermediate=0.28; Good=0.39). Domestic hot water need for the kitchen and the bathroom are computed separately. The constants 16 and 64 represent the normative monthly hot-water needs for a reference dwelling of volume $V = 192$ m^3 for kitchen use and bathroom use respectively. The coefficients 0.055 and 0.22 are linear adjustment factors that increase hot-water consumption with dwelling volume above 192 m^3, reflecting the regulatory assumption that larger dwellings typically host more occupants and therefore require proportionally more kitchen and bathroom hot water. The minimal value for V is set to 192. D_m represents the monthly duration, exposed in Table 8:

$$E_{\text{DHW,kitchen},m} = (16 + 0.055\,(V - 192))\,D_m \tag{2.2.4}$$

$$E_{\text{DHW,bathroom},m} = (64 + 0.22\,(V - 192))\,D_m \tag{2.2.5}$$

2.2.2 Losses from storage

Storage losses from the hot-water storage tank refer to the amount of energy that is lost from the domestic hot-water buffer because the stored water gradually cools down over time. Even when no hot water is being drawn, the tank continuously loses heat to the surrounding environment through its walls, insulation and fittings.

$$E_{\text{storage},m} = \frac{q_{\text{tank}} \cdot V_{\text{tank}}}{12} \tag{2.2.6}$$

Where q_{tank} is the annual storage loss per unit volume and V_{tank} is the volume of the tank. We assume that its value depends on the insulation of the pipes (Bad=23.4 ; Intermediate=17 ; Good=11.9). We also assume that the volume of the tank is 100 L if A<100; 150 L if 100<A<200 and 200 L if A>200.

2.2.3 Contribution from solar thermal panels

Solar thermal panels can cover part of the domestic hot-water demand by converting incident solar radiation into heat and transferring it to the storage tank; this contribution is computed as the product of a fixed efficiency factor of 0.5, the monthly solar irradiance ($I_{so,m}$, see Table 11) for a 35° inclination and for which we take the average of the different orientations, and the collector surface area A_{so}, such that:

$$E_{\text{so},m} = 0,5 A_{\text{so}}\, I_{so,m} \tag{2.2.7}$$

2.2.4 Efficiency of the domestic hot water system

The Efficiency (η_{DHW}) of the domestic hot water system represents the number of kWh of useful water heating obtained from 1 kWh of energy. As Woonsurvey does not provide information on the domestic hot water system, we assign the domestic hot water technology from the declared main heating source. Gas, fuel oil and wood/pellet dwellings use the corresponding fuel-specific efficiency. Shared-heating dwellings are assigned the default efficiency of 1.00 and are allocated to the non-electric component. Direct-electric dwellings use an electric boiler, while heat-pump households use the heat pump for both heating and domestic hot water.

Table 5: Generation efficiency for domestic hot water

Energy carrier	$\eta_{\mathbf{DHW}}$
Gas	0.765
Fuel oil	0.800
Wood / pellets	0.760
Electric boiler	1.00
Heat pump (electricity)	1.40
Shared heating	1.00

Source: Own estimations based on Vlaamse Overheid (2022).

2.3 Auxiliary energy

Auxiliary energy refers to the electricity required to operate the technical components that ensure the proper functioning of the heating and ventilation systems, independently of the energy used to generate heat itself. It includes (i) the electricity consumed by the central-heating circulation pump that distributes heat throughout the dwelling, and (ii) the electricity used by ventilation fans to ensure air exchange and indoor air quality.

$$E_{aux} = E_{pump} + E_{ventilation} \tag{2.3.1}$$

2.3.1 Energy for the circulation pump

It is computed as the product of a conventional coefficient 0.7, the heated volume V, and a conversion factor 3.6 converting kWh into MJ:

$$E_{pump} = 0,7 \cdot 3,6 \cdot V \tag{2.3.2}$$

2.3.2 Energy for the ventilation fans

Ventilation energy is calculated on a monthly basis as a function of the month-duration factor D_m (see Table 8, the heated volume V, and the specific fan power of the ventilation system, denoted by 0.235. The annual ventilation energy demand is obtained by summing the monthly values over the twelve months of the year:

$$E_{ventilation} = \sum_{m=1}^{12} (D_m \cdot 0.235 \cdot V) \tag{2.3.3}$$

2.4 Photovoltaic panels

Photovoltaic (PV) panels reduce the theoretical electricity consumption of a dwelling by the production they generate. The yearly photovoltaic electricity production E_{PV} is computed as the sum of the monthly productions:

$$E_{\mathrm{PV}} = \sum_{m=1}^{12} E_{\mathrm{PV},m} \tag{2.4.1}$$

where 0,7 is a reduction factor, $I_{so,m}$ is the solar irradiance at an angle of 35 degree (see Table 11) for which we take the average of the different orientations, A_{PV} is the surface of the photovoltaic panels (see section 1.3) and O_{PV} is the PV panel output per square meter, set at 125.

$$E_{\mathrm{PV},m} = \frac{0,7 \cdot I_{so,m} \cdot A_{PV} \cdot O_{PV}}{1000} \tag{2.4.2}$$

3 Renovation Costs

The total renovation cost ($Cost$) is defined as the sum of the individual costs associated with each upgraded building component towards the category "good" from the Woonsurvey. These include the cost of insulating walls ($Cost_{wall}$), floors ($Cost_{floor}$), and roofs ($Cost_{roof}$), the cost of replacing or upgrading windows ($Cost_{win}$) (see Section 3.1), as well as the cost of installing a heat pump ($Cost_{hp}$) and photovoltaic/thermal panels ($Cost_{pa}$) (see Sections 3.2 and 3.4):

$$Cost = Cost_{wall} + Cost_{floor} + Cost_{roof} + Cost_{win} + Cost_{hp} + Cost_{pa}. \tag{3.0.1}$$

For flats, studios and rooms, roof and floor insulation are excluded from the set of individual renovation options. Woonsurvey does not identify the position of these units within their building and therefore does not establish whether they are directly exposed to the roof, ground, a cellar or another unheated space. It also provides no information on how the cost of works to the commonly managed building envelope would be allocated among co-owners.

3.1 Components of the envelope

The cost calculations for the building envelope follow the 2026 methodology used by the Flemish Energy and Climate Agency (VEKA) to produce the average price indications reported on Flemish energy performance certificates (Vlaams Energie- en Klimaatagentschap, 2026c). This methodology decomposes each renovation measure into the standard work items required to carry it out. VEKA derives the prices from Arch-Index, Aspen Index, UPA-BUA and consultation with building professionals, and periodically revises the parameter values. The numerical parameters used below are taken from the accompanying VEKA workbook (Vlaams Energie- en Klimaatagentschap, 2026d).

The VEKA methodology explicitly limits its average price indications to single-family houses and does not provide automated price indications for apartments or collective residential buildings. The cost estimates retained for the renovation options available to flats, studios and rooms in Renobel should therefore be interpreted as approximations obtained by applying price parameters derived for single-family houses.

The renovation target for walls, roofs and floors is $U = 0.24$ W/(m^{2}K), the component-level target of the Flemish long-term renovation strategy for 2050 (Vlaams Energie- en Klimaatagentschap, 2024). In Renobel, attaining this target moves the renovated component to the “good” category.

For each opaque component x, the additional thermal resistance required by the renovation is calculated from its dwelling-specific initial U-value, U_x (see Table 1):

$$R_{\text{supp},x} = \max\left(0, \frac{1}{0.24} - \frac{1}{U_x}\right). \tag{3.1.1}$$

Consequently, the insulation cost varies across dwellings according to the initial performance of the component.

3.1.1 External walls

Renobel models only external wall insulation. This solution can consistently bring the wall to $U = 0.24$ W/(m^{2}K), whereas cavity-wall insulation alone cannot. Walls shared with adjoining dwellings are excluded.

The cost covers removal and replacement of rainwater downpipes, sill adaptations, external insulation and finish, treatment of penetrations and openings, adaptation of the roof overhang, and scaffolding.

The complete external-wall renovation cost is:

$$\begin{aligned} Cost_{\text{wall}} &= f_{\text{wall}}(A_{\text{walls,ext}}) \\ &\times \left[\begin{array}{l} \underbrace{(93.48 + c_{\text{ins,wall}}(U_{\text{wall}}))\, A_{\text{walls,ext}} + c_{\text{surf,wall}}\,(A_{\text{walls,ext}} + A_{\text{win}})}_{\text{area-based façade works}} \\ + \underbrace{250.87 A_{\text{win}}}_{\text{opening adaptations}} \\ + \underbrace{73.58\sqrt{A_{\text{walls,ext}} + A_{\text{win}}}}_{\text{roof-overhang adaptation}} \end{array} \right]. \end{aligned} \tag{3.1.2}$$

where $A_{\text{walls,ext}}$ is the net opaque wall area, A_{win} is the window area, and their sum is the gross exposed façade area (see Section 1.2).

The factor outside the brackets, f_{wall}, is the VEKA correction for the size of the renovated wall area:

$$f_{\text{wall}}(A_{\text{walls,ext}}) = \begin{cases} 1.50 & 0 < A_{\text{walls,ext}} \le 15, \\ 1.00 & 15 < A_{\text{walls,ext}} \le 100, \\ 0.90 & A_{\text{walls,ext}} > 100. \end{cases} \tag{3.1.3}$$

3.1.1.1 Area-based façade works. The first term contains the work items charged per square metre of façade. The external finish costs €93.48 per m^2 of net opaque wall, and the insulation item varies with the initial wall U-value:

$$c_{\text{ins,wall}}(U_{\text{wall}}) = 7.1187 R_{\text{supp,wall}} + 11.3132. \tag{3.1.4}$$

In the VEKA workbook, 7.1187 and 11.3132 are respectively the slope and intercept of the linear regression of insulation prices on thermal resistance (Vlaams Energie- en Klimaatagentschap, 2026d).

The remaining surface-based works are charged on the gross exposed façade area. They comprise removal of rainwater downpipes (€1.06/m^2), treatment of penetrations (€5.30/m^2), new rainwater downpipes (€8.70/m^2), and scaffolding (€17.48/m^2) when the gross area exceeds 12.25 m^2. VEKA evaluates this condition for each wall part; because Renobel observes only aggregate façade areas, it evaluates the condition on the total exposed façade area. Consequently,

$$c_{\text{surf,wall}} = \begin{cases} 15.06 & 0 < A_{\text{walls,ext}} + A_{\text{win}} \leq 12.25, \\ 32.54 & A_{\text{walls,ext}} + A_{\text{win}} > 12.25. \end{cases} \tag{3.1.5}$$

3.1.1.2 Opening adaptations.

Some VEKA work items are charged per metre of window sill or opening perimeter, whereas Renobel observes only the total window area. Assuming square windows of 2 m^2, their estimated number is $A_{\text{win}}/2$, their total sill length is $A_{\text{win}}/\sqrt{2}$, and their total perimeter is $2\sqrt{2}A_{\text{win}}$.

The €53.00/m rate covers sill adaptations and the €75.44/m rate covers opening finishes and new sills. Multiplying these rates by the estimated total lengths gives:

$$\frac{53.00}{\sqrt{2}} + 75.44(2\sqrt{2}) = 250.87 \quad \text{€/m}^2 \text{ of window.}$$

The calculation does not account for doors or opaque panels.

3.1.1.3 Roof-overhang adaptation.

The term $73.58\sqrt{A_{\text{walls,ext}} + A_{\text{win}}}$ in Equation 3.1.2 estimates the cost of adapting the roof overhang. VEKA sets the price at €147.15 per metre and estimates the corresponding length for each wall part as one half of the square root of its gross area. Because Renobel observes only the aggregate façade areas, this VEKA expression is applied once to the total exposed façade area. The coefficient 73.58 corresponds to 147.15×0.5.

3.1.2 Windows

The model assumes complete replacement of each existing window by a new PVC window, rather than replacement of the glazing alone. The new frame has $U_f \leq 1.5$ W/(m^{2}K) and the glazing has $U_g \leq 1.0$ W/(m^{2}K), corresponding to the Flemish 2050 renovation target for windows (Vlaams Energie- en Klimaatagentschap, 2024). Removal of the existing window and lifting equipment are included; interior reveals, window boards and ventilation inlets are excluded. The cost is

$$Cost_{\text{win}} = f_{\text{win}}(A_{\text{win}})\, 711.22\, A_{\text{win}}. \tag{3.1.6}$$

The VEKA quantity correction is applied to the total window area:

$$f_{\text{win}}(A_{\text{win}}) = \begin{cases} 1.20 & 0 < A_{\text{win}} \leq 10, \\ 1.00 & 10 < A_{\text{win}} \leq 100, \\ 0.90 & A_{\text{win}} > 100. \end{cases} \tag{3.1.7}$$

3.1.3 Roof

Renobel selects internal roof insulation because it is the least-cost VEKA variant that reaches $U = 0.24$ W/(m^{2}K). The total cost is

$$Cost_{\text{roof}} = f_{\text{roof}}(A_{\text{roof}})A_{\text{roof}}\, c_{\text{roof}}(U_r). \tag{3.1.8}$$

The VEKA quantity correction is

$$f_{\text{roof}}(A_{\text{roof}}) = \begin{cases} 1.50 & 0 < A_{\text{roof}} \leq 15, \\ 1.00 & 15 < A_{\text{roof}} \leq 100, \\ 0.90 & A_{\text{roof}} > 100. \end{cases} \tag{3.1.9}$$

The VEKA unit cost $c_{\text{roof}}(U_r)$ is

$$c_{\text{roof}}(U_r) = 35.0494 + 4.7133 R_{\text{supp},r} + 5.30\,\mathbb{1}\left(\frac{1}{U_r} - 0.38 < 1.20\right), \tag{3.1.10}$$

VEKA sets a base price of €29.7494/m^2 for internal insulation and the vapour barrier. This price increases by €4.7133/m^2 for each additional 1 m^{2}K/W of required thermal resistance. A fixed €5.30/m^2 is added for penetrations; hence the constant $35.0494 = 29.7494 + 5.30$.

The final term adds €5.30/m^2 for removing an existing weak insulation layer, including its vapour barrier. VEKA estimates the resistance of this existing insulation as $1/U_r - 0.38$, where 0.38 m^{2}K/W is VEKA's fixed assumption for the combined resistance of the basic roof structure (0.11), air layer (0.13), internal surface (0.10) and external surface (0.04), all expressed in m^{2}K/W. The indicator equals one, and the removal cost is included, when the estimated existing insulation resistance is below 1.20 m^{2}K/W; otherwise it equals zero. The work includes internal insulation, a vapour barrier and treatment of penetrations. It excludes new interior finishes, adaptations to roof windows or dormers, replacement of the roof covering and structural repairs.

3.1.4 Floors

The total floor-renovation cost is

$$Cost_{\text{floor}} = f_{\text{floor}}(A_{\text{floor}})A_{\text{floor}}\, c_{\text{floor}}(U_f). \tag{3.1.11}$$

The VEKA quantity correction is applied separately by floor type:

$$f_{\text{floor}}(A_{\text{floor}}) = \begin{cases} 1.50 & 0 < A_{\text{floor}} \leq 15, \\ 1.00 & 15 < A_{\text{floor}} \leq 100, \\ 0.90 & A_{\text{floor}} > 100. \end{cases} \tag{3.1.12}$$

The execution technique depends on the presence of a cellar.

3.1.4.1 With a cellar. A floor above a cellar is insulated from below at cellar-ceiling level. Its VEKA unit cost is

$$c_{\text{floor}}(U_f) = 13.5146 + 12.9101 R_{\text{supp},f}. \tag{3.1.13}$$

The base €13.5146/m^2 is the intercept of VEKA's fitted insulation-price function. The price increases by €12.9101/m^2 for each additional 1 m^{2}K/W of required thermal resistance. The cost includes insulation below the cellar ceiling and framing where mineral wool requires it. No new internal floor or finishing layer is included.

3.1.4.2 Without a cellar. Without a cellar, the floor is renovated from above and its build-up is reconstructed. Its VEKA unit cost is

$$c_{\text{floor}}(U_f) = 299.6079 + 10.7557 R_{\text{supp},f}. \tag{3.1.14}$$

The coefficient €10.7557/m^2 is the increase in the insulation price for each additional 1 m^{2}K/W of required thermal resistance. The fixed part is composed as follows:

$$\begin{aligned} 299.6079 = {} & 49.5232 + 15.1616 + 142.4858 \\ & + 0.15(511.0128) + 0.25(63.1416). \end{aligned} \tag{3.1.15}$$

The terms represent, respectively, removal of the existing finish and screed, the intercept of the insulation and moisture-barrier price function, a new screed with standard finish and skirting, replacement of 15% of the concrete slab, and excavation over 25% of the floor area.

3.2 Heat Pump

To determine heat pump installation costs, we first estimate the required power P, as the system size is a key cost driver. We restrict heat pump installation to dwellings requiring less than 20 kW, as units above 20 kW remain relatively uncommon for the residential sector (Joint Research Centre, 2023). Following Energie (2000), the total required power is defined as the sum of the power needed for space heating (P_{hs}) and domestic hot water (P_{DHW}):

$$P = P_{hs} + P_{DHW}. \tag{3.2.1}$$

The heating component P_{hs} is the product of the heat losses, the design temperature difference ΔT, set to 25 K (18°C indoors and −7°C outdoors), and a safety coefficient $f_s = 1.2$:

$$P_{hs} = E_{\text{loss}} \times \Delta T \times f_s. \tag{3.2.2}$$

The domestic hot water component P_{DHW} is assumed to be 750 W for dwellings with 2–4 occupants and 1 kW for those with up to 6 occupants.

The VEKA 2026 workbook assigns a cost of €13,780 to a 7 kW air-to-water heat pump for a dwelling with at most 100 m^2 of usable floor area, and €19,080 to a 14 kW unit for a dwelling with at least 200 m^2. VEKA interpolates between these values according to usable floor area (Vlaams Energie- en Klimaatagentschap, 2026d). However, floor area alone does not account for differences in envelope performance and resulting heating demand.

Renobel therefore retains the dwelling-specific required power P as the cost driver and uses the two VEKA installations as calibration points. The linear function through $(7, 13780)$ and $(14, 19080)$ is

$$Cost_{\text{hp}} = 8480 + 757.14P, \tag{3.2.3}$$

where P is expressed in kW. The coefficient €757.14/kW is the increase between the two VEKA prices divided by their 7 kW power difference, and €8,480 is the corresponding intercept. Between 7 and 14 kW, the equation interpolates the VEKA price points. For required powers outside this interval, it is an extrapolation; the model nevertheless applies it up to the 20 kW eligibility limit.

3.3 Boiler replacement

The life-cycle-cost model assumes that a dwelling which retains its existing gas, fuel-oil or pellet heating technology will face one future replacement of its heating generator. This is a replacement investment rather than a maintenance cost. It is added to every evaluated option without a heat pump and is set to zero when the option installs a heat pump.

The official Flemish comparison of heating-system costs reports investment costs, including installation and excluding VAT, of €4,000 for a natural-gas boiler, €6,000 for a fuel-oil boiler and €10,000 for a pellet boiler (Vlaamse Overheid, 2025). Gas and fuel-oil boiler replacement is subject to 21% VAT (FOD Financiën, 2025). For pellet boilers, Renobel assumes that the dwelling qualifies for the 6% renovation VAT rate (FOD Financiën, 2025).

The resulting replacement cost, expressed in euros, is:

$$Cost_{\text{boiler}} = \begin{cases} 4{,}840, & \text{natural gas,} \\ 7{,}260, & \text{fuel oil,} \\ 10{,}600, & \text{pellets,} \\ 0, & \text{other energy sources or installation of a heat pump.} \end{cases} \tag{3.3.1}$$

This cost is included directly in the life-cycle-cost comparison and is not treated as an eligible renovation expenditure for subsidy calculations.

3.4 Photovoltaic and solar thermal panels

3.4.1 Photovoltaic panels

The installation of photovoltaic panels is restricted to households living in houses and is limited to a maximum area of one quarter of the roof surface. Protopadaki et al. report an installation cost of €1,100 per kilowatt-peak (kWp) at the September 2022 price level (Protopadaki et al., 2023). With approximately 5 m^2 per kWp (Ecoconso, 2025), this corresponds to €220/m^2, excluding VAT. After updating this amount from the ABEX index applicable in September 2022 to the index of 1 January 2026 (Association belge des Experts, 2026), the cost used by Renobel is €258.13/m^2, including 6% VAT.

3.4.2 Solar thermal panels

According to InfoZonneboiler.be (2025b), households typically install around 1 m^2 of solar thermal collector area per person. The installation cost amounts to approximately €1,200 per square meter, excluding VAT (InfoZonneboiler.be, 2025a).

4 Additional information for heat pumps

The efficiency of the heat pump, expressed through its Seasonal Coefficient of Performance (SCOP), depends on the heat pump's Coefficient of Performance (COP). To avoid relying on a default COP value, we aim for greater precision by computing it explicitly. The COP represents the efficiency of the heat pump for a certain supply temperature and a certain exterior temperature. But, as exterior temperatures change during the year (and thus also the supply temperatures), it is the Seasonal coefficient of performance (SCOP) that represents the weighted average efficiency of the heat pump during a year.

A first important assumption is that we consider ground heating for buildings built after 2010. As ground heating allows for a lower heating temperature for the same heating comfort, it is also paired with a higher SCOP that we estimate at 4.2 (Daikin, 2025).

In order to compute the SCOP for the buildings built before 2010, we need to make hypotheses about the following parameters:

- The size of the emitters (radiators). This is a very important point as larger emitters allow for a lower heating temperature and lead to a higher SCOP (better efficiency). We consider that the size of the radiators in houses built before 2010 is aligned with the heating need (supply temperature) for the most extreme conditions (-7°C).

- The COP of air-water heat pumps: We use the formula from Terry and Galvin (2023) which retrieves the COP from the supply temperature and the exterior temperature for air-water heat pumps. We consider four different COP, for temperature points 2°C; 7°C; 12°C and 17°C. These temperature points correspond to specific supply temperatures (see below).

$$COP = 0.4 \times \frac{273 + T_{supply}}{\max(T_{supply} - T_{ext},\ 15)}$$

- The maximal supply temperature of the heat pump (for an exterior temperature of -7°) is determined by the insulation of the building. We follow Vandevelde et al. (2023) who performed an analysis for Flanders on this. They associated the insulation of the building with the required temperature needed to heat the building in the coldest conditions. We compute an average U-value of the building in order to assign it a letter from a to f (see Table 6), and thus a supply temperature. The average U-values are computed for each building, depending on the surfaces of its component.

Table 6: U-values and corresponding Maximal Supply temperature

	a	**b**	**c**	**d**	**e**	**f**
Windows	1.5	2.5	3.0	3.5	3.6	5.0
Roof	0.24	0.4	0.8	1.2	1.3	1.9
Walls	0.24	0.6	0.6	1.4	1.9	2.2
Floor	0.24	0.4	1.5	2.1	2.7	2.8
Average U-value	<0.49	0.5-0.91	0.92-1.26	1.27-1.89	1.9-2.24	>2.25
$\boldsymbol{T_{\max}}$	**65°**	**65°**	**75°**	**75°**	**90°**	**90°**

Note: Average U-values are computed assuming an envelope composed of 20% windows, 15% floor, 20% roof and 45% walls.

Source: Own calculations based on Vandevelde et al. (2023).

- Supply temperature is derived from the weather-compensated heating curve used by Terry and Galvin (2023):

$$T_{\text{supply}} = \begin{cases} T_{\max} & \text{if } T_{\text{ext}} \leq T_b, \\ T_{\max} + (T_{\min} - T_{\max}) \dfrac{T_{\text{ext}} - T_b}{T_{\min\_ext} - T_b} & \text{if } T_b < T_{\text{ext}} < T_{\min\_ext}, \\ T_{\min} & \text{if } T_{\text{ext}} \geq T_{\min\_ext}. \end{cases}$$

  where:

  - T_{supply} : heating system supply temperature (°C),
  - T_{ext} : outdoor air temperature (°C) (see Table 7),
  - $T_{\max}$: maximum supply temperature (see Table 6),
  - $T_{\min}$: minimum supply temperature (set at 45°C),
  - T_b : Outdoor temperature associated with $T_{\max}$ (set at −7°C),
  - $T_{\min\_ext}$: outdoor temperature above which the supply temperature plateaus at $T_{\min}$ (set at 15°C).

- Exterior temperatures play an important role in the COP of heat pumps. Table 7 represents the percentage of time at these temperatures in Flanders. It is constructed based on official European data (Joint Research Centre, 2025) concerning the average temperature hour by hour during the whole year, since 20 years in Flanders. We only consider temperatures below 20 degrees as no heating is required beyond that level.

Table 7: Distribution of exterior temperatures in Flanders

Exterior temperature (in °C)	**Percentage**
0-5	21,5%
5-10	28%
10-15	27%
15-20	23%

Source: Joint Research Centre (2025)

For buildings built before 2010, we only consider two kinds of air-water heat pumps, which are the ones with maximal supply temparature of 75°C and 65°C. With the parameters defined above, we can compute the SCOP for those two heat pumps with the following formula with 4 bins (representing 0-5°C; 5-10°C; 10-15°C; 15-20°C):

$$SCOP = \sum_{j=1}^{4} \omega_j \times COP(T_j)$$

- ω_j: share of time spent in temperature bin j, with $\sum_j \omega_j = 1$
- $COP(T_j)$: coefficient of performance at representative temperature T_j
- T_j: representative outdoor air temperature for bin j (midpoint of the bin)

Eventually we get a SCOP of 2,9 and 3,4 for heat pumps with maximal supply temperature of 75°C and 65°C respectively.

5 Additional tables

Table 8: Duration of months D_m (Ms) and average outdoor temperature $T_{e,m}$ (°C) in Flanders

Month	D_m	$T_{e,m}$
January	2.678	3.2
February	2.419	3.9
March	2.678	5.9
April	2.592	9.2
May	2.678	13.3
June	2.592	16.2
July	2.678	17.6
August	2.678	17.6
September	2.592	15.2
October	2.678	11.2
November	2.592	6.3
December	2.678	3.5

Source: Vlaamse Overheid (2022).

Table 9: Normal-incidence solar factor g for selected glazing types

Glazing type	g_{win}
Standard double glazing	0.77
High-performance double glazing	0.65
Triple glazing	0.70

Source: Own estimations based on Vlaamse Overheid (2022).

Table 10: Monthly solar irradiance $I_{so,m}$ (MJ/m^2) by orientation (at 90°) in Flanders

Month	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
Jan	25.4	26.9	45.3	85.1	108.0	85.1	45.3	26.9
Feb	42.1	46.4	78.7	128.5	158.7	128.5	78.7	46.4
Mar	79.6	95.6	146.6	204.0	233.7	204.0	146.6	95.6
Apr	117.0	151.7	214.0	260.6	272.2	260.6	214.0	151.7
May	169.0	218.6	285.0	315.0	306.9	315.0	285.0	218.6
Jun	183.5	232.6	291.9	308.8	292.9	308.8	291.9	232.6
Jul	178.5	225.5	285.2	307.9	296.6	307.9	285.2	225.5
Aug	146.2	190.2	258.7	300.4	303.5	300.4	258.7	190.2
Sep	98.0	126.2	194.3	259.0	286.7	259.0	194.3	126.2
Oct	61.4	71.4	121.1	188.4	227.6	188.4	121.1	71.4
Nov	30.4	32.8	58.1	106.1	134.5	106.1	58.1	32.8
Dec	19.7	20.7	34.8	68.7	87.7	68.7	34.8	20.7

Source: Vlaamse Overheid (2022).

Table 11: Monthly solar irradiance $I_{so,m}$ (MJ/m^2) by orientation (at 35°) in Flanders

	N	NO	O	ZO	Z	ZW	W	NW
Jan	48.8	50	67	92.4	104.8	92.4	67	50
Feb	81.7	87.9	118	152.3	169.3	152.3	118	87.9
Maa	154.9	178.5	224.9	267.8	287.8	267.8	224.9	178.5
Apr	244.4	282.1	336.7	376.7	391.8	376.7	336.7	282.1
Mei	375.7	403.1	457.5	490.6	499	490.6	457.5	403.1
Jun	409.9	428.1	475.2	499.3	503.2	499.3	475.2	428.1
Jul	394.7	415.4	463.2	489.8	495.4	489.8	463.2	415.4
Aug	318.2	353	411.5	450.8	463.8	450.8	411.5	353
Sep	192.7	236.2	298.1	349.7	372.5	349.7	298.1	236.2
Okt	119.8	134.3	180.4	228.5	251.8	228.5	180.4	134.3
Nov	58.9	61.2	84.6	116	131.5	116	84.6	61.2
Dec	38	38.6	51.3	72.6	82.9	72.6	51.3	38.6

Source: Vlaamse Overheid (2022).

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