Quantifying the energy, climate, and air emission benefits of ROCKWOOL products for building insulation

Prepared for:

ROCKWOOL

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1. Introduction

The ROCKWOOL Group is a global leader in stone wool solutions. To assess the energy, carbon, and air emissions savings by the usage of sold ROCKWOOL building insulation products, there is a need for a robust and transparent calculation methodology. Therefore, ROCKWOOL asked Guidehouse Inc. to develop a methodology to calculate the energy, CO_2, SO_2, NO_x, and particulate matter (PM)[1] emission savings of its building insulation. Guidehouse developed this methodology independently of ROCKWOOL and approves the outcomes, based on the underlying assumptions. ROCKWOOL acknowledges that uncertainties and assumptions made due to data limitations, as described in this document.

The methodology was first developed in 2017. The emission factors were updated in 2021, 2024 and 2025.[2] While there are currently no industry-wide standards for calculating avoided energy and emission savings, this methodology is aligned with the five-step framework for assessing avoided emissions outlined in the latest World Business Council for Sustainable Development (WBCSD) report, published in 2025.

These steps include defining a time frame, setting a reference scenario, assessing the lifecycle emissions of both the solution and the reference scenario, calculating the avoided emissions, and validating the contribution legitimacy (1).

About Guidehouse

Guidehouse is purpose built to help commercial and public sector clients navigate complex challenges across industries and geographies with an integrated model that breaks down silos to maximize efficiency.

Consultants work with clients to 'imagine' a new future, team across our digital and technology services to 'build' new resilient solutions, and then often 'operate' programs for clients to ensure sustained value.

At Guidehouse, we're united by a shared commitment to purposeful impact. Moreover, our approach is rooted in an innovation-first mindset that ensures lasting change. The Sustainability Solutions team includes industry-leading experts in climate finance risks and opportunities, science-based targets, circular economy, lifecycle analysis, climate policy, adaptation strategy, biomass solutions, and carbon pricing.

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The energy, CO_2, SO_2, NO_x, and PM emission savings calculated using the approach described in this document represent the lifetime emission savings achieved by ROCKWOOL products for building insulation. These savings are compared against an updated reference scenario. In earlier versions, the same U-values were applied across all building types. In 2025, a distinction between

[1] Particulate matter (PM) is defined as PM10 (>90%).

[2] Changes in 2025 included the consideration of decarbonisation, a change of the reference scenario for new buildings and refurbished buildings, and the inclusion of avoided emissions through cooling

the different applications of ROCKWOOL products to new constructions and refurbishments were made to provide a more detailed calculation.

- For new buildings, U-values are based on the thermal performance that would inherently result from compliance with the regulatory standards applicable in each country. In regions where building codes enforce nearly net-zero emissions, the most conservative (i.e., lowest) U-values are applied.
- For refurbished buildings, the reference scenario is based on the average U-values of building stock constructed between 1980 and 1990. Data on U-values for walls, floors, and roofs were collected for each country. These values are primarily sourced from the INSPiRE project, available via the European Commission website (2), along with various online research publications.

In this approach, annual space heating savings are defined as the reduction in space heating demand with respect to the reference situation. Note that the energy savings are expressed as a reduction in space heating demand. This number reflects the decarbonisation effects of factors over the products expected lifetime, which are included in final energy use.[3,4] The CO_2 and air emission savings are calculated based on the direct or combustion-only emission factors (respectively) of the current fuel mix per country or region for space heating purposes[5]. Upstream emissions related to the extraction, production, and transportation of these fuels are excluded from the calculation. Including these upstream emissions would lead to an estimated 5% to 20% increase in the resulting CO_2 savings.[6] By excluding the upstream processes, ROCKWOOL is using a conservative approach for calculating CO_2 and air emission benefits. For heat generated by electricity and district energy, transport losses between the location where the emissions occur (e.g., the power plant) and the location where the energy is used for space heating purposes (i.e., the building) have been included.

[3] Space heat saving over lifetime considers decarbonisation of heating degree days.

[4] When calculating avoided emissions for decarbonisation, we have only considered CO_2 emissions

[5] The fuel mix is considered as stable over the next decades, due to the lack of reliable information regarding their evolution. However, fuel mix will be updated every three years. Additionally, the air emission factors are based on projected 2030 values, incorporating future developments.

[6] Range is based on a high-level assessment of different sources for the upstream impacts of fuels, including life cycle analysis (LCA) software, public sources (e.g., UK Defra and the Dutch government), and Guidehouse's own research.

2. Methodology

Energy, CO_2, SO_2, NO_x, and particulate matter (PM) emission savings over the lifetime of ROCKWOOL insulation products are calculated based on sales data and application inputs. Based on our latest update, these calculations have been further detailed into specific applications: building envelope components[7] (including roofs, walls, and floors) and flat roofs[8], both considered in the context of new constructions and building refurbishments. For over 80% of sales, input parameters are assessed at the country level, ensuring precise calculations. For countries with lower sales volumes, regional estimates are used.

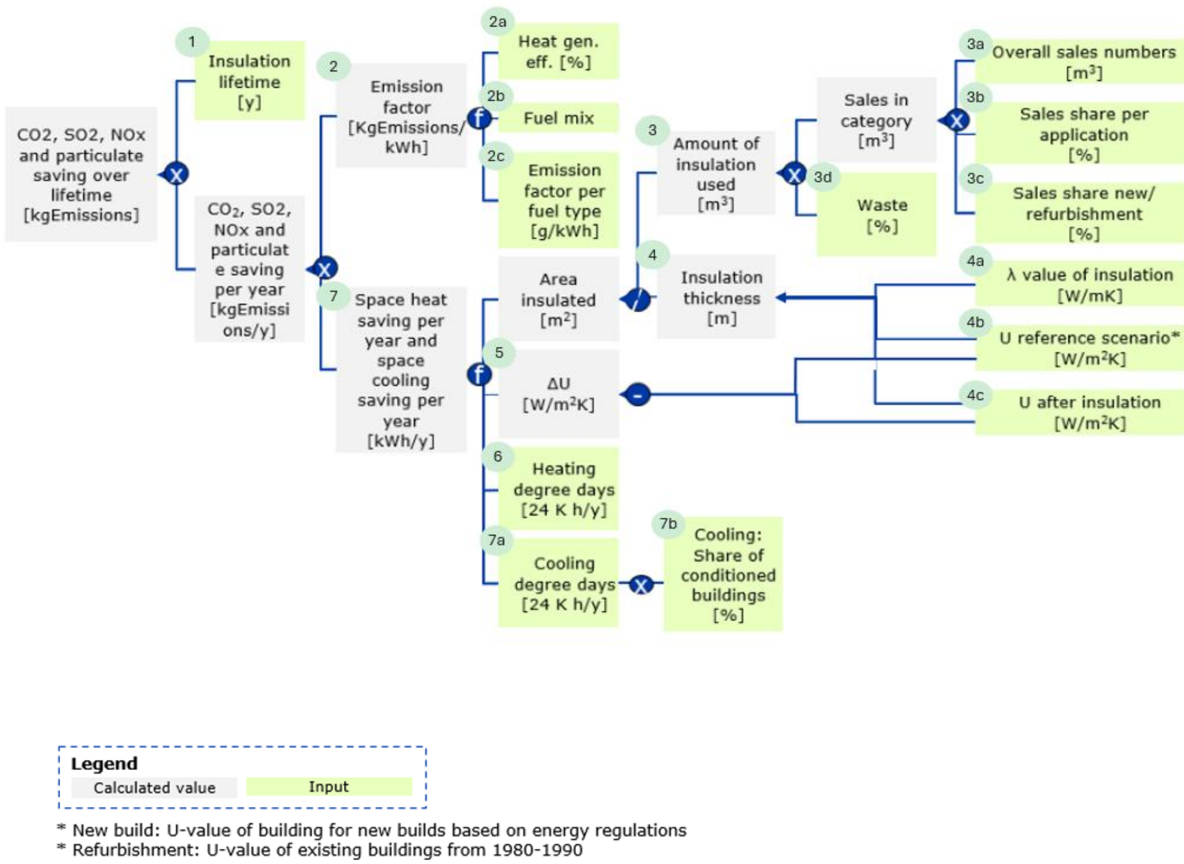

Figure 1: Calculation methodology items

[7] This year, building envelope has been further disaggregated into specific product categories, including roofs, walls, floors, to allow for more granular analysis.

[7] Flat roofs are recognised for their contribution to building energy savings. Their thermal conductivity (lambda) values are consistent with “roofs” within the building envelope.

		Application				
		New buildings	Refurbished buildings		New building: Flat roofs	Refurbished buildings: Flat roofs
		Roofs	Walls	Floors		
1. Insulation lifetime		50-65 years			50 years	
2. Emission factor of space heat in each country	2.Emission factors of space heat in each country	0.011-0.353 (kgCO_2 /kWh of space heat), depending on fuel mix				
	2a. Heat generation efficiency (%)	85% for coal, 95% for biomass, 98% for oil, 95% for gas, 99% for district heating, 100% for direct electricity, 520% for air heat pumps, and 350% for cooling electricity (except for Russia and “other” regions)				
	2b. Fuel mix	Varying per country				
	2c. Emission factor per fuel type	Varying per type of emission (CO_2, SO_2, NO_x, and PM) and per country. Emission factor for electricity and district heating have accounted for future decarbonisation				
3. Amount of insulation used per category	3a. Overall sales (m^3)	Confidential.				
	3b. Sales share per application (%)	Assumption based on ROCKWOOL expert judgement				
	3c. Sales share new/refurbishment (%)	Confidential.				
	3d. Share of insulation used (%)	98% (2% waste based on Eurima)				
4. Insulation thickness	4a. Lamda value of insulation (W/m^2K)	0.034 - 0.042				
	4b. U-value for the reference scenario (W/m^2K)	Varying per building type, application, and country				
	4c. U-value after insulation (W/m^2K)	Varying per building type, application, and country				
5. ΔU		See U-value before and after				
6. Heating degree days		481 – 6672 days (accounted for future decarbonisation)				
7. Space cooling saving per year	7a. Cooling degree days	5.5 – 1590 days (accounted for future decarbonisation)				
	7b. Share of conditioned-buildings (%)	10-90% varying per country				

Table 1 – Overview application methods

2.1 Rationale behind inputs

For each application group, both general and specific assumptions were made, as outlined in Table 1. In case high uncertainty exists on a specific input, the most conservative option is used - i.e., the option that leads to the lowest energy and emission savings.

Regarding the **insulation lifetime** *(1)*, a distinction is made between the building envelope and flat roofs. For the building envelope, a standard lifespan of 65 years is applied across all regions except 'Asia' and 'Other'. Flat roofs are assigned a lifespan of 50 years. This approach is based on two key factors:

- ROCKWOOL insulation in the US, Canada, and the Netherlands declares a 75-year durability. The stone wool fiber used in these regions meets EUCEB bio solubility standards[9], consistent with stone wool fiber produced in other ROCKWOOL facilities. Therefore, a 65-year lifespan is extrapolated globally, in line with ROCKWOOL's Environmental Product Declaration (EPD) (3) and Product Category Rules (PCRs) (4) for thermal insulation.
- The building lifespan data is based on observed building lifespan, with online publications indicating a minimum of 65-year lifespan for each country.

To calculate the **emission factor for space heating in each country** *(2)*, the following inputs are factored in:

- The heat generation efficiency per fuel type *(2a)*,
- The fuel mix of each country where insulation is applied *(2b)*,
- The emission factor of that fuel *(2c)*.

This emission factor of the respective fuels indicates the emission per kWh of useful heat in the building and not the emissions per kWh of final energy delivered to the buildings (e.g. fuels). The difference between these two values is caused by the efficiency of the heating system (e.g. the boiler). The heating fuel mix for each country has been updated using the most up-to-date sources.

The assumptions regarding heat generation efficiency (2a), are based on the assumed best available technologies between 2021 and 2030, as outlined by Ecofys and IEEJ (5), and supported by technical experts from Guidehouse. To ensure conservative estimates, efficiency values at the higher end of the range have been applied, since lower efficiencies would result in greater emission savings due to increased fuel consumption required to meet the same space heating demand. In practice, average generation efficiencies are expected to be lower. The most conservative estimate for gas is drawn from Ecofys and IEEJ (6).

The fuel mix of each country where insulation is applied (2b) is based on a variety of different online publications. The share of fuels in the final energy consumption of the residential sector for

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[9] European Certification Board of Mineral Wool Products is a voluntary initiative by the Mineral Wool industry. It is an independent certification authority.

space heating in 2022 of oil, gas, coal, and electricity for European countries is based on Eurostat (7). For the UK and Canada, data on the share of energy carriers is sourced from the international energy agency (IEA) (8) (9). For the USA, data was obtained from the US Energy Information Administration (EIA) (10). The fuel mix for China and Asia is based on a national forecast from DNV (11), while data for Russia is from the World Bank data (12).

The percentage share for the energy carriers: ambient heat, biomass and district heating, in European countries was initially based on a 2019 study by the European commission (13). For other countries, data from respective sources were applied.

The emission factor of each fuel type (2c) is specific to the type of emission being calculated (CO_2, SO_2, NO_x, or PM)[10]. Emission factors can vary by country and are sourced from internationally recognised databases, as outlined below.

For CO_2, the emission factor are derived from the 2019 refinement of the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories for coal, gas, and oil (14). Since 2019, these guidelines have not been updated, the emission factors remain consistent. Moreover, the IPCC's emission factors closely align with those published by the German Environmental Agency in 2022, verifying their continued accuracy (15). The biomass emission factor is set at a conservative value of 0 to only include CO_2 emissions from fossil fuels. The emission factors for both ambient heat and cooling are adjusted to reflect the future decarbonisation of electricity, ensuring a conservative and forward-looking approach. These projections are based on the Enerdata Energy Outlook (16) under the nationally determined contribution (NDC) scenario[11] (17). Emission factors are time-weighted across the product's lifetime to capture changes in the electricity mix, with linear extrapolation applied beyond 2050 where data is unavailable. This method accounts for regional variations in decarbonisation pace and aligns with long-term climate targets

The emission factor for district heating is adjusted to reflect future decarbonisation targets outlined in national regulations. The emission factor evolves annually in line with changes in each country's energy mix. Time-based weighting approach over the lifetime of the respective country/building type is applied to each individual country. For European countries, the Energy Efficiency Directive (EU/2023/1791) (18) serves as the baseline, and for Canada, the Green Building Strategy (19), which mandates a phase-out of fossil fuels after 2050. In regions lacking reliable data, an annual average decrease in emission factor, based on IEA data from 2017 to 2023 (20), is applied to future years.

For air emissions (SO_2, NO_x, and PM), most emission factors are derived from the GEMIS database, version 5.1, published in March 2023 (21). The data used in the tool reflects the processes modeled in GEMIS for 2030 across various fuel types. For the USA, where GEMIS lacks data on air emission factors for natural gas and oil combustion, the figures were sourced from the U.S. Energy Information Administration's 2023 report (22). When 2030 process data was unavailable in GEMIS for a European country, the lowest emission factor from equivalent processes within the EU for 2030 was applied to ensure a conservative estimate, resulting in

[10] The decarbonisation of these emission types over the lifetime of the ROCKWOOL products is not considered in the calculations, since no valid data sources were found.

[11] NDC scenario refers to each country's individual climate action plan submitted under the Paris Agreement, it reflects current policy commitments

minimal emission savings. For regions or countries outside Europe where 2030 data was also missing, the most recent available process data from GEMIS (21) was used. If no relevant processes were available, the minimum values from Europe were applied to these regions.

For district heating, the most recent data available in GEMIS is based on 2020. “No allocation” was selected for any cogeneration processes that were part of the district heating energy mix. The lowest available emission factor from all countries was applied to countries for which no data on air emissions from district heating in 2020 was available.

For biomass emission factors across all countries, the data is derived from the average values of the processes "wood-pellet-EU-heating-2030" and "wood-logs-heating-EU 15kW-2030" as provided by GEMIS. These values are used as a general proxy for all countries and regions due to the lack of more specific, localized data.

The **amount of insulation used per category** *(3)* across each application (building envelope and flat roof) and market (new construction and building refurbishment) is derived from ROCKWOOL building insulation sales data in m^3 *(3a)*, sales share per application *(3b)*, sales distribution based on value in Millions of EUR over new construction and building refurbishments *(3c)*, and the share of insulation that is used in buildings *(3d)*.The percentage distribution between new construction and refurbishment was updated in 2025 for key markets, based on 2024 sales data.

ROCKWOOL sales data *(3a)* is broken down into application and product specifications - building envelope (roofs, walls, floors), and flat roof *(3b)* are provided by ROCKWOOL. Guidehouse does not validate this data independently but conducts a general review by comparing it with figures from the previous year and checking for reference inconsistencies,

To calculate the amount of insulation that is used *(3d)*, a waste percentage of 2% is assumed. This assumption is based on the Product Environmental Footprint Category Rules (PEFCR) (23), which is part of the European Commission’s Single Market for Green Products initiative for thermal insulation products and a report by the European Insulation Manufacturers Association (EURIMA) (24). KNAUF (25) also assumes a loss of materials in construction site of 2% in its product environmental declaration, which is verified until 2026.[12]

The **insulation thickness** *(4)* is calculated using the weighted average λ-value of the insulation material *(4a)*, the U-value of the building before insulation (reference scenario) *(4b)*, and the U-value after insulation *(4c)*. For refurbishments, assumptions are made regarding the proportion of cases where existing insulation is removed before installing new material versus cases where new insulation is added on top of the existing layer. In the latter scenario, less new insulation is required per square meter of building envelope (or flat roof) to reach the desired U-value. The percentage split is based on ROCKWOOL market experience, and varies by regions[13].

The U-value of the building before insulation (reference scenario) (4b) differs depending on whether it is a new construction or refurbishment, assuming that new buildings are more likely to last longer. and differs between product categories building envelopes (roofs, walls and floors) and flat roofs, as outlined in respective sources.

[12] However, this parameter is not critical, as even doubling the amount will only decrease the overall outcome by 2%.

[13] The number is based on a conservative calculation based on ROCKWOOL U-value calculator.

The weighted average λ-value of the insulation material$_{(4a)}$ is calculated based on ROCKWOOL sales data for each product type and the average λ-value of these product types. It is calculated on a country level for building envelope within different product categories (roofs, walls, floors), and flat roof insulation applications separately.

The U-value of the building before insulation (reference scenario) $_{(4b)}$ differs depending on whether it is a new construction or refurbishment, assuming that new buildings are more likely to last longer, and differs between product categories building envelopes (roofs, walls and floors) and flat roofs, as outlined in the respective sources:

- For new construction, the reference case is defined as the situation where insulation material is applied between two brick walls, which is then removed, leaving an air gap and resulting in a U-value range. In these cases, U-values are based on country-specific regulatory requirements (e.g., nearly net-zero building, green building codes), which vary by country (see Table 1 for the range of U-values).
- For refurbished buildings, the average U-values are based on building stock constructed between 1980 and 1990, primarily sourced from the INSPiRE project

Similarly, the U-value after insulating $_{(4c)}$, uses the most conservative approach, where the minimum u-value per applicable region was chosen for the respective country.

- For new construction, post-insulation U-values are used to reflect typical renovated conditions. Data is primarily sourced from the EU Building Stock Observatory (2011–present), with values differentiated by product category across building envelope components—roofs, walls, floors, and flat roofs.
- For refurbished buildings, average U-values are based on post-2000 building stock, primarily sourced from the INSPiRE project. Where data is limited, a 5% improvement over the reference scenario is applied, following predictions outlined in an Ecofys report for the European Commission (23).

The **ΔU** $_{(5)}$ is calculated based on the difference between the U-value in the reference case$_{(4b)}$ and the U-value after applying ROCKWOOL building insulation material$_{(4c)}$.

The number of **heating** $_{(6)}$ **and cooling degree days** $_{(7a)}$ **for the respective lifetime** (from the year of sales onwards) is obtained from the international project CMIP6, which is a model used by IPCC scientists to calculate the evolution of temperature in the different areas of the world. The model is based on the SSP1-2.6 scenario[14], selected as a conservative approach to avoid overestimating potential savings. To accurately model the climate-adjusted performance of the product's operational timeline, the timeline is segmented into three IPCC-defined time horizons: near-term (2024–2040), medium-term (2041–2060), and long-term (2061–2089). Each horizon has a specific degree day, which reflects the expected thermal demand based on projected climate conditions. To integrate these into a single representative metric, we apply a weighted

[14] As defined in the IPCC 6th assessment, this scenario reflects a future pathway where global sustainability efforts are strong, and greenhouse gas emissions are significantly reduced to limit warming to below 2°C.

average formula that multiplies each period's degree days by its duration in years, then divides the total by the full lifespan (26).

The calculation tool has been enhanced to include **cooling-related energy use and emissions**(7). In addition to incorporating cooling degree days (7a) (as stated above) to quantify the need for indoor cooling, air conditioning prevalence rates, sourced from the IEA (27), have been integrated to reflect realistic percentages of buildings equipped with air conditioners across different regions. A Coefficient of Performance (COP) of 300% or 350% (COP3.0-3.5) is applied based on regional context, assuming all buildings adopt high-efficiency systems, sourced from the European Commission (28). This approach reflects a conservative scenario and a high efficiency system, without overestimating energy savings[15].

[15] Avoided cooling accounts for a small share of the total avoided emissions.

Appendix A. References

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