

Methodology

How we measure impact in buildings

Insights publication No. 01/2025

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effectiveness of decarbonization
measures

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The Belimo Climate Foundation is presenting for the first time an in-depth insight into the methodology for assessing the effectiveness of decarbonization measures. Based on the evaluation of current projects, initial data is provided that enables a differentiated classification of various types of measures regarding their effectiveness.

The Belimo Climate Foundation (BCF) is committed to the decarbonization of the building sector – scientifically sound, technologically effective, and networked in partnership. As a non-profit foundation, its goal is to promote and test solutions for reducing greenhouse gas emissions from existing buildings, as well as making their impact measurable. A central concern of the Belimo Climate Foundation is to make the actual effectiveness of decarbonization measures comprehensible and comparable. Only with sound evaluation methods can the effectiveness and efficiency of measures be reliably assessed and further developed in a targeted manner. The precise identification of the impact therefore forms the basis for all funding decisions by the BCF while serving as a guide for decision-makers and experts in the entire building sector.

This article aims to provide transparency about how the Belimo Climate Foundation determines the effectiveness of funded decarbonization measures in the building sector. The focus is on the methodical calculation approach, the key figures used, and initial findings from ongoing projects. The article demonstrates how impact measurement supports decisions regarding the implementation of measures and strengthens the transfer of knowledge within the sector.

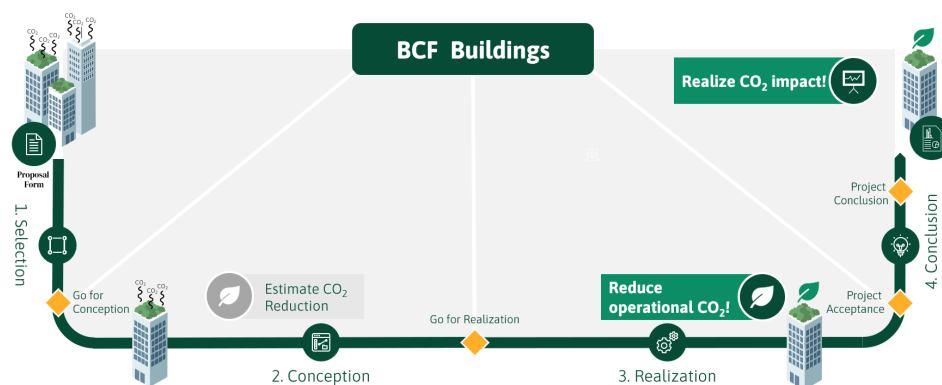


Figure 1: BCF Building projects follow a four-phased approach to meet their goals to save carbon emissions and to share valuable knowledge with society.

Calculation approach for effectiveness in building decarbonization

As part of the BCF Buildings initiative, the Belimo Climate Foundation supports decarbonization projects of non-profit organizations with technical application knowledge and financial resources. The project is divided into four coordinated phases.

Project proposals are carefully selected, assessed, and evaluated in the first phase 1. Selection. The evaluation model includes both the assessment of the non-profit organization as an institutional sponsor and the evaluation of its building regarding its decarbonization potential.

The conception phase, 2. Conception, involves the identification of possible CO₂ reduction measures and an independent assessment by external experts. This involves analyzing potential CO₂ savings and developing concrete proposals for measures. The foundation finances the report, provides expertise, and supports data collection.

This is followed by the realization phase, 3. Realization, in which the proposed measures are implemented. The Belimo Climate Foundation contributes financially to the implementation, supports the project with technical application knowledge, and documents its progress.

The final phase, 4. Conclusion, is used for evaluation. The CO₂ savings achieved are calculated, and the results are analyzed and communicated publicly. This preserves empirical data and makes the knowledge available for future projects.

Measures towards net zero

Every building that is modernized as part of a BCF Buildings project is based on the principle of a reduction path towards net zero (Figure 2).

Two key reference values are used to classify the property: Specific final energy consumption and specific greenhouse gas emissions. The aim is to reduce both parameters to the lowest possible level, but only to the extent that this is justifiable, both from an economic point of view and the carbon emissions caused by implementing the measures.

Five established types of measures are available for the decarbonization of existing buildings and their development towards net zero. These lead to lower energy requirements and/or to lower greenhouse gas emissions.

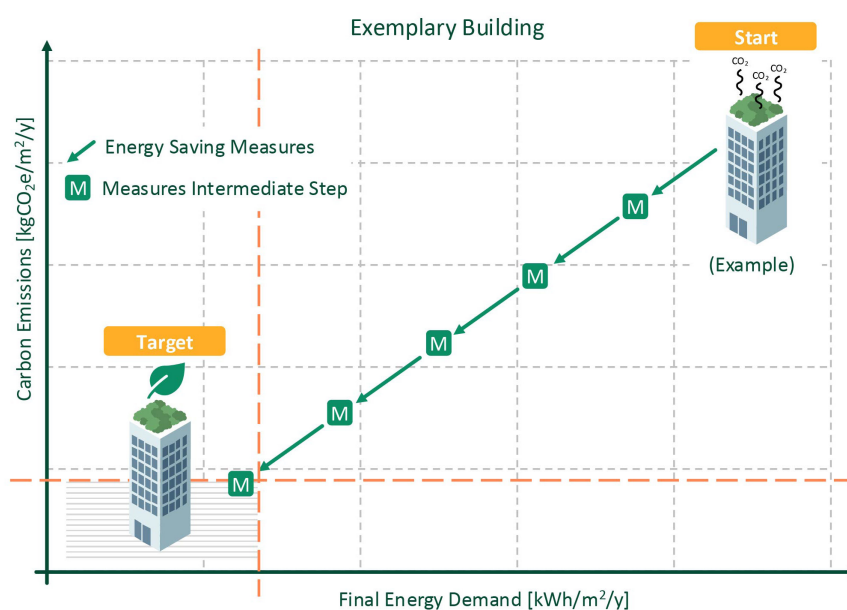


Figure 2: BCF Building projects consider all kinds of measures to decarbonize existing buildings towards net zero goals.

1. Controls – Building automation control system: Adjustments to the operation of the existing system to optimize energy flows within the building. Devices and control systems can be replaced, but the HVAC system has not changed in principle.

2. Passive – Building envelope: Energy-efficient refurbishment of the building envelope (windows, façade, roof, etc.) to reduce thermal energy losses and increase comfort.

3. Active – HVAC technical installations: Interventions in technical systems for heating, ventilation, and air conditioning with modern solutions to achieve energy efficiency and performance gains.

4. Thermal Energy – Renewable thermal primary energy: Switch to an alternative primary energy source to provide the building with thermal energy, with allowance for beneficial carbon factors.

5. Electrical Energy – Renewable electrical primary energy: Switch to an alternative primary energy source to provide the building with electrical energy, with allowance for beneficial carbon factors.

To achieve the target of net zero with ultimate consistency, a sixth type of measure, namely so-called negative emissions, would need to be implemented as well. Negative emissions include both natural sinks and technical processes that remove CO₂ from the atmosphere and store it permanently. According to BCF, net zero decarbonization without negative emissions is not possible in the foreseeable future. This is also confirmed by globally recognized standards such as the Science-based Target Initiative (SBTi) framework. This makes it possible to offset a small proportion of residual emissions that are technically or economically difficult to avoid, known as negative emissions – in order to achieve net zero. The Belimo Climate Foundation is currently developing ways to offer non-profit organizations the option of incorporating negative emissions into their climate ambitions. The focus of BCF Building projects is on measures that can be directly influenced by the owners of buildings. These are the measures listed above. What is not within the direct sphere of influence of the project are the CO₂ factors of the primary energies used (grid electricity, district heating, gas, etc.).

The projects conducted by the Belimo Climate Foundation regularly provide the opportunity to enhance public understanding of the potential and limits for achieving net zero and to raise awareness of the issue. Activities carried out as part of BCF Insights projects fall into this area.

Calculation methodology

It is widely acknowledged that a multitude of different measures are usually required along the entire reduction path of a building towards net zero. There are often complex interactions between individual measures which can reinforce or restrict one another. When determining the impact of individual measures, this influence is considered to the extent that it can be traced through direct feedback. This allows the measures to be directly compared with one another and categorized for better decision-making. They are to be understood as a snapshot, whereby changes outside the perimeter of the building (e.g., changes in the emission factor of grid electricity over time) are accounted for in simple models where foreseeable.

As explained above, the aim is to reduce both operational greenhouse gas emissions and the building's final energy consumption with effective and efficient measures. Given the climate targets and the resulting diminishing residual budget for permissible additional greenhouse gas emissions each year, the pure operational emissions are insufficient, and therefore the embodied carbon emissions of each measure must also be taken into account. The consideration of greenhouse gas emissions is analogous to the profitability analysis of a construction measure to reduce costs. Every measure to reduce CO₂ emissions in the operation of a building is preceded by initial emissions during construction.

This is the principle of life-cycle analysis of measures. This allows important key figures and comparison values to be determined for each individual intervention. The simplified representation of costs and carbon emissions as a cumulative output over the life span of a measure is shown in Figure 3.

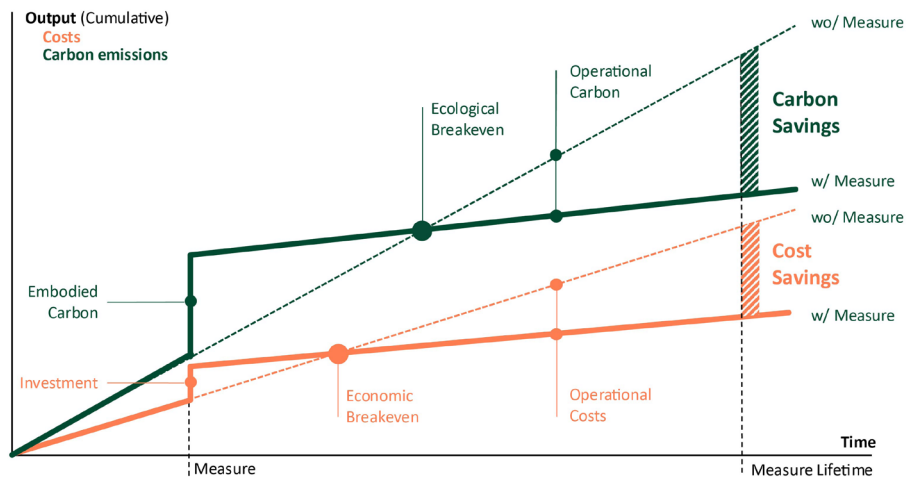


Figure 3: Cumulative output of both costs and carbon emissions in case of an arbitrary decarbonization measure.

Considerations also relevant for calculating the total savings by the specified date include any renewals of the measure during the review period and the emissions that would be generated anyway. This results in a refined accounting model for determining carbon emission savings per measure. This is shown in Figure 4.

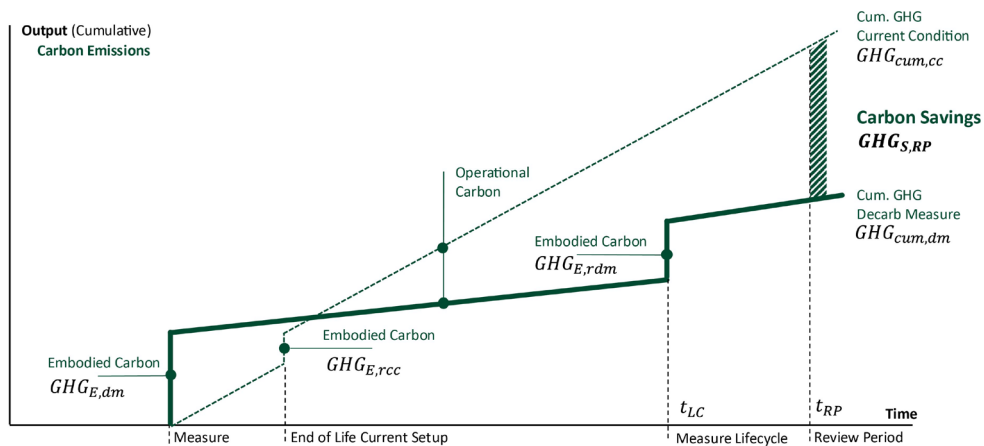


Figure 4: Cumulative output of both costs and carbon emissions in case of an arbitrary decarbonization measure.

A fixed review period is set for achieving the net zero target in each case. The BCF Buildings projects are designed to help achieve the global climate targets set out in the Paris Agreement. The current calculation model is based on a review period of 25 years. If the expected life span of a measure is less than the specified review period and a re-implementation of such a measure is necessary, then the resulting carbon emissions are added as a whole number.

To take into account the scenario that the measure under consideration would not be implemented, the associated embodied carbon emissions that maintain the current status are counted accordingly. The costs are analogous to the model for carbon emissions. The accounting model for determining the cost savings per measure is shown in Figure 5.

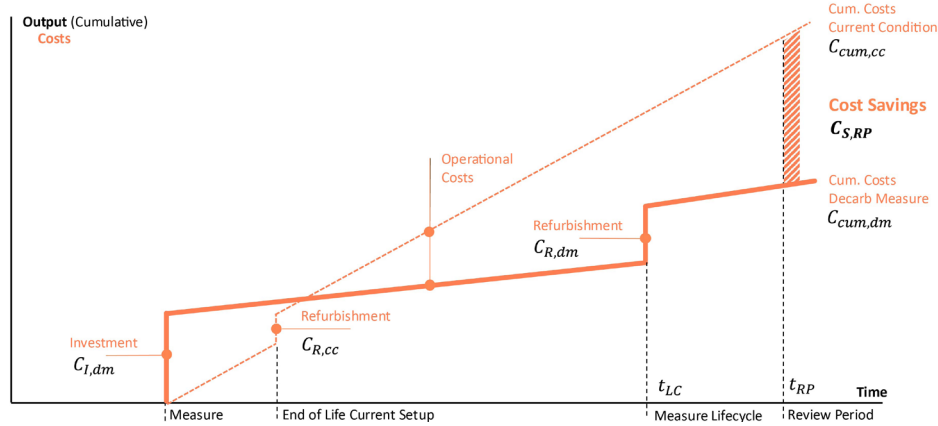


Figure 5: Detailed life-cycle cost analysis model of an arbitrary measure as it is used in the BCF Building projects key figure calculations.

On this basis, the following key accounting formulas can be derived to determine the impact of individual measures:

Carbon Savings Total

$$GHG_{S,RP} = GHG_{S,o} \times t_{RP} - GHG_{E,dm} - GHG_{E,rdm} \times \left| \frac{t_{RP}}{t_{LC}} \right| + GHG_{E,rcc}$$

Cost Savings Total

$$C_{S,RP} = C_{S,o} \times t_{RP} - C_{I,dm} - C_{I,rdm} \times \left| \frac{t_{RP}}{t_{LC}} \right| + C_{I,cc}$$

The amortization periods of the measures are also key comparative figures and are shown from both an ecological and economic perspective. The scenario that maintaining the current status would incur costs is also included here:

Ecological Breakeven

$$t_{B,GHG} = (GHG_{E,dm} - GHG_{E,cc}) / GHG_{S,o}$$

Economic Breakeven

$$t_{B,C} = (C_{I,dm} - C_{I,cc}) / C_{S,o}$$

The measures aim to reduce greenhouse gas emissions, provided that the investment costs are justifiable. In practice, however, it is often unclear exactly how much it costs to reduce one ton of CO₂ emissions, which are the mitigation costs. In addition to reducing greenhouse gas emissions in the BCF Building projects, the BCF aims to create more transparency regarding mitigation costs. These are calculated as follows:

Carbon Mitigation Costs

$$C_{M-GHG} = (C_{I,dm} - C_{I,cc}) / GHG_{S,RP}$$

The information for calculating the key figures in the projects is provided by the respective energy consulting office and is approved by the owner in consultation with the Project Audit Committee of the Belimo Climate Foundation. In the concept phase, 2. Conception, the information on individual measures is based on estimates, model calculations or simulations. Once the measures have been

implemented in the final phase, 4. Conclusion, they are based on measured consumption data and actual project costs.

Metrics and key figures used

In the concept phase, the planned measures are described; possible variants are discussed and ultimately recorded in a list of measures. The measures are then quantified, and the key figures are calculated in accordance with the procedure described above. Several parameters are determined for each measure, of which the following are among the most important:

Life span of the measure t_{LC}

Creation emissions $GHG_{E,dm}$

Investment costs $C_{I,dm}$

Savings in operating emissions $GHG_{S,o}$

Savings in operating costs $C_{S,o}$

The aim of each measure is to reduce both operational greenhouse gas emissions and final energy consumption, while also actively shaping the reduction path (see Figure 2). In addition, the key figures presented below are available for each measure. These form the basis for ecologically and economically effective decisions. (see Table 1).

Icon	Key Performance Indicator	Variable	Unit	Description
	Total Carbon Savings	$GHG_{S,RP}$	[tCO ₂ e]	Total GHG emission savings of the measure over the reporting period
	Ecological Breakeven	$t_{B,GHG}$	[yr]	Breakeven point when accumulated operational GHG emission savings equal embodied GHG emission
	Total Cost Savings	$C_{S,RP}$	[CHF]	Total cost savings of the measure over the reporting period
	Economic Breakeven	$t_{B,C}$	[yr]	Cost breakeven point when accumulated operational cost savings equal initial investment
	Carbon Mitigation Costs	C_{M-GHG}	[CHF/tCO ₂ e]	Relative costs to save a ton of GHG emissions

Table 1: Key figures used to estimate the ecological and economic efficacy of decarbonization measures.

Priority should be given to implementing measures that have a high potential for reducing both CO₂ emissions and costs. It is important to ensure that these measures are both ecologically and economically viable in the short term. Ultimately, the measures should work efficiently. The specific mitigation costs per ton of CO₂ saved thus become the central comparative figure in the project.

Suitable measures for decarbonizing a building and implementing the targeted reduction path towards net zero cannot be determined solely on the basis of key figures. Each building has an individual lifecycle and specific structural characteristics. The focus is always on providing occupants with a safe and comfortable space. Certain measures are unavoidable at a given point in time, even if they lead to modest key figures in individual cases. Such deviations must be accepted. Nevertheless, the key figures make it possible to identify the relevant variables and look for innovative solutions in a targeted manner.

If you are interested to explore how we use this methodology to gather data from our buildings projects please read the related publication *Building a project data base* which will soon be published.

PUBLISHED BY
Belimo Climate Foundation
c/o BELIMO Automation AG
Brunnenbachstrasse 1
8340 Hinwil
Switzerland
www.belimoclimatefoundation.org

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