A structured method to define goals when developing a building energy performance assessment method in a legislative framework

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Abstract. To boost the energy performance of buildings, the EU has established a legislative framework including the Energy Performance of Buildings Directive (EPBD). Through this document, EU state members are incentivized to set up a Building Energy performance Assessment Method (BEAM), tailored to the specific needs of the country. There is no standard definition for the energy performance of a building. Since the options are numerous, it is important for the policymaker to define the goals of their specific BEAM first, before developing the BEAM itself. The definition of these goals is a subjective matter and can differ when asked to different organizations in the building sector. To comprehend the desires and perspectives from each different group, a structured overview of the goals that are important for the specific region is needed. For this paper, a method was developed to provide this structured overview and was tested on the legislative energy performance of buildings (EPB) framework of Flanders, Belgium. The Flemish framework was initiated in 2006 and is still in action today. The method consists of two steps. In the first step, a multi-level tree structure for goal mapping based on the Goal Breakdown Structure (GBS) was developed. The main goal, reducing global warming, is on top of the tree structure, which then subdivides into many sub-goals on different levels. An example of a goal on the lowest level of the structure could be the insulation level of the walls. In the second step, prominent stakeholders in the Flemish building industry, including policymakers, researchers, manufacturers, contractors and building owners, were surveyed to capture their expectations from a BEAM and to query whether the current BEAM corresponds with those expectations. The goal of this survey was to receive qualitative, not quantitative input from the stakeholders. In total, 33 respondents completed the survey. The survey results showed that, in general, the desired goals have not changed substantially compared to the pre-set goals in 2006. Trias Energetica is still the preferred guideline for the decision-making process of the building owner, although its absolute power has decreased slightly and seems to be more prone to the conditions. The current indicator for the overall energy needs (E level) is still strongly preferred, while the recently introduced S level (assessment of the envelope) attracts mixed feelings in terms of usefulness to the entire EPB framework. The overheating indicator receives the most critique for not being accurate enough due to the simplified, single zone BEAM.
1. Introduction
The European policy framework for buildings has been evolving since the early 1990s. A wide array of measures have been adopted across individual EU Member States to actively promote better energy performance of buildings. After 2002, the issue gained strong momentum when the Directive on Energy Performance of Buildings (EPBD) [1] was adopted. Two of the key requirements stated within are:
- Minimum standards on the energy performance of new buildings and large buildings undergoing ‘major renovation’.
- General framework containing a methodology for calculating the integrated energy performance of buildings.

The EPBD was recast in 2010 [2] to make the goals more ambitious and to reinforce the implementation. One of these goals is the following:

- Setting up EU–wide nearly zero-energy buildings requirements: by the end of 2020 all newly constructed buildings will have to consume ‘nearly zero’ energy and the energy will have to come ‘to a very large extent’ from renewable sources. As for new buildings occupied and owned by public authorities, this requirement must be met from the beginning of 2019 onwards.

The EU legislative framework for buildings requires EU Member States to adopt their detailed national application of the EPBD definitions, supported by national policies for their implementation. However, there is no standardized procedure for setting up the general energy performance framework. According to a synthesis report on the nation plans for nearly zero energy buildings (nZEBs) [3], the concept of specific criteria for low energy performance, such as nZEB, became widely accepted among the different EU Member States. The definition for nZEB is still ambiguous, described as “a very high energy performance” or “a very significant extent by energy from renewable sources”.

Achieving the energy savings in buildings is a complex process. Policymaking in this field requires a meaningful understanding of several characteristics of the building stock. Reducing the energy demand requires the deployment of effective policies which in turn makes it necessary to understand what affects people’s decision-making processes, the key characteristics of the building stock, the impact of current policies, … In this paper, a distinction is made between 3 major influences on the decision-making process of the building owners, in the context of a legislative energy performance framework:

- **The definition and calculations of the energy balance of a building.** The policy maker must decide on the specific building and design measures and on the boundary conditions that will be allowed to influence the energy balance of a building.
- **The legislative framework.** The calculation method from the previous bullet point is adjusted to fit into the legislative context. This means that indicators and requirements must be set to define and subsequently evaluate the energy performance of the building.
- **Influences outside of the legislative framework.** The goal of the framework is to incentivize the building owner in making energy efficient decisions. However, these decisions may be influenced by personal factors such as financial status, habits, environmental awareness, …

The policymaker has many decisions to make and, as shown in a review on the energy performance of buildings in EU Member States [4], the options are numerous. On top of that, Member States do not have one specific goal, but many different and overlapping goals on many different levels. How to make sure these goals are compatible and, in combination, provide the desired incentives to the building stock?

The aim of this study is to provide a structured overview of the different goals that could be embedded in an energy performance framework and to test this structure on an actual case, specifically the Belgian region of Flanders. This is done in two steps. Firstly, developing a structured template based on the Goal
Breakdown Structure (GBS). Secondly, prominent stakeholders in the Flemish building industry are surveyed to capture their expectations from a BEAM and to query whether the current BEAM corresponds to their expectations. The survey and the template follow the same structure. This way, it makes sure that every aspect of the building measures spectrum is taken into account.

2. Methods

2.1 Goals breakdown structure

The GBS is the culmination of three concepts [5]: the hierarchical relationship of product development, the work breakdown structure and requirements traceability. The GBS follows two rules for decomposition:

- Nothing missing. Each layer must contain every goal needed to ensure the project achieves the next higher-level goals.
- Nothing extra. No layer should contain any extraneous goals; goals not needed to achieve the layer above.

In this study, when talking about the relation between two goals on subsequent levels, we will be talking about “the goal” as the higher-level goal and “the method” as the lower-level goal. However, this “method” is also perceived as a goal that can be broken down in different goals on a lower level.

The aim of the structure developed in this study is to serve as a template for the goals in a specific legislative context. This means that one specific goal could have different methods in different legislative frameworks. It is up to the policymaker to decide on the goals that are set forward in their specific context.

On top of the GBS, one finds the most extensive, but also most abstract goal. There are many methods to make sure that the goal on this level is reached. In the context of this study, this goal is to reduce global warming. At the bottom of the GBS one finds the most specific and detailed goals. It is clear and unambiguous what should be done to reach this goal. In this study, this could be the specific thickness of the insulation layer of the walls. In this paper, the focus lies on the improvement of the energy performance of the building, which is one of the ways to reduce global warming. This method represents the top goal of the GBS structure used in this study.

It is important to take into account that the GBS is not only different between Member States, but also different between a Member State and its building owners. In general, the GBS for the building owner is a decision tree where some of the goals are predefined by the policymaker through the legislative framework. This is to make sure that the top goal, energy performance, is achieved. It is up to the policymaker to establish these predefined goals on different levels, while maintaining room for the building owner’s freedom of choice.

The freedom of choice for a specific goal can be adjusted in three possible ways:

1. The policy maker establishes an indicator to evaluate if the goal is achieved. A requirement is set on this indicator and the building owner is obligated to meet this requirement.
   a. e.g., a minimum value must be achieved on an indicator for the overall energy performance of the building.
   b. e.g., a minimum insulation thickness must be applied.

2. No requirement is set; however, the achievement of the goal is taken into account to evaluate the achievement of the goal on a higher level.
   a. e.g., improving the insulation level of the building envelope will improve the energy performance of the building.
3 The achievement of the goal is not taken into account to evaluate the achievement of the goal on a higher level.
   a. e.g., the improvement of the ventilation system, does not affect the indicator that evaluates the performance of the building envelope.
   b. In this category one usually finds the boundary conditions. e.g., a decrease of the comfort level, cannot be used to improve the evaluation of the energy performance.

2.2 Template for the energy performance goals
The top level of the GBS used in this paper starts with the main goal: improving the energy performance of the building. To subdivide this main goal into different subgoals on the second level, the comfort level in the building was chosen as a starting point. The main reason people consume energy in their buildings is to achieve a good comfort level. The maintenance of a good comfort level results from a balance between a reduction of the comfort level in the building by external factors on one hand and the countering of this reduction by the aid of systems on the other hand. This results in four subgoals on the second level which aid to improve the energy efficiency of the building to maintain the comfort level. The following sections show an overview of the structure used in this study.

1. Choosing the boundary conditions which have an influence on the comfort level
   Usually, the boundary conditions are predefined in an energy performance of buildings (EPB) context, since a building owner has little control over these conditions, e.g., the weather patterns. There are exceptions to the rule, such as the availability to take shading from adjacent buildings into account in the Flemish EPB framework [6]. Climate conditions could have a large influence on the actual energy performance [7]. The policymaker could allow the choice of location to influence the energy performance of the building. Three subgoals for this branch are defined:
   a. Choosing the location of the building
      • weather patterns, topography, urban heat island effect, shading of the environment, …
   b. Adjusting the user behaviour
      • heat gains by occupants, window opening behaviour, temperature set points, …

2. Blocking the influence of the boundary conditions
   The goal of this branch is to block the influence of the boundary conditions as much as possible. In general, these are all the building measures, systems and user behaviour that help to reduce the influence of the boundary systems without using energy on a continuous basis. Note that the user behaviour can also have a negative effect on the comfort level (e.g., see section 1b.)
   a. The materials chosen and their specific properties
      • U values of the building elements, the airtightness, the thermal capacity, …
   b. Improving the building design
      • compact building, orientation of the rooms, glass percentage, shading, …
   c. Automation of the building envelope
      • automatic shading, free cooling, solar water heater, sensors, …
   d. User behaviour
      • manual adjustment of the building envelope such as manual shading, window opening against overheating, clothing behaviour, …

3. Improving the efficiency of the energy systems
   a. Improving the system properties
      • reducing heat losses of the heating system, higher storage capacity, heat recovery systems, aging, quality of execution, …
   b. Improving the system design
      • dimensioning of the system, positioning and location of the system, …
   c. System automation
• temperature sensors, CO₂ sensors, …

4. **Reducing the use of fossilised resources**
   a. **Energy production and exchange**
      • photovoltaic panels, thermal solar energy system, energy exchange with the grid, …
   b. **Using sustainable power sources**
      • green energy supplier, use of green energy systems, participation

2.3 Survey
For each of the goals in the overview above, the policymaker must decide on the freedom of choice of the building owner. Specifically, if the building owner must achieve the goal, can achieve the goal or if the achievement of the goal has no impact on the energy performance of the building. This question was asked to prominent stakeholders in the Flemish building industry for each of the subgoals mentioned in the overview above. An example of a question is shown in Figure 1. The survey was divided into two parts. In the first part, the respondent was asked to provide an opinion on the utilization of different building measures. The respondent was also asked to perceive the concept of "an energy performant building", unrelated to the legislative framework of Flanders. In the second part, the respondent was asked if the weight of specific building measures on the current energy performance framework in Flanders is too high, too low or good.

| influence on energy performance score | optional comment |
|--------------------------------------|-----------------|
| MUST | CAN | CAN'T |
| optimize the dimensioning of the building | O | O | O |
| optimize the compactness of the building | O | O | O |
| optimize the orientation of rooms | O | O | O |
| optimize the functionality of rooms | O | O | O |
| optimize the layout of the building | O | O | O |
| other | O | O | O |

**Figure 1.** Overview of the participants of the survey.

The goal of this survey was to receive qualitative, not quantitative input from the stakeholders. In total, 33 respondents completed the survey. Figure 2 provides an overview of the participants.

**Figure 2.** Overview of the participants of the survey.
3. Results and discussion
In this section the most important results of the survey will be explained as it is not possible to go through all 57 questions of the survey. The results from part 1 and 2 of the survey are combined into one graph, both explaining the desires of the participants for an energy performance framework (should/can/can’t) and their opinion on the influence in the current energy performance framework (too much/good/few).

3.1 Trias Energetica
The first graph concerns the concept of Trias Energetica. Trias Energetica tackles the last three subgoals, defined in the second level of the GBS template and is an ingrained rule of thumb in the construction business. It is a three-step strategy: 1) reducing the energy needs, 2) using sustainable energy, 3) improving the efficiency of the technical systems.

Figure 3 and 4 provide an overview of the opinion of the correspondents on the use of Trias Energetica as a guideline in building energy performance.

Only 3 respondents think that the three-step Trias Energetica should be the preferred guideline. The most common comment was that this guideline is somewhat outdated and that it is important to decide on these different strategies depending on the context of the building. Sometimes sustainable energy or improved techniques are available or wanted before the improvement of the envelope. Some other participants claimed that Trias Energetica cannot be a goal on itself and it is necessary to look at alternatives that are not looking at minimal energy use. Another comment was that this rule does not incentivizes the occupant to improve their behaviour.
3.2 Comfort
The results from the survey showed that there is little consensus on how to implement specific comfort criteria. The overall opinion is that the current method is to be simplified to correctly assess the discomfort. Because of the monthly calculations, the hourly temperature fluctuations are not taken into account accurately enough and peak temperatures are flattened. The overheating indicator drew the most criticism. The 23°C that is assumed for the overheating calculations is perceived too low and specific building measures, such as solar shading and passive cooling are not incentivized enough.

For the domestic hot water, lighting quality and domestic appliances, the most common opinion was that this could not be calculated accurately because of the changing occupant behaviour and therefore should not be taken into account. Some respondents suggested that more research could be done on a standard user profile, applied to all energy performance calculations.

3.3 Boundary conditions
In the current Flemish framework, all boundary conditions are assumed to be constant for every building except for the shading from the environment, which can be used to reduce the solar heat gains. The choice of typology is usually defined by the specific plot the house is built on. However, because of the large correlation between typology and compactness, different typologies on average have different energy performances (e.g., less heating loads in apartments opposed to detached buildings). Figure 5 shows the responses from the survey concerning the boundary conditions.

![Figure 5](image)

**Figure 5.** Can or can’t the building owner use these boundary conditions to improve the energy performance score?

Interestingly, most of the respondents were in favour of making the climate zone influential for the energy performance score. This to take into account different exterior temperatures, e.g., the urban heat island effect. For the other boundary conditions, most of the respondents agreed with the current implementation in the framework. Only a few correspondents mentioned the fact that the shading from the environment is bound to change in time.
3.4 Building envelope

Figure 6 and 7 provide an overview of the response concerning the building envelope.

**Figure 6.** Which building envelop measures can or can’t be used to improve the energy performance?

**Figure 7.** Which building envelop measures should be prioritized in the legislative framework

Insulating remains the most desired method to reduce the energy needs and improve the performance of the building. Half of the respondents think that the influence of the occupant on the envelope should be utilized to influence the performance, although many stated that this is hard to evaluate as the occupancy can change. Some suggested to do recalculations as soon as new occupants enter the building. Others stated that standardized user profiles could be used to influence the energy performance.

3.5 Sustainable energy & systems

Figure 8 and 9 provide an overview of the responses concerning the systems.

**Figure 8.** How to incorporate sustainable energy into the energy performance framework?

**Figure 9.** Should system efficiencies influence the energy performance evaluation?
Some respondents stated that the use of energy efficient appliances and the use of a green electricity provide can’t be used because it is easily changeable. Others remark that some measures are sometimes not possible if the location does not allow it, like producing renewable energy or using waste heat from industry. The measures which are already most ingrained in the current framework are in the survey perceived.

The best way to improve the system efficiencies is still perceived to be the recovering of the heat losses. All measures are perceived to be able to influence the energy performance. One respondent stated that improving storage capacity is not interesting enough at the moment because batteries are still too expensive. Figure 10 shows an overview of the responses concerning the influence of the used systems.

![Figure 10](image1.png)

**Figure 10.** How is the influence of the systems in the current framework?

The most important point of critique is again related to the overheating and cooling leads. Because of the current focus on insulation levels, cooling and overheating become more important. However there is critique on the use of a fictitious cooling in the current framework. This fictitious cooling is calculated, assuming a cooling system. Only when the overheating indicator has a large enough value this fictitious cooling will be taken into account. A remark related to the heating system is that in the current calculation method a single zone building model is assumed and thus the whole building is assumed to be heated, which is not the case in reality.

### 3.6 Indicators and requirement

One of the questions surveyed the opinion of the respondent on the indicators currently used in the energy performance framework. The results are shown in Figure 11.

![Figure 11](image2.png)

**Figure 11.** Which indicators and requirements are useful for the EPB framework?
The E level, evaluating the total energy performance of the building, is the most ingrained indicator, although some comments stated that there is too much focus on this indicator. The K level and net heating demand are old indicators. For the K level the problem was that the U values of the partitions was the only building measure that gave a real incentive. For the net heating demands the problem was that it was not technology neutral. The S level has been developed to provide a solution for these problems. The S level, evaluating the energy performance of the building envelope, is a fairly recent indicator and it seems that trust in this indicator has still to be raised. The critique is that it is too hard to understand.

**Figure 12.** Analysis of the survey results

Figure 12 provides an analysis of the most interesting answers given in the survey. The different goals have been marked by different colours depending on their desired influence in the energy performance framework (green= should be a goal, orange= can be a goal, red=can’t be a goal) The strength of the colours provide information on the number or correspondents that have chosen the specific colour (the darker the colour the higher the percentage). The goals in red provide an overview of where there is a discrepancy between the desires of the respondents and the influence of these building measures on the E level, the indicator for the overall energy performance in the Flemish framework.

4. Conclusion
In general the predefined goals, put forward by the respondents in the survey, agree with the already existing framework in Flanders. However, there is no proof how biased the respondent is if he’s already acquainted with the existing framework, even though it was specifically asked to discard the knowledge of the existing framework in the first part of the survey.

Also it became clear that the calculation method behind the energy performance were not always understood in great detail, leading to misconceptions. This was also stated by some of the respondents
and seems to be most applicable to the S level. Probably because this indicator is fairly recently introduced in the legislative framework and people are not yet fully acquainted with the mechanisms behind it.

The reduction of the energy demand is most put forward as an influential strategy to achieve energy performance. Especially the improvement of the insulation level, which is closely related to the old K level indicator, more familiar to the general public. The S level was specially designed to serve as an indicator for the performance of the envelop, aiming for technology neutrality.

The most common remarks were on the evaluation of the overheating in the building. There were different problems stated about this indicator. One is that the calculation method is hard to understand and too simplified to be accurate. It is believed to provide false incentives to building measures used to prevent overheating like shading and free cooling. This survey was focused on the overall energy performance of the building. However, it could be interesting to reconstruct the GBS structure while focusing on the overheating problem as the main goal.

Using the GBS technique could provide a useful overview of the desires of the different stakeholders. This information could be used by the policy maker to construct a tailored made set of indicators, or to adjust the current indicators. Or if there are misconceptions, to provide better information on the current legislative framework.

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