Building Energy Efficiency for Massive market Uptake
2014

Final version of the protocol for the improved integrated design methodology aimed at replication.

BEEM-UP

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BEEM-UP

Building Energy Efficiency for Massive market UPtake

Integrated Project

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Demonstration of Energy Efficiency through Retrofitting of Buildings

Deliverable 1.8: Final Holistic Methodology Description

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable description

Besides the ambitious targets for energy efficiency the BEEM-UP project takes into account a holistic understanding based on the three dimensions “economy”, “ecology” and “society”. This target was merged with an optimisation approach on building performance that does not aim at hard targets but rather on achieving a result that is as good as possible.

BEEM-Up addresses this need by evaluating the performance of a large number of possible refurbishment concepts and assessing their environmental and economic performance from a life time perspective (from the generation of the building materials over the usage phase to the deconstruction).

This is done by defining sound individual refurbishment solutions for all parts of a building and then combining them amongst each other. This way every possible combination is assessed on its performance in a wide range of established indicators.

Besides generating data on the performance of the concepts over a defined life time the trade-off between different indicators can be visualized and the tool could for example be used to calculate the amount of subsidies that is needed to achieve a certain reduction in environmental impact.

Social aspects can be taken into account by highlighting the technological solutions that are related to them.

The methodology was applied to all three sites in BEEM-UP and found to be a useful tool to reflect the applied solutions beyond energy efficiency.

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Chapter 1 Holistic Methodology Description

Non-Scientific description of the BEEM-UP methodology for holistic assessment of Pareto optimal refurbishment scenarios

Besides the ambitious targets for energy efficiency in BEEM-UP a holistic assessment was conducted to evaluate the impact of side effects of energy efficiency measure and provide a scope of understanding that would encompass economic, environmental and social aspects.
This deliverable provides the description of the final version of this methodology. Its main aim is to provide a non-scientific description that allows stakeholders to assess the potential of the methodology for their respective situation

1.1 Background

Currently, EU legislative regulations and most labels give hard or semi-hard targets for new buildings as well as for refurbishment measures (DIN EN 18 599 2007; MINERGIE 2012). Targets are somewhat adaptive as, for example, the minimum running prime energy demand is often related to the surface to volume ratio of the building (DIN EN 18 599 2007). Such targets are commonly designed in a way that there is a certain incentive to build buildings with sensible surface to volume ratios without making other approaches impossible to realize when other frame conditions demand them. In buildings, this could mean compensating with more insulation or a more efficient heating system. Hard or semi-hard targets generally made sense when they were created, but are becoming increasingly inappropriate as the system boundaries and the number of indicators and dimensions of sustainability aspects increase.
Though still partly based on regional legislative frameworks, building labels such as the one from the DGNB (DGNB 2012) try to approach this problem by including site quality as one of their criteria or create country or climate specific versions of their labels, such as BREEAM (2012), which is always based on the regional legislative framework. LEED (2012) is currently setting up a region specific approach.

However, for refurbishments, the site is fixed, as it is in many cases for new buildings, and from an environmental point of view, the frame conditions that made the building happen in the first place are more complex than simple site quality. Buildings are often already connected to complex networks within the city, and now in the case of refurbishments have to be optimized based on our current understanding of sustainability and currently perceived problems, such as anthropogenic climate change. A change of site is very often simply not an option, regardless of the potential such a measure would have. This leaves some buildings at a severe disadvantage in their efforts to achieve the hard targets, while in other cases it keeps planners from realizing optimal buildings, as the site does not allow for easy achievement of the hard targets. Very often hard targets either make buildings more difficult to realize, especially from an economic point of view, or less well performing than would be possible as only the minimal target levels are aimed for.

The central problem with legislative approaches is the focus on minimal performance levels, while the central problem with building labels is the attempt to achieve a maximum performance in all areas. As maximum performance in all dimensions is generally accepted to be difficult in the building sector, this often results in the labeling of only lighthouse projects in which costs either do not matter for reasons of prestige, or that follow entirely different economic rules than the bulk of the market. A promising step is the implementation of minimal performance levels in all associated criteria in order to achieve a certain overall status or ranking (for example, a DGNB Gold ranking demands at least a silver ranking in each sub criteria) (DGNB 2012). Especially when considering refurbishments, the options for the site should be measured against each other instead of hard targets. This allows for the realization of optimal solutions instead of realizing, for example, a certain level of energy efficiency regardless of costs. Instead of naming a certain performance as a minimal target, the recommendation should be: "As good as possible". Of course, the value of such an optimization approach depends heavily on the indicators chosen. These should cover all relevant aspects of the building process. Referring to the introduction, all three pillars of sustainability should be covered with suitable indicators tailored to the specific conditions of the building sector.

As an alternative to the race toward maximum performance, an optimum performance that achieves a sensible balance of all dimensions of sustainability (including and visualizing their trade off of course) involved should be aimed for in order to achieve a massive up-scaling effect. The definition proposed and used within BEEM-UP according to this would be

- **Maximum performance**: best possible performance according to one indicator or in one dimension of sustainability, and therefore not affected by weighting.
- **Optimal performance**: best possible overall performance over several indicators or dimensions of sustainability, affected by weighting

The methodology in BEEM-UP aims to provide optimal performance rather than maximum performance and include a wide range of indicators. This would not only allow for the holistic scope but also offers an up-scaling potential beyond lighthouse projects as is the essence of the BEEM-UP idea.

1.2 Developed Methodology

1.2.1 The main Idea

When thinking about the refurbishment of buildings, a great number of options exist. These cover active technologies, defined as technologies consuming energy in the usage phase (housing services and appliances), and passive technologies, defined as technologies without energy consumption in the usage phase (insulation, window frames and glazing), as well as changes in user behavior through training.

Besides the described problem that different indicators favor different technologies, they are also in a complex interchange concerning their effectiveness.
A system that might be suitable for a building with a large demand (e.g., a heat pump with an excellent COP, but on the other hand, with high investment costs) might be completely oversized or an unrealistic cost factor for a well-insulated building.

The general problem is that it is becoming increasingly difficult, even for experts, to make correct assumptions about the exact effects of the interaction of building technologies, especially when considering multiple dimensions of sustainability, site-specific conditions and a large number of indicators.

Options that might look good on paper might not actually be realistically applicable on site. Especially with refurbishment, there is a multitude of frame conditions that can make the application of certain options impossible. Examples range from site conditions (grounding that hinders the application of soil based heat pumps) to social conditions (tenants that cannot temporarily moved out of their homes, making the application of inside insulation rather impossible), as well as legislative aspects (nobody can be forced to limit himself to only one fridge or one TV, however sensible this might be).

The BEEM-UP approach is therefore based on the following principles:

- A preliminary evaluation of experts should identify suitable options for the site. Unrealistic options therefore are taken out from the beginning.
- The options left should be kept flexible. This allows the option to be tailored to the site and to react to interactions with other options.
- Out of the options available a larger number of concepts are to be generated. This ensures that the optimal solution is not missed due to working with rough guesses.

The interaction between different indicators is certainly a main interest, especially concerning the application of different indicators from each dimension of sustainability. With a large base of experience regarding the nature of interactions, certain types of buildings could be identified in which the planner should emphasize a certain dimension of performance because a unique opportunity presents itself. Sound understanding of these principles can be a valuable contribution not only to individual buildings but also to future city quarter development.

As a first step, analyzing the potential of this approach with an assessment of the interaction between the environmental dimension and the economic dimension of sustainability, for which data is easiest to access, is conducted below.

1.2.2 Methodology Description

For all three sites within the BEEM-UP project, the application of active and passive technologies was assessed by internal experts from the building sector (mainly LuWoCo, but including site managers with economic background and experts for tenant involvement with a background in social science) in the beginning of the project, based on their experiences with various refurbishments.
The technologies in question included housing services (heating, ventilation, domestic hot water generation and electrical equipment) and improvements of the envelope (insulation, improvements of air tightness, and exchange of windows and frames).

Great care was taken to identify sound measures that are feasible from a constructive point of view. As an example, insulation thicknesses were chosen that are available (e.g., 100 mm was chosen instead of 95 mm in the case of EPS insulation) and only options that are applicable were chosen (e.g., wall make-ups that are correct in terms of hygro- thermal behavior, insulation systems that can be applied to the existing walls, solutions that comply with local building law, etc.).

In this way, each measure is already an optimized solution in its own field. One option for each measure covers work that would need to be done regardless of existing or threatening damage, as an “anyway solution”. This option is always a minimal solution and marked as the base solution in the table above.
The associated costs and material demands were assessed for all measures based on the recent experiences of the site managers.
As a next step, the measures were combined with each other, resulting in a large number of overall refurbishment scenarios.

The results were then analyzed and discussed with the decision makers. The process can be taken from the flowchart below (Fig. 1).

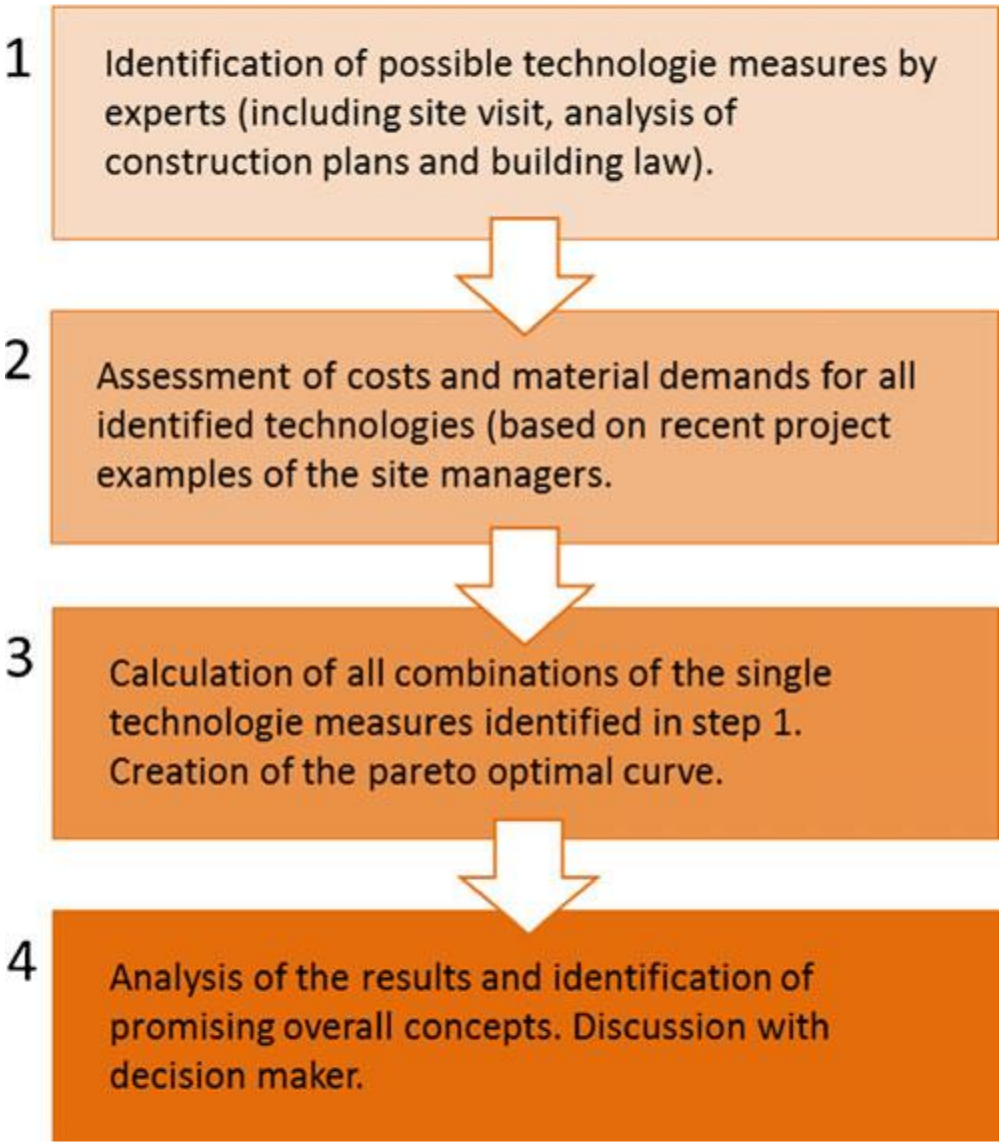

Fig. 1 BEEM-UP Holistic Methodology flowchart

1.2.3 Methodology Visualization

Figure 2 shows a schematic visualization of the results:

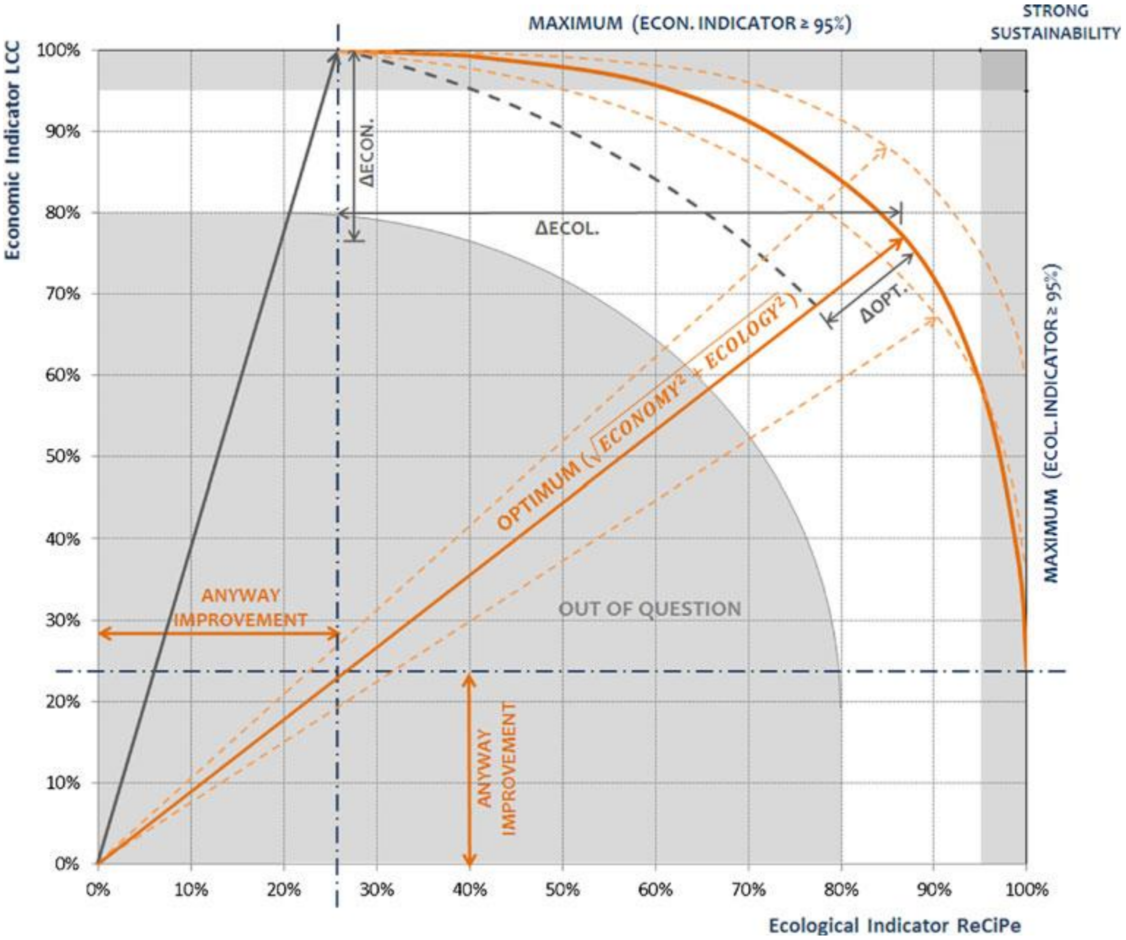

Fig. 2 BEEM-UP Holistic Methodology schematic result

Each overall concept (calculated as described above) has a certain performance in terms of LCC and environmental LCA that is resulting in its ranking on Y-axis or X-axis respectively and therefore its position in the grid.
A high ranking on one axis indicates a good performance for the respective indicator (e.g., low life cycle costs or a low environmental impact). Points to the upper right therefore perform well in both dimensions while point to the lower left perform badly.

All results are normalized, with the worst result for both dimensions being 0 and the best being 100 accordingly. The results of the assessment form a large cloud of points with generally environmentally promising results tending to be economically not well performing and vice versa.

For many concepts, there are alternatives that are assessed as preferable in both dimensions. The most promising results form a curve that is marked with a (dotted) orange line. This line follows the original definition of Pareto-optimal data points for a data cloud in two-dimensional space.

1.3 Example results from BEEM-UP sites

1.3.1 General results

Figure 3 shows all 729 results, resulting from 6 measures, each with 3 possible options, for the indicators LCC and the LCA for ReCiPe for the site in Paris/France:

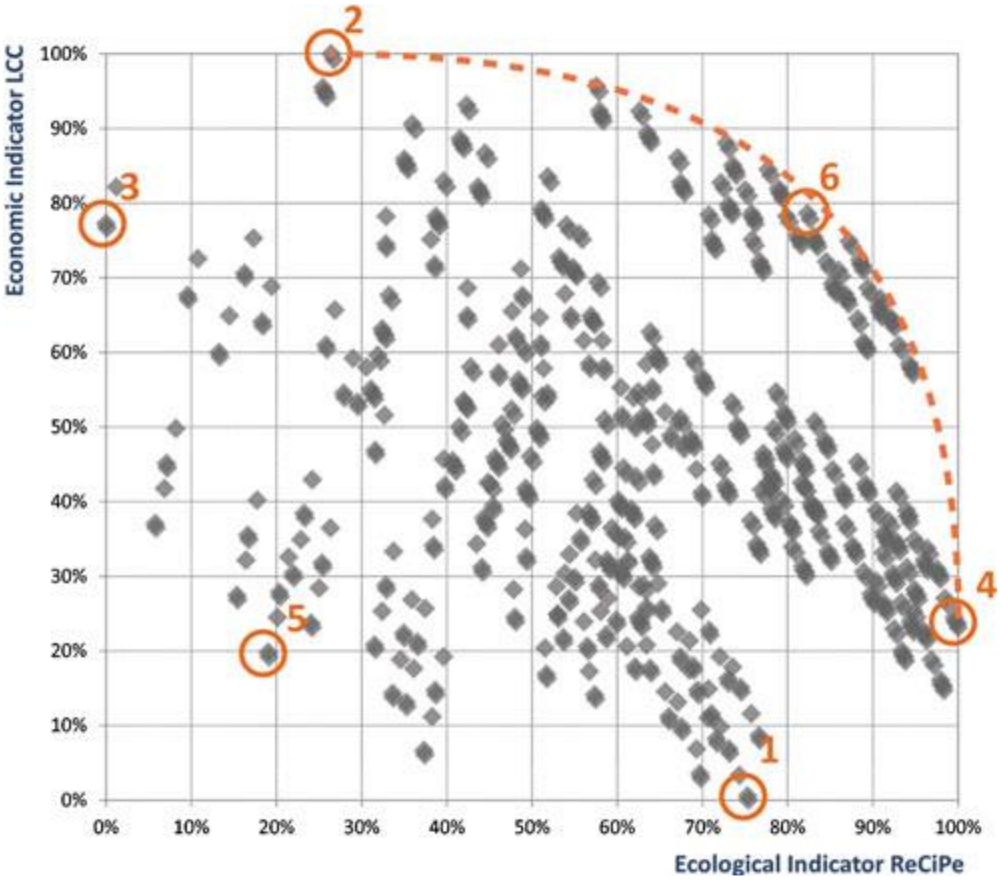

Fig. 3 BEEM-UP Results for the French site

Applied to the topic addressed within the holistic assessment in BEEM-UP it does not make sense to realize a concept that is surpassed in both the assessed indictors (e.g., environmentally less damaging and at the same time less costly).

1.3.2 Impact of specific technologies

There are several clusters of points within the cloud that are dominated by certain technologies. These can be visualized by highlighting the points that include the respective technology.

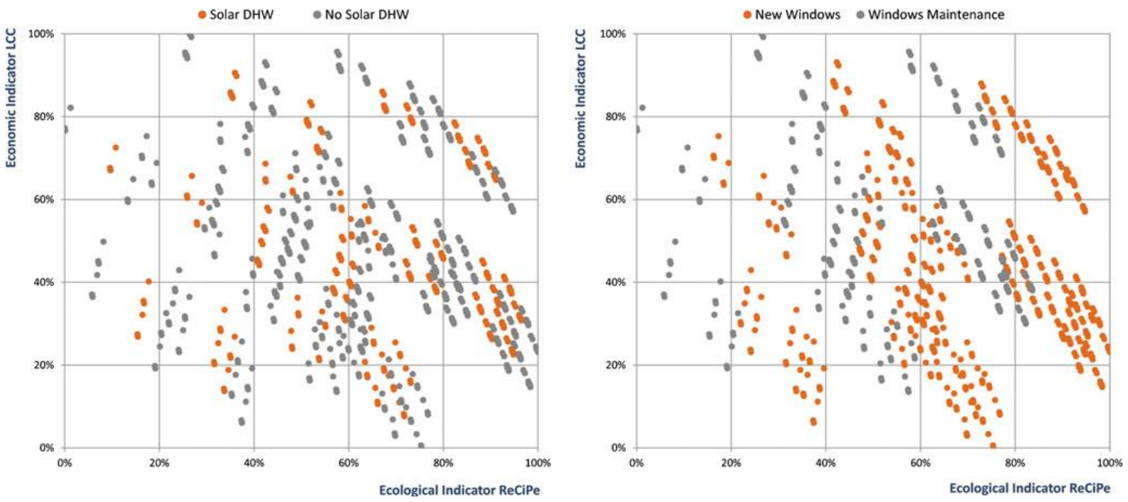

Fig. 4 BEEM-UP visualization of individual technologies

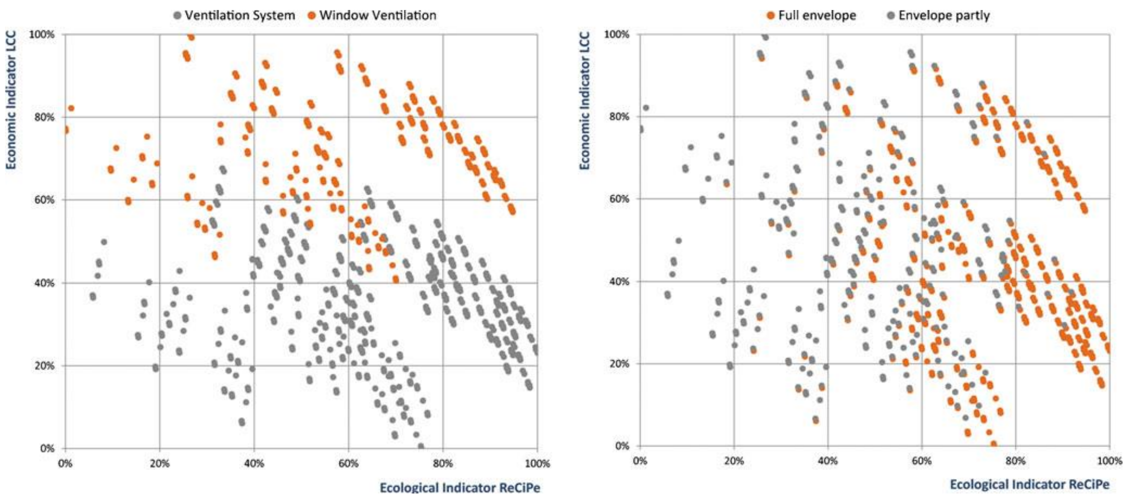

Fig. 5 BEEM-UP visualization of individual technologies

Figure 4 and 5 show the LCC/LCA ReCiPe assessment with certain technologies marked in color.
Some technology measures like window ventilation and insulation (5b) dominate entire clusters (5a). Most technologies, like the exchange of windows (4b), partial as opposed to full envelope insulation (5b) and ventilation (5a), are clearly favorable in one dimension while being less attractive in the other dimension (they perform environmentally well, while being expensive). Technology measures like solar hot water generation (4a) diffuse the entire cloud of concepts and do not create a huge impact on the overall performance.

1.3.3 Social Aspects

The visualization of individual technologies also allows for addressing social indicators. The BEEM-UP project and its large scale tenant involvement showed that the relevant social indicators for the different stake holders varied too much to be implemented into an overall methodology. Very often however they are linked to certain technologies being a “must have” or “no go”.

An example for this is ventilation that was named as a “must have” even though it was economically not optimal. However the new air-tight façade was assumed to result in greater mold growth (based on the experiences of the site manager with their tenants life style and behavior).

A counter example where measures that could be proven to be Pareto optimal but would result in long mandatory leaves of the tenants to conduct the works – something that was not deemed to be socially acceptable.

While these factors could (and likely never can) be generalized, the methodology allows to take their consequences into account so that by feeding in the knowledge of the site managers, socio culturally specific social aspects can be taken into account.

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