D3.1: Guideline I - nZEB Processes

COST REDUCTION AND MARKET ACCELERATION FOR VIABLE NEARLY ZERO-ENERGY BUILDINGS

Effective processes, robust solutions, new business models and reliable life cycle costs, supporting user engagement and investors' confidence towards net zero balance.

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D3.1: Guideline I - nZEB Processes

Authors (Editors):

Tobias Weiss [1], Klara Meier [2], Armin Knotzer [1], Regina Höfler[1]

Authors (Contributors):

Anna Maria Fulterer[1], Jens Gloeggler[2], Roberta Pernetti[3], Federico Garzia[3], Bjorn Berggren[4]; Åse Togerö[4]; Benjamin Köhler[5], Ramy Saad[6], Christian Denacquard[6], Cristina Foletti[7], Mirco Balachia[8], Davide Torriglia[8]

[1] AEE INTEC
[2] ATP Sustain
[3] eurac research
[4] Skanska
[5] Fraunhofer ISE
[6] Bouygues Construction
[7] Moretti
[8] 3i engineering

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FOREWORD

This report summarises the results of Work Package 'WP03 – Cost reduction potentials in processes', part of the Horizon2020 - CRAVEzero project

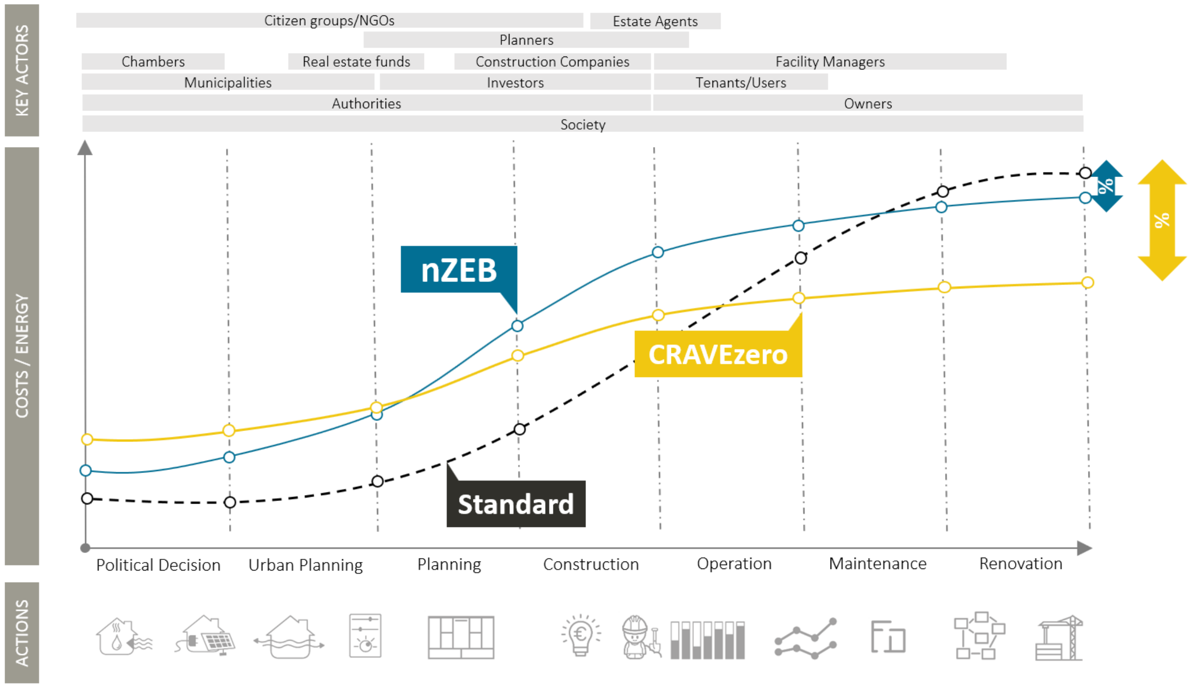

Figure 1: CRAVEzero approach for cost reductions in the lifecycle of nZEBs.

Cost optimal and nearly zero energy performance levels are principles initiated by the European Union's (EU) Energy Performance of Buildings Directive, which was recast in 2010 and amended 2018. These will be major drivers in the construction sector in the next few years because all new buildings in the EU from 2021 onwards are expected to be nearly zero energy buildings (nZEB). While realised nZEBs have clearly shown that nearly-zero energy target could be achieved using existing technologies and practices, most experts agree that a broad scale shift towards nearly-zero energy buildings requires significant adjustments to prevailing building market structures. Cost-effective integration of efficient solution sets and renewable energy systems, in a form that fits with the development, manufacturing and construction industry processes, as well as with planning, design, and procurement procedures, are the major challenges.

The following guideline presents a framework for ensuring the process quality of the new nZEBs. We will outline the key actions needed to ensure the achievement of energy and cost related goals presenting a replicable planning, design, construction, and operation process. The development of a clear and comprehensive life cycle process that includes the potential for specific and measurable actions (both cost savings and energy) is critical to ensure goals are met in a cost-effective manner.

In this guideline the "CRAVEzero process" is described. It organises the process of briefing, designing, constructing and operating nZEBs in different life cycle phases. Actions, stakeholder-relations, pitfalls and bottlenecks, as well as the required goals, are pointed out in detail. Considering the importance and the complexity to reach the nZEB standard in a cost-optimal way for all the different stakeholders during the process, multiple actions are required. These are however missing in the standard planning process. This report provides an operative methodology to achieve the best conditions towards cost optimal nZEBs in the whole planning, construction and operation process considering all relevant decisions, co-benefits, involved players as well as relevant cost reduction potentials. A process map that connects the entire project lifecycle for design, planning, operation and end of life phase accompanies this report. This process map is a workflow that points out cost reduction potentials through all the stages of the process where all the different parts are linked to provide summaries and reports to the decision-makers in leadership roles.

The main additional advantages of integrating the "CRAVEzero process" into standardized building processes are listed as follows:

- Reduce risks
- Speed-up construction and delivery
- Control costs and energy performance
- Foster integrative design and make optimal use of team members' expertise
- Establish measurable success criteria

Furthermore, during the whole process, four critical issues have to be tracked for new nZEBs:

- How efficiently can energy be consumed?
- How much energy can be produced on-site?
- Which environmental conditions can be controlled?
- How can be defined thermal comfort and what co-benefits can be expected?

As a main result this report also comes along with a downloadable "life cycle tracker tool", an easy-to-use Excel file with VBA macros that combines project roles, actions, and design responsibility matrix. It is based on the experience of the whole consortium in the area of holistic project management with a focus on integral building planning of nZEBs. It gives support on how key performance parameters to achieve successful nZEBs should be prioritized and can be tracked along the whole life-cycle-process. A short manual of the tool can be found in chapter 7.
It can be downloaded here: http://www.cravezero.eu/lifecycletracker

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CHAPTER 1

INTRODUCTION

1.INTRODUCTION

In addition to legal and urban boundaries, buildings are essentially defined by the client. Owners or investors want to construct or renovate buildings for a specific purpose. Also, the buildings technical quality and the comfort standard have to be achieved within project specific budget limitations. Architects and specialised planners translate the client's ideas and wish into real plans and are responsible for the appropriate execution of the building project. Construction companies and craftsmen from numerous different disciplines are involved in constructing the building. There is a constant coordination process between the client, the planners and the contractors in order to prepare the construction of a building and if necessary, to react to changing conditions like costs, schedules, requests from the client, weather, etc. (Arnold 2005).

Especially in the planning phase, the choice and combination of building materials and technologies and the execution on the construction site as well as the overall integral planning, construction and operation are of great importance. The range of services provided to buildings in the urban context today has also changed over time and gained new aspects. Nearly zero energy buildings increasingly become active participants of our energy supply infrastructure and raise new challenges concerning the quality of planning, construction and operational phase of a building. This results in new approaches to innovative energy concepts for both the building and districts. Innovations related to the realisation of nZEBs arise in different life cycle phases of buildings and at different points of the value chain in the building industry. To reduce costs, accelerate processes and assure the quality of nZEBs the right decisions have to be taken at the ideal time within the overall process.

1.1. OBJECTIVE

To optimise nZEB planning activities at different levels, from urban and spatial planning to the building's detailed design.

The focus on the developed method, the "CRAVEzero process", is to promote a common, interdisciplinary understanding of the complexity of nZEB planning processes for all involved stakeholders. A well organised and transparent process is a key issue of achieving the goal of cost-optimal and sustainable nZEBs throughout the entire life cycle phase.

The complexity of processes in the life cycle of nZEBs is one of the main reasons why nZEB developments fail in the planning, construction or later on in the operational phase. Already from the very beginning, prerequisites must be created in order to define the requirements, and clear project objectives must be defined. Too often, promising building concepts fail to achieve costs and energy goals because project participants are not sufficiently aware of the manifold interactions of holistic planning contexts.

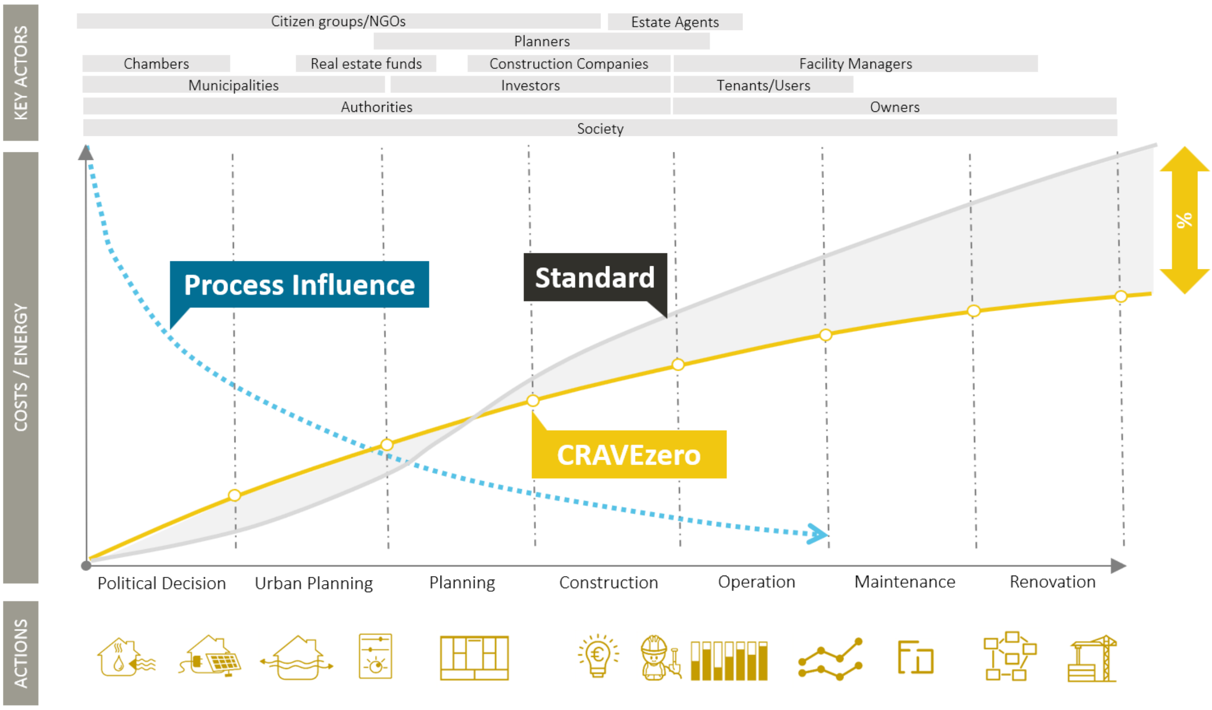


Figure 2: The influence on the process decreases while the costs increase during the life cycle of a nZEB

In order to minimise risks and possible bottlenecks, obstacles must be identified at an early stage. It is necessary to establish a common planning understanding for nZEBs among all actors early on. The design of new nZEBs begins with maximizing passive design, yet limiting energy consumption from the grid. To do this, planners often need to challenge the norms of traditional designs.

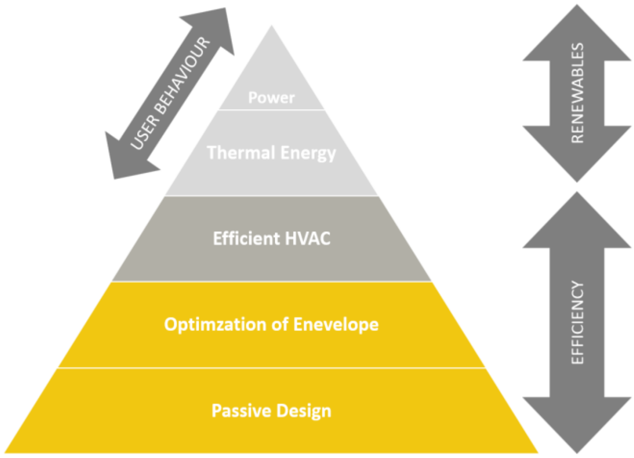


Figure 3: Steps to reach nZEB standard

Each building has its unique process, where architects often start from scratch, collect the information and constraints of the local context, develope the building, carry out cost-optimal performance analyses, hopefully include an evaluation of the potential for using renewable energy. This means extra costs for the design process. Stakeholders repeat almost the same procedures without a coordinated and standardised process. As a starting point, an organized framework for a systematic approach for the life cycle process of low-cost nZEBs is needed. A clear connection between the building performances and the related costs is essential for ensuring the clarity of the process. A strategic element in the whole process is the introduction of a performance-based procurement approach as a common practice not only for public tendering but also for private construction.

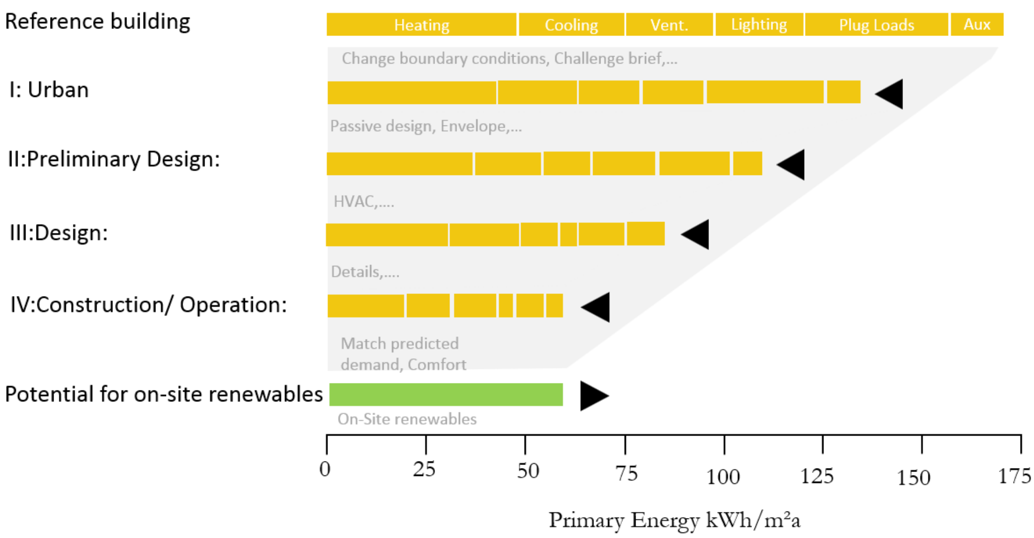


Figure 4: Process steps to reach nZEB-standard along life cycle phases

1.2. STATE OF THE ART

(Ferrara et al., 2018) state that in fact buildings with high energy performance have become technically feasible, but are not yet cost-effective. This constitutes the main barrier in their implementation. The principle of cost-optimality has been introduced to move national minimum energy performance requirements towards the achievement of economically feasible nZEB targets, considering also operating, replacement and disposal costs.

A framework for the cost-optimal design of nZEBs has been presented by (D'Agostino and Parker, 2018). This framework study contains data regarding costs, energy prices and climate data. One important conclusion is that the most common optimized nZEB configuration foresees a combination of good insulation, building airtightness as well as class A++ appliances, lighting, and home energy management systems along with PV. Depending on the climate, airtightness and insulation (colder climates) or efficiency of appliances as well as lowering solar gains (warmer climates) has to be considered first.

Recent Austrian studies have shown that construction costs of buildings near passive house standard increase compared to those of minimum nZEB requirements in a range of 4 to 6%, but these highly efficient variants reduce the primary energy demand by 72% (Ploss, et al. 2017). (Berggren, Wall and Togerö 2018) tried to break traditional ways of calculating nZEB profitability with LCC analysis trying to quantify the added value of a green building in monetary terms. Their assessment was based on a planning process also including socio-economic parameters influenced by the quality of the building.

(D'Agostino and Parker, 2018) show how the optimal measure set can be found. But how can the knowledge on optimal design be tied to the building process? Which actors should be involved, and what actions have to be taken in the process at which time step? Is the traditional development process of buildings suitable to realize market penetration of high-level nZEB buildings?

In order to get answers to these questions, it is important as a first step to clarify with which construction procedure the project is to be handled.

One prominent example of different construction procedures implying on the interface between phases lies in the decision on the project delivery system (Konchar and Sanvido, 1998). In Europe, the standard project delivery system is designed bid build. This means that there is a clear cut between the design phase and the build phase, which is marked by the procurement of the construction companies ("bidding"). Important implications are that construction companies do not take part in the planning phase and that the owner has to invest additional time for assigning construction contracts. An alternative approach is the design-build approach, which is increasingly used worldwide for construction projects.

(Torcellini et al., 2004) have studied the realization process of nZEB buildings[1] looking at various case studies on nZEB construction processes. They investigated the project delivery system of high-performance / low energy buildings and came to the conclusion that performance-based design-build was the best approach to realize a high quality at low cost (Deru and Torcellini, 2004; Crawford, Czerniakowski and Fuller, 2011; Pless, Torcellini and Shelton, 2011). In performance-based design-build, the planning and construction phase are strongly interconnected since the owner engages a team of planners and constructors to plan and realize the whole building for a thoroughly defined function and at a fixed cost. The owner moreover monetarily awards the team for achieving an even higher standard throughout the process. The important point is that performance-based design-build can be used to integrate planning and construction phase for achieving the specific goal of a high-performance nZEB by assigning this as well-defined target to the planning and construction team.

(Konchar and Sanvido, 1998) conclude that design-build show major advantages in terms of costs and performance compared to other project delivery systems.

What does this mean for the goal of promoting nZEBs? It means that it is not only important to consider single actions of single users in determined building phases. (Pless, Torcellini and Shelton, 2011) agree that design-build allows for higher achievements of energy-efficient buildings and nZEBs. They argue that it is the integration of planning and construction that allows reaching more ambitioned targets. This means in fact that the actors of planning and construction need to work in an exchanging way.

A detailed case study on the design-build process is included in the report on the building of the NREL facility in the US (U.S. Department of Energy, 2012). Just like integrating planning and construction can enhance the possible outcome, the same can be expected from intertwining urban planning and planning, also including actors of the operation phase into the planning phases, as it was also found in the "Renew School" project (Kondratenko, Van Loon, Poppe, 2014).

Energy matters can be considered in the land use plan on a large scale level or in detail: In many European countries efforts are growing to consider energy matters already in an early planning phase (Zhivov et al., 2014).

1.3. STAKEHOLDER RELATED PROCESSES

In order to be able to optimise existing processes, technical qualifications, actions to be taken and roles must be known and tasks and functions of the stakeholders assigned.

The assessment of the process for nZEBs depends strongly on the perspective. Building owners, investors, tenants, the construction industry, providers of energy efficiency solutions and planners have different interests and are involved in different phases in the life cycle of buildings. There is a general lack of understanding, transparency and uniform methods when it comes to the overall process of nZEBs. Which costs and time horizons are significant for different actors and to what extent?

In the life cycle of a building, there are different interests of the actors and derived from this also different perspectives, observation periods and target values. There is the tenant/user, the real estate agent, the building contractor, planner, property manager, investor, owner and also the company which is directly or indirectly involved in the building process. As shown in Figure 5, these actors are involved in the overall process over a certain period of time. While the tenant is primarily interested in the operational phase, the planner is usually more likely to deal with the building only until its completion. If a property is financed and used by the resident himself, the entire life cycle up to a change of use is usually of interest. Depending on the approach, this can be between 25 years, after repayment of the bank loan, and up to 50 years, after increased consideration of the use. For society as a whole, the entire service life of a building, including its demolition and disposal, usually counts.

The period under consideration must, therefore, be determined in advance with the parties involved. For most of the considerations of the entire building, between 25 and 50 years have proven to be reasonable.

Stakeholders	Time expectancy
Tenant / user	3 – 30 years
Real estate agents	1 – 2 years
Builder/ Construction company	1 – 5 years (Guarantee)
Planner	1 years
Property management	1 – 50 years (Contract duration)
Investor	1 – 5 years
Building owner / landlord	20 - 50 years
Building owner (public)	50 – 100 years
Society	> 100 years

Figure 5: Stakeholders' time expectancy of a nZEB project

☐ Indirect Influence

✓ Direct Influence

Stakeholders	Lifecycle Phase: Urban Planning / spatial planning	Planning	Construction	Operation	Maintenance and repair	Renovation	End of life
Tenant / user				✓	✓	☐	
Real estate agents			☐	✓			
Builder/ construction company			✓			✓	✓
Planner	✓	✓	✓			✓	
Property management				✓			
Investor			☐	✓			
Building owner / landlord		✓	✓	✓	☐	✓	
Building owner (public)		✓	✓	✓	✓	✓	
Society	✓	✓	✓	✓	✓	✓	✓

Figure 6: Stakeholders' influence in nZEB life cycle phases

1.4. CO-BENEFITS

Similar to the stakeholder related-processes, the different target criteria and co-benefits also vary depending on the perspective of the stakeholder. Figure 7 shows the criteria and co-benefits according to the interests of the different actors. In addition to low rental costs, the tenant is also interested in low operating costs and thus in a good energy standard, e.g. so that he or she has low heating costs. The building contractor is usually anxious to keep his or her building costs low. In the case of owner-occupied real estate, both cost components are important, the initial investment as well as the running costs. For public owners and users the total life cycle costs and also the effects such as CO_2 emissions are important.

□ Indirect relationship

✓ Direct relationship

	Benefits					Co-benefits						
Stakeholders	Marketability	Lettability	Value development	Rental income	Comfort	Durability	Arch. quality	Image	Energy Savings	User satisfaction	Climate protection	Energy autonomy
Tenant / user		□			✓	□	✓	✓	✓	✓	□	□
Real estate agents	✓	✓	✓	✓	□		□	✓	□	□		
Builder/ construction company						✓	□			□		
Planner		□	□		✓	✓	✓	✓	✓	✓		
Property management		✓	✓			✓			✓	✓		
Investor	✓	✓	✓	✓			□	□				
Building owner / landlord	✓	✓	✓	✓	✓	✓	□	✓	✓	✓		□
Building owner (public)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Society	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure 7: Stakeholders related benefits and co-benefits of nZEBs

In addition to the optimisation criteria and thus the benefits that can be directly assessed in monetary terms, there are also different co-benefits for the individual actors, which often cannot be assessed directly in monetary terms and therefore do not appear in the life cycle cost analysis. These benefits and co-benefits are shown in Figure 18. These concern marketability, rentability, value development, comfort, but also image, climate protection or regional goals such as energy autonomy. Where possible, these benefits and additional benefits should be taken into account in the decision-making process. These additional criteria can often overlap the main criteria. An example of this is the use of an air heat pump in a very noise-sensitive environment. The air heat pump can perform relatively well in terms of energy and costs, also in terms of life-cycle costs, but can lead to problems due to increased noise pollution at the property and the neighbouring properties. It is important to quantify added value of nZEBs in monetary terms, communicating and presenting business opportunities in a business language that potential investors are familiar with, as technical performance is less likely to attract their interest (Bleyl, 2016). Co-benefits such as increased productivity, improved health, publicity value, etc. need to be quantified. The calculation may not be complex; the challenge is to gather well-proven input data for the calculations.

However, examples exist where increased productivity, higher revenue, reduced employee turnover, reduced absenteeism, etc. have been quantified (Brew, 2017). Additionally, studies do exist which may be used as a basis for analysing added values.

Studies show that staffs in green buildings perceive a positive effect of their work environment and productivity (Thatcher, 2014) (Brew, 2017) (Singh, 2010). In one case, a 10 000 m² office building, increased productivity of 0.3 % was reported, equal to 8 €/m²a.

Two studies have found reduced absenteeism in green buildings (Thatcher, 2014).
An American study showed that roughly 20-25 % of 534 companies reported higher employee morale, easier to recruit employees and more effective client meetings (Miller, 2009). Additionally, 19 % reported lower employee turnover.
In addition to well-being and productivity, higher revenues from rent or sales may be expected. Bleyl et al. reviewed previous studies and concluded that higher rent income might range roughly between 5 % and 20 %. Furthermore, higher market valuations may range from below 10 % to up to 30 %.
It should be noted, in relation to green buildings, productivity and wellbeing, that a recent study pointed out, that social factors may have a greater impact, in monetary terms, than environmental factors (Hugh, 2016).
The value of a positive news article about a specific building or a specific project could also be comparable to advertising costs in the specific source, in which the article is published (Berggren, 2017).
One way to discuss the importance and investigation on different co-benefits may be to rank them as presented in Figure 8. The classification is a subjective judgement, highlighting the relevance and the difficulty in valuing the co-benefits discussed above.

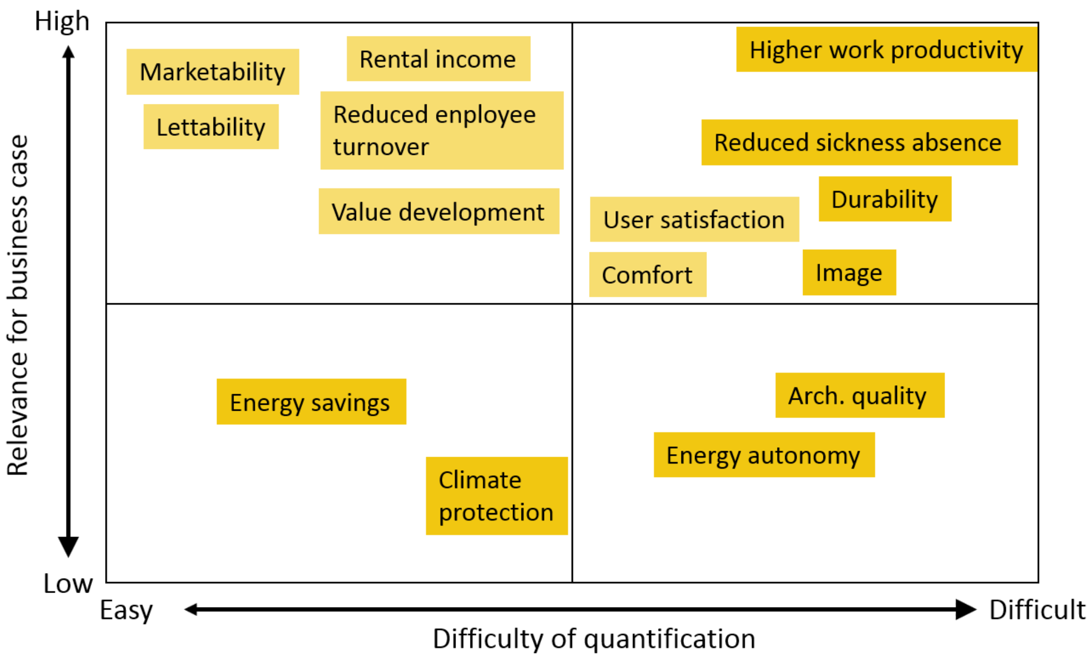


Figure 8: Co-benefits classification in nZEBs, based on Bleyl et al. [1].

1.5. THE PROCESS OF NZEBS – BARRIERS AND CHALLENGES

In the course of the ISEC Conference 2018 in Graz, Austria, a survey was conducted during a workshop, which focused on planners, researchers and contractors.
The online survey tool Mentimeter was used for this purpose. The results can be immediately evaluated and shared with the respondents in real time. In this way, the results could be discussed in the subsequent panel discussion of the workshop. Based on the experiences in the various professions, the survey asked what challenges are seen in the implementation of nearly zero-energy buildings, what is needed to make highly efficient buildings more marketable and what added value is seen in such buildings.

A total of **102** people took part in the survey, divided into three occupational groups as follows:

- Planners: 40
- Researchers: 57
- Construction companies: 5

1. What are the main challenges (barrieres) to realise a nZEBs?

From the survey results of the first question, which can be seen in Figures 5 and 6, it can be seen that the challenges are similarly on average by all groups of actors surveyed. However, there is no consensus among the groups of actors surveyed.

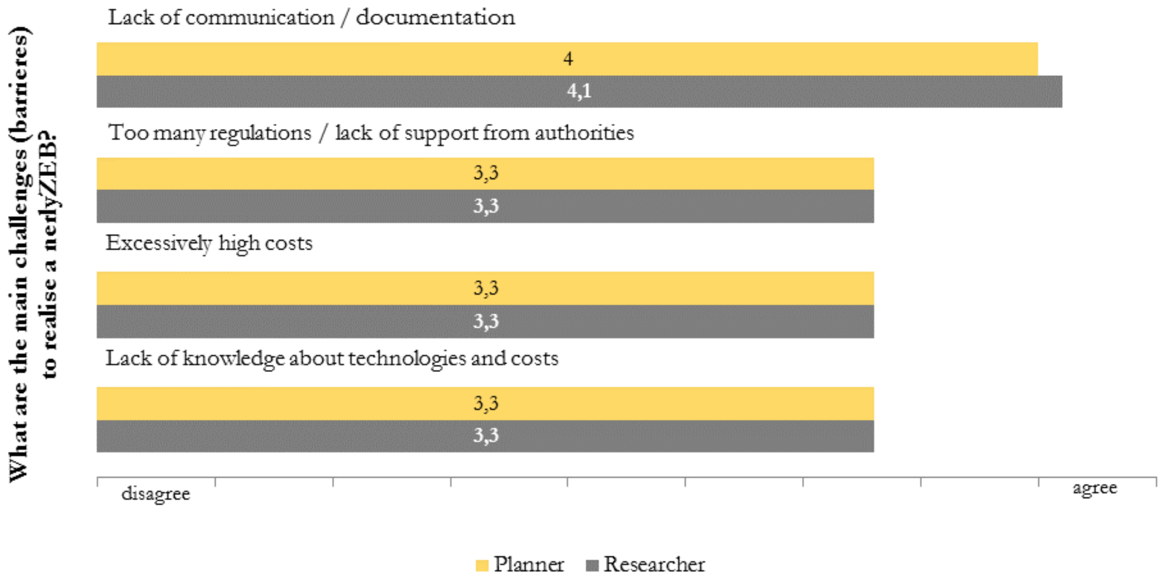


Figure 9: Mentimeter survey answers of planners and researchers dealing with implementation challenges and showing specific median values

On closer examination and analysis of the results in Figure 9, it becomes clear that lack of communication and documentation is a big barrier for all stakeholders. Most of the participants see the lack of knowledge about technologies and their costs as a barrier, whereas the generally higher costs are not seen on average. This is particularly noticeable among the groups of planners as well as among the construction companies.

2. What is needed for a market uptake of nZEBs?

The second question dealt with the market uptake of nearly zero energy buildings and what is needed to increase it. As one can see in figure 10 the potential for increasing the market uptake is seen in all four possible answers but in slightly varying degrees.

The distribution of the responses makes it clear that there should be more collaboration of the planning teams and stricter legally binding building requirements. What is noticeable is that in general the opinions within the expert groups differ only slighlty.

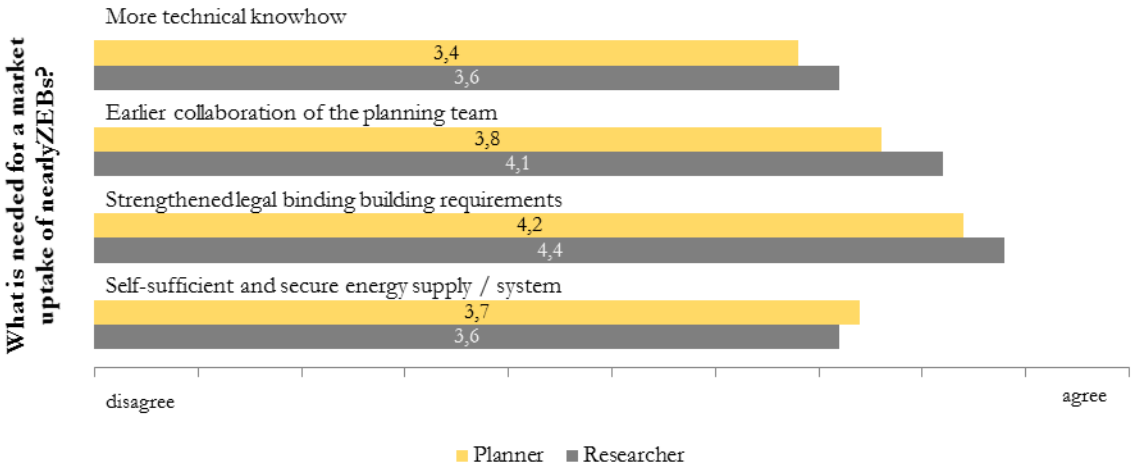


Figure 10: Mentimeter survey answers of planners and researchers dealing with nZEB marketability and showing specific median values

3. What is the added value of building nZEBs?

In order to be able to specify the added value of nZEBs, the four topics most relevant to the interviewed stakeholders with regard to added value should be filtered out at this point of the survey. Figure 11 clearly shows that the focus is particularly on resource savings and climate protection. This added value is the clear leader for both researchers (23%) and planners / practitioners (22%). But lower operational costs (17%) and less energy dependency (16% / 18%) are also important factors for the added value of nZEBs.

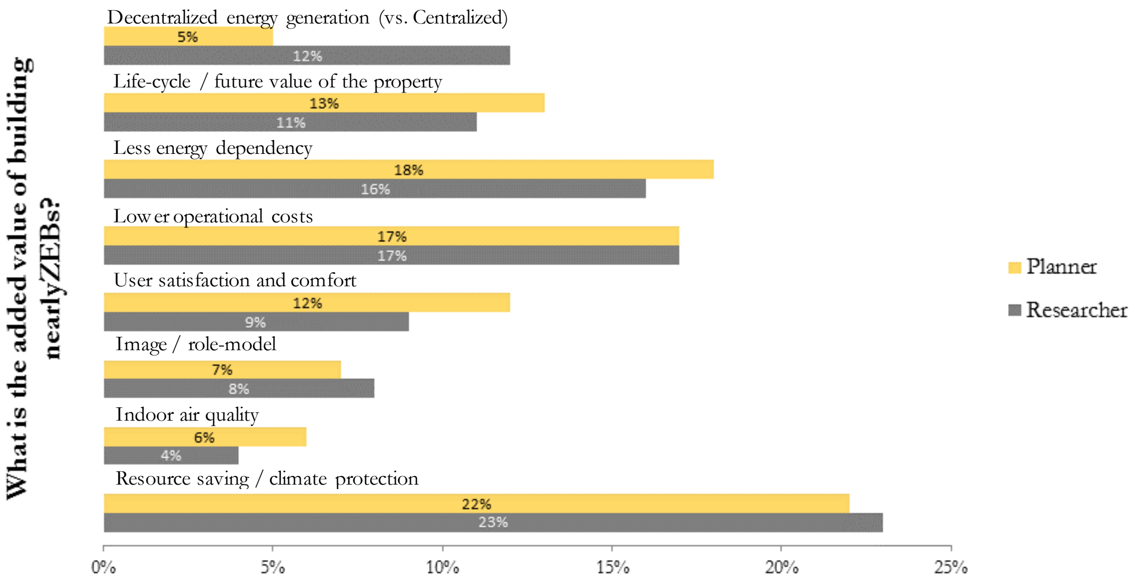


Figure 11: Mentimeter survey answers of planners and researchers with the share of added value points for nZEB

The greatest disagreements between the individual groups of actors arise in decentralized energy generation (vs centralized). Although 12% of researchers say that this is an important added value, only 5% of planners and contractors agree. In addition to these survey results, there are other challenges associated with the implementation of nearly zero energy buildings. For example, the individual interfaces and responsibilities between the actors and the integration of different technologies at best possible time are often unclear. In addition, communication between those responsible must be improved, as implementation is often made more difficult because it is unclear who needs which information and when.

FRAMEWORK FOR ENSURING THE PROCESS QUALITY OF THE NEW nZEBS

1.6. FRAMEWORK FOR ENSURING THE PROCESS QUALITY OF THE NEW NZEBS

Achieving the nZEB goal with reduced costs requires additional strategies as well as refinements of an existing design, construction, operation, and maintenance practice.
The following chapters present a framework for ensuring the process quality of the new nZEBs. It outlines the key actions needed to ensure the achievement of energy and cost related goals using replicable planning, design, construction, and operation process. The development of a clear and comprehensive life cycle process that includes specific and measurable actions (both cost savings and energy) is critical to ensure that goals are met cost-effectively.

The following chapters each describe a phase of the overall life cycle process from urban planning, planning, construction and operation until the end of life of a nZEB. All chapters are structured as follows:

- **Existing process:** A process map describing the overall process and steps to be taken for all related stakeholders for all phases of a project's lifecycle
- **Pitfalls and bottlenecks:** Pitfalls and bottlenecks are listed that can endanger deadlines, budgets and quality of the nZEB project
- **Actions:** Various actions that can be allocated in the specific phase to promote nZEBs are presented
- **Process evaluation results:** Actions are assigned to the main drivers and other stakeholders in order to clarify the question of responsibility. In addition, the various dependencies of the actions and possible cost saving potentials are listed.

CHAPTER 2

POLITICAL DECISION AND URBAN PLANNING PROCESS

2. POLITICAL DECISION AND URBAN PLANNING PROCESS

2.1. OVERALL PROCESS

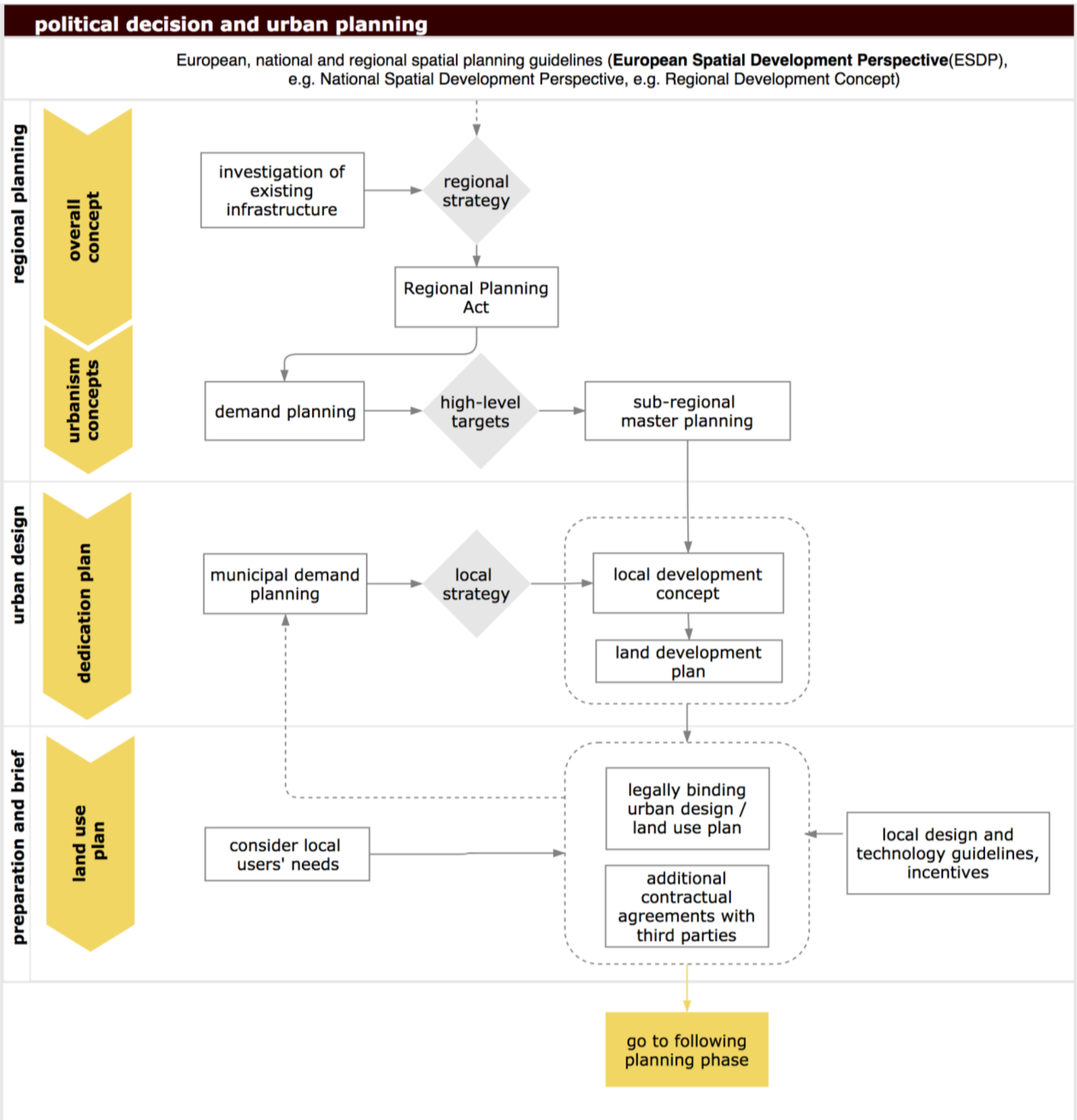


Figure 12: Urban planning process

The political decision and urban planning process prepare for the whole building process from planning to construction and use. It is an on-going process that influences building use also at later times or leads to a change in the energy system of buildings. It is in this phase that the public/common interest for low emission and low cost for public services is considered.

Decisions may be made on:

- infrastructure design
    - street location, design, use
    - sewer system
    - public transport
    - energy supply
    - educational buildings
- land-use plan
    - commercial zones
    - industrial zones
    - residential zones
    - green areas, recreational zones
- building type (detached, multi-family…)
- energy consumption level
- building orientation
- aesthetic aspects like façade colour and roof shape

Political decisions and urban planning are usually done proceeding from a large scale (e.g. regional planning) to a local scale.

The main tasks on each decision and planning level are:

- investigation and analysis of the existing situation
- definition of a strategy
- consideration of demand
- definition of targets for spatial order
- documentation and implementation of strategy and targets

These documents may come in the form of plan material, regulations, laws, treaties with third parties, e.g. energy suppliers, landowners etc. The documents may be legally binding or hold recommendations for further planning on a more detailed level.

2.1.1.REGIONAL PLANNING

Several actions can be taken on a regional planning level to promote nZEBs. These include the definition of the political and legal framework, as well as offering funding schemes and awareness raising. Also, the definition of targets is an important action on the regional level, since regions can often be linked to specific climates which again have an impact on the building design. Actions can have the intention to encourage, enable or enforce.

Enable:

- Definition of political and legal framework for nZEBs (provides Authority)
- Assessment of energy efficiency and renewable energy potentials

Encourage:

- Funding schemes for nZEBs (provides Instruments)
- Development and implementation of strategies for awareness raising (provides Information)

Enforce:

- Set long term regional targets for spatial planning (provides Targets)
- Regional efficiency improvement targets supporting nZEBs (provides Targets)

2.1.2.URBAN DESIGN

Urban design goes into further details. To what extent urban design can be enforced is usually defined in regional plans. The focus here is to consider environmental conditions like sunshine, microclimate and wind lanes, and infrastructural conditions on a neighbourhood level. Infrastructural conditions on neighbourhood or district level include thermal and electrical microgrids, seasonal storage as well as renewable energy use and building envelope attributes and targets. Again, actions are grouped by their intent. For most of the actions in urban design, it is not yet fixed, whether their target is to

- Encourage by providing information on cost-optimal or energy-optimal solution.
- Enforce by providing information and authority on the optimal solution, e.g. regarding building orientation or renewable energy use, e.g. in a legally binding land use plan.
- Enable by providing information on optimal solutions as well as subsidies to those willing to implement them.

The decision on whether to enable, encourage or enforce normally lies in the competence of the municipal level.

One important action is the "Definition of Integrative Design Team".

Other actions are:

Enable

- Urban masterplanning allowing highly compact buildings (provides Authority)

Enforce

- Definition of basic envelope attributes and energy targets (provides Authority)

Enable/Encourage/Enforce:

- Preparation of budget for renewables and estimate return on investment/ LCC (provide Instruments)
- Optimize building orientation and zoning (provides Information/Authority)
- Optimize solar aAccess in urban layout (provides Information/Authority)
- Work with urban microclimate (Information or Information/Authority)
- Consideration of thermal / electrical microgrids on district level (provides Information/Authority)
- Consideration of seasonal storage on district level (provides Information/Authority)

2.1.3. PREPARATION AND PROJECT BRIEF

In this part of the political decision and urban planning phase, user needs are integrated into the land development plan to create a land use plan, which becomes legally binding after the political decision process.

Enable:

- A connection request for PV / drilling permit for geothermal: Define and constitute an efficient process to ease the process of approval (provide Instruments)

Enforce:

Apply strategy towards efficient use of land: Enforce efficient land use in the land use plan and corresponding locally bound subsidies and infrastructure development (provide Targets)

Enable/Encourage:

- Assessment of the potential for decentralized renewable power generation: Provide information and encourage the development of decentralized power generation
- Requirements analysis (Provide Information and Instruments)

2.2. PITFALLS AND BOTTLENECKS

It's important to be aware of the common pitfalls that can compromise project success in the urban planning phase. Below, six pitfalls and bottlenecks are listed that can endanger deadlines, budgets and quality of the nZEB project during the urban planning phase.

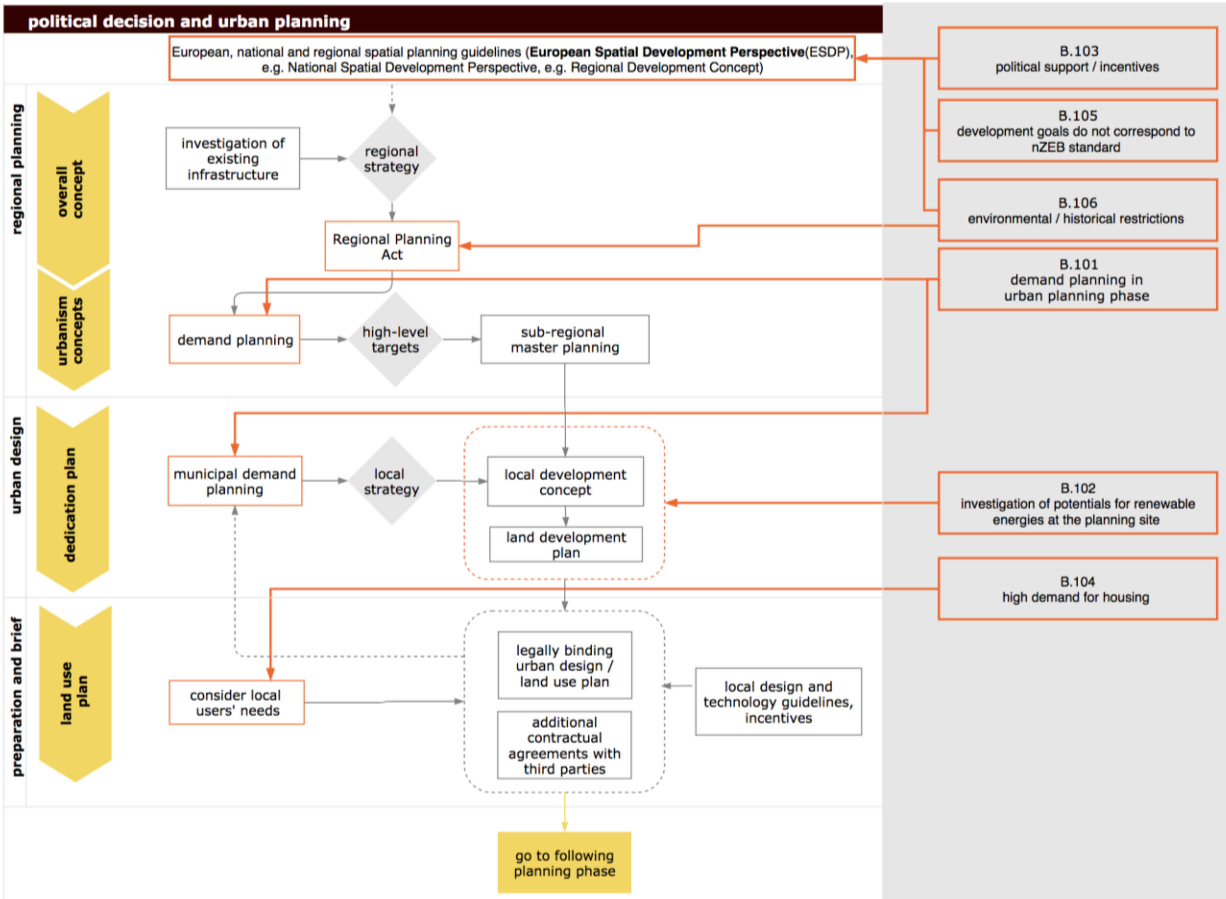


Figure 13: Urban planning process considering bottlenecks

B.101: Demand planning in the urban planning phase

The building authorities, together with the planners, must design the framework conditions for a new district, considering the technical and legal regulations. This part of the city must take both energy and social aspects into account to be fit for the future.

B.102: Investigation of potentials for renewable energies at the site

When developing new urban districts, the integration of renewable energies must be taken into account at an early stage. In addition, supply systems with waste heat/cooling from neighbouring districts should be analysed. As a result of this early analysis of the existing qualities, the building structure can be adapted for optimal exploitation of the potentials.

B.103: Political support / incentives

Funding schemes within the framework of urban development planning can be used to integrate analyses for near-zero energy districts into the process. The conceptual basis for the development of a nearly-zero energy district is influenced by the boundary conditions determined in this phase.

B.104: High demand for housing

Due to the high demand for residential buildings in some European regions, energy aspects are often not taken into account. It is important, also there, to start new development areas with sustainable and innovative concepts.

B.105: Development goals do not correspond to nZEB standard

The current rules for the development of new urban areas often do not comply with the general requirements for the construction of nZEBs.

2.3. ACTIONS

In the following, the different steps of the political decision and urban planning phase will be described more detailed, introducing actions that can be allocated in this phase to promote nZEBs.

The political decision and urban planning phase is layered into different levels. It is of uttermost importance that the interdependencies between these levels work well: That means that there have to be well-defined and checked mechanisms for information exchange between the levels. For example, it makes no sense to offer subsidies for certain energy supply systems on regional level if on a local level, other systems are preferred. Moreover, in some cases, it can be useful to integrate actions on different levels. A joint planning team of regional, urban and energy planners could, e.g. better integrate interests both of urban population and extra-urban environment.

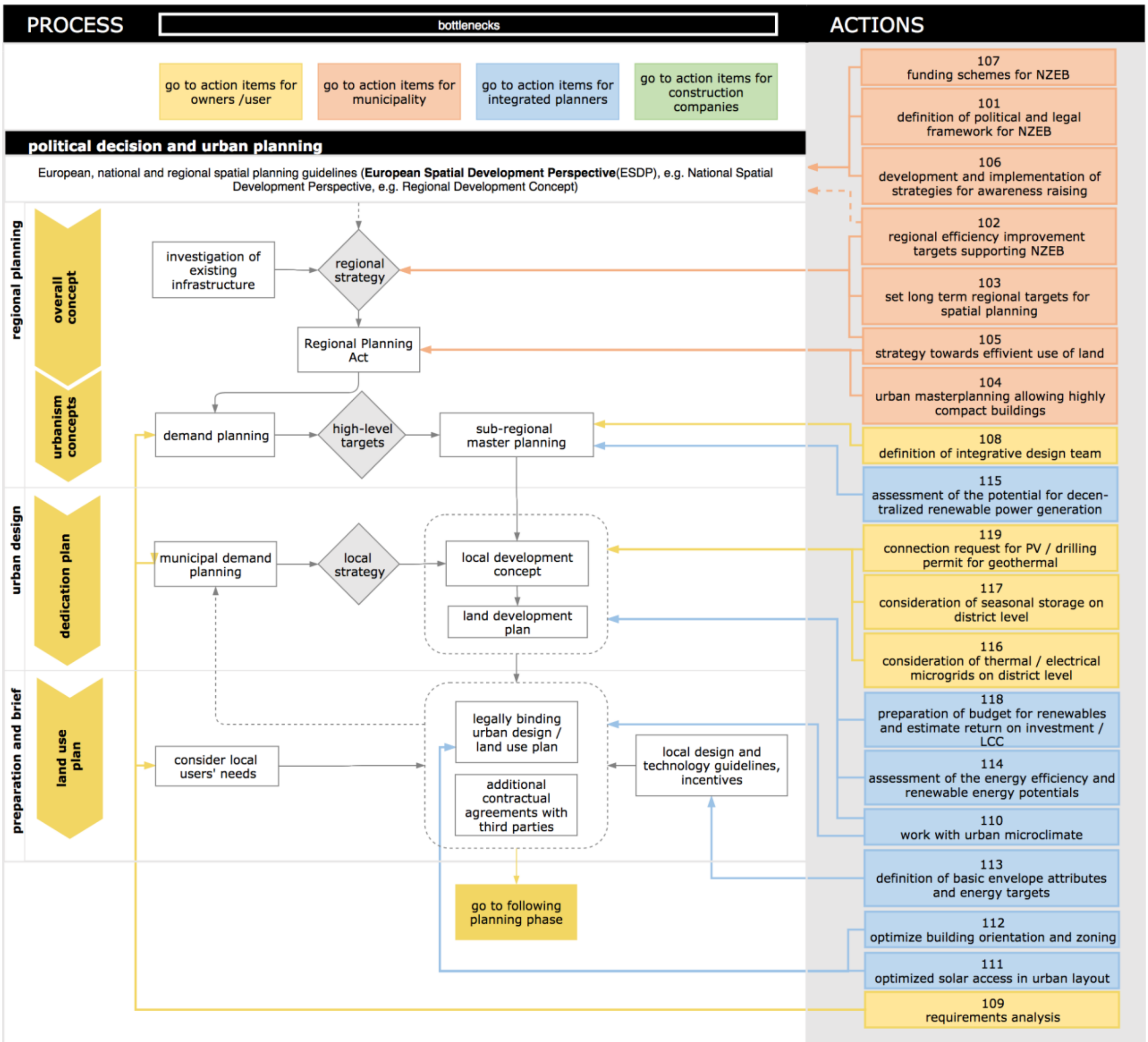
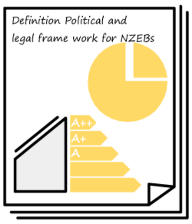


Figure 14: Urban planning process with stakeholder-related actions (numbered as 101 to 119)

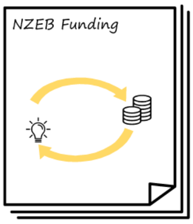
1.1 Definition of the political and legal framework for nZEBs



Lack of a political and legal nZEB framework might lead to higher follow-up costs: This is the case, if economically feasible and energetically reasonable solutions are inhibited due to legal limitations. Increased investments in energy-related nZEB technologies and services derive most likely from legal framework stimulating socio-economic development.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Authorities	Citizen groups/NGOs; Society; Politicians	**- €** [2]		**- €€**	Energy savings and CO_2-reduction

1.2 Funding schemes for nZEBs



Funding schemes usually aim at investment costs, e.g. by conceding a defined amount of money in the construction phase. They might however also influence follow up costs, by reducing taxes, annuities or interests on pay-back rates. And there are some examples of subsidies directly supporting a monitoring-based operation of the nZEB technologies implemented.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economics) Chambers	Authorities; Politicians		**- €**	**- €**	Energy savings and CO_2-reduction

1.3 Development and implementation of strategies for awareness raising

If awareness-raising is accompanied by dissemination of implementable measures, costs for planning and decision making are reduced. Follow up costs can be strongly reduced due to advanced user behaviour, which depends on well-edited information about nZEB and ends users' awareness.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Politicians	Tenants/Users; Authorities; (Economic) Chambers; Citizen groups/NGOs	**- €**		**- €€**	User acceptance

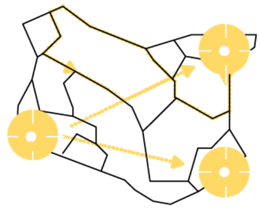
[2] [**-€,-€€,-€€€,+€,+€€,+€€€**] The cost savings or higher costs depending on the action are shown in the table below. Therefore -€ means that less costs are required than in a conventional planning procedure. On the other hand, +€ means that the costs increase. The number of € also indicates whether the change is big or small com-pared to the already known costs. The cost estimation for the different actions and the different cost-causing project steps were made in the course of the research project with the help of the project partners.

1.4 Regional efficiency improvement targets supporting nZEB

When regional governments define binding overall nZEB targets and priorities the planning process is more focused and straight. If additional funding for the construction phase is offered, investment costs can be saved. Highly efficient low energy buildings that are well embedded into their surrounding energy system moreover save follow up costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Politicians	Authorities; Planners; Municipalities; Citizen groups/NGOs; Society	- €	- €	- €€	CO_2-reduction and value development

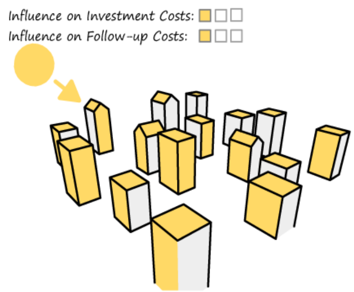
1.5 Set long term regional targets for spatial planning



The spatial distribution of buildings has an impact on their energy consumption and life-cycle costs (Moghadama *et al.*, 2015). This is mainly due to mobility and infrastructure needs. When aiming at a nZEB, infrastructure and mobility cannot be neglected. The use of existing infrastructure in higher density leads to lower investment costs for infrastructure, both for the building owner as well as the municipality.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Politicians	Authorities; Planners; Municipalities; Citizen groups/NGOs; Society	- €	- €	- €€	Energy and resource savings

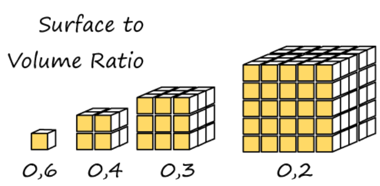
1.6 Assessment of the energy efficiency and renewable energy potentials



The relevant regulation framework and surrounding grid condition of a specific area have a great influence on the assessment of energy efficiency and renewable energy potential. If defined clearly and use of renewables from the grid is possible, then no additional costs arise during planning and construction. Even more, the operation will save costs by lower energy demand and by exploiting the low marginal costs of existing renewable energy grids.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Landlords; Planners; Municipalities; Society			- €	Resource savings, CO_2-reduction

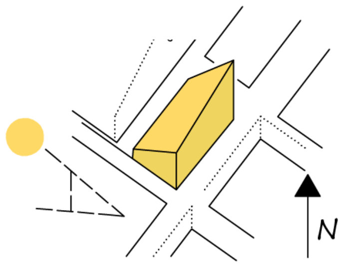
1.7 Urban master planning allowing highly compact buildings



In order to reduce costs in compact buildings, an urban masterplan is required. In addition to optimized energy consumption, compact buildings usually have reduced planning, investment and construction costs: Reasons are reduced material consumption, more similar units as well as fewer access areas.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Municipalities	Owners; Authorities; Citizen groups/NGOs; Politicians; consultants		- €	- €€	Energy and resource savings

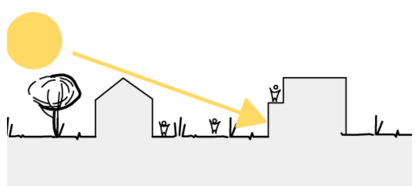
1.8 Optimize building orientation and zoning



Building orientation is often fixed by the legally binding land use or urban plan. But within this boundary, window orientation or functional zoning can lower the potential energy demand by detailed planning. Due to this energy saving, follow up costs will be reduced.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Real estate fund; Authorities; Municipalities; Citizen groups/NGOs; Politicians	+ €		- €	Resource savings, user comfort, daylighting in winter

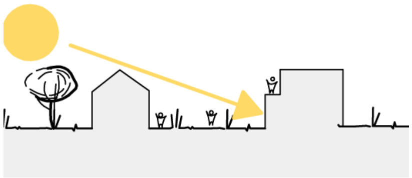
1.9 Optimize solar access in urban layout



When solar access is actively given to a quarter's layout by spatial planning and included in the land use plan, an energetic and economic optimum can be found for neighbouring buildings/properties. That means low follow-up costs by energy saving using passive solar gains.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Landlords; Authorities; Municipalities; Politicians	+ €		- €	Resource savings, comfort

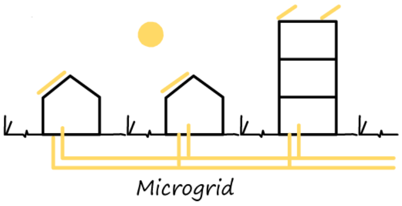
1.10 Work with urban microclimate



Costs arise mostly due to non-standard planning. Green facades were traditionally used to save construction costs: they replaced the final plaster finish (Köhler, 2008). A green façade or roof can also reduce follow up costs: Green facades and roofs clean the air (Bianchini and Hewage, 2012) and thus mean a lower necessity for ventilation and filtering systems, moreover less maintenance for the wall is needed.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
	Municipalities; Authorities; Planers; Citizen group/ NGOs; Society		+ €	- €	User satisfaction, microclimate, air quality, passive cooling

1.11 Consideration of thermal / electrical microgrids on the district level



A micro-grid is a stable and often renewable-based source for heat/power that has to be considered when supplying energy to nZEB. It reduces investment costs since generation and storage are large-scale and thus more cost-efficient. Moreover, maintenance and replacement again keep costs low due to the economy of scale.

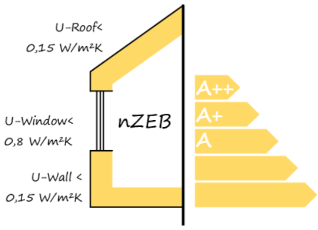
MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Utilities	Landlords; Authorities; Planers; Municipalities; (Economic) Chambers; Politicians	+ €	- €		Resource savings, fast reaction to changes in the energy market, autonomy

1.12 Consideration of seasonal storage on district level

Several studies by (Braun, Klein and Mitchell, 1981; Lindenberger *et al.*, 2000; Nordell and Hellström, 2000; Schmidt, Mangold and Müller-Steinhagen, 2004) show the potential of seasonal storage systems regarding renewable energy and costs. Seasonal storage should be considered if low supply temperatures are needed, and renewable energy sources are available. For economic feasibility, it can be meaningful to include a back-up or peak supply system with low system costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Utilities	Landlords; Authorities; Planers; Municipalities; (Economic) Chambers; Politicians		+ €	- €	A higher share of renewables, autonomy

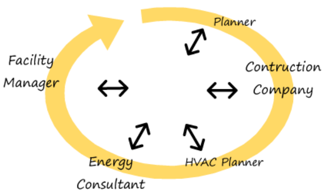
1.13 Definition of basic envelope attributes and energy targets



Energy-related basic envelope attributes and targets can be defined on a regional or district level, e.g. in the building code. Therefore also building energy certification systems are used. Sometimes this lowers planning costs since the possible solution frame is limited, but sometimes it increases them, since some planners are not familiar with implementation. Mostly construction costs increase because of extended effort with on-site implementation, but energy demand goes down.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Authorities; (Economic) Chambers; Citizen groups/NGOs		+ €	- €	Energy savings, comfort

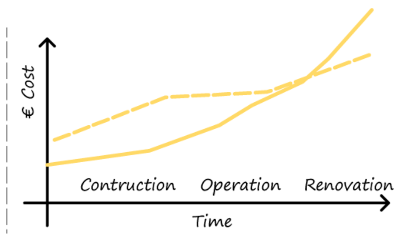
1.14 Definition of the integrative design team



In terms of costs, an integrated urban design process increases planning costs since the interaction between different players requires more involvement. Follow up costs are expected to be lower, both for end users and the public (cf. Lippaiová and Reith, 2014, Bragança, Vieira and Andrade, 2013).

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Real estate fund; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	+ €		- €€	Resource savings and CO_2-reduction

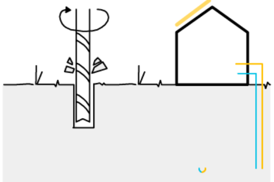
1.15 Preparation of budget for renewables and estimate return on investment / LCC



In order to find a cost-optimal nZEB solution, investment and life-cycle costs, as well as feed-in tariffs for renewables, have to be known (Hamdy, Sirén and Attia, 2017). To allow for fast and reliable LCC calculation, it is essential that information on costs, prices and tariffs is made available. One difficulty is that future energy prices are fixed on – uncontrollable - international markets, but the policy could counteract here in future.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Authorities; Municipalities; Investors; (Economic) Chambers; Politicians; Utilities	+ €	+ €	- €	LCC know-how

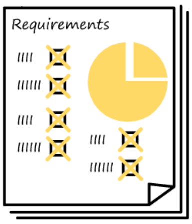
1.16 A connection request for PV / drilling permit for geothermal



Due to the traditional structure and organization of electricity grids, access for feed-in is still limited. In order to avoid unnecessary troubles and costs later on, it is essential to ask for a grid connection request. The same is true for geothermal energy by deep drilling – permission and technical expertise is necessary to keep operating costs low.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Landlords; Authorities; Planners; Municipalities; Utilities			- €	Value development, energy savings

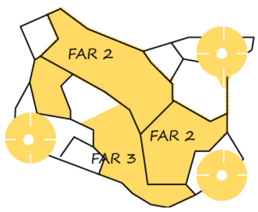
1.17 Requirements analysis



Each planning process has to be preceded by an analysis of requirements. The resulting chart of requirements can concern functional issues, but also limits on costs and energy consumption as well as technological systems to be used. Requirements can be obligatory by law and lead to lower costs in all stages of the process.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Planners, Citizen groups/ NGOs;	- €	- €	- €	Resource savings and value development

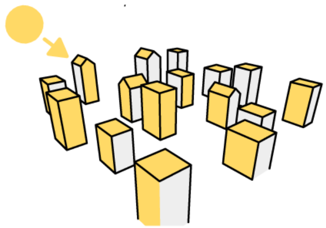
1.18 Apply strategy towards efficient use of land



Successful measures towards efficient use of land and densification lead to lower follow-up costs. Investmentment costs might increase, e.g. for the realization of Green roofs (Porsche and Köhler, 2013) or ambitious planning for geometry and foundation, but also decrease since investments in public infrastructure are lower if smaller areas need to be accessed.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Municipalities	Landlords; Authorities; Planners; Society; Politicians		- €	- €	Resource savings

1.19 Assessment of the potential for decentralized renewable power generation



In many European regions, GIS-based analyses are available to assess the potential of renewable energy use on-site. Different types of assistance are offered for the promotion of decentralized renewable energy. Very often, decentralized renewable power generation is subsidized by fixed feed-in tariffs, and additionally lowers the running energy costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Construction company; Authorities; Utilities			- €	CO_2-reduction

2.4. PROCESS EVALUATION RESULTS

2.4.1. LIST OF ACTIONS RELATED TO STAKEHOLDERS AND OTHER ACTIONS

In the following table, the various actions were assigned to the main drivers and other stakeholders in order to clarify the question of responsibility. In addition, the various dependencies of the actions are listed in the right-hand column of the table to show which actions and stakeholders need to be communicated subsequently.

Table 1: List of actions - urban planning

	ACTIONS	MAIN DRIVER	STAKE-HOLDERS	INFLUENCES ON OTHER ACTIONS
1.1	**Definition Political and legal framework for nZEBs**	Authorities	Citizen groups/NGOs; Society; Politicians	1.2, 1.7, 1.13, 1.16, 2.25
1.2	**Funding Schemes for nZEB Buildings**	(Economic) Chambers	Authorities; Politicians	1.1, 1.11, 1.15, 2.12, 2.13, 2.17, 2.25, 4.8
1.3	**Development and Implementation of strategies for awareness raising**	Politicians	Tenants/Users; Authorities; (Economic) Chambers; Citizen groups/NGOs	1.4, 1.5, 1.10, 1.18, 2.5, 2.27, 3.7, 4.3, 4.6
1.4	**Regional efficiency improvement targets supporting nZEB**	Politicians	Authorities; Planners; Municipalities; Citizen groups/NGOs; Society	1.10, 1.12, 1.18, 2.9, 3.10
1.5	**Set long term regional targets for spatial planning**	Politicians	Authorities; Planners; Municipalities; Citizen groups/NGOs; Society	1.1, 1.9, 1.10, 1.12, 1.19, 1.21, 2.5, 2.21
1.6	**Assessment of energy efficiency and renewable energy potentials**	(Economic) Chambers	Landlords; Planners; Municipalities; Society	1.11, 1.17, 2.6, 2.9, 2.17
1.7	**Urban Masterplanning Allowing highly compact buildings**	Planners	Owners; Authorities; Municipalities; Citizen groups/NGOs; Politicians	1.12, 2.5, 2.6, 2.27
1.8	**Optimize Building Orientation and Zoning**	Planners	Real estate fund; Authorities; Municipalities; Citizen groups/NGOs; Politicians	1,7

	ACTIONS	MAIN DRIVER	STAKE-HOLDERS	INFLUENCES ON OTHER ACTIONS
1.9	**Optimize Solar Access in Urban Layout**	Planners	Landlords; Authorities; Municipalities; Politicians	1.7, 1.8, 1.18, 1.19, 2.6, 2.27
1.1	**Work with Urban Microclimate**	Municipalities	Tenants/Users; Owners; Authorities; Planners; Citizen groups/NGOs; Society	1.5, 1.18, 3.10
1.11	**Consideration of Thermal / Electrical Microgrids on District Level**	Utilities	Landlords; Authorities; Planners; Municipalities; (Economic) Chambers; Politicians	1.1, 1.6, 1.15, 1.17, 1.19, 2.12, 2.13, 2.27, 3.7, 3.10
1.12	**Consideration of Seasonal Storage on District Level**	Utilities	Authorities; Planners; Municipalities; Investors; (Economic) Chambers; Citizen groups/NGOs	1.1, 1.6, 1.11, 1.17, 2.9, 2.17, 2.27, 3.10
1.13	**Definition of Basic envelope attributes and Energy Targets**	Planners	Owners; Authorities; (Economic) Chambers; Citizen groups/NGOs	1.6, 1.19, 2.2, 2.9, 2.20, 3.10
1.14	**Definition of Integrative Design Team**	Owners	Owners; Real estate fund; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	1.2, 1.3, 1.4, 1.18, 2.6, 2.21, 2.25
1.15	**Preparation of budget for renewables and estimate return on investment/ LCC**	Planners	Authorities; Municipalities; Investors; (Economic) Chambers; Politicians; Utilities	1.2, 2.25
1.16	**Connection request for PV / drilling permit for geothermal**	Owners	Landlords; Authorities; Planners; Municipalities; Utilities	1.1, 1.4, 1.17, 2.6, 2.21, 2.25, 2.27
1.17	**Requirements Analysis**	Planners	Tenants/Users; Owners; Real estate fund; Authorities; Municipalities; Investors; (Economic) Chambers; …	1.4, 1.5, 1.15, 2.4, 2.17, 2.21, 2.25, 3.2
1.18	**Apply Strategy towards efficient use of land**	Municipalities	Landlords; Authorities; Planners; Society; Politicians	1.5, 1.7, 1.10
1.19	**Assesment of the Potential for Decentralized renewable power generation**	Planners	Owners; Construction company; Authorities; Utilities	1.1, 1.6, 1.11, 3.7

2.4.2. LIST OF ACTIONS RELATED TO COSTS

The cost savings or higher costs depending on the action are shown in the table below. Therefore -€ means that less costs are required than in a conventional planning procedure. On the other hand, +€ means that the costs increase. The number of € also indicates whether the change is big or small compared to the already known costs. The cost estimation for the different actions and the different cost-causing project steps were made in the course of the research project with the help of the project partners.

Table 2: List of actions in relation to costs - urban planning

	ACTIONS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS
1.1	**Definition Political and legal frame work for nZEBs**	- €	X	- €€
1.2	**Funding Schemes for nZEB**	X	- €	- €
1.3	**Development and Implementation of strategies for awareness raising**	- €	X	- €€
1.4	**Regional efficiency improvement targets supporting nZEB**	- €	- €	- €€
1.5	**Set long term regional targets for spatial planning**	- €	- €	- €€
1.6	**Assessment of the energy efficiency and renewable energy potentials**	X	X	- €
1.7	**Urban Masterplanning Allowing highly compact buildings**	X	- €	- €€
1.8	**Optimize Building Orientation and Zoning**	+ €	X	- €
1.9	**Optimize Solar Access in Urban Layout**	+ €	X	- €
1,10	**Work with Urban Microclimate**	X	+ €	- €
1.11	**Consideration of Thermal / Electrical Microgrids on District Level**	+ €	- €	X
1.12	**Consideration of Seasonal Storage on District Level**	X	+ €	- €
1.13	**Definition of Basic envelope attributes and Energy Targets**	X	- €	- €
1.14	**Definition of Integrative Design Team**	+ €	X	- €€
1.15	**Preparation of budget for renewables and estimate return on investment/ LCC**	+ €	+ €	- €
1.16	**Connection request for PV / drilling permit for geothermal**	X	X	- €
1.17	**Requirements Analysis**	- €	- €	- €
1.18	**Apply Strategy towards efficient use of land**	X	- €	- €
1.19	**Assesment of the Potential for Decentralized renewable power generation**	X	X	- €

2.4.3.LIST OF ACTIONS – WORK BREAKDOWN STRUCTURE

The following diagram gives an overview of all actions assigned to urban planning. In addition, they are further divided into three categories in order to clearly define to which part of the planning the individual actions belongs to.

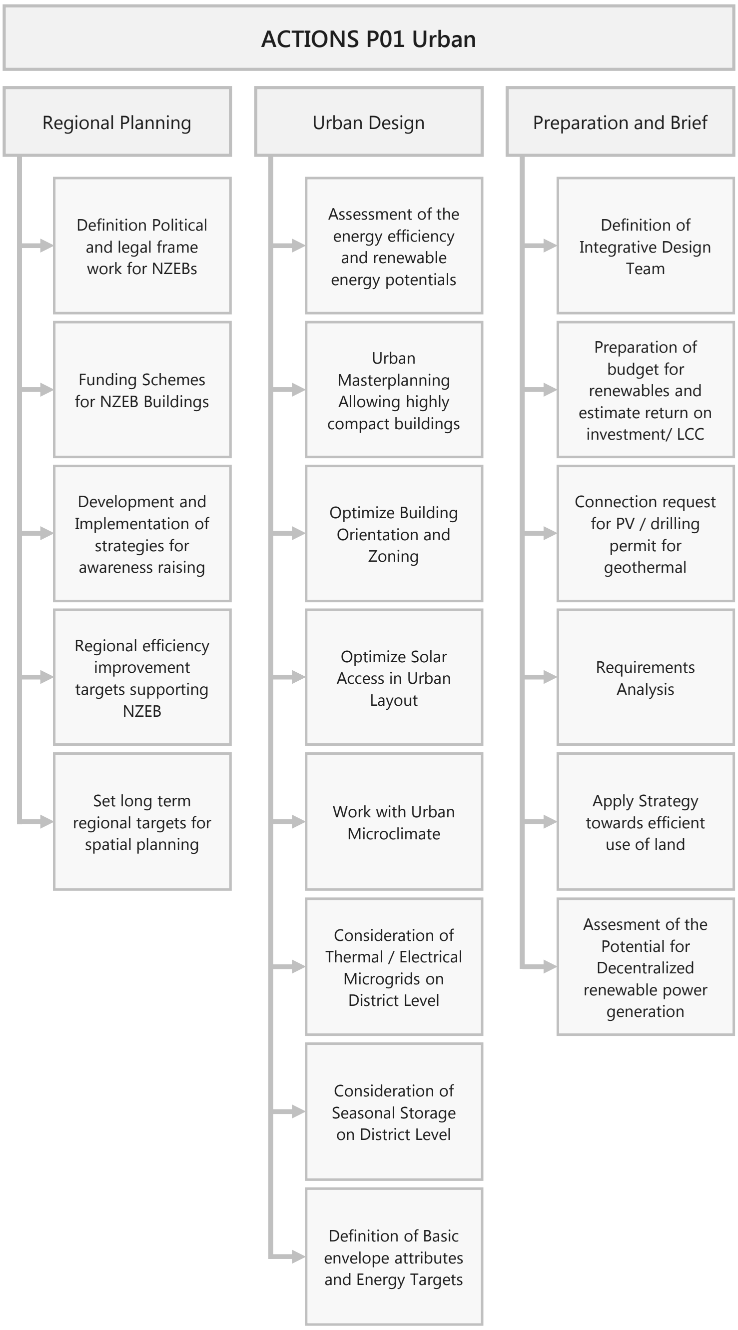


Figure 15: List of actions in urban planning "work breakdown structure" (WBS)

2.4.4.LIST OF ACTIONS – RELATIONS BETWEEN THE ACTIONS

In order to ensure successful cooperation of the stakeholders, it is important to show in which dependencies their actions are and in consequence, they are related to other stakeholders and actions. The following figure shows the dependencies of the different actions. This analysis is based on the preference analysis and was developed based on the ideas of the PLENAR planning tool, which aims to show interdisciplinary relationships in order to achieve a common understanding of planning.

In addition to the different actions of the phase to be considered, the main responsible actors are listed in order to obtain a quick overview. The coloured fields describe the dependencies of the different actions on each other. The red fields describe a bilateral, while the blue fields describe partial correlation (e.g Action 1: "Definition of political and legal framework" has a bilateral correlation, marked in red with Action 2 "Funding Schemes for nZEBs). The grey fields indicate which actions are connected to other phases

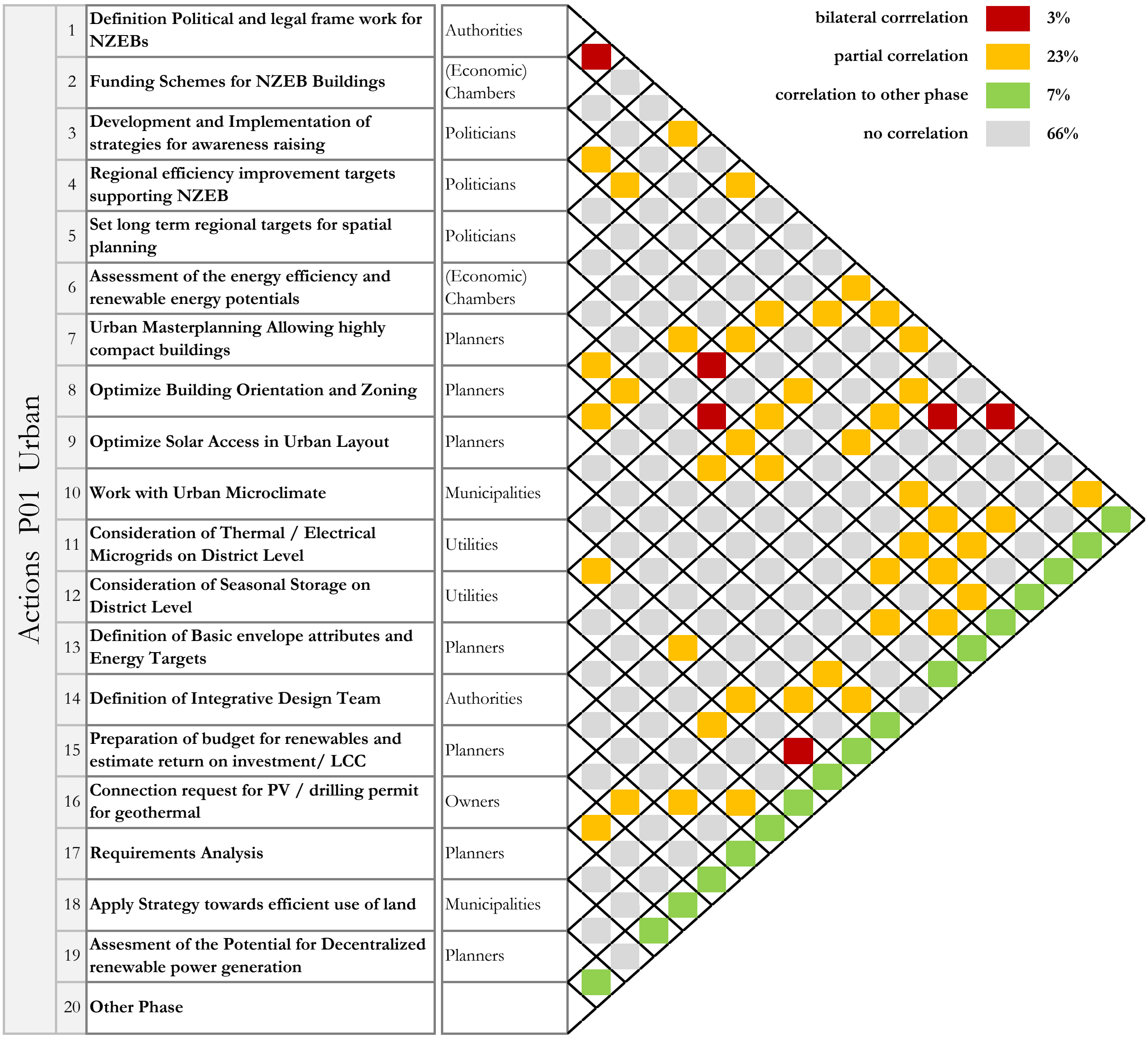


Figure 16: Urban planning process with stakeholder-related actions

CHAPTER 3

INTEGRATED BUILDING DESIGN PROCESS

3.INTEGRATED BUILDING DESIGN PROCESS

3.1. OVERALL PROCESS

An integrated building design process may have many definitions and meanings. In general, it may be considered a holistic approach, which considers the interactions between different actions, rather than optimising them separately. E.g. optimising building layout/plans from a user perspective may have major effects for the superstructure of the building, which in turn causes unnecessary additional costs.
It is important that the process is supported by the entire design team. The outcome of the process should be targeted to create a building with:

- Architectural quality
- High energy efficiency/low environmental impact
- Healthy indoor climate

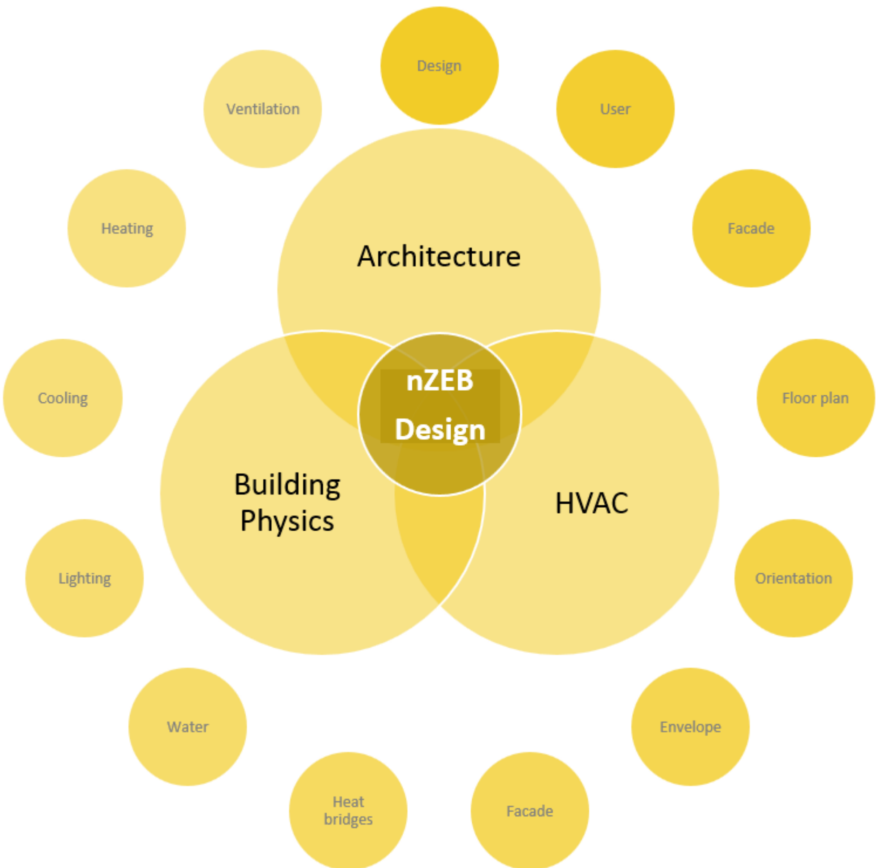


Figure 17: Integrated nZEB planning process

PROCESS

bottlenecks

go to previous phase

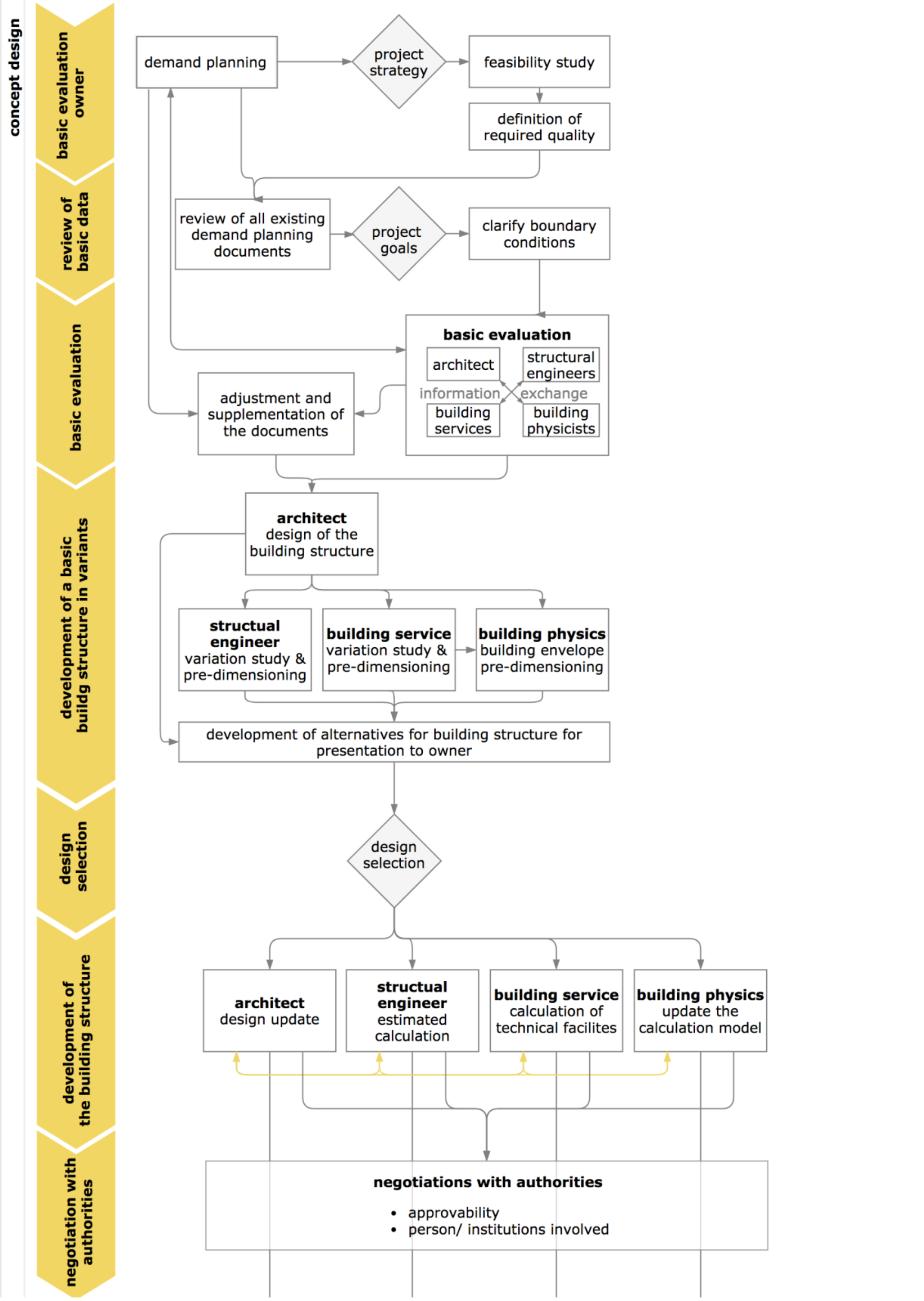
go to action items for owners /user

go to action items for municipality

go to action items for integrated planners

go to action items for construction companies

planning phase



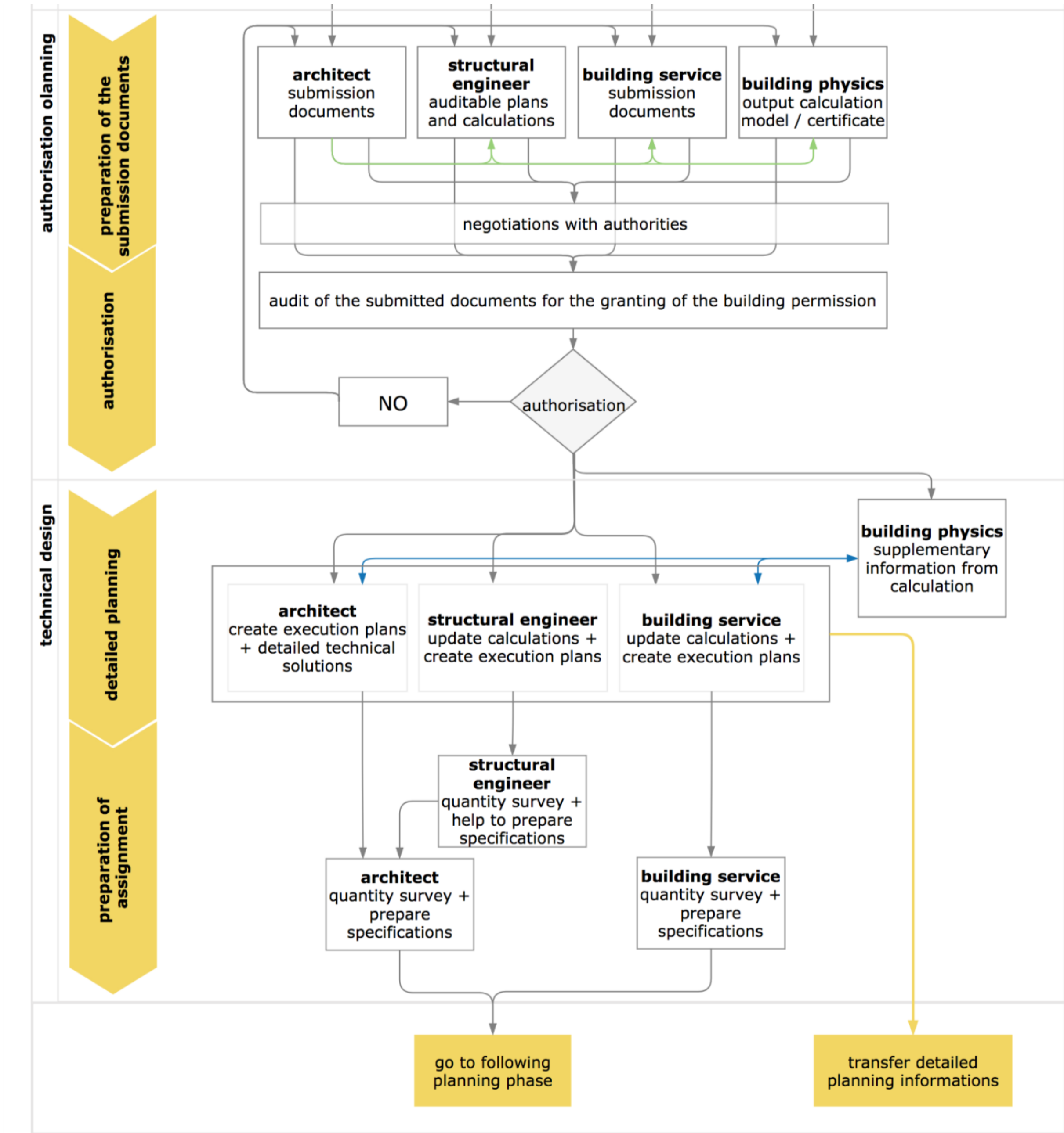


Figure 18: Integrated planning process / planning phase

3.1.1.CONCEPT DESIGN

The concept design starts with demand planning. To be able to start the demand planning it is important to understand the client´s requirements and clearly define the project goals. It is important that the entire design team understands the goals of the project and understands that the work needs to be iterative and depends on cooperation. For projects with considerably higher goals, like nZEBs, the design process should start with a feasibility study showing important technical solutions, costs, savings and potential solution sets that work well together. This provides a basis for decision of the main targets for the project. The most relevant feasibility studies are made with contribution from the architect, the energy specialist, the developer/ investor, the

construction manager and with insights from experts on sustainability, technical installations etc.
The overall verification method of the project goals is already defined in the concept design. The project team also needs to define how to verify the energy performance of the building. Should it be done by calculations/simulations and/or measurements in the operation phase? Exactly which software or which measuring equipment to use is usually not defined at this early stage of the process.
During the concept design, also critical pitfalls and bottlenecks which may affect the project goals need to be identified.

The quality of the processes depends on the project organization and the information provided about project goals and framework conditions.
It is the client's task as project manager to put together a project team (if this task is not delegated to the contractor, i.e. a so-called "general contractor") that can meet the requirements of its project objectives in every phase of the project. It is also up to the client to determine the degree of outsourcing of responsibility and decision-making power and to define roles and tasks for all related planning team members. In order to avoid the problems of coordination and cooperation, project participants, as well as the definition of responsibilities, decision levels, and the technical competencies corresponding to the complex requirements, lay the basis for a life-cycle oriented process (cf. IG-Lebenszyklus, 2014). It is important to choose how many and which specialists will be employed for the project, depending on the scope and complexity of the task. The expert knowledge from various disciplines should always be considered in order to achieve a holistically optimized building in which different requirements are balanced (BMWi, 2015, p. 4). In addition, integrative project organization should have a quality assurance effect, since several instances can check compliance with the required services.

Only a simultaneous and comprehensive interdisciplinary project team can fully deal with the dependencies between function, form and energy and thus also identify and evaluate the manifold cost effects of actions in the process.

This applies in particular to the financial consequences of architectural decisions on energy costs that cannot be determined by the LCC calculation. But also, the extended consideration of the environmental impacts requires corresponding experts and close cooperation in order to be able to evaluate and compare variants promptly. Close and iterative cooperation also reduces information losses and planning collisions and thus prevents time- and cost-intensive planning loops. Energy consultants ensure the processing of the required qualities in planning and execution, especially those that cannot be quantitatively defined in advance. A variant of different methodologies and procedures can be used: Variant development, comparative life cycle assessment and a constant target/actual comparison of the proposed solutions with the main project targets.
Information exchange between the partners in the process becomes even more relevant to the more complex. This is important because the main cause of planning errors and missed deadlines lies in the inadequate and incorrect availability of information. Therefore, the definition of communication channels is of great importance for the reduction of data and time loss. Smooth and transparent communication is the key to efficient planning of nZEBs. This must be maintained throughout the entire process, as subsequent decisions must be made on the basis of all information from previous decisions and dependencies.

Integral BIM (building information modelling) project:
The digital planning process of the BIM planning method is characterized by the changed structures of cooperation and communication in the planning teams.
Integral planning is the prerequisite for a lifecycle-oriented process that meets the economic, ecological and socio-cultural objectives. Architects and engineers work simultaneously and team-oriented on the best innovative solution and constantly check if qualitative and quantitative goals are reached. A data model, building information modelling – BIM, maps the process from the initial idea to all virtual planning variants and the real construction processes to the lifelong operation of the building.
The integral design phase is divided into different phases, in which know-how carriers from the different specialist areas come together. This development takes place in the investigation of variants and the

evaluation of the different concepts on the basis of ecological and economic considerations. The integral design method makes it possible to compare variants with each other and to select the concept that corresponds to the objectives of the client and the target values.

3.1.2.AUTHORISATION PLANNING

When the authorisation planning phase begins, the design team may have changed (new members come in and members may have left the team). It is therefore important to revisit and review the goals of the project, ensuring that goals and targets are understood by all members. During authorisation planning, the final design is not defined in detail. However, in order to handle critical issues which may affect the project goals (identified in the concept design) some technical solutions may need to be studied in detail.
Also, this part of the process is iterative and depends on cooperation. Interdisciplinary work is crucial in this part of the process. In order to facilitate the iterative and interdisciplinary work, it is advisable to gather the entire design team 2-4 times per month where the entire design team work on the project.
The verification of the project goals are defined more in detail and responsibility of the verification is defined.

In all European countries, there are regulations that regulate how construction may be carried out. These standards are necessary in order to plan and build safe, "healthy", energy-efficient and barrier-free buildings. Basically, Pedro et. al. defined five procedures in a publication according to which an approval procedure can operate (Pedro, 2010).
1) Exemptions: construction works that have to meet the planning demands and the technical requirements but are exempt from the permit procedure.
2) Building notice: construction works that have to be notified to the building authority but can be carried out without a building permit.
3) Light procedure: construction works that require a building permit but compliance of building design with building regulations is only insured for part of the technical requirements.
4) Regular procedure: construction works that require a building permit and compliance of building design with building regulations is ensured for all the technical requirements.
5) Regularization: construction works that have been built without the required building permit or contrary to the terms and conditions specified in the building permit, but may be legalised.

In the different European countries, there are different combinations of possible approval procedures:
- Exemptions and regular procedure (e.g. Belgium, Cyprus, Hungary, Romania and Scotland).
- Exemptions, building notice and regular procedure (e.g. Austria, Bulgaria, Czech Republic, France, Italy, Luxembourg, Malta, Portugal, Slovenia, Sweden, Northern Ireland and England & Wales).
- Exemptions, light procedure and regular procedure (e.g. Germany, Lithuania, the Netherlands and Spain).
- Exemptions, building notice, light procedure and regular procedure (e.g. Estonia, Ireland and Slovakia).

Table 3: Types of construction permits in different countries (Pedro, Meijer, Visscher, 2010)

	EXEMPTIONS	BUILDING NOTICE	LIGHT PROCEDURE	REGULAR PROCEDURE	REGULARIZATION
Austria	✓	✓		✓	
France	✓	✓		✓	
Germany	✓		✓	✓	
Italy	✓	✓		✓	
Sweden	✓	✓		✓	

The approval process basically includes the steps:

- pre consultation
- (planning permit)
- submission
- plan approval

Not all steps are applied equally in all European countries.

Within the scope of the pre-consultation, information about regulations on use, building height, maximum structural mass, etc. can be requested. With the exception of Bulgaria, this inspection is a voluntary process step that makes the approval process a more reliable and secure one for the planner / building owner. The information provided is handled differently in the countries of the European Union.

Table 4: Given information during the pre-consultation are binding / non-binding for the permission process (Pedro, Meijer, Visscher, 2010)

	BINDING INFORMATION	NON-BINDING INFORMATION
Austria		✓
France		✓
Italy	✓	
Sweden	✓	

The next step in authorisation is handled differently in the European Union. In some countries, a planning permit must first be issued before a final permit is given. But the planning permission is not yet a binding approval for the construction of the building. The separate approval of design and building is carried out in France and Sweden. In Austria, Germany and Italy there is only one approval process for the building.

Information on building standards and the procedure for approval can be found on the internet in all EU countries. Codes, brochures and paper forms, can also be downloaded from the internet. In one-third of the countries, electronic intake of a building permit application is already possible or being implemented in some countries (Pedro, Meijer, Visscher, 2010).

3.1.3.TECHNICAL DESIGN

When the technical design phase starts; the configuration of the design team may have changed (new members come in and members may have left the team). It is therefore important to revisit and review the goals of the project; ensuring that they are understood by all members.

Assumptions made in the concept design and authorization planning need to be checked and verified (e.g. ventilation rates, specific values for thermal bridges, type of thermal insulation etc.).

Also, this part of the process is iterative and depends on cooperation. Interdisciplinary work is crucial in this part of the process. In order to facilitate the iterative and interdisciplinary work, it is advisable to gather the entire design team 2-4 times per month where the entire design team work on the project.

During technical design, the verification of the goals of the project is defined in detail.

As the commissioning tests are crucial for the outcome of the project, these tests need to be defined in this phase.

In order to manage information in an effective way, it is important that all members of the design team have access to information (e.g. specifications, Gantt scheme, drawings etc.). This is effectively handled by using cloud-based management tools.

If the client has chosen to procure the project as a BC[3] the client manages the design team. The advantage of a BC for the client is that the client has the possibility to control the design in detail. However, the client may not have the competence to do this, needing external consultants. Furthermore, if the contractor is not involved, the design team may lack the insight of cost drivers, ending up with a costly design.

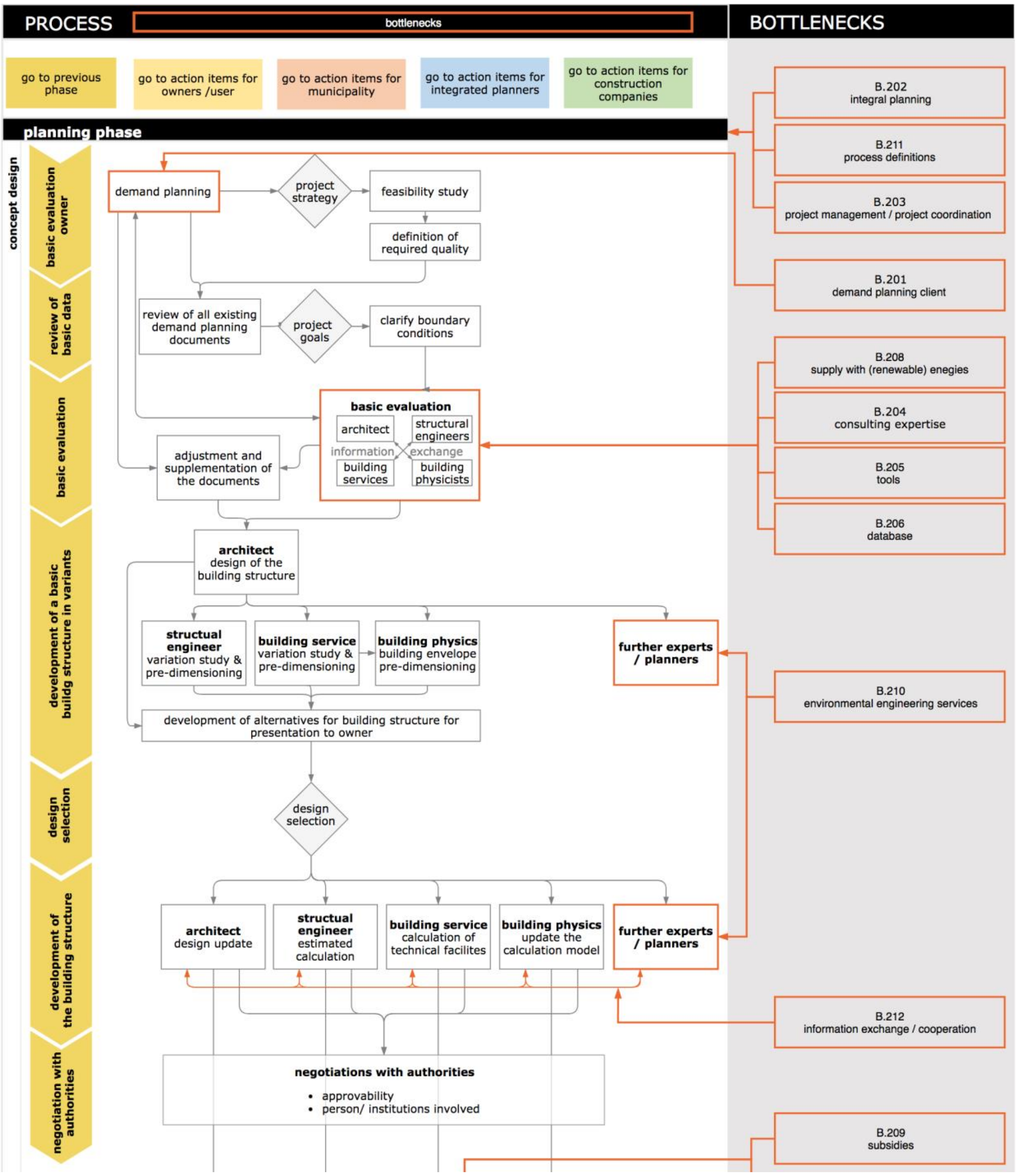
For the other types of procurement, the contractor manages the design team. The risk of errors in design is transferred to the contractor, and the contractor involvement will facilitate the work to achieve a cost-effective design. However, the client experiences a loss of influence on the design.

[3] Build contracts (BC)

In these projects, the client has (before contractor involvement) designed a building, including technical design, and asks different contractors for their bid. Usually the lowest bid wins the contract.

In this case, the client holds the risk of errors in design and the contractor is not part of the design process.

3.2. PITFALLS AND BOTTLENECKS



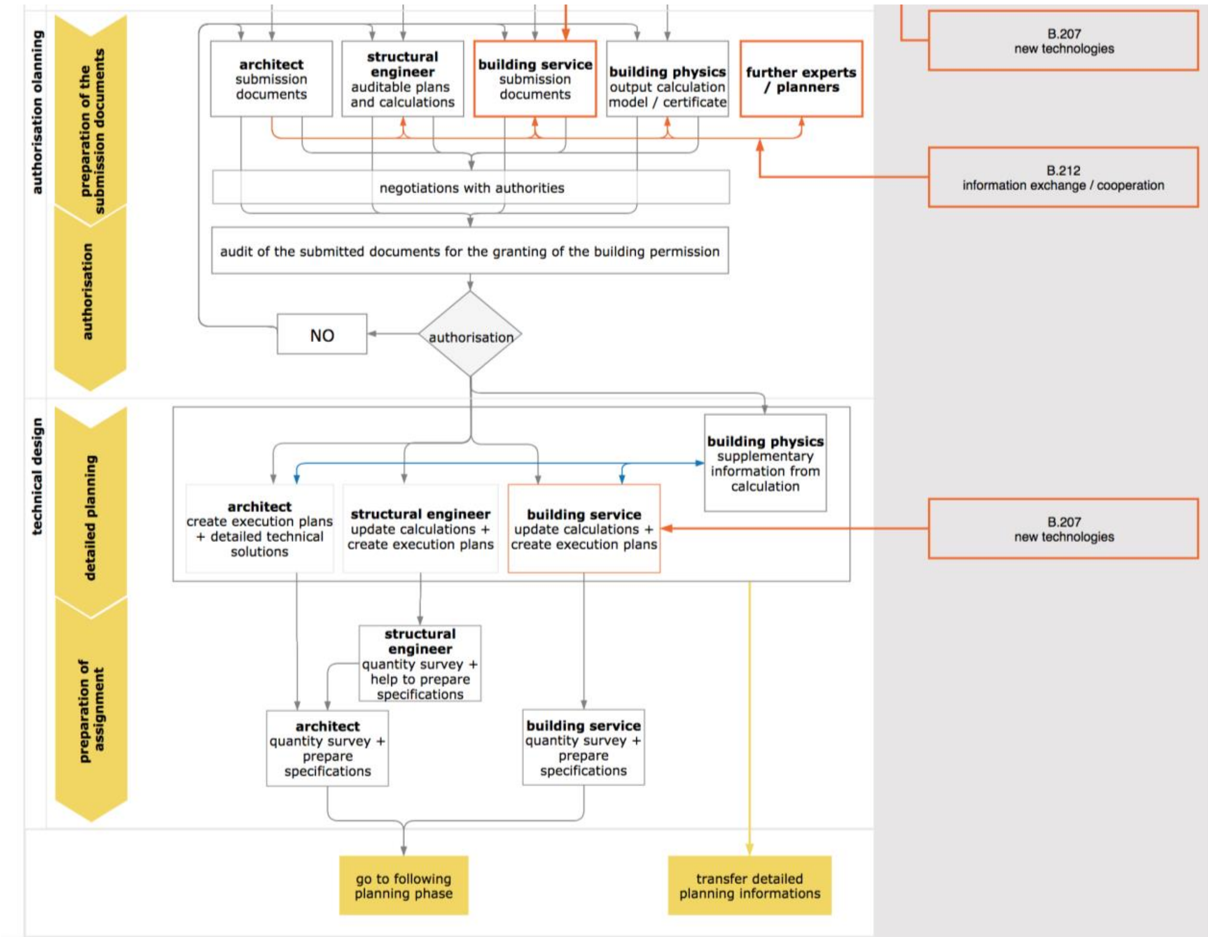


Figure 19: Integrated planning process with bottlenecks

B.201: Demand planning client

At the beginning of the planning process, it is important to describe the demand exactly, because on this basis the planning is set up by the integral planner team. In the context of this demand planning, it is necessary to define precisely what the client's objectives are in terms of life-cycle costs, the environment and social factors. These objectives must be described in such a way that they can be measured based on a few parameters (numerical values).

B.202: Integral planning

In order to be able to plan nZEBS, it is important that all planning departments work together as a team. This is necessary because new technologies have to be combined with complex geometric requirements. In order to implement this task both effectively and sufficiently, it is necessary for the individual disciplines to work on a common basis in a continuous exchange of information.

B.203: Project management / - coordination

nZEBs are mostly complex systems that have been developed for a specific building structure. These systems are usually developed in early planning phases based on concepts. These concepts are continuously refined during the project. Changes to these systems usually have far-reaching consequences, such as delays and inefficiencies in the planning process. Good information management must also be carried out with the construction site to be able to implement the planned systems accordingly.

B.204: Consulting expertise

To provide comprehensive advice to the customer, it is important to relate the effects of the decisions to the life cycle of a building or to a subsystem of a building. The impact of decisions on life-cycle costs, environmental impacts and social aspects must be clearly identified so that the decision can be made based on a secure database.

B.205: Tools

Implementing a nZEB in planning requires an early assessment and evaluation of a variety of parameters, which are classically only examined at a later planning stage. Therefore, it is necessary to develop new methods and tools, so that the necessary results can be worked out at the desired time in the planning process.

B.206: Database

To be able to estimate a building in future use phases realistically, it is important to carry out the calculations and evaluations based on a reliable data basis. In addition to operating data such as maintenance, cleaning and repair costs, this should also include costs for an end-of-life scenario, energy prices and price increases. The scope of the database is so essential because a building functions as an overall concept and thus the entire life cycle of a component has an influence when considering the economic viability of alternatives.

B.207: New technologies

Using new technologies or a new combination of individual known elements, it can become relevant to incorporate the experience of executing companies at the planning stage, as they often have further experience of execution problems or other restrictions. This early involvement avoids uncertainties in scheduling and design problems. This reduces the risk of testing new systems as all relevant parties work together to solve problems.

B.208: Supply with (renewable) energies

The type of supply and the renewable energy sources available at the building site must be checked and analyzed in early planning phases to be able to design the most energy-efficient and cost-effective overall system possible. See some relevant actions to that within the next chapter 4.3.

B.209: Subsidies

To receive some government-sponsored subsidies, it is necessary to send the application before installing the plant and wait for confirmation from the authority. If you do not follow the correct procedure, it is possible not to receive the grant. So, if the request is not processed in time, it slows down the whole process and postpones the installation.

B.210: Environmental engineering services

The influence of a technical or structural solution on the life cycle of a building is not investigated. This means that costs during the use phase, environmental impacts and social standards are not considered. Due to the lack of analysis and verification during operation, it is difficult to make reliable statements on these issues.

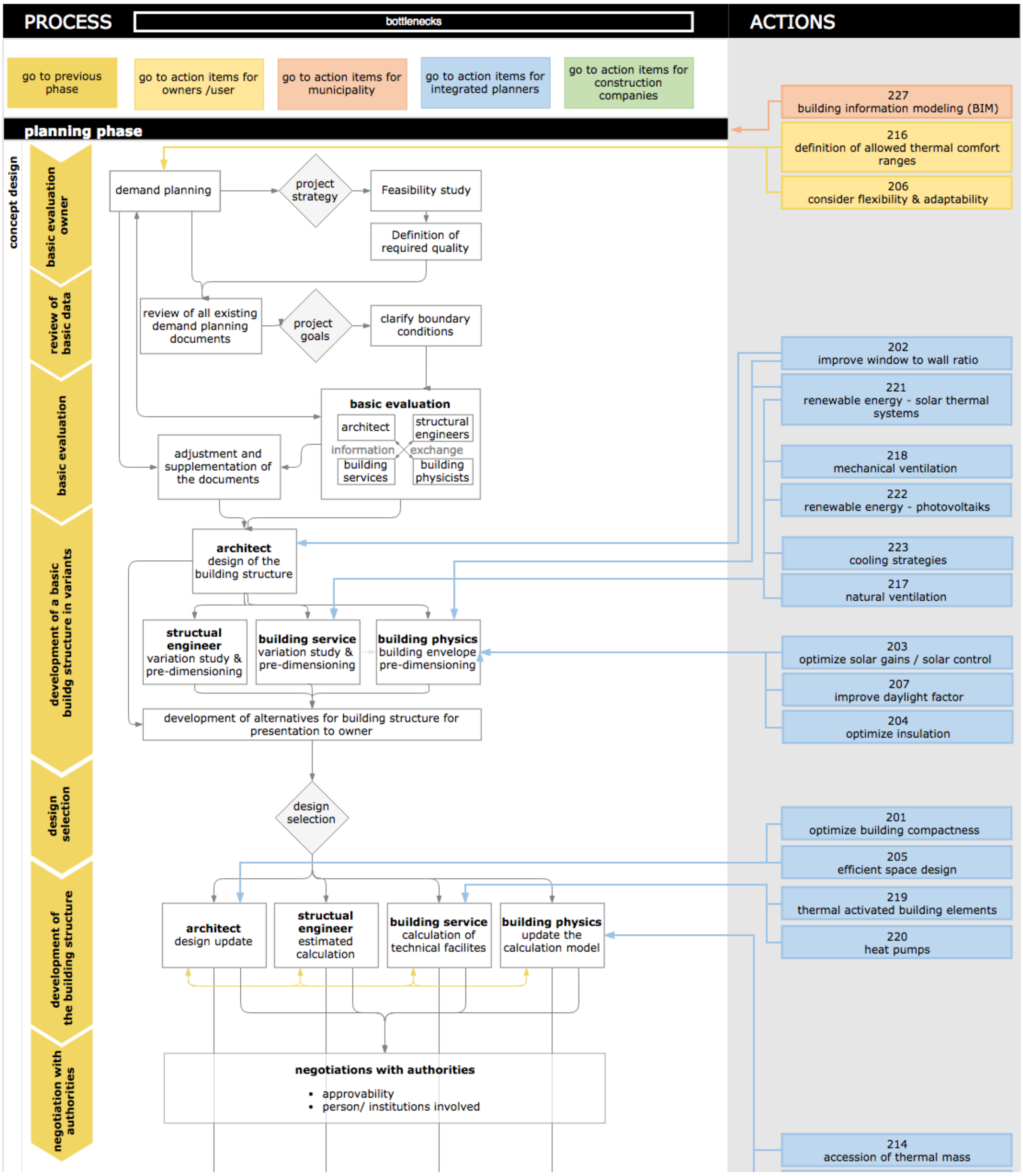
B.211: Process definitions

To be able to assenble a nZEB plan, new process flows are required. This results from the changed requirements the quality of the construction task. To achieve the goals, cooperative / participative processes and working methods must be developed.

B.212: Information exchange / cooperation

Due to the mostly complex systems of nZEBs it is necessary that all parties involved in planning, construction and use are in a constant exchange of information. This exchange must be described in the processes, so that a cooperative co-operation becomes possible.

3.3. ACTIONS



PROCESS
bottlenecks
ACTIONS
go to previous phase
go to action items for owners /user
go to action items for municipality
go to action items for integrated planners
go to action items for construction companies
planning phase
concept design
basic evaluation owner
review of basic data
basic evaluation
development of a basic buildg structure in variants
design selection
development of the building structure
negotiation with authorities
demand planning
project strategy
Feasibility study
Definition of required quality
review of all existing demand planning documents
project goals
clarify boundary conditions
basic evaluation
architect
structural engineers
information exchange
building services
building physicists
adjustment and supplementation of the documents
architect design of the building structure
structual engineer variation study & pre-dimensioning
building service variation study & pre-dimensioning
building physics building envelope pre-dimensioning
development of alternatives for building structure for presentation to owner
design selection
architect design update
structual engineer estimated calculation
building service calculation of technical facilites
building physics update the calculation model
negotiations with authorities
approvability
person/ institutions involved
227 building information modeling (BIM)
216 definition of allowed thermal comfort ranges
206 consider flexibility & adaptability
202 improve window to wall ratio
221 renewable energy - solar thermal systems
218 mechanical ventilation
222 renewable energy - photovoltaiks
223 cooling strategies
217 natural ventilation
203 optimize solar gains / solar control
207 improve daylight factor
204 optimize insulation
201 optimize building compactness
205 efficient space design
219 thermal activated building elements
220 heat pumps
214 accession of thermal mass

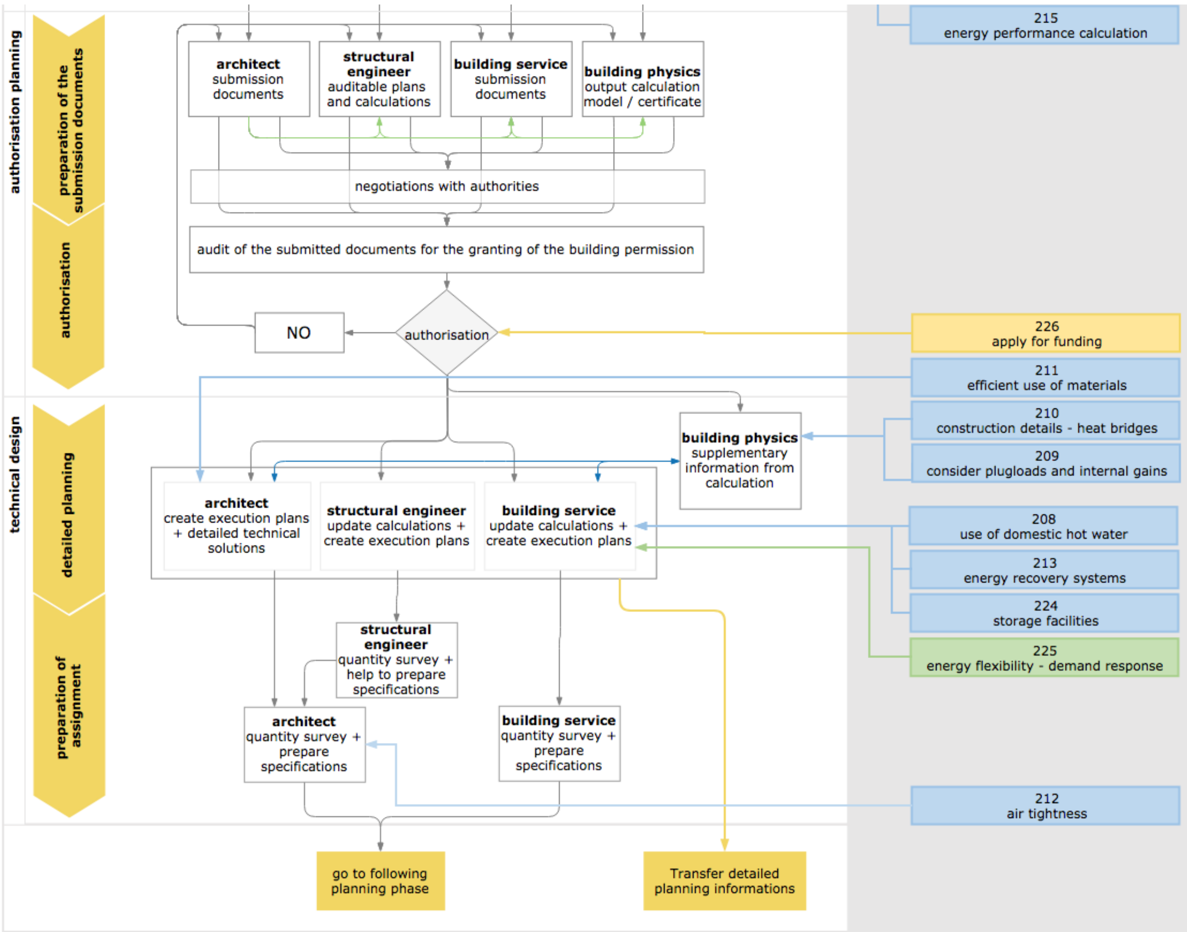
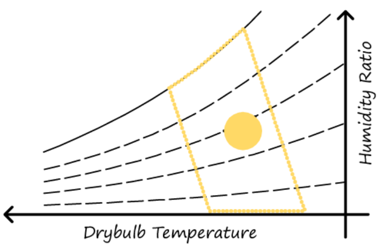


Figure 20: Integrated planning process with actions

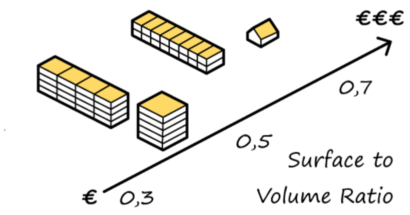
2.1 Definition of allowed thermal comfort ranges



Thermal comfort is a subjective need but tried to be defined objectively as the quality of the building's indoor environment. To increase thermal comfort, the planner must define optimal materials and technologies related to the building envelope and HVAC system. That could raise planning and investment costs, but satisfied users in the long run decrease effort and maintenance.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Tenants/Users; Owners; Utilities	+ €	+ €	- €	Comfort

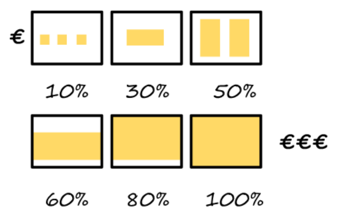
2.2 Optimize building envelope (compactness and insulation)



The planner should aim for buildings with the lowest form factor and good insulation to decrease heat losses, thermal bridges and to reduce overheating problems. Improving the compactness doesn't influence the planning cost and has further positive effects: It reduces the amount of construction materials needed, provides better comfort conditions for the resident and decreases heating energy demand. (NHBC Foundation, 2016, The challenge of shape and form).

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Authorities	Owners; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs			- €€	Value development

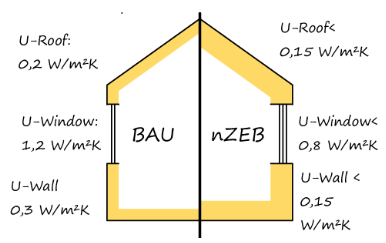
2.3 Improve window to wall ratio



Glazing and transparent components of a building influence the energy balance during summer and winter. Moreover, the transparent parts create high heat losses. It follows that a properly designed building with optimized (low) window to wall ratio and U-value contributes to minimising the investment costs, overall energy demand and follow-up costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Construction company; Authorities; Municipalities; (Economic) Chambers	+ €	- €	- €	Comfort and rental income

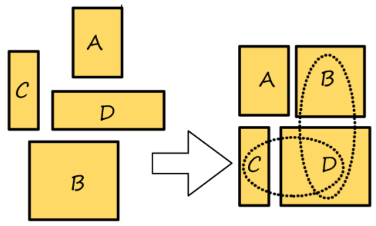
2.4 Optimize insulation



It is important to choose materials with low thermal conductivity and to optimize the thickness of external building components. Decreasing the U-value the number of construction materials needed increases and, therefore, also investment costs. On the other hand, improving the insulation provides better comfort conditions (increases mean radiant temperature and decreases local discomfort) and reduces follow-up costs, related to heating energy demand.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Real estate fund; Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs		+ €	- €€	Comfort

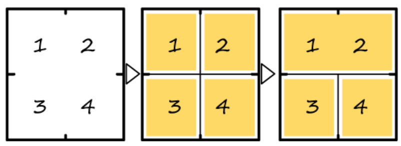
2.5 Efficient space design



Effective space planning ensures not only optimal use of floor area without wasted space, but has also positive effects on people inside building and on energy saving potential. Even if it requires some extra costs in the design, it rationalises the functional needs and the heating/cooling requirements, which later on saves energy costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Tenants/Users; Owners; Construction company; (Economic) Chambers; Utilities	+ €		- €	Resource savings

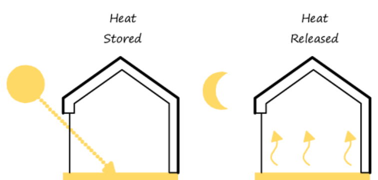
2.6 Flexibility & adaptability



Applying the concept of flexibility and adaptability not only to components of a building and its structural design but also to its technologies and installations, makes it possible to achieve changes quickly. Moreover, the building is designed for different uses and is switched from a short life cycle to a long life cycle. It requires bigger planning and investment costs, because of a more complex HVAC system; but it permits to reduce follow up costs since it is possible to heat or cool only one part and not the whole building.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Construction company; Authorities; (Economic) Chambers; Utilities	+ €	+ €	- €	Value development

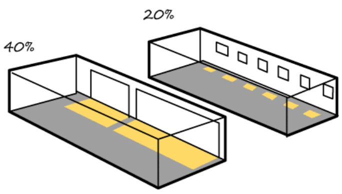
2.7 Optimize solar gains / solar control



Passive solar design techniques require high knowledge on solar geometry and shading system technologies, as well as on modelling or simulation of solar gains; therefore they raise planning costs. Optimisation of solar gains can reduce or even eliminate the demand for mechanical cooling, heating and artificial daytime lighting. By sometimes creating higher investment costs, it decreases maintenance and annual energy costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Construction company; Authorities;	+ €	+ €	- €€	User satisfaction, comfort

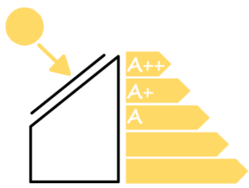
2.8 Improve the daylight factor



By optimising the daylight quotient, life cycle costs for lighting can be saved. A daylight simulation must be carried out as part of the planning process in order to determine the daylight quotient. Additional costs may arise in the context of investment costs since partly larger window areas (also inside the building, e.g. to corridors) or directing reflectors are usually planned in the course of optimisation.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Authorities	Tenants/Users; Owners; Real estate fund; Planners; Municipalities; (Economic) Chambers; Society	+ €	+ €	- €	Comfort, health and CO_2-reduction

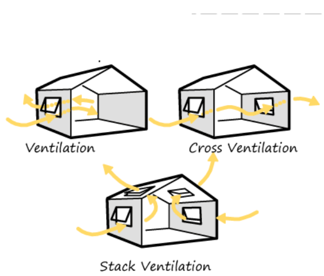
2.9 Energy performance calculation



By determining the energy demand values using simulation, user-specific statements can be made about the quality of the building. These simulations cause considerable additional costs within the framework of the planning process. However, these can be reduced in a cooperative BIM planning process if it is possible to transfer the building geometry from the BIM into the simulation software. More detailed planning can lead to focused investment and lower energy costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Authorities	Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society	+ €	- €	- €	Value development and energy savings

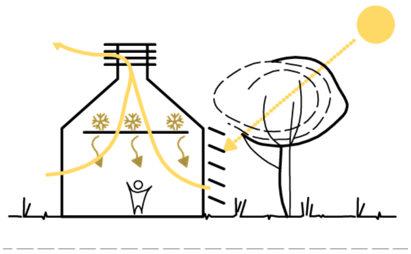
2.10 Natural ventilation



Due to the passive approach, no final energy is required, although not in all nZEB natural solutions would keep high indoor air quality. But natural ventilation also assists mechanical ventilation systems in cooling down buildings during summer. In the context of planning, however, these systems require an increased planning effort and thus higher costs there.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Construction company; Planners; (Economic) Chambers; Politicians	+ €		- €	Comfort

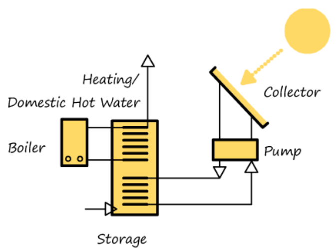
2.11 Cooling strategies



Passive, active and hybrid systems are available for cooling conditioning of a building. In order to keep usage costs and investment costs as low as possible, care should be taken during the planning process to optimize strategies for a passive supply of the building and to minimize active cooling solutions. A high relation of passive to active cooling will give the cost savings during operation.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Construction company; Planners; Municipalities; (Economic) Chambers; Society; Utilities	+ €	+ €	- €	Comfort

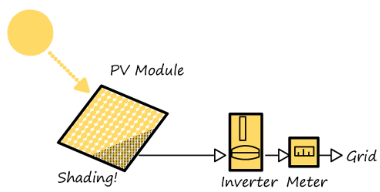
2.12 Renewable energy – solar thermal systems



As solar thermal systems are widespread and used for many years there is already a good knowledge about the planning, system design and operation available. However, planning still accounts for a large share of the overall system costs, including a good storage solution. Optimized planning might be more expensive than standard planning processes, but it can reduce the investment and operation costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Construction company; Authorities; Planners; (Economic) Chambers; Society; Politicians; Utilities	+ €	+ €	- €€	Increased autarky and resource savings

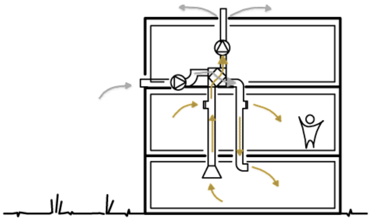
2.13 Renewable energy – photovoltaics



As the investment costs for PV systems already decreased tremendously in the past years, the levelized costs of electricity (lcoe) are already below the purchasing costs for electricity in many countries for most electricity consumers. Due to the already low lcoes, the maximization of the own-consumption is of major importance for the cost efficiency of the systems. According to (Köhler et al., 2018), there are also large cost saving potentials associated with the PV system itself (cabling, cells, grid connection, mounting), which cannot be influenced directly by the planning.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Real estate fund; Construction company; Authorities; Planners; Municipalities; Investors; (Economic) Chambers;		+ €	- €	Increased autarky and some rental income

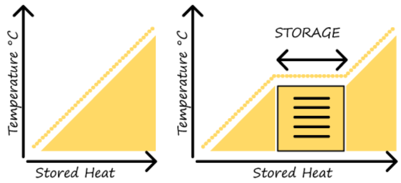
2.14 Mechanical ventilation



Mechanical ventilation systems are of high need for health and indoor air quality. They are often accompanied by heat recovery units, so ventilation heat losses can be reduced significantly, which means lower heating loads are to be expected. However, these ventilation systems often require a high amount of electricity to transport the air throughout a year. In addition, maintenance and repair costs are to be expected during operation.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Owners; Real estate fund; Construction company; Authorities; Planners; (Economic) Chambers; Society; Politicians	+ €	+ €		High socio-economic value, comfort

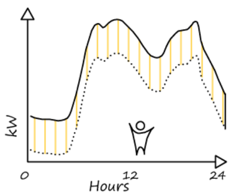
2.15 Domestic hot water



For electricity as well as hot water consumption, especially in residential buildings, primarily the users and their behaviour have a major influence on the energy demand and the resulting usage costs. During planning, care should be taken to keep distribution and storage losses as low as possible and to enable renewable generation of hot water, so the follow-up costs will be low.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Tenants/Users; Real estate fund; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities			- €	Energy savings

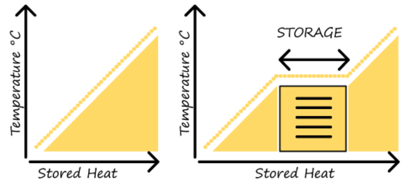
2.16 Plug loads and internal gains



By integrating internal heat gains into a thermal simulation or energy balance, the heating demand in winter and system adjustments can be greatly reduced. However, a specific detailed consideration requires an increased planning effort. In cooling mode, however, these internal heat sources have a negative effect on the required cooling capacity. This is currently relevant in non-residential buildings. But a detailed analysis and low-cost consideration of the internal heat sources including plug loads also makes sense for the living area.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Tenants/Users; Construction company; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society; Politicians; Utilities		- €	- €	Comfort and resource savings

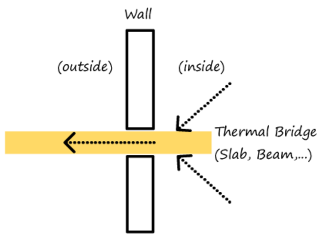
2.17 Storage facilities



The development of heat and electricity storage systems is currently under considerable pressure for investigating new systems. Most of these systems are still characterized by high investment costs, but support the usage of cheap renewable energy systems like biomass and solar thermal systems, which causes low operation costs.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Authorities; Municipalities; (Economic) Chambers; Society; Utilities		+ €	- €€	Role model/ pioneering role

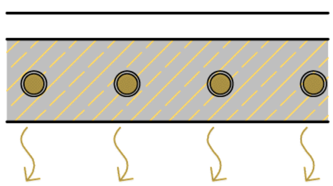
2.18/19 Construction details - heat bridges and air tightness



Through a detailed analysis of the quality of the component junctions, heat losses/thermal bridges and ventilation losses can be avoided. Through these measures, it is possible to reduce the heating demand, but much hinder construction damages in the utilization phase. The calculation of the thermal bridges, junction gaps and similar is connected with planning effort. However, the result of this calculation has a great influence on the sustainability of the constructions.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Authorities; Municipalities; (Economic) Chambers; Society; Utilities	+ €		- €	Comfort, quality assurance, construction value

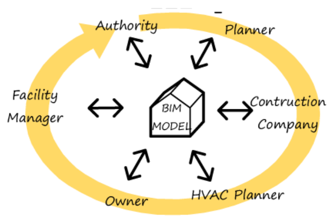
2.20/22 Thermal activated building (TAB) elements – accession of thermal mass



The TAB systems deliver heating and cooling power to the room with low-temperature differences between supply flows and the room. The prediction of thermal loads is, therefore, an important factor for efficient operation and thermal comfort. Generally, the integration and optimal operation within the HVAC system is essential and requires a slightly higher planning effort compared to other available heating and cooling solutions, but offers savings and storage/flexibility capacity to the building's energy system.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Construction company; Planners; Municipalities; Investors; (Economic) Chambers; Utilities	+ €		- €	Comfort and energy storage

2.21 BIM systems



Building information modelling, allowing all the partners in a project to work together on a digital integrated design model, offers benefits during both design and construction. There are important savings to reach concerning quality and control, e.g. the planning of different installations creating clarity and promoting integration of different installation works. However, to achieve the desired output, educated personnel who know how to work with BIM is needed, and extra time and resources (i.e. costs) in the early planning.

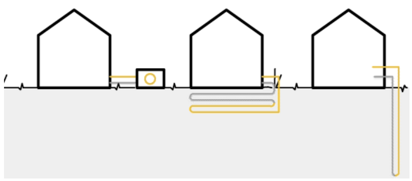
MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Owners; Construction company; Planners; Citizen groups/NGOs; Utilities	+ €		- €	Role model/ pioneering role

2.23 Energy recovery systems

Energy recovery systems like for ventilation or wastewater treatment systems with heat recovery units are costly when installed, but effective when re-using heat. An important factor is the electricity consumption of the pumps or auxiliary energy needed to run the recovery system – it is decisive for the return on investment.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Authorities	Owners; Planners; (Economic) Chambers; Citizen groups/NGOs; Utilities		+ €	- €	Energy and resource savings

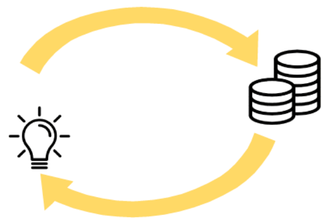
2.24 Heat pumps



The annual work rate, defined as the ratio of the heat produced to the electrical energy consumed, averaged over one year, is the most important factor defining if a specific heat pump system is saving primary energy and running costs or not. When the ratio is lower than 2.5, no primary energy or cost-saving potential is left, and the heat pump comes near to be a "direct powered" heating system.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Owners; Authorities; Planners; Municipalities; Investors; Citizen groups/NGOs; Politicians; Utilities			- €	Use of energy flexibility

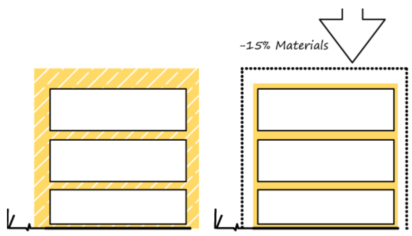
2.25 Apply for funding



Funding helps the market to advance with continuously improved energy performance within the newly constructed building stock as a long-term result. Applications are often time-consuming, even more so in the cases where collaboration between many actors is required, but the planning quality increases. However, most often the cost reduced due to external funding covers working hours in the design phase, some investment in related environmental technologies and so follow-up costs.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Authorities; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Politicians		- €	- €	Value development and quality assurance

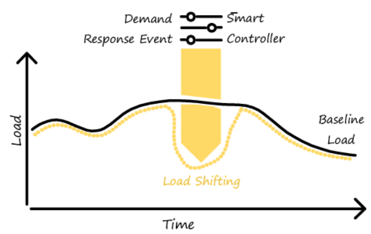
2.26 Efficient use of materials



For a nZEB it is important to economize the use of materials, but also to reduce unnecessary investment costs there. Focus on efficient material use may lead to higher costs in the design phase, especially if there are quantitative targets to reach in terms of climate load, demanding CO_2-calculations of different materials and constructions. However, if the focus is to optimize for example the amount of insulation in the construction, a simplified way could be to calculate the costs per reduced kWh for this solution compared to other technical solutions, so that the cost-efficient alternatives are chosen.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Authorities; Planners; Municipalities; Politicians	+ €	- €		Resource savings

2.27 Energy Flexibility – Demand Response



Demand response and energy flexible operation of a building requires additional monitoring, communication and automation technologies and therefore additional investment costs. On the other hand, under the current market environment, the achievable cost savings (or revenues) with demand response are very limited or not existing (especially for small capacities/ loads). The topic is interesting for a future fluctuating renewable energy market to save costs.

MAIN DRIVER	STAKEHOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Tenants/Users; Owners; Authorities; Planners; Municipalities; Citizen groups/NGOs; Utilities		+ €	- €	Fossil energy savings

3.4. PROCESS EVALUATION RESULTS

3.4.1. LIST OF ACTIONS RELATED TO STAKEHOLDERS AND OTHER ACTIONS

In the following table, the various actions were assigned to the main drivers and other stakeholders in order to clarify the question of responsibility. In addition, the various dependencies of the actions are listed in the right-hand column of the table to show which actions and stakeholders need to be communicated subsequently.

Table 5: List of actions - planning

	ACTIONS	MAIN DRIVER	STAKE-HOLDERS	INFLUENCES ON OTHER ACTIONS
21	**Definition of Allowed Thermal comfort ranges**	Planners	Tenants/Users; Owners; Utilities	2.4, 2.6, 2.9, 2.21, 3.6, 4.9
22	**Optimize Building Envelope (Compactness and Insulation)**	Authorities	Owners; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs	2.3, 2.4, 2.19, 2.20, 2.21, 2.22, 2.26, 3.4
2.3	**Improve Window to Wall Ratio**	Planners	Owners; Construction company; Authorities; Municipalities; (Economic) Chambers	2.21, 3.4, 3.6
2.4	**Optimize Insulation**	Owners	Real estate fund; Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs	2.2, 2.22, 2.26, 3.6
2.5	**Efficient Space Design**	Planners	Tenants/Users; Owners; Construction company; (Economic) Chambers; Utilities	1.8, 2.6, 2.8, 2.16, 2.21, 3.11, 4.2, 4.8
2.6	**Flexibility & Adaptability**	Owners	Construction company; Planners; (Economic) Chambers; Utilities	1.17, 2.5, 2.21, 2.27, 3.3, 4.8
2.7	**Optimize Solar Gains / Solar Control**	Planners	Owners; Construction company; Authorities; (Economic) Chambers; Utilities	1.6, 1.9, 1.18, 2.12, 2.13, 2.27
2.8	**Improve Daylight Factor**	Authorities	Tenants/Users; Owners; Real estate fund; Planners; Municipalities; (Economic) Chambers; Society	1.8, 2.3, 2.21
2.9	**Energy performance Calculation**	Authorities	Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society	2.2, 2.7, 2.20, 2.26
2.10	**Natural Ventilation**	Owners	Construction company; Planners; (Economic) Chambers; Politicians	1.7, 1.8, 2.14
2.11	**Cooling Strategies**	Owners	Tenants/Users; Construction company; Planners; Municipalities; (Economic) Chambers; Society; Utilities	2.2, 2.9, 2.10, 2.14, 2.16, 3.6
2.12	**Renewable Energy - Solar Thermal Systems**	Owners	Construction company; Authorities; Planners; (Economic) Chambers; Society; Politicians; Utilities	1.2, 1.6, 1.9, 2.7, 2.15, 2.17, 2.25, 3.7
2.13	**Renewable Energy - Photovoltaics**	Owners	Tenants/Users; Real estate fund; Construction company; Authorities; Planners; Municipalities; Investors; (Economic) Chambers; Citizen groups/NGOs; Society; Politicians; Utilities	1.2, 1.6, 1.16, 2.17, 2.25, 2.27, 3.7
2.14	**Mechanical Ventilation**	Citizen groups/NGOs	Owners; Real estate fund; Construction company; Authorities; Planners; (Economic) Chambers; Society; Politicians	2.19, 3.1, 4.8
2.15	**Domestic Hot Water**	Citizen groups/NGOs	Tenants/Users; Real estate fund; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	1.17, 2.7, 2.12, 2.17, 4.9

	ACTIONS	MAIN DRIVER	STAKEHOLDERS	INFLUENCES ON OTHER ACTIONS
2.16	**Plugloads and internal gains**	Planners	Tenants/Users; Construction company; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society; Politicians; Utilities	2.11, 2.21, 3.6, 4.9
2.17	**Storage facilities**	Planners	Owners; Authorities; Municipalities; (Economic) Chambers; Society; Utilities	1.17, 2.12, 2.13, 2.15, 2.24
2.18	**Construction Details - Heat Bridges**	Planners	Owners; Construction company; (Economic) Chambers; Citizen groups/NGOs	2.3, 2.21, 3.6, 3.8, 4.7
2.19	**Air tightness**	Planners	Authorities; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society	2.2, 2.3, 2.4, 3.5, 4.7
2.20	**Thermal Activated Building Elements**	Owners	Construction company; Planners; Municipalities; Investors; (Economic) Chambers; Utilities	2.2, 2.9, 2.21, 2.26, 3.4, 4.6, 4.8
2.21	**BIM systems**	Authorities	Owners; Construction company; Planners; (Economic) Chambers; Politicians	1.14, 2.3, 2.5, 2.6, 2.18, 3.1, 3.9, 4.8
2.22	**Accession of Thermal Mass**	(Economic) Chambers	Owners; Construction company; Planners; Citizen groups/NGOs; Utilities	2.4, 2.26
2.23	**Energy Recovery Systems**	Authorities	Owners; Planners; (Economic) Chambers; Citizen groups/NGOs; Utilities	1.17, 2.7, 2.27, 4.7, 4.8
2.24	**Heat Pumps**	(Economic) Chambers	Owners; Authorities; Planners; Municipalities; Investors; Citizen groups/NGOs; Politicians; Utilities	1.16, 2.17, 2.21, 4.6, 4.7
2.25	**Apply For Funding**	(Economic) Chambers	Authorities; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Politicians	1.1, 1.2, 1.15
2.26	**Efficient use of materials**	Citizen groups/NGOs	Authorities; Planners; Municipalities; Politicians	2.2, 2.4, 2.20, 3.4
2.27	**Energy Flexibility - Demand Response**	(Economic) Chambers	Tenants/Users; Owners; Authorities; Planners; Municipalities; Citizen groups/NGOs; Utilities	1.17, 2.6, 2.17

3.4.2.LIST OF ACTIONS RELATED TO COSTS

The cost savings or higher costs depending on the action are shown in the table below. Therefore -€ means that fewer costs are required than in a conventional planning procedure. On the other hand, +€ means that the costs increase. The number of € also indicates whether the change is big or small compared to the already known costs. The cost estimation for the different actions and the different cost-causing project steps were made in the course of the research project with the help of the project partners.

Table 6: List of actions related to costs - planning

	ACTIONS	Influence on Planning Costs	Influence on Investment Costs	Influence on Follow-Up Costs
2.1	**Definition of Allowed Thermal comfort ranges**	- €	+ €	- €
2.2	**Optimize Building Envelope (Compactness and Insulation)**	+ €	X	- €€
2.3	**Improve Window to Wall Ratio**	+ €	- €	- €
2.4	**Optimize Insulation**	X	+ €	- €€
2.5	**Efficient Space Design**	+ €	X	- €
2.6	**Flexibility & Adaptability**	+ €	+ €	- €
2.7	**Optimize Solar Gains / Solar Control**	+ €	+ €	- €€
2.8	**Improve Daylight Factor**	X	X	- €
2.9	**Energy performance Calculation**	+ €	- €	- €
2.10	**Natural Ventilation**	+ €	X	- €
2.11	**Cooling Strategies**	+ €	+ €	- €
2.12	**Renewable Energy - Solar Thermal Systems**	+ €	+ €	- €€
2.13	**Renewable Energy - Photovoltaics**	X	+ €	- €€
2.14	**Mechanical Ventilation**	+ €	+ €	X
2.15	**Domestic Hot Water**	X	X	- €
2.16	**Plugloads and internal gains**	X	- €	- €
2.17	**Storage facilities**	X	+ €	- €€
2.18	**Construction Details - Heat Bridges**	+ €	X	- €
2.19	**Air tightness**	X	+ €	- €

	ACTIONS	Influence on Planning Costs	Influence on Investment Costs	Influence on Follow-Up Costs
2.20	**Thermal Activated Building Elements**	+ €	X	- €
2.21	**BIM systems**	- €	X	X
2.22	**Accession of Thermal Mass**	+ €	X	- €
2.23	**Energy Recovery Systems**	X	+ €	- €
2.24	**Heat Pumps**	X	X	- €
2.25	**Apply For Funding**	X	- €	- €
2.26	**Efficient use of materials**	+ €	- €	X
2.27	**Energy Flexibility - Demand Response**	+ €	+ €	- €

3.4.3. LIST OF ACTIONS – WORK BREAKDOWN STRUCTURE

The following diagram shows an overview of all actions assigned to planning. In addition, they are further divided into three categories in order to clearly define which part of the planning the individual actions belong.

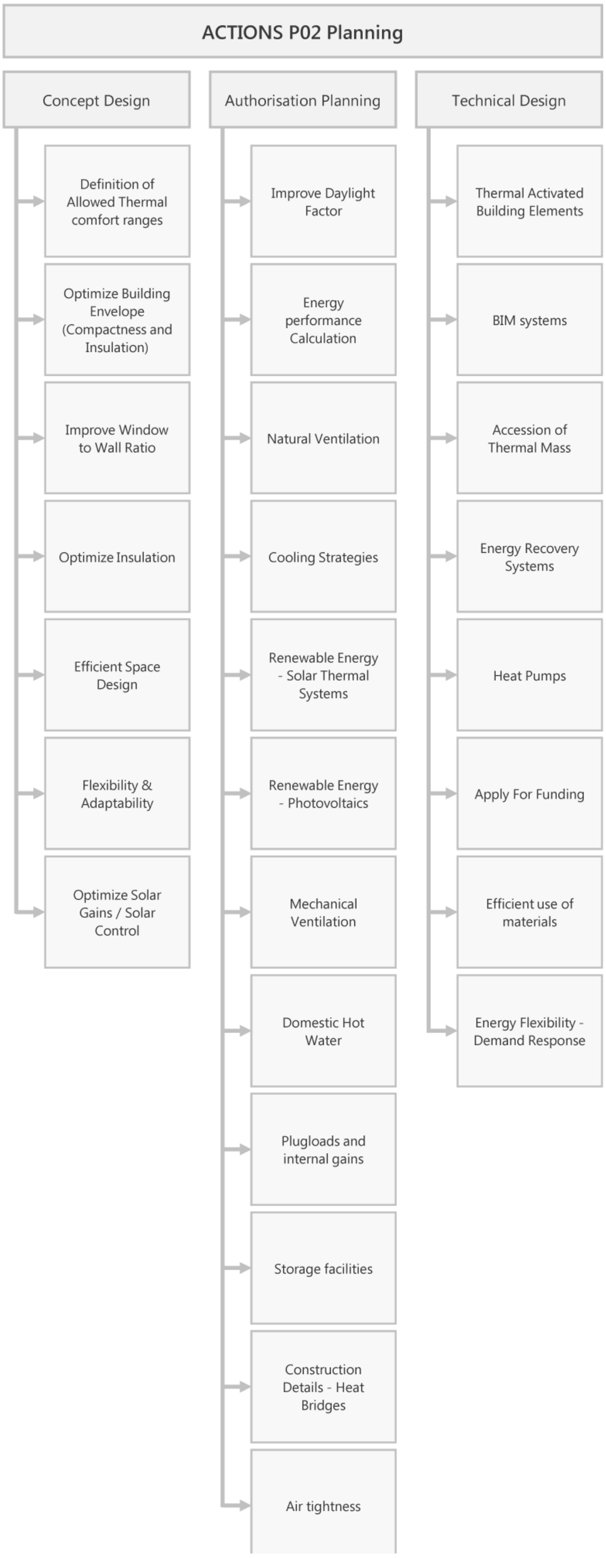


Figure 21: List of actions - planning

3.4.4.LIST OF ACTIONS – RELATIONS BETWEEN THE ACTIONS

The following figure shows the correlations between the different actions and stakeholders. A more detailed description can be found in chapter 2.4.4.

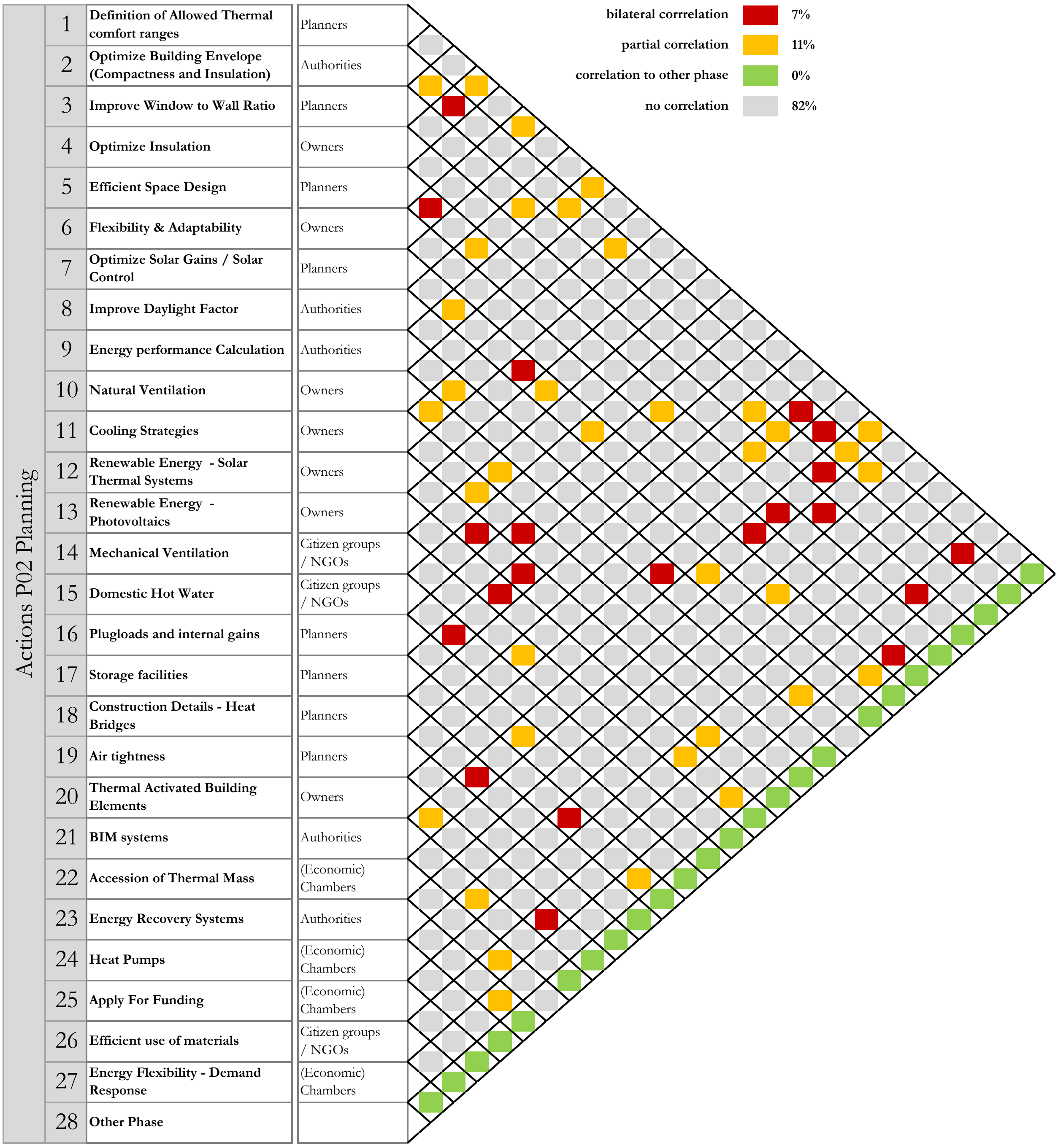


Figure 22: Correlation of actions in planning

CHAPTER 4

CONSTRUCTION PROCESS

“TOWARDS A LEAN CONSTRUCTION MANAGEMENT FOR nZEBS”

4.CONSTRUCTION PROCESS / NZEB – LEAN CONSTRUCTION MANAGEMENT

4.1. OVERALL PROCESS

Considering the building as a manufactured product also allows for the application of lean management strategies, which have been widely used in the industry sector (starting from automotive). In the building sector, there are only a few experiences, mainly performed in big and very complex construction sites but also in smaller, standardized and highly industrialized concepts (for example BoKlok, a housing product by IKEA and Skanska). CRAVEzero focuses on lean construction and operational protocols, which can also be applied for low and mid-rise investment for low LCC nZEBs. CRAVEzero will develop construction and facility management (quantitative and qualitative) indicators, and relative evaluation methods, enabling monitoring and control of the effectiveness and viability of a comprehensive low LCC nZEB development process, as well as generally better exchanges of data in the form of usable information and knowledge among the stakeholders involved.

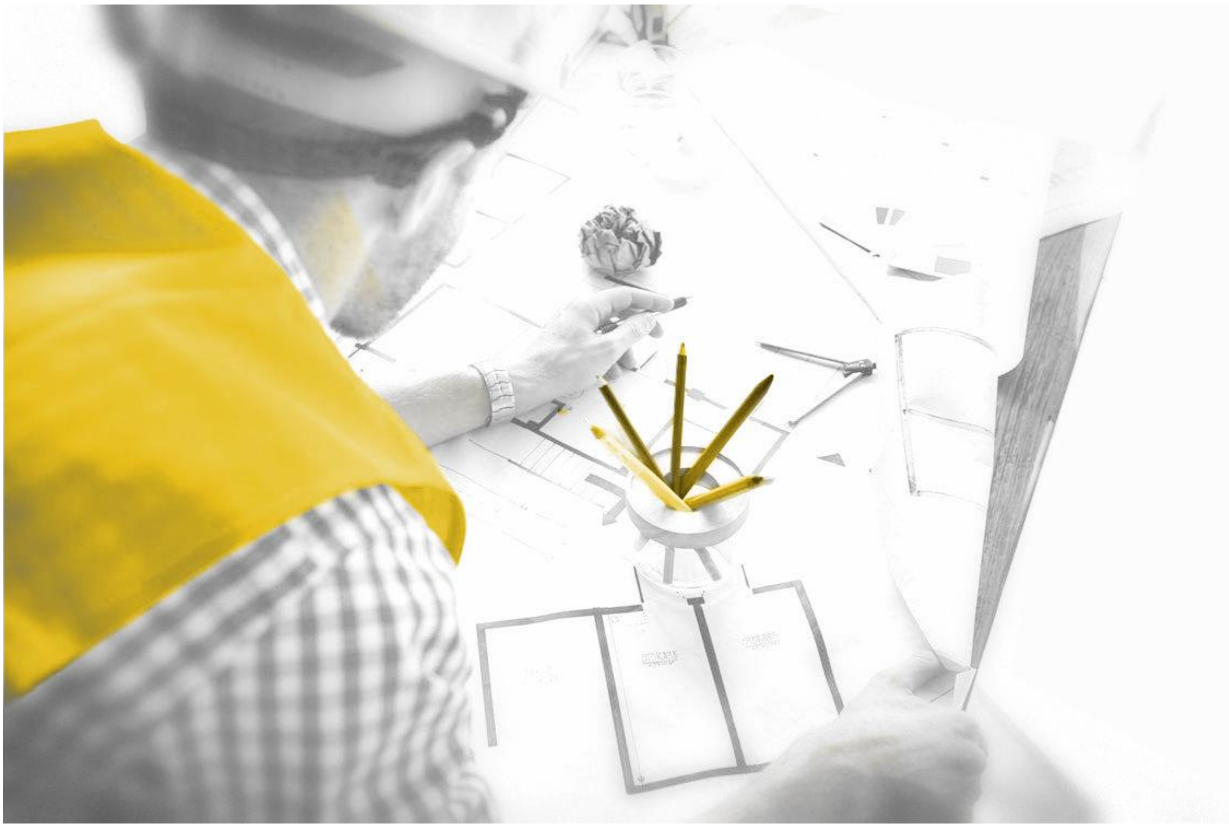


Figure 23

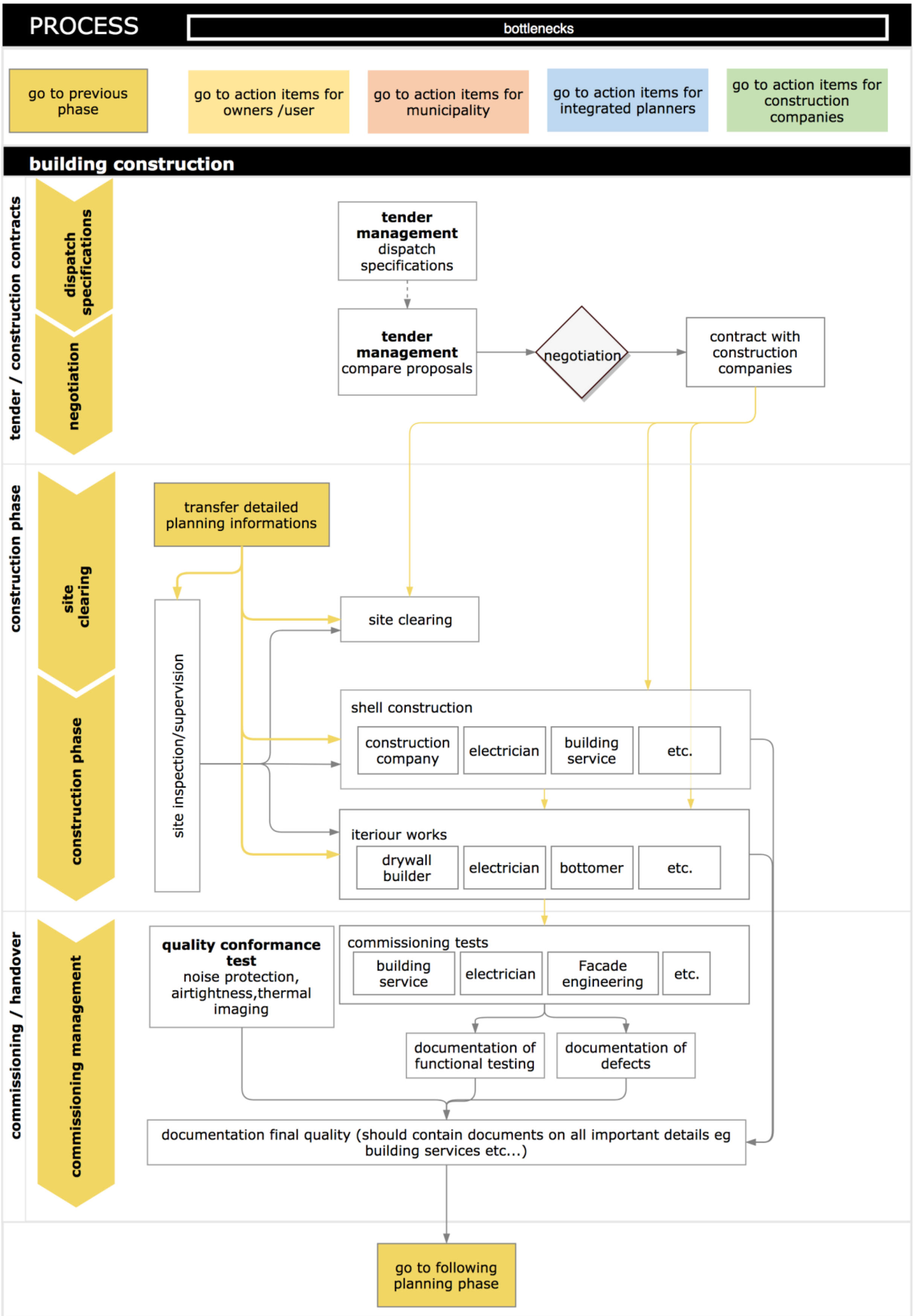


Figure 24: Construction process

4.2. TENDER/CONSTRUCTION CONTRACTS

Once a project is approved and gets the authorization by authorities, construction companies are involved in a negotiation phase.
The company receives all project documents and construction guidelines, then draws up an economic statement detailing the quantities, processes and costs to realize the building and exposes it to his client. The construction company seeks to comply with all customer requests and where possible offers improvements. Subsequently, the negotiation between the parties starts, the customer compares the different offers to determine the company that will carry out the work.
This phase of negotiation takes place between the company and the direct investor supported by his or her reference technicians (fund, private person or real estate) in the case of work as a general contractor. If, on the other hand, the company is required to perform only the role of the constructor of the building, it will deal with those involved in carrying out the intervention on behalf of the client and who will coordinate the various professional figures.

4.2.1.CONSTRUCTION PHASE

As the permissions are obtained, the construction phase can start.
The very first phase is related to the preparation of the site, keeping the construction site as clean and uncluttered as possible, then the realization of the excavation for the foundation.
The construction company can start, from the realization of the foundation and then all the bearing structure. If precast elements are used this phase is easier, scaffolding are avoided, and the construction is faster.
When the structure is complete, and the envelope is closed other skilled workers can start to realize technological systems (electric and HVAC), to install windows, to do interior works up to complete with finishing elements.
Lean construction is an approach developed to improve efficiency and effectiveness of the construction process. Managing a lean construction means minimizing the waste of time, resources and materials, and thereby maximizing value. The presence of a general contractor, which manages and coordinates all suppliers and operators, makes it possible to optimize the entire system through collaboration, the elimination of obstacles and to fluidize the process, with the aim of achieving the value desired by the customer.
A key premise for successful lean construction is that materials and tools are available when an operation is scheduled to start, equipment, design and people are in place. Breaking down the work and planning it with a focus on letting the different disciplines work separately as much as possible in an area and handling the interfaces between disciplines. This can be achieved through defining a number of "construction phases" and sequencing these.
Useful is a structure of planning meetings to ensure that all operations can start when planned.
Another point that can be crucial to avoid slowdowns is to give detailed "rules" for the decision power of each level.
The constructions have to reach the maximum functionality, with the satisfaction of the final users. Manufacturers and suppliers will have to be involved in the design as soon as possible, to achieve integration and cost-effectiveness of the building. Current achievements, progress, compliance with project requirements must be verified by specific coordinated and continuous measures. Better is facilitating quality control throughout the construction process, rather than doing this at the end when correcting problems is much more difficult and expensive.
Allowing an open communication between owner, project manager, contractors and engineering consultants is an issue that guarantees a better outcome.
The use of prefabricated systems and the displacement of the workings as much as possible outside the building site is a winning strategy. Using this technology it is possible to apply the principles of lean production to construction. Off-site construction reduces on-site work and locates it mainly in the factory, allowing reorganization of technologies and process aimed at greater efficiency and quality. The

main improvements between the standard method of construction and the off-site are:

- Guarantee of better control and quality of the product. Thanks to the industrialized systems the production is optimized and the performances guaranteed;
- Production times are reduced thanks to the effectiveness and precision of production processes;
- On-site operations are reduced to a minimum, the risk of unforeseen events, delays and additional costs are reduced;
- The scheduled times and costs are more certain, reduction of uncertainty to the realization of the projects.

The reliability of the goods produced, the traceability of the components, their programmable maintenance as well as the containment of the energy costs become aspects decisive for off-site construction.

Another strength of lean construction is the improvement of health, safety and environment and also job satisfaction (quality of working condition is improved, better cooperation and fewer conflicts are a guarantee).

4.2.2.COMMISSIONING/ HANDOVER

At the end of the construction, compliance with the project must be guaranteed. Checks and measurements are performed already during the execution of the work, but at the end real tests are carried out to ensure the efficiency of the building (static test, blower door test, verification of the electrical system, etc.).

Together with the building, the customer is given a manual of use and maintenance, which collects all indications for the correct use of the building and the components installed in it. The manual intends to provide general advice to optimize the use of the new home and to manage scheduled maintenance services efficiently.

Today, thanks to digitized systems, such as BIM, it is possible to provide a real identity card of the building, to be used for the management of the entire life cycle of the building.

After the realization of the building it is necessary to do some test to verify the operational phase of the HVAC and energy production system. The first test is the production of electricity of the PV system that has to be similar to the design parameter. Another important test is related to the balance of radiant flow heating and mechanical ventilation to provide heating and ventilation according to design.

The last test considered is the blower door test that is necessary to evaluate real air infiltration in nZEB building to correct the presence of realization fault that can increase energy consumption and cause structural damage during operational phases.

The maintenance of the systems is important to preserve the energy efficiency of the overall building. The solution is to monitor and control some important parameter such as energy consumption or heat production of the HVAC system. The principal purpose of energy monitoring is to store data to implement automatic statistical analysis to predict failure of HVAC components.

Commissioning advantages:

The organized planning of the processes of the commissioning of trades and plant components has the goal of achieving the functionality required in the order demonstrably and transparently.

This is a process which is intended to prove the entire functionality of all systems in order to ensure the function of the individual trades.

The result of the organization of the commissioning is a functional building with all plants, which ensures the use for the client from the first day on.

Basic determination within the scope of commissioning are guaranteed parameters by the contractor as the basis for performance measurements and contract fulfillment.

The objective of the organized commissioning is to maintain a functional and energy-efficient object with all plant components of the technical building equipment.

The operating parameters on which the planning is based and which correspond to the client's specifications must be verified by the trade contractor.
Necessary adjustments of operating parameters in order to achieve optimizations are to be initiated organizationally. This is achieved by trial operation and long-term monitoring of the technical building equipment in operation by the facility manager.
The determination of the methods to be applied in the course of commissioning is also important for determining the basic principles (verification by the respective trade contractor). This concerns the tools and activities for implementation. This is a prerequisite for preparing or organizing the commissioning by suitable persons in view of a large number of different requirements of the parties involved in the construction work and the type of use.
Due to the given complexity of the project, the assurance and control of the desired quality is an important and desired service of the client. This service is to be provided by the respective contractor as proof of his complete fulfillment of the contract.
This interface matrix enables the creation of task allocations, proof allocations, scheduling, the capacity of personnel, etc.

Procedure for commissioning:

Before handover/acceptance

- Completion of the plant by the respective contractor
- Quality inspection by the respective contractor
- Quality control by adjacent trades together
- Elimination of open services by the respective contractor
- Acceptance by the client or his vicarious agents
- Elimination of defects by the contractor
- The takeover by the client

After takeover

- Real operation during the warranty period by the facility manager
- The final determination by the client or by its vicarious agent
- Elimination of defects by the tradesman
- The release of the contractor from warranty

Step 1 Performance assessment

Verification of the performance of the service in accordance with the contract as a prerequisite for the acceptance of the service (which means an apparent acceptance).

The acceptance consists of:

- The completeness check
- The proof of the functional test = commissioning
- Proof of function measurement = proof of commissioning
- The proof of the cross-industry safety function test = proof of the official requirements
- The proof of the function test covering all Trades = commissioning
- The cross-functional measurement = verification of the trial operation

Step 2 Completeness check

Proof that:

- The delivery has been made in full to the extent provided for in the contract
- The components or the system components are properly installed in compliance with the technical and official regulations and standards
- There is accessibility for operation
- All official documentation is available

Step 3 Scope of inspection

- Comparison of the delivery with the contract, both in terms of scope and material
- Checking compliance with technical and official safety regulations
- Proof of submission of all documents necessary for the operation
- Proof of submission of all necessary documents for energy management
- Evidence of the training and instruction provided, above all in safety-related matters (accident management)

Step 4 Function test

- Verification of the contractual functionality of the plant, the technically correct installation and the effectiveness of the individual components.

Step 5 Function measurement

- Verification of the assured nominal values to be provided by the plants under load (random checks).

Step 6 Checks

Determination of the material quality, the execution quality and proof of the trouble-free and efficient operation of the plant components.

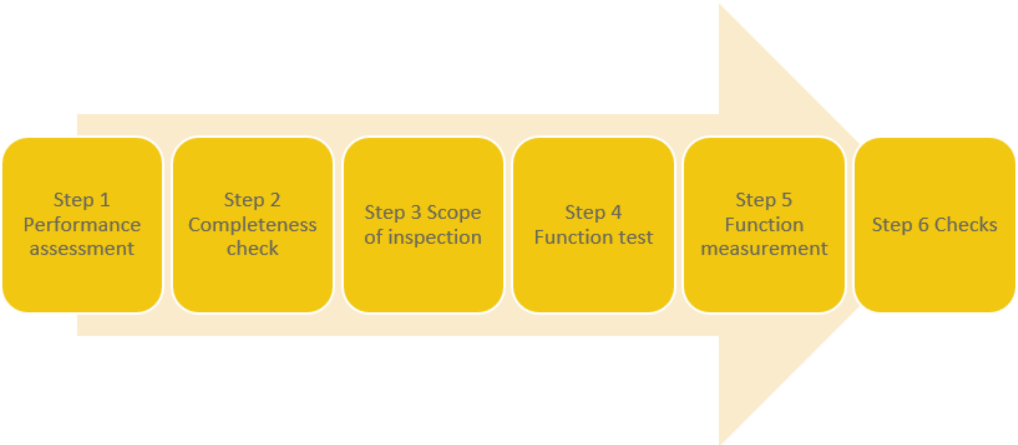


Figure 25: Commissioning procedure after takeover

4.3. PITFALLS AND BOTTLENECKS

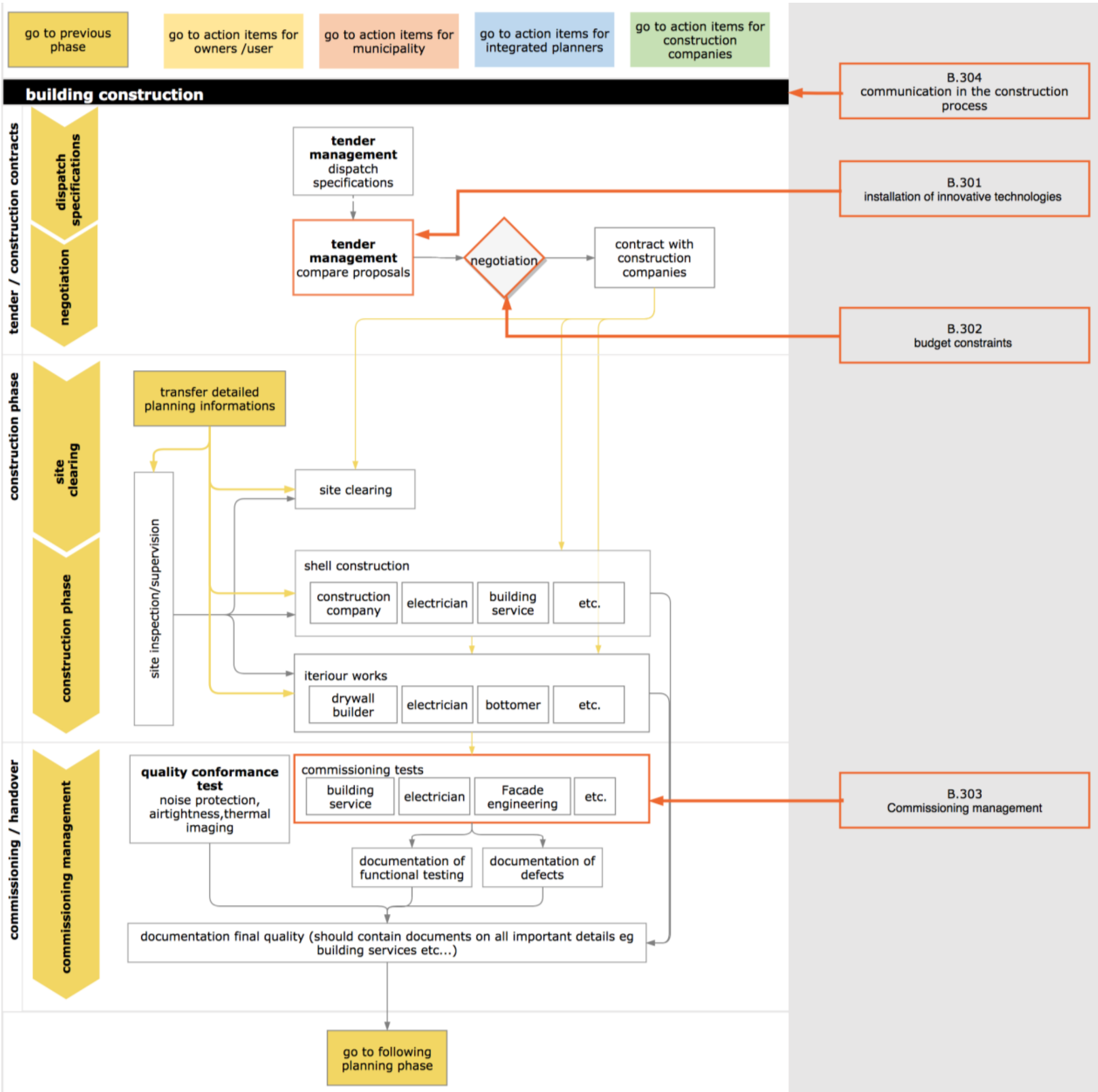


Figure 26: Construction process- bottlenecks

B.301: Installation of innovative technologies

To achieve the energetic status of a nZEB, it is necessary that the overall quality of the building is at a very high level. The development of new constructions and the installation of new technologies must be made by an experienced team. Lack of experience can lead to problems in building operation or construction defects.

B.302: Budget constraints

During the construction work, it is recognized that the expenditure is greater than it was estimated by the planner team. These misjudgements can lead to the client's request for changes in planning, which then leads to high additional costs, as a nZEB is based on complex building concepts.

B.303: Commissioning management

nZEBs often have complex building technology, which requires complex commissioning and eventually monitoring during operation to achieve the desired quality. This measurement can reduce the risk of failures in building operation, as all components are checked individually and in interaction. This testing and comprehensive documentation can identify weaknesses and modifications compared to planning.

B.304: Communication in the construction process

To set up the complex system of a nZEB, increased communication between the individual participants is necessary, as the different systems are closely linked. In addition, it is necessary to keep comprehensive documentation of the interaction of the individual systems as well as the functionality of the individual systems.

4.4. ACTIONS

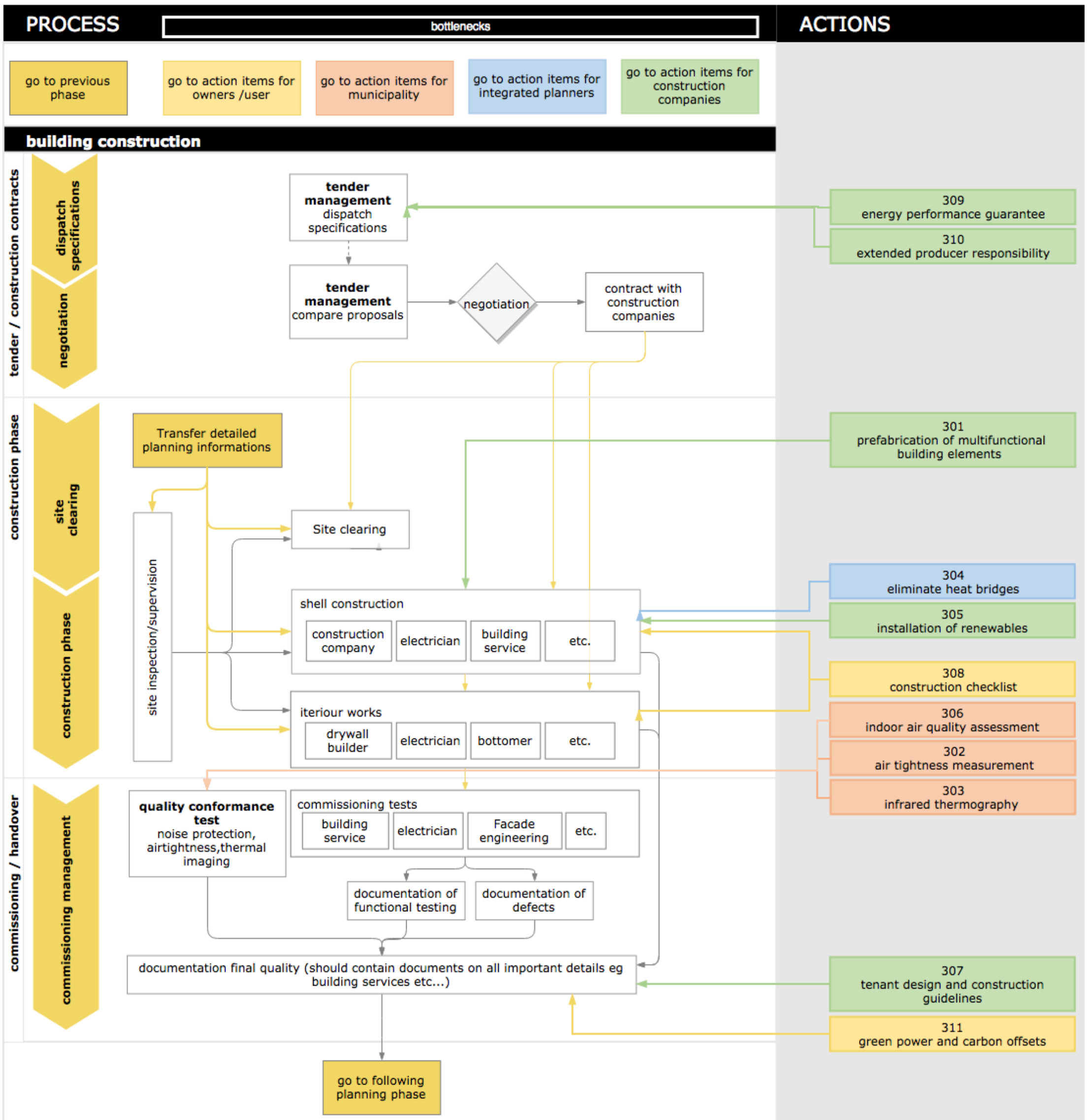


Figure 27: Construction process- actions

3.1 Tenant design and construction guidelines

Informed tenants and users of buildings means in most cases easier detailed planning effort because things could be simplified in some cases. For the "second generation" of occupants or users of buildings such guidelines can ease the maintenance and operation when they are informed about building services and procedures properly.

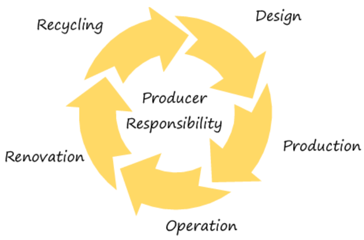
MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Real estate fund; Planners; Investors; Utilities	- €		- €€	Energy savings

3.2 Energy performance guarantee

The direct benefit from a guaranteed energy performance is the reduced risk for the client/investor, but there are also indirect savings in terms of reduced costs during the follow-up mainly due to the enhanced efforts to succeed with the energy performance, thus gaining effect from doing "everything right" during the design and construction. Of course, the extra effort means some extra costs initially but that is likely to be paid back by good energy related management, thereby reducing mistakes and errors.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Utilities	Tenants/Users; Owners; Real estate fund; Planners; Investors; (Economic) Chambers	+ €	- €	- €	Value development and service quality

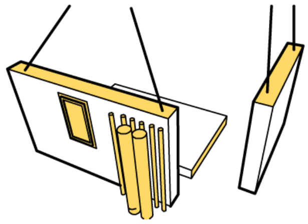
3.3 Extended producer responsibility



The producer is encouraged to improve the quality of the product to promote durability. Being responsible for the disposal of the product stimulates the producer to evaluate the entire life cycle of the asset, in order to identify solutions that reduce waste management costs and increase recycling levels. By supporting the material recycling markets, it helps to reduce the extraction or import of raw materials, avoiding risks deriving from price fluctuations.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Owners; Construction company; Authorities; Planners; Municipalities; Politicans	- €	- €€		Resource Savings

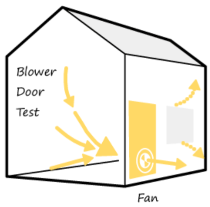
3.4 Prefabrication of multifunctional building elements



The use of integrated and standard modular systems permits to optimize design and coordinates different competences in an early stage. On-site installations are reduced to a minimum, the risk of unforeseen events, delays and over-costing are reduced. Replicating standardized procedures is useful to better control the execution on site and reduce construction defects. Considering the entire life cycle it is preferable to be able to replace only some components of the building's envelope to improve performance.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Construction company; Planners; (Economic)Chambers	- €			Value development and quality assurance

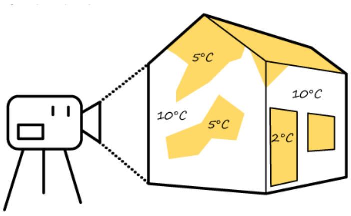
3.5 Air tightness measurements



The planning cost is negligible as few requirements are to be included in the air tightness specification tests. Additional remedial works could be necessary if performance is not obtained, but it mainly involved labour cost and smoke test to identify air leakage. Regarding follow-up costs, an air tightness performance will be able to confirm the designed energy performance.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Construction company; Authorities; Planners; Citizen groups/NGOs		+ €	- €	Quality assurance and construction value

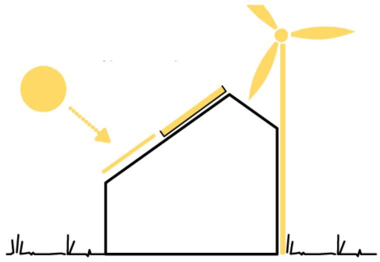
3.6 Thermography infrared



No incidence on planning costs since the infrared camera test is done before handover when the building is under commissioning process. The investment cost of the test requires the rent of the thermal camera. Additional remedial works could be necessary if performance is not obtained. The cost of these works could be minor or major depending on the origin of the defect. Regarding the follow-up cost, this test will verify the compliance of the designed envelope quality.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Owners; Construction company; Authorities; Planners; Citizen groups/NGOs		+ €	- €	Quality assurance and construction value

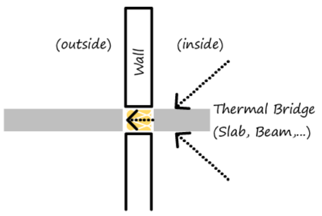
3.7 Installation of renewables



Installing renewable energy sources has a positive impact on the carbon footprint emission and the self-consumption of cheap energy on-site. Various types of renewables could be used depending on site constraints: solar, wind, geothermal, combined heat and power (CHP) from biogas, etc. The size of the renewable installation will depend on the objective retained in order to offset partial or total building's energy consumption in operation.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	p	+ €	+ €	- €€	CO_2-reduction

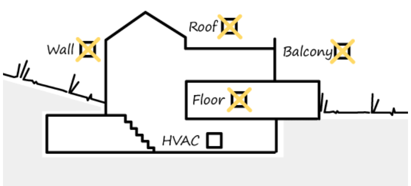
3.8 Eliminate heat bridges



The investment cost due to eliminate the heat bridges is moderate. Alternative solutions for thermal blockers are to be considered to reduce overall thermal losses like: external insulation, external self-bearing balconies and similar. Regarding the follow-up cost, thermal bridges contribute to a relatively high part of the energy performance, especially when given to the ground where heat losses sustain over long times during the year.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Construction company; Authorities; (Economic)Chambers; Citizen groups/NGOs		+ €	- €	Quality assurance and construction value

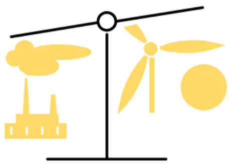
3.9 Construction checklists



Identify critical nodes and pitfalls of the construction during the design phase help to monitor them during the realization of the building. Measures and test carried out to ensure the efficiency of the building components can assure the quality of the building and prevent future problems. Also important is to verify that the project goals are reached and respected. To correct defects during the construction phase, it is even much better to prevent them during design phase, or immediately after specific construction work.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Real estate fund; Construction company; Planners; (Economic)Chambers	- €		- €	Value development

3.10 Green power and carbon offsets

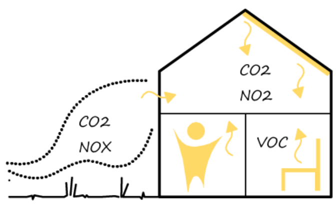


Purchasing carbon offsets or chose for green power certified electricity allows to compensate for the emissions of greenhouse gases and increases the implementation of green power plants. The more planned and placed investments in such projects, the more costs on fossil energy later on can be reduced.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Tenants	Owners; Citizen groups/NGOs; Society; Utilities		+ €	- €€	CO_2-reduction

3.11 Indoor air quality (IAQ) assessment

Co-Benefits: User Acceptance



IAQ assessment means define criteria in an early stage and slightly affects the cost during the building life cycle, and it is not directly connected to operation adjustment in order to reduce the energy cost. Nevertheless, it is strategic to improve the comfort conditions of the occupants, because it could reduce the maintenance and building services system costs.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Tenants/Users; Owners; Construction company; Authorities; Planners; Municipalities	+ €		- €	Comfort

4.5. PROCESS EVALUATION RESULTS

4.5.1.LIST OF ACTIONS RELATED TO STAKEHOLDERS AND OTHER ACTIONS

In the following table, the various actions are assigned to the main drivers and other stakeholders in order to clarify the question of responsibility. In addition, the various dependencies of the actions are listed in the right-hand column of the table to show which actions and stakeholders need to be communicated subsequently.

Table 7: List of actions - construction

	ACTIONS	MAIN DRIVER	STAKEHOLDERS	INFLUENCES ON OTHER ACTIONS
3.1	**Tenant Design and Construction Guidelines**	Owners	Tenants/Users; Real estate fund; Planners; Investors; Utilities	2.2, 2.3, 2.4, 2.12, 2.13, 2.18, 2.26, 3.4, 3.8, 3.9, 4.7
3.2	**Energy performance guarantee**	Utilities	Tenants/Users; Owners; Real estate fund; Planners; Investors; (Economic) Chambers	1.19, 2.17, 2.23, 3.7, 4.1, 4.4, 4.7
3.3	**Extended producer responsibility**	Citizen groups/NGOs	Owners; Construction company; Authorities; Planners; Municipalities; Politicians	3.5, 3.9, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.9
3.4	**Prefabriction of multifunctional Building Elements**	Planners	Owners; Construction company; Planners; (Economic) Chambers	1.17, 2.20, 2.26, 3.9, 4.8
3.5	**Air Tightness Measurements**	(Economic) Chambers	Construction company; Authorities; Planners; Citizen groups/NGOs	2.19, 2.26, 3.11, 4.8
3.6	**Thermography infrared**	(Economic) Chambers	Owners; Construction company; Authorities; Planners; Citizen groups/NGOs	2.3, 2.4, 2.16, 2.18, 2.21, 2.23, 3.8
3.7	**Installation renewables**	Owners	Authorities; Planners; Municipalities; (Economic) Chambers; Citizen groups/NGOs; Society; Politicians; Utilities	1.11, 1.16, 1.17, 1.19, 2.9, 2.17, 3.9, 4.2, 4.5
3.8	**Eliminate Heat Bridges**	Planners	Construction company; Authorities; (Economic) Chambers; Citizen groups/NGOs	2.3, 2.4, 2.18, 2.22, 2.26
3.9	**Construction checklists**	Owners	Real estate fund; Construction company; Planners; Investors; (Economic) Chambers	2.2, 2.3, 2.4, 2.14, 2.18, 3.1, 4.7, 4.9
3.10	**Green Power and Carbon Offsets**	Tenants/Users	Owners; Citizen groups/NGOs; Society; Utilities	1.9, 2.7, 2.12, 2.13, 2.24, 2.27
3.11	**Indoor Air Quality Assessment**	Citizen groups/NGOs	Tenants/Users; Owners; Construction company; Authorities; Planners; Municipalities; Citizen groups/NGOs	2.10, 2.11, 2.14

4.5.2.LIST OF ACTIONS RELATED TO COSTS

The cost savings or higher costs depending on the action are shown in the table below. Therefore -€ means that less costs are required than in a conventional planning procedure. On the other hand, +€ means that the costs increase. The number of € also indicates whether the change is big or small compared to the already known costs. The cost estimation for the different actions and the different cost-causing project steps were made in the course of the research project with the help of the project partners.

Table 8: List of actions related to costs - construction

	ACTIONS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS
3.1	**Tenant Design and Construction Guidelines**	- €	X	- €€
3.2	**Energy performance guarantee**	+ €	- €	- €
3.3	**Extended producer responsibility**	- €	- €€	+ €
3.4	**Prefabriction of multifunctional Building Elements**	- €	- €	X
3.5	**Air Tightness Measurements**	X	+ €	X
3.6	**Thermography infrared**	X	+ €	- €
3.7	**Installation renewables**	+ €	+ €	- €€
3.8	**Eliminate Heat Bridges**	X	+ €	- €
3.9	**Construction checklists**	X	- €	+ €
3.10	**Green Power and Carbon Offsets**	+ €	+ €	- €€
3.11	**Indoor Air Quality Assesment**	+ €	X	- €

4.5.3.LIST OF ACTIONS – WORK BREAKDOWN STRUCTURE

The following diagram shows an overview of all actions assigned to construction. In addition, they are further divided into three categories in order to clearly define in which part of the construction the individual actions belong.

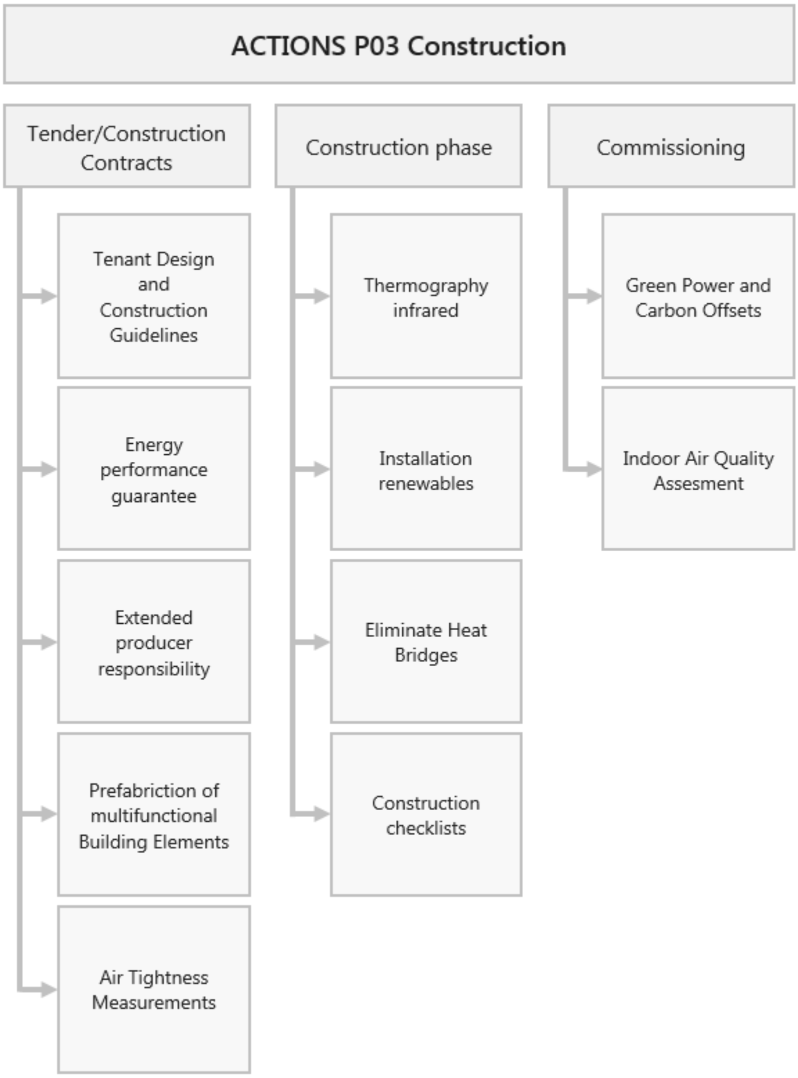


Figure 28: List of actions in construction

4.5.4. LIST OF ACTIONS – RELATIONS BETWEEN THE ACTIONS

The following figure shows the correlations between the different actions and stakeholders. A more detailed description can be found in chapter 2.4.4.

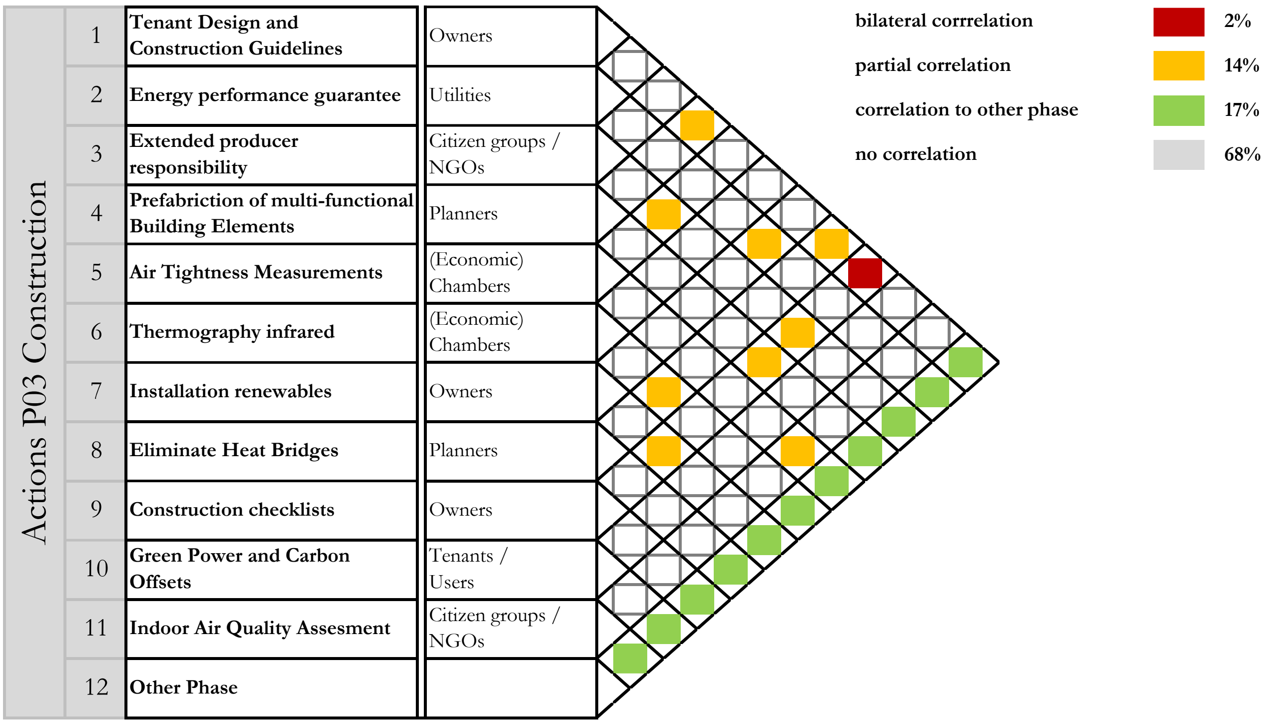


Figure 29: Correlation of actions in construction - own representation following the PLENAR planning tool

CHAPTER 5

BUILDING OPERATION PROCESS

5.BUILDING OPERATION PROCESS

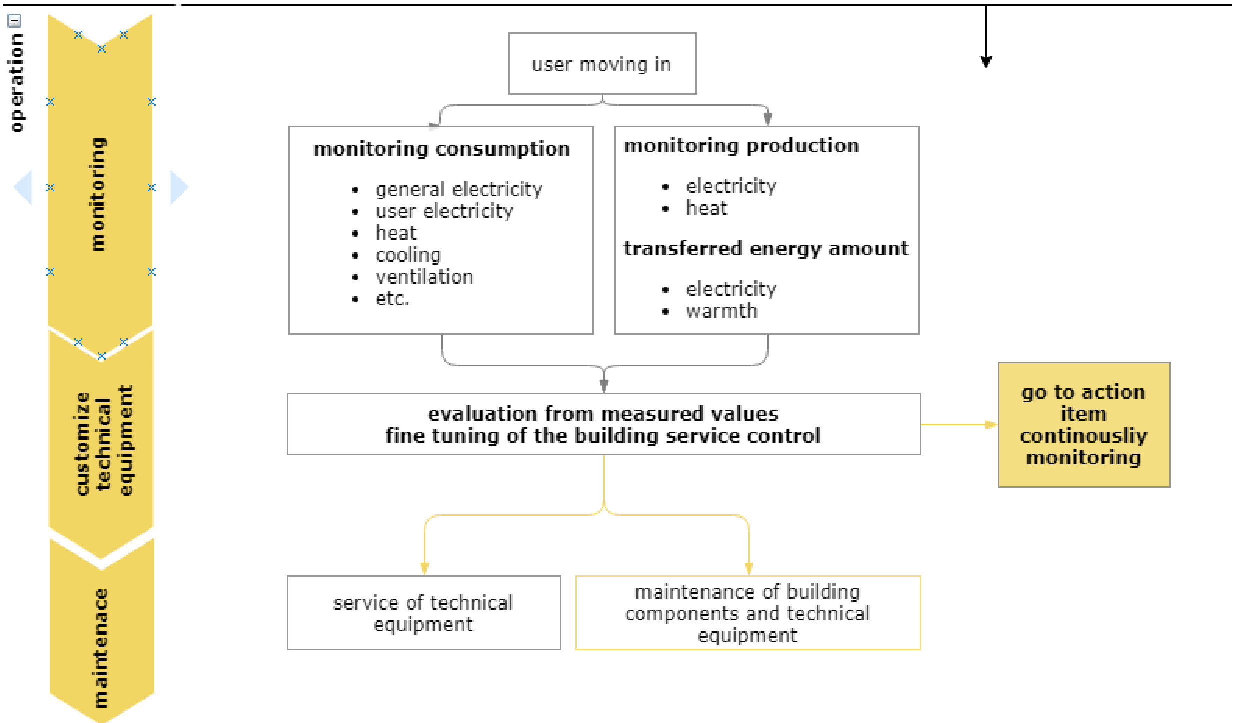
5.1. OVERALL PROCESS

At the end of the construction process, once the building is commissioned, tested, certified and the user has moved in, it is important to ensure the proper building operation. Facilities' operations and maintenance include a broad spectrum of processes, tools and services required to assure that the building will perform the functions for which it was designed and constructed. An appropriate user behaviour, occupant involvement, continuous monitoring and an optimized maintenance raise potential for cost reduction and savings.

Operation and maintenance represent the greatest expense in owning and operating a building over its life cycle. The Royal Academy of Engineering (Royal Academy of Engineering,1998) reports that the typical costs of owning an office building for 30 years are in the ratio of:

- 0,1 to 0,5 for design costs;
- 1 for construction costs;
- 5 for maintenance costs;
- 200 for costs of operating the business during the lifetime of the building, including staff costs.

Therefore, to recover the initial construction cost, since it is the smallest amount, the maintenance and operating costs should be minimized. An optimized monitoring system permits to control the energy consumption, the efficiency of facilities and thermal parameters of buildings continuously. For example, if in winter the detected outdoor temperature exceeds the set-point, it will be possible to decrease heating power. So, the optimal temperature and thermal comfort conditions can be reached as well as the energy consumption reduced.



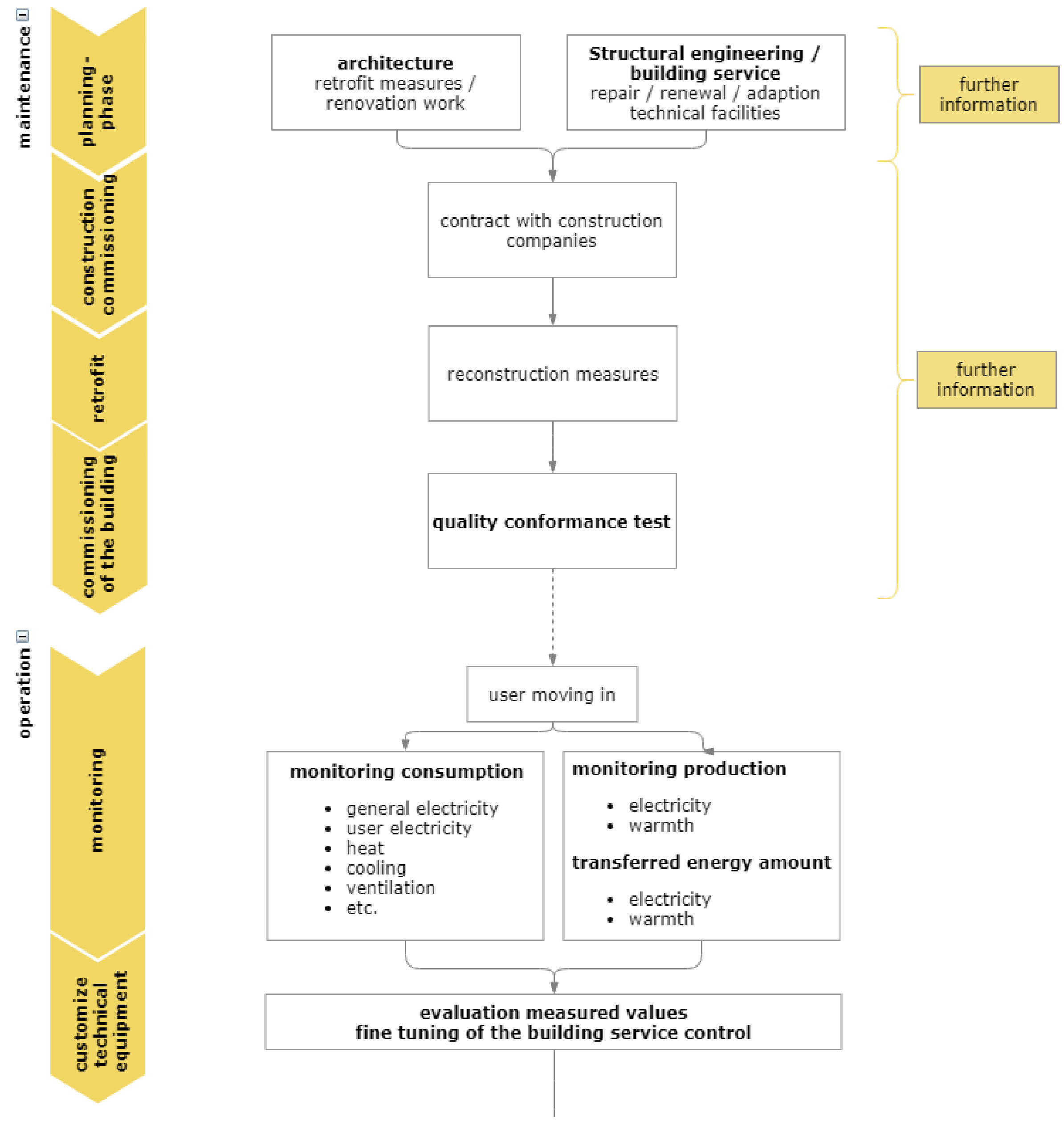


Figure 30: Operation process

5.1.1.OPERATION

During the operation phase, the tenants and owners of the building are the main actors. An operation and maintenance plan can be used to ensure that the building functions in the manner defined in the planning phase. This includes component life expectancy, a plan for recurring operating and maintenance sessions, deceptive routines, target values and performance indicators, and a plan for recurring inspections of target values. In addition, a complete and always up-to-date documentation of the building, services and the plant technology is required during operation in order to be able to control building services engineering and to exclude damage due to incorrect operation, care and maintenance.
Another strategy to improve the operation of buildings is to influence user behaviour. Improving user behaviour can lead to energy cost savings of around 15%. Therefore, occupant and operator training can have a positive impact. Users should be informed about how they can operate building technology in

an energy-efficient way. In addition, a user profile can be created in the planning phase in order to design the building concept accordingly and positively influence the operation phase.
Problem detection and optimisation is also an option to secure the efficient operation of a nZEB. The monitoring of all technical building functionalities (see below) is important in order to achieve the nZEB standard in operation. A continuous comparison should be made between the planned and the actual consumption. If the energy consumption of a particular system is not as planned (too high) or to detect leaks, system problems, etc., advanced control and integrated problem/ fault detection should provide automatic alerts.
Another concept to ensure efficient building operation is advanced energy measurement. In addition to monitoring energy consumption and on-site production from renewable sources, energy-consuming equipment, which accounts for more than 10% of total energy consumption, must be monitored separately. For electricity, it is necessary to monitor both consumption and demand. Data must be accessible remotely. All meters in the system should be able to report hourly, daily, monthly and annual energy consumption.

5.1.2.MONITORING

The energy demand of nZEBs is usually calculated with simple tools in the planning phase of the building process. Only in a few cases, measurements are taken during the operation phase of the building, proving not only the energy performance / efficiency but also comfort conditions. Thus, field monitoring, meant as an observation of building's real operation parameters for the evaluation of its system energy performance through measurements sampled and recorded at regular intervals, becomes a necessary part of energy-efficiency programs. From this perspective "monitoring" is not only aimed at controlling building facilities to ensure suitable comfort conditions (as usually perceived as Building Energy Management Systems - BEMS), but it favours energy efficiency by increasing the awareness of building owners/ facility managers with respect to energy use, suggesting energy saving measures to be adopted and evaluating them afterwards (audit, diagnosis and continuous commissioning).
Although the recognition of the effectiveness of a monitoring system, measurement campaigns for energy performance assessments are not yet a common practice in buildings and they are often limited to research or demonstration projects. Major barriers are the equipment cost and the effort required in monitoring activities, spanning from the system planning to the elaboration of the collected data (post-processing). However, with regards to the financial aspect, monitoring has demonstrated to be a highly cost-effective means of obtaining significant energy savings around 10 to 20%. The larger and more complex the building is, the more profitable the monitoring is likely to be. Standardized monitoring procedures, in particular for new buildings or comprehensive retrofit, are easily available. There are international standards like ISO 50006 and ISO 50015 together with the „International Performance Measurement and Verification Protocol (IPMVP)" of the Efficiency Valuation Organization (EVO) which all help in assessing procedures on monitoring.
Following steps are particularly relevant for the assessment of nZEB:

- Collection of building data
- Definition of monitoring boundaries
- Selection of metrics and relevant data required
- Selection of data frequency and duration of measurements
- Identification of suitable sensors and data acquisition system
- Final planning of the monitoring equipment and installation
- Definition and implementation of data post-processing (e.g. performance indicators)
- Definition of a standard reporting

5.1.3. MAINTENANCE

All facilities of the building require maintenance during its service life. It is possible to perform both planned preventive or predictive maintenance and corrective (repair) maintenance. Preventive Maintenance (PM) consists of a series of time- and IT-based maintenance requirements that provide a basis for planning, scheduling, and executing scheduled maintenance. PM includes lubricating, cleaning, adjusting and replacing components. Predictive Maintenance attempts to detect the onset of a degradation mechanism with the goal of correcting it prior to a significant deterioration in the component or equipment. Corrective maintenance is a repair necessary to return the equipment to properly functioning condition or service and may be either planned or un-expected. Some equipment, at the end of its service life, may need an overhaul: a restoration to a completely serviceable condition as prescribed by maintenance serviceability standards.

The purposes of a complete maintenance program include:

- reduce unscheduled shutdowns and repairs;
- reduce capital repairs;
- extend equipment life;
- minimize life-cycle costs;
- provide safe, functional and reliable systems and facilities.

One example is heating or hydraulic balancing: it is very important especially when centralized heating systems with significant line lengths and numerous pressures reducing branches, bends and fittings are used in a nZEB. The flow and heat transfer, with increasing distance from the boiler system and pump, are increasingly low accompanied by some comfort problems, so a hydraulic compensation has to be done. Thanks to this maintenance measure it is possible to achieve 5-10 % energy savings, increase comfort and intercept other problems as heating system's noise.

5.2. RENOVATING A BUILDING: DEFINITIONS AND LEVELS

The renovation represents an important step of the building life cycle that allows ensuring the proper operation of a building increasing the life cycle perspective. The word "renovation" can be adopted for describing different levels of intervention. Renovation can deal with interventions for replacing or upgrading a single element or multiple parts of the building as well as the installation of RES.

Thanks to the EPBD (Energy Performance of Buildings Directive EPBD defined in 2002, recast in 2010 and updated in 2018), the renovation of a building has to be linked with an improvement of the energy performance, and according to the level of the renovation each Member State established - different performance requirements for either the single element or the overall building.

By using a classification by BPIE, when the application of a single measure (e.g. installation of a new boiler or roof insulation) can be defined as minor or simple renovation, and it is usually expected energy saving up to 30%.

BPIE also introduced another level, i.e. moderated renovation, implementing from 3 to five building elements, allowing for a saving ranging from 30 to 60%.

Concerning higher levels of interventions, the Energy Efficiency Directive 2012/27/EU introduced the concept of deep renovation as a "*refurbishment that reduces both the delivered and the final energy consumption of a building by a significant percentage compared with the pre-renovation levels, leading to a very high energy performance*". Implementing a deep energy renovation means to adopt an integrative approach at the whole building level, allowing for a more cost-effective process and for higher energy savings in comparison to the adoption of separate energy retrofit measures.

Although the EU Directives do not provide a quantitative definition of a deep renovation, it is possible to link the concept to the major renovation, introduced by the EPBD 2010/31/EU as a set of interventions fulfilling one of the following conditions:

- either more than 25% of the surface of the building envelope undergoes renovation
- or the total cost of the renovation of the building envelope, or the technical building systems are higher than 25% of the overall value of the building.

The Energy Efficiency Directive EED does not provide a quantitative energy saving target for a deep renovation but stated that it represents a solution able to reduce both the delivered and final energy consumption of a building by a significant percentage compared with the pre-renovation levels. On the other hand, the European Commission promotes several funding programs (e.g. Horizon 2020, Life, etc.) aimed to find effective solutions for deep renovation, and set, as a reference value, a minimum primary energy saving objective at least of 60% comparing to pre-renovation.

The most ambitious level is the renovation towards nZEB, aimed at implementing the set of measures to an existing building leading to that target, usually reducing up to 90% of the building energy consumption.

BPIE associated average renovation cost for the building surface according to the level of intervention, as reported in the table below.

Table 9: Average cost for different renovation level

LEVEL	COST OF THE RENOVATION [€/M²]
Minor	60
Moderate	140
Deep	330
nZEB	580

5.2.1.1. BUILDING RENOVATION PROCESS: SPECIFICITIES

The renovation of a building follows a path similar to a new construction: it is linked to a new life cycle of the building and presents the same macro phases design, construction and operation.

Nevertheless, the initialisation is different, since the renovation process usually starts from one of the following issues:

- Failure in the equipment or building elements,
- Reached end of life of one or more elements
- Upgrading performances (e.g. energy, safety, etc.)
- Different needs of the users (e.g. new building use)

Moreover, each design and construction process is affected by several uncertainties, that can be easily identified and solved for a new construction, while they are more difficult to be identified during a renovation, and starting the activities is needed for having a clear overview of the possible issues. The uncertainties can lead to higher cost and longer implementation time, affecting the estimated LCC of the intervention.

The uncertainties and difficulties could be linked with:

- Lack of original plans and drawings (or incorrect copies)
- The difficulty of identifying the features of the element (layers and materials)
- Conservation needs
- Compatibility of the renovation with existing structure and materials

5.2.1.2. RENOVATION VS NEW CONSTRUCTION

When renovating the building or proceeding with a new construction could be challenging for a building owner since the decision strongly affects the building life-cycle cost. The decision whether to renovate or to rebuild needs to consider both the profitability of energy savings and if proceeding with a new building would lead to minor uncertainties.

There are several tools and approaches for supporting this decision making in this field, and usually, the main factors are related to the investment cost, the future market value of the existing building, the energy and environmental impact of the applied measures (Morelli, 2014)

The analysis of the cost and benefits for supporting the decision deals to four main categories: (1) planning, (2) facilities management, (3) project requirements, (4) site considerations.

In particular, it is possible to identify some key aspects to be considered in the process:

Planning

1. Defining the expectations and targets of the stakeholders involved is a key activity for the decision making

2. The use of the building before and after the renovation is an important issue to be analysed since a deep reshaping of the building could be needed in case of changing the use

Facilities management

Designing a new building would allow installing new facilities and technologies without constraints due to the existing structure, and the materials, as well as HVAC and electric systems, can be selected only according to cost-effective life cycle criteria, reducing the maintenance costs.

Project requirements

1. The requirements promoted by the building codes are always evolving and could mean to fulfil ambitious targets with the overall building, having a high impact on the cost. In this regard, a detailed analysis of the costs of additional works is strategic for the decision.

2. The structural safety of the building is a crucial issue for driving the decision. In particular, an analysis of the consistency of the existing structure and the investigation of past interventions is needed.

3. The materials used in existing buildings (e.g. asbestos, pollutants, etc.) could not meet the current requirements for a building. Thus an additional repair has to be implemented increasing the timing and the cost of the renovation.

Site considerations

Renovating a retail store in an area where there is no economic growth is a good example of why the location is crucial. Is the building in a location where renovations will actually generate a return on the investment?

5.3. PITFALLS AND BOTTLENECKS

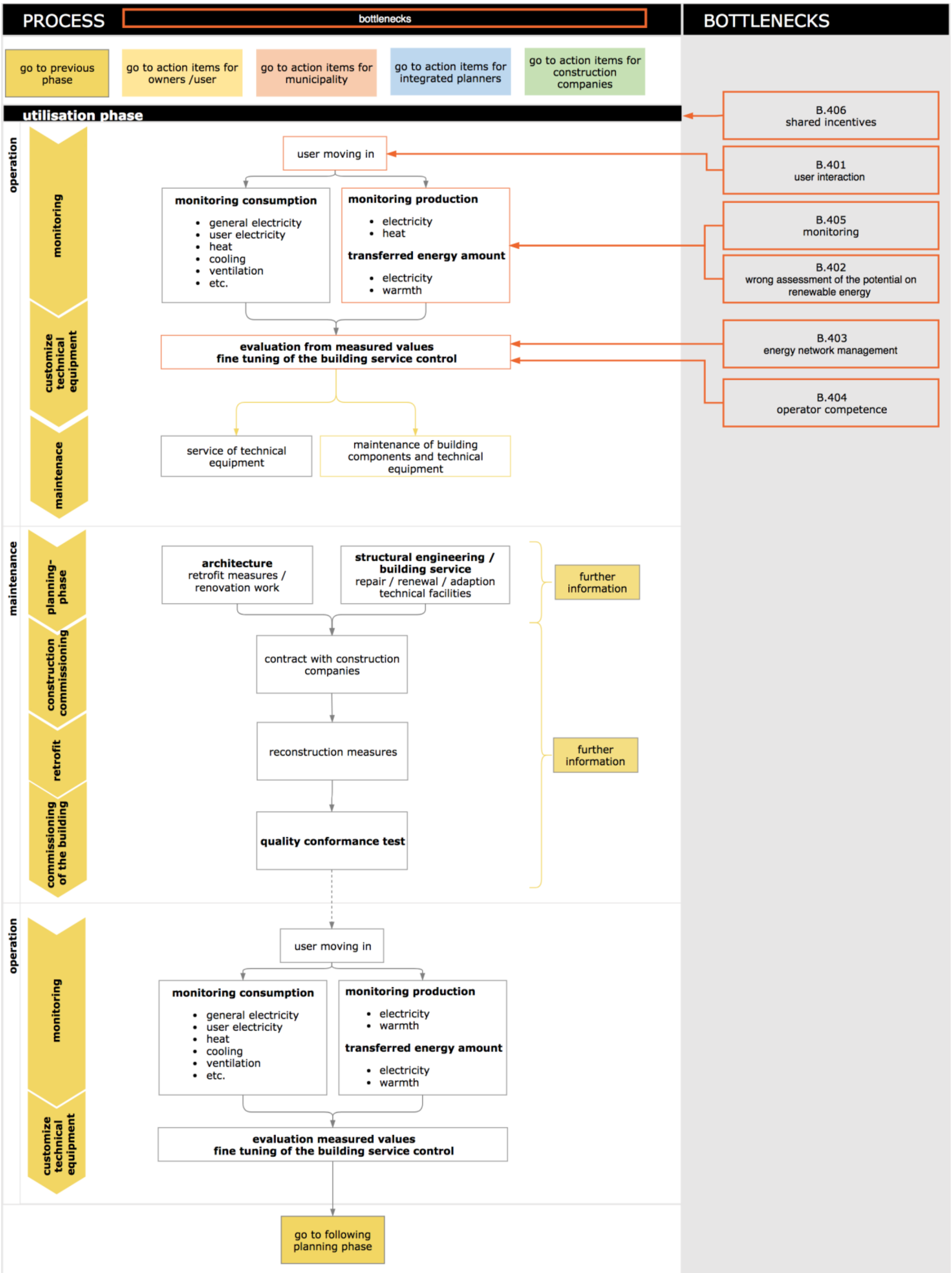


Figure 31: Operation process – pitfalls

B.401: User instruction

To ensure that the building is operated according to plan, a building manual must be handed over to the user/operator. Without these instructions, errors may occur due to incorrect operation. These errors can reduce the service life of individual components and lead to higher consumption than determined in the planning process.

B.402: Wrong assessment of the potential on renewable energy

The uncertainty quantification of solar energy yield calculations is important for managing the financial risks of an investment in a photovoltaic or solar thermal system. Quantifying the energy yield is subject to several uncertainties introduced by the different elements in the renewable energy conversion chain.

B.403: Energy Network Management

The management of heating/cooling networks is an integral part of a small-scale utility. To ensure these supply structures, basic conditions for efficient supply must be defined in the planning phase. To save costs and energy for this network, a holistic network management has to be implemented.

B.404: Operator Competence

Operator training is necessary to ensure energy-efficient building operation. The building operator must be able to manage innovative and highly complex technical building systems. Furthermore, he must be able to detect malfunctions by measuring the parameters evaluated during operation. Only through these actions it is possible to avoid failure to achieve the energy targets due to improper building operation.

B.405: Monitoring

Due to a lack of monitoring of the media flows, it is not possible to check the energy and media consumption. However, this monitoring is necessary to ensure efficient operation and fault management of the building. This monitoring can be used to determine parameters for future projects in order to validate the functionality of new technical concepts.

B.406: Shared incentives

The added value of planning a nZEB is usually only apparent in the use phase. Investors who only construct buildings and then sell them with the highest possible profits can only generate this added value but have no positive effect on the quality of the building themselves. For this reason, incentive models should be created that make it interesting for investors to plan and build nZEBs.

5.4. ACTIONS

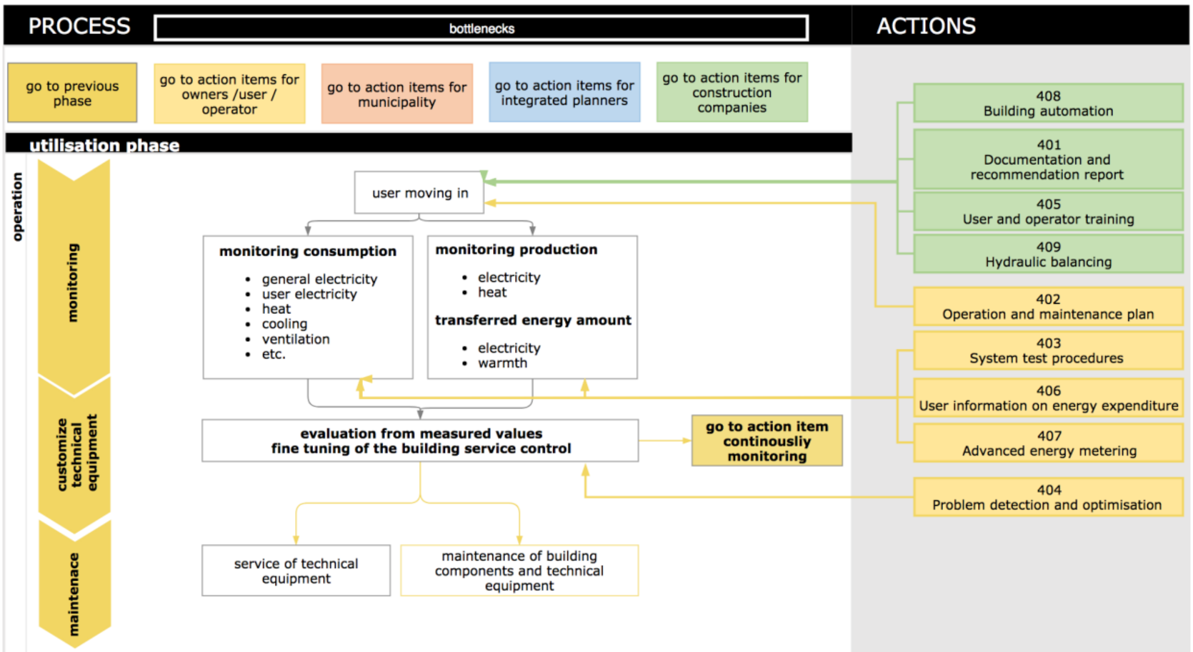


Figure 32: Operation process – actions (part 01)

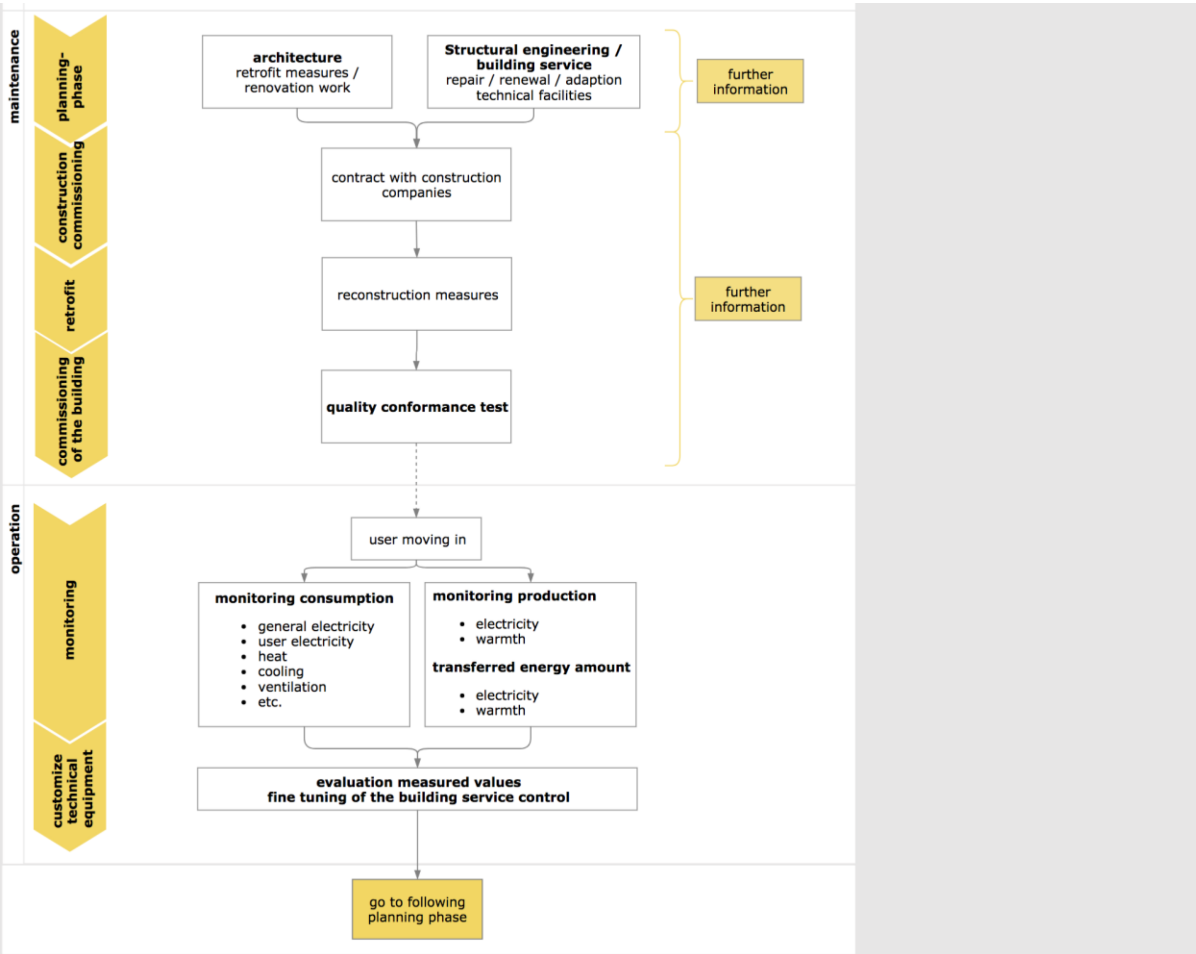


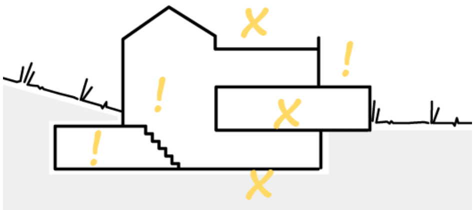
Figure 33: Operation process

4.1 Operations and maintenance plan

The operation deals with the daily functioning of the buildings, including the costs for the energy supply. The maintenance costs are directly connected with the operation ones, since they are strategic to improve or (at least) keep an acceptable level of energy-efficiency of the building. Developing an operations and maintenance (O&M) plan is a key activity to proper allocate the maintenance budget during the life cycle, and to control the effective management of the building.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities			- €	Energy savings, value development and quality assurance

4.2 Documentation and recommendations report



The operation and maintenance manuals (OMM) are the reference documentations which gather all the technical data, test, set point parameters etc. No incidence on planning costs as the task will be done at the end of the construction works. The investment cost regarding OMM is moderate (collection of datasheets, tests results, drawings etc.). Regarding the follow-up cost, those OMM will guide the user to stick to the initial setup value in order to avoid consumption gap.

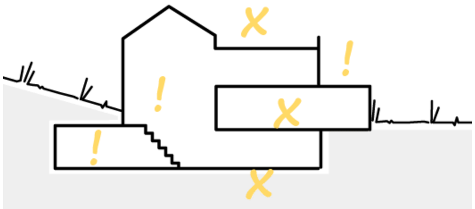
MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Construction company; Authorities; Planners; (Economic) Chambers; Utilities		+ €	- €	Value development and quality assurance

4.3 Occupant and operator training

Concerning the operator / on-site facility manager, an effective training is strategic for ensuring the proper functioning and maintenance of the building's HVAC system, especially for nZEB where new and not proven technologies are installed. In this regards, there are also specific trainings and certification programmes that can enable the operators in effective facility management and the occupants in "effective" use of the building services system.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Construction company; Authorities; Planners; Municipalities; (Economic)		+ €	- €	Energy savings, user sat.

4.4 Optimize energy performance/ detection of problems



This activity can be connected to the issue of Fault Detection and Diagnosis (FDD), representing the strategy supporting the facility manager in discovering and identifying the root causes of faults in building systems, equipment, and controls (Frank et al, 2018). The fault detection can be done manually, by periodical checking of the facility manager exploiting the monitored data, or with an automated system. This second option requires an advanced algorithm for the elaboration of the monitored data to detect and diagnose unwanted operating conditions (i.e. faults) in the equipment, and sensors, and controllers of the significant HVAC system devices.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Construction company; Authorities; Planners; (Economic) Chambers; Utilities		+ €	- €	Energy and resource savings

4.5 Advanced energy metering

Different literature evidences the benefits of long-term monitoring, since it allows for controlling the proper operation and the efficiency of the building and the systems installed, ensuring the quality of the performances. For new construction, it generally occurs towards the end of the construction timeframe, before the building is turned over to the owner. In every case, it should be one final quality assurance step to verify that building systems are optimized and operating efficiently. According to the availability of budget, it is possible to perform monitoring, with different level of detail and at whole building level as well as focused on specific subsystems.

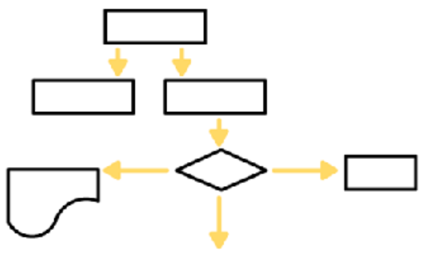
MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Utilities	Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers	+ €	+ €	- €	Energy savings and CO_2-reduction

4.6 User information on energy expenditure

Providing feedback is an engagement technique widely used to reduce the energy consumption of a building by increasing the awareness of the users. There are two main categories: i) direct feedback, providing real-time information to the consumers typically from display or a software application, ii) indirect feedback, where data are elaborated by the utility company such as additional costs before the communication to the users.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Citizen groups/NGOs	Tenants/Users; Authorities; Municipalities; (Economic) Chambers; Utilities		+ €	- €	Energy and resource savings

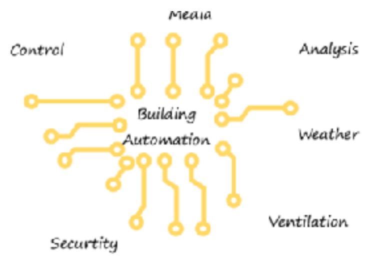
4.7 System test procedures



It defines the whole building operation organization through full functional analysis and measures the building key parameter as energy consumption, water consumption, indoor air quality etc. The investment cost regarding test commissioning is moderate. Additional remedial works could be necessary if performance is not obtained. These procedures ensure that the system will perform as designed. Regarding the follow-up cost, this testing will verify the compliance of the designed nZEB systems.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Owners	Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	+ €	+ €	- €€	Energy savings and quality assurance

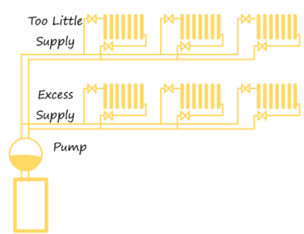
4.8 Building automation



Building automation represents a centralised and digital control system of the building's HVAC components through a Building Energy Management System (BEMS). Building automation is an effective approach for nZEBs, since it allows for managing the energy demand and for controlling effectively the heating, ventilation and air conditioning systems in a building including forecast and flexibility options.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
Planners	Owners; Authorities; Municipalities; (Economic) Chambers; Utilities	+ €	+ €	- €€	CO_2-reduction and energy flexibility options

4.9 Hydraulic balancing



A typical measure to increase the efficiency of the heat distribution system of a building is the hydraulic balancing, not taking much effort and cost from an heating system-installation expert, but in some cases having a great effect on the user's comfort and heat consumption of the whole building.

MAIN DRIVER	STAKE-HOLDERS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS	CO-BENEFITS
(Economic) Chambers	Tenants/Users; Owners; Citizen groups/NGOs; Utilities			- €	Comfort and energy savings

5.5. PROCESS EVALUATION RESULTS

5.5.1. LIST OF ACTIONS RELATED TO STAKEHOLDERS AND OTHER ACTIONS

In the following table, the various actions were assigned to the main drivers and other stakeholders in order to clarify the question of responsibility. In addition, the various dependencies of the actions are listed in the right-hand column of the table to show which actions and stakeholders need to be communicated subsequently.

Table 10: List of actions - operation

	ACTIONS	MAIN DRIVER	STAKEHOLDERS	INFLUENCES ON OTHER ACTIONS
4.1	**Operations and Maintenance Plan**	Owners	Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	3.1, 3.3, 3.9, 4.2, 4.4, 4.7, 4.8
4.2	**Documentation and Recommendations report**	Owners	Construction company; Authorities; Planners; (Economic) Chambers; Utilities	3.10, 4.1, 4.5, 4.6, 4.9
4.3	**Occupant and operator Training**	Owners	Tenants/Users; Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	3.1, 3.3, 3.9, 4.1, 4.2, 4.4, 4.5, 4.6
4.4	**Problem Detection and Optimisation**	Owners	Tenants/Users; Construction company; Authorities; Planners; (Economic) Chambers; Utilities	4.2, 4.3, 4.7, 4.8
4.5	**Advanced Energy Metering**	Utilities	Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers	2.9, 3.2, 4.7
4.6	**User Information on Energy Expenditure**	Citizen groups/NGOs	Tenants/Users; Authorities; Municipalities; (Economic) Chambers; Utilities	4.2, 4.3, 4.7, 4.8
4.7	**System Test Procedures**	Owners	Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities	3.3, 3.9, 4.2, 4.6, 4.8
4.8	**Building Automation**	Planners	Owners; Authorities; Municipalities; (Economic) Chambers; Utilities	4.1, 4.2, 4.4, 4.6
4.9	**Hydraulic Balancing**	(Economic) Chambers	Tenants/Users; Owners; Citizen groups/NGOs; Utilities	2,24

5.5.2.LIST OF ACTIONS RELATED TO COSTS

The cost savings or higher costs depending on the action are shown in the table below. Therefore -€ means that less costs are required than in a conventional planning procedure. On the other hand, +€ means that the costs increase. The number of € also indicates whether the change is big or small compared to the already known costs. The cost estimation for the different actions and the different cost-causing project steps were made in the course of the research project with the help of the project partners.

Table 11: List of actions in relation to costs - operation

	ACTIONS	INFLUENCE ON PLANNING COSTS	INFLUENCE ON INVESTMENT COSTS	INFLUENCE ON FOLLOW-UP COSTS
4.1	**Operations and Maintenance Plan**	X	X	- €
4.2	**Documentation and Recommendations report**	X	+ €	- €
4.3	**Occupant and operator Training**	X	+ €	- €
4.4	**Problem Detection and Optimisation**	X	+ €	- €
4.5	**Advanced Energy Metering**	+ €	+ €	- €
4.6	**User Information on Energy Expenditure**	X	+ €	- €
4.7	**System Test Procedures**	X	X	- €
4.8	**Building Automation**	+ €	+ €	- €€
4.9	**Hydraulic Balancing**	X	X	- €

5.5.3.LIST OF ACTIONS – WORK BREAKDOWN STRUCTURE

The following diagram shows an overview of all actions assigned to operation. In addition, they are further divided into three categories in order to clearly define in which part of the planning the individual actions belong.

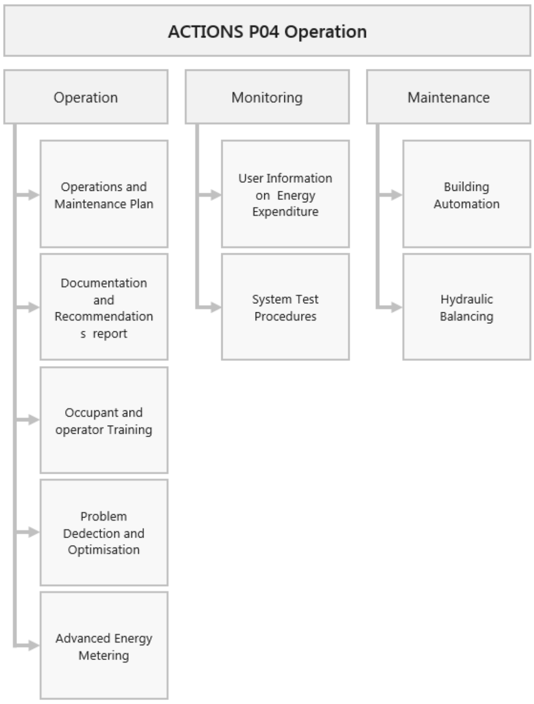


Figure 34: List of actions in building operation

5.5.4. LIST OF ACTIONS – RELATIONS BETWEEN THE ACTIONS

The following figure shows the correlations between the different actions and stakeholders. A more detailed description can be found in chapter 2.4.4

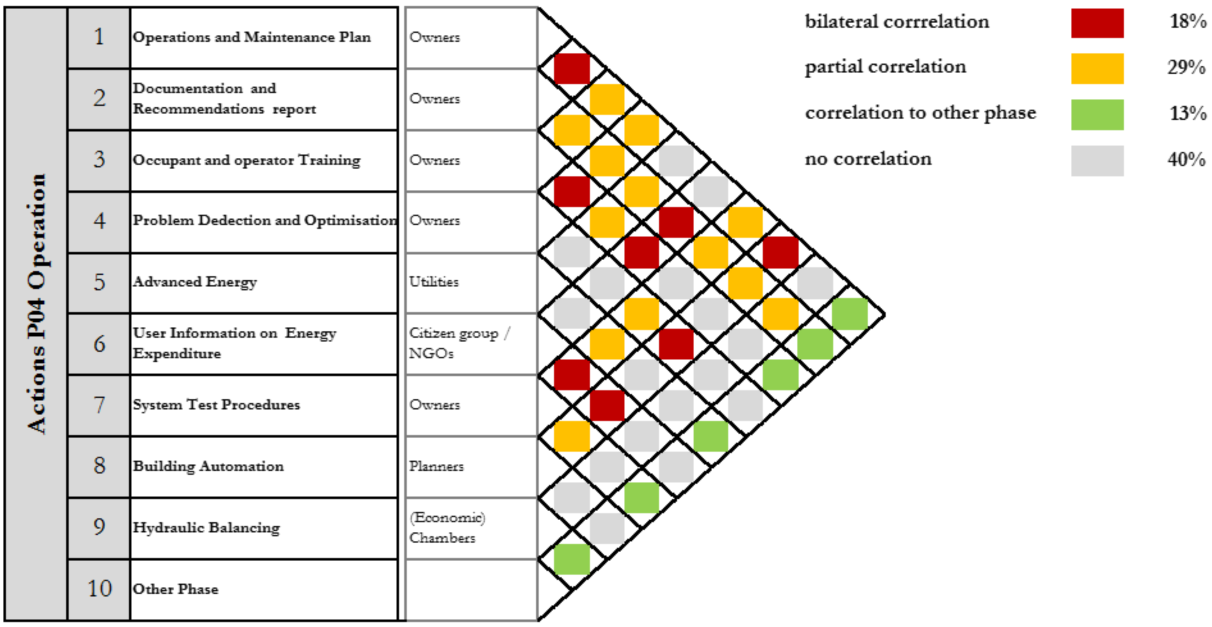


Figure 35: Correlation of actions in building operation

CHAPTER 6

END OF LIFE

6.END OF LIFE

6.1. OVERALL PROCESS

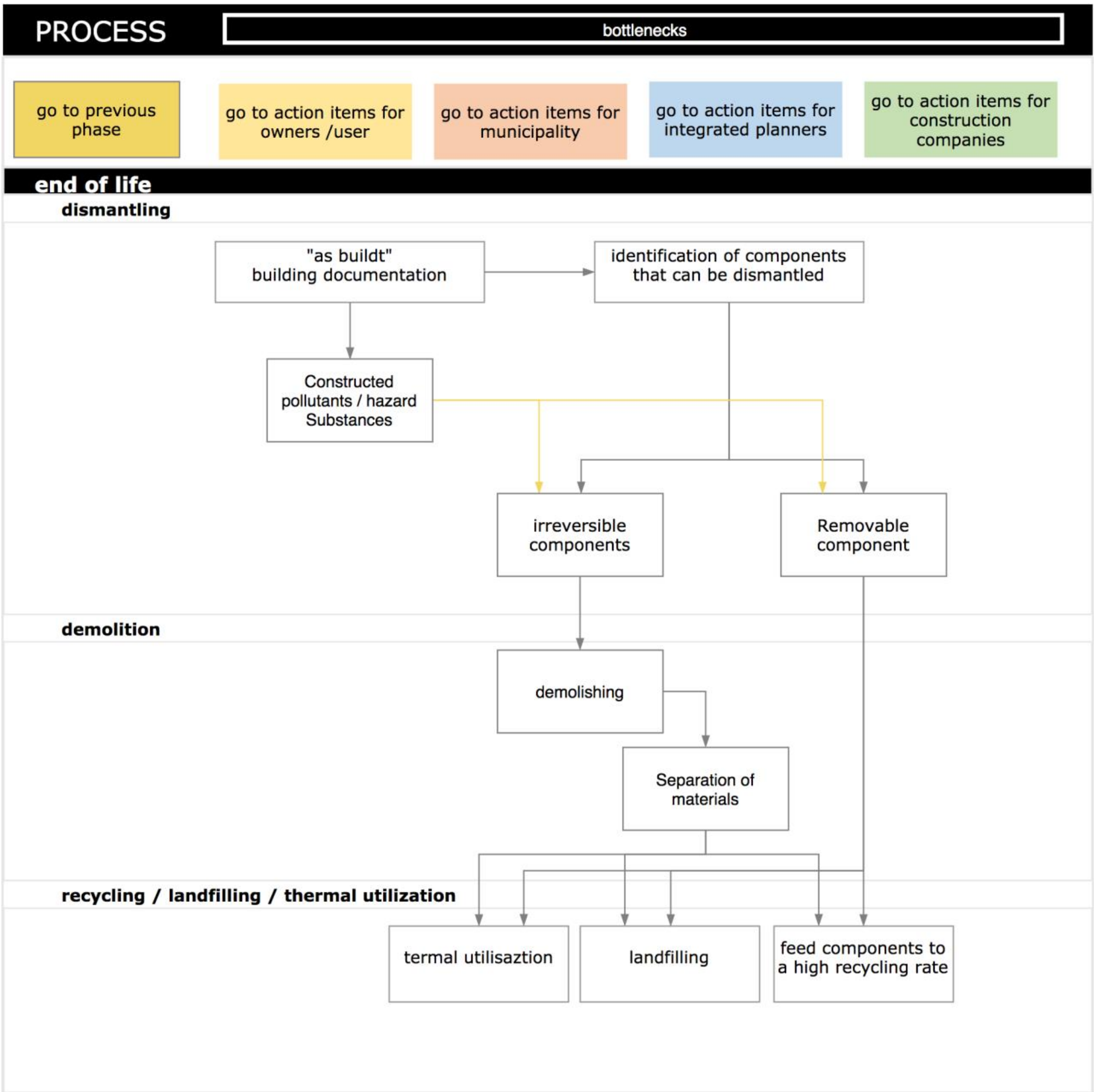


Figure 36: End of life process

The volume of waste from the construction sector with - 871 million tons (EU, 2018) is the largest man-made waste stream in the EU (ECORYS, 2016). The DGNB, LEED and BREEAM certification systems have been assessing the recyclability of buildings for several years to reduce the environmental impact of buildings (DGNB; 2018), (USGBC; 2018), (BREEAM 2016). With the "Levels assessment system", the EU has launched an assessment system that promotes the idea of a circular economy. A two-year test phase for this system began in 2018. In

addition to five other key areas, the system evaluates the building's resource efficiency (Level(s), 2018).
According to an EU publication, most materials contained in construction and demolition waste are easy to recycle. This allows the waste stream from the construction sector to be identified as an important source for the production of secondary raw materials. The EU Waste Framework Directive (2008/98/EC) sets a recycling target of 70% for 2020 (EU, 2018).
88 % of construction and demolition waste in the EU was recycled on average in 2014. In this evaluation, recycling is assessed in terms of reuse, recycling, material recovery and backfilling.
The recycling data differ considerably in European countries. Here, for example, 11 member states have a recycling rate of over 95 %, but two member states have a recycling rate of less than 40 % (EU, 2018).

To further increase the recycling rate, the "EU Construction & Demolition Waste Management Protocol" describes a waste management process. This process is intended to reduce the amount of waste. According to this, first, a waste identification is carried out on the basis of a detailed inventory of the building to be demolished. The waste is then separated into its various components, hazardous waste and recyclable materials. Furthermore, for an efficient recycling, a transparent management system is needed, which allows to register the different types of waste and their quantities and to set up an efficient logistics system. This logistics system should pay special attention to short transport distances. The further processing of construction waste must then take place in highly efficient sorting and processing plants in order to guarantee a consistent quality of recycled material (ECORYS, 2016).

In addition to this European Union protocol, many research projects address the management of waste in the construction sector.
The IBO institute in Austria has developed the EI Waste Disposal Indicator, a planning tool that assesses the amount of waste generated in the planning process according to the type of waste. The potential recycling path of constructions is evaluated (IBO, 2018). The research project "Urban Mining" of the TU Berlin is developing a guideline for the evaluation of the recyclability of constructions for the city of Berlin (Vogdt; 2018). Within the framework of the research project "MAVO BauCycle", the Fraunhofer Institute develops recycling processes for heterogeneous building rubble in order to subsequently process it into homogeneous building products in new production facilities. New sorting technologies based on optical computing are being developed to produce new recyclates and secondary raw materials from construction waste. New innovative logistics platforms must be developed in order to implement this goal of raw material cycles (Fraunhofer Institut, 2016).
Besides the developments towards an improved understanding of raw material recycling, the office "SuperUse Studios" starts from the point of view that reuse is the optimized recycling. With harvest map, they have created a portal that offers materials that can be expanded for reuse from an existing building (SuperUse, 2015)

7.CONCLUSION

The focus of the described “CRAVEzero process”, is to promote a common, interdisciplinary understanding of the complexity of nZEB planning processes for all involved stakeholders. A well organised and transparent process is a key issue of achieving the goal of cost-optimal and sustainable nZEBs throughout the entire life cycle phase.

In the previous chapters this process was described. The overall life cycle process of briefing, designing, constructing and operating nZEBs was illustrated in different life cycle phases. Actions, stakeholder-relations, pitfalls and bottlenecks, as well as the required goals, were pointed out in detail. Key actions needed to ensure the achievement of energy and cost related goals for a replicable planning, design, construction, and operation process were presented.

Based on the results from this guideline and to further provide an operative methodology to achieve the best conditions towards cost optimal nZEBs all achieved results of the report have been summarized and structured in a “lean management protocol” the so-called “life cycle tracker tool”.

As a main result this report comes along with the downloadable “life cycle tracker tool”, an easy-to-use Excel file with VBA macros that combines project roles, actions, and design responsibility matrix. It is based on the experience of the whole consortium in the area of holistic project management with a focus on integral building planning of nZEBs. It gives support on how key performance parameters to achieve successful nZEBs should be prioritized and can be tracked along the whole life-cycle-process.

It can be downloaded here: http://www.cravezero.eu/lifecycletracker

It helps stakeholders in different phases of the life cycle to structure the whole planning, construction and operation process in a framework ensuring a high process quality of new nZEBs.

7.1. LEAN MANAGEMENT PROTOCOL

The following sub-chapter presents a short manual on how to use the CRAVEzero-life-cycle-tracker accompanying the report.

The “CRAVEzero-life-cycle-tracker” accompanying this report is a shared interdisciplinary tool for all involved stakeholders realizing nZEBs, providing a shared framework for the organization and management of building projects.

It can be used for both as process map and a management tool, providing important actions that need to be taken to reach the goal and best practice guidance from the CRAVEzero consortium. It reflects the actions in nZEB project management and provides strategic leadership. It incorporates nZEB design principles, promotes integrated working between project team members, and provides the flexibility to match project specific challenges. “CRAVEzero-life-cycle-tracker” is an easy to customize electronic document that can be adapted to the specific needs of any practice, team or project. It organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. It details the tasks and outputs required at each stage, which may vary or overlap to suit specific project requirements. It is a downloadable spreadsheet, in Microsoft excel format, containing customisable tables allowing easy creation of the project roles, design responsibility matrix and multidisciplinary schedules of services. It is part of the mindset of stakeholders involved in the construction industry and is woven into their processes. It can be downloaded here: http://www.cravezero.eu/lifecycletracker

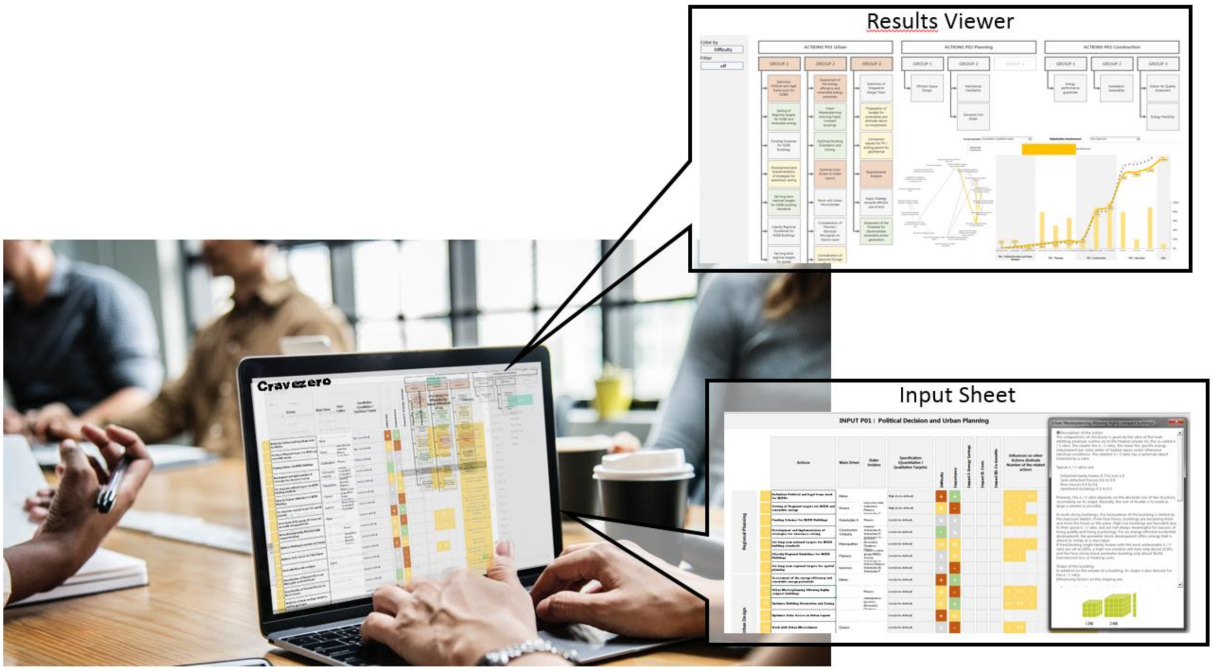


Figure 37: Visualisation of the CRAVEzero-life-cycle-tracker tool

In the following the way to use the "CRAVEzero-life-cycle-tracker" for the own nZEB planning process is described. We advise read this subchapter only in combination with the tool, since it presents a short manual of the tool – otherwise feel free to skip this subchapter.

1) DEFINE ACTIONS:

The "CRAVEzero-life-cycle-tracker" tool consists of four phases from urban planning till operation and renovation and more than 50 key actions along the whole process. All actions important for a specific project to reach the nZEB standard were determined and systematically chosen with the involved stakeholders. Actions are selectable (able to be 'switched' on or off).

The fixed process phases ensure consistency for the overall CRAVEzero methodology.

The ability to switch certain actions on or off and to vary the content of others provides a modular structure used to produce a focused and bespoke practice or project-specific version.

PHASES:

- Urban Planning
- Planning
- Operation
- Renovation

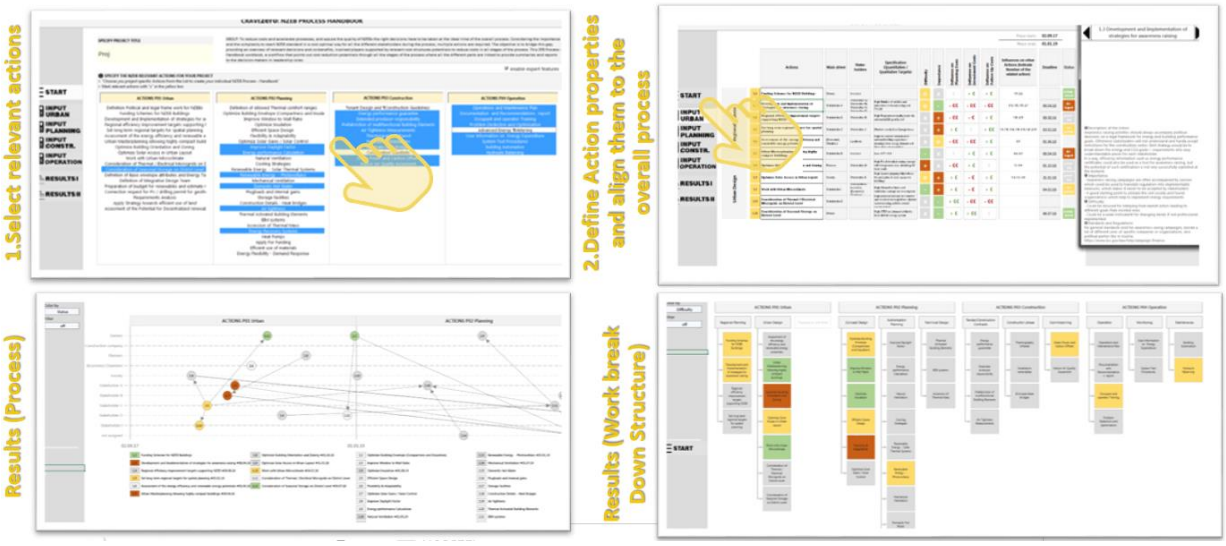


Figure 38: Screenshots of the "CRAVEzero-life-cycle-tracker" tool in order to select and define project specific actions

2) SET GOALS

All actions as can be seen in Figure 39 are rated with regard to their degree of influence on costs in different phases. Furthermore, correlations between the actions can be defined. Example: Correlation between action 1 and action 2 shows us the relationship between building mass (action 1) and energy-consumption (action 2). Depending on the state of knowledge of the stakeholders, their rating can be compared with reference values (expert features) or predefined reference values that have been developed in the project can be used. Significant deviations from this reference values, but also between the actors, enable a structured discussion, and reveal information gaps of the participants. As a first stage, the instrument ensures a common understanding of planning within a short period of time, which qualifies the further planning process. The framework can be individually adapted and used by planning teams. In the further course of the project, these findings serve as the basis for formulating project goals, which support the development of a requirement specification as a requirements profile.

Phase starts: 01.10.20
Phase ends: 31.12.10

	Actions	Main driver	Stake-holders	Specification (Quantitative / Qualitative Targets)	Difficulty	Importance	Influence on Planning Costs	Influence on Investment Costs	Influence on Follow-Up Costs	Influences on other Actions (Indicate Number of the related action)	Deadline	Status
4,1	Operations and Maintenance Plan	Construction company		Low: No plan	o	+	- €	X	- €	3.1, 3.3, 3.9, 4.2, 4.4, 4.7, 4.8		
4,2	Documentation and Recommendations report			Low: Commissioning + component documentation	o	+	X	+ €	- €	3.10, 4.1, 4.5, 4.6, 4.9		
4,3	Occupant and operator Training			Low: User + operator guide is available	o	o	X	+ €	- €	3.1, 3.3, 3.9, 4.1, 4.2, 4.4, 4.5, 4.6		
4,4	Problem Dedection and Optimisation			Low: Simple energy measurements and control	+	+	X	+ €	X	4.2, 4.3, 4.7, 4.8		
4,5	Advanced Energy Metering			Low: Most important energy consuming parts of the building (Heating, electricity and domestic hot water) and yearly checked	o	o	+ €	+ €	- €	2.9, 3.2, 4.7		
4,6	User Information on Energy Expenditure			Low: No information about energy expenditure	o	o	X	+ €	- €	4.2, 4.3, 4.7, 4.8		
4,7	System Test Procedures			Low: No specifications for system test procedures were made	o	-	+ €	+ €	- €€	3.3, 3.9, 4.2, 4.6, 4.8		
4,8	Building Automation			Low: Not bus connected control system with only basic regulation possibilities	o	-	X	+ €	- €€	4.1, 4.2, 4.4, 4.6		
4,9	Hydraulic Balancing			Low: Hydraulic balancing is not considered during planning and warranty, but later	o	+	+ €	+ €	- €€	2,24		

Figure 39: Action list generated within the "CRAVEzero-life-cycle-tracker" tool

3) ASSESS IMPORTANCE AND RISKS

Tasks, goals, requirements and wishes and their backgrounds are analysed also in terms of their interdependencies, can be prioritised in a project-specific way, for example, according to energy and cost efficiency (see also Figure 14).

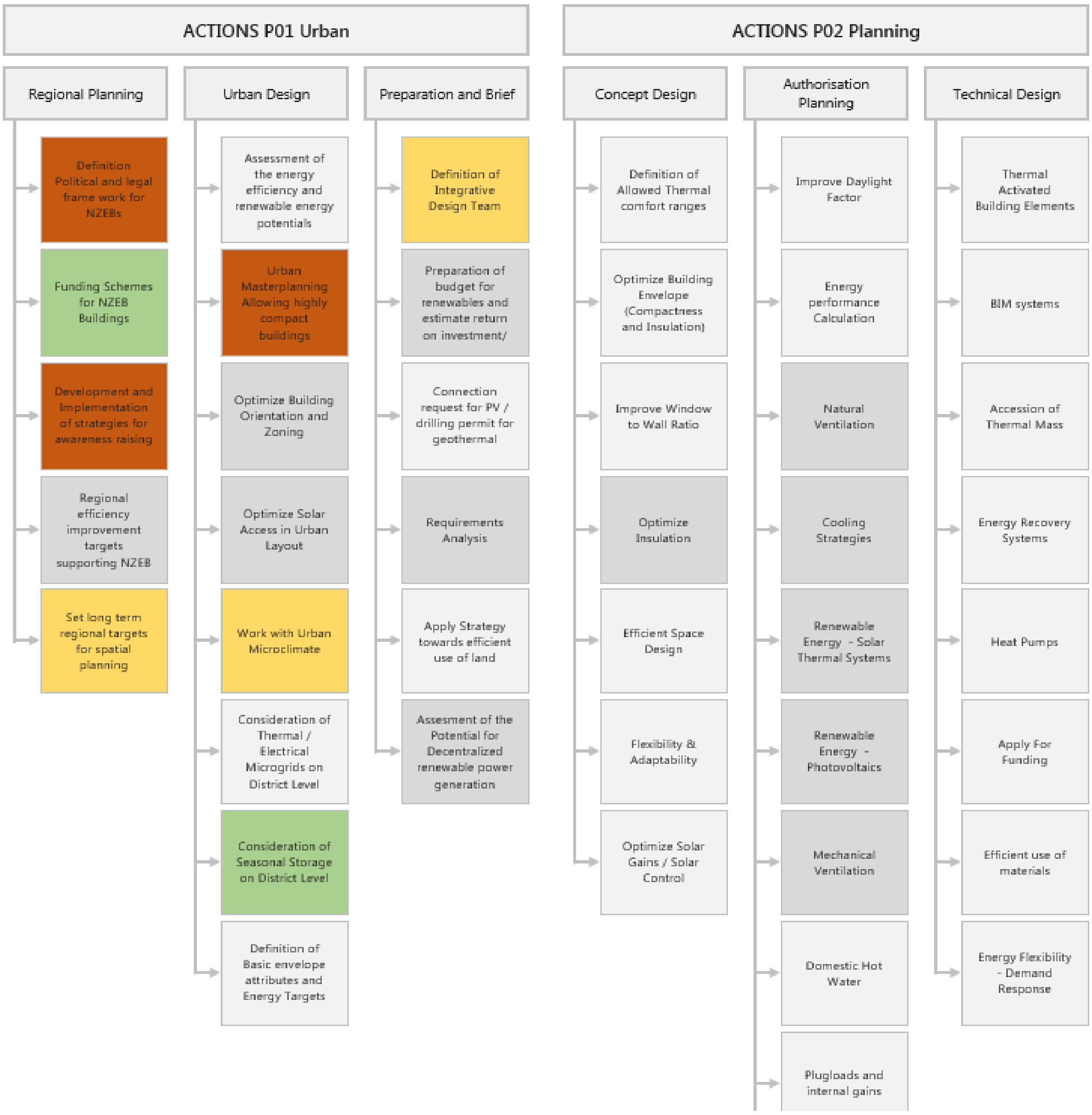


Figure 40: Automatically generated work-break-down-structure (WBS) of one result-sheet in the "CRAVEzero-life-cycle-tracker" tool – different colours addressing different prioritised actions to be taken in a specific predefined process

4) PROCESS SUPPORT

The "CRAVEzero-life-cycle-tracker" is also suitable for project-accompanying documentation of the results at planning meetings, in which the work steps or tasks are iteratively reflected and updated for the next planning phases.

Professional qualifications and understanding of roles, tasks and functions for the planning process is a necessity.

5) EVALUATION

All correlations of actions and stakeholder can be assessed with regard to their respective relevance or the degree of their influence on costs, difficulty and importance of co-benefits.

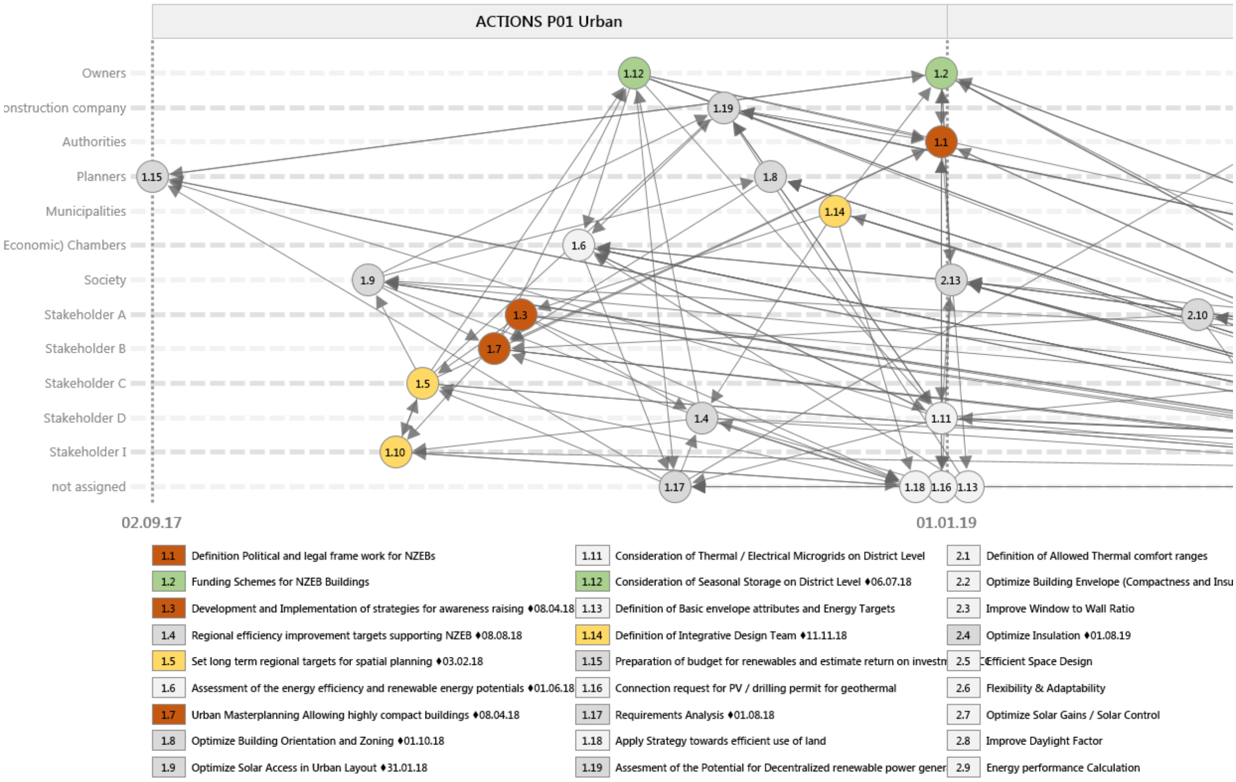


Figure 41: Correlation of actions as one result-sheet in the "CRAVEzero-life-cycle-tracker" tool – different colours addressing different prioritised actions to be taken in a specific predefined process

ANNEX I: DETAILED DESCRIPTION OF NZEB ACTIONS

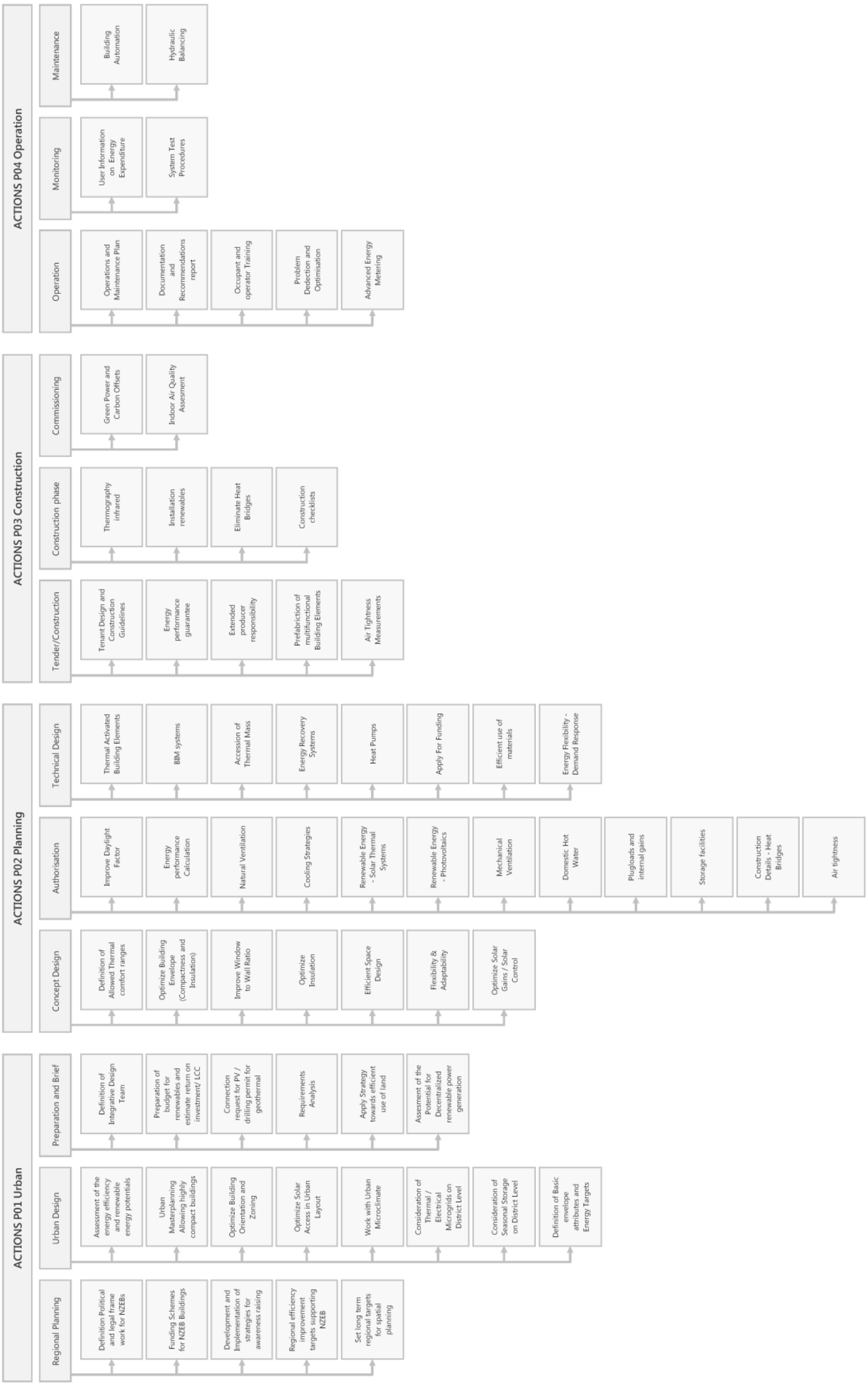


Figure 42: Overall list of actions in building operation - WBS

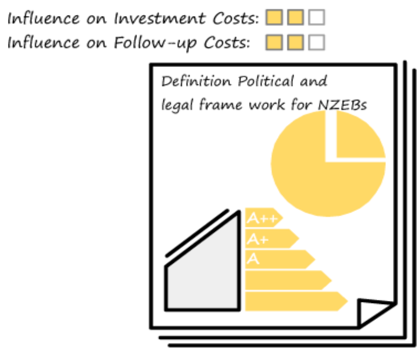
ACTION: Definition Political and legal framework for nZEBs
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Development of laws and regulation designed to achieve nZEB policy goals:

- The European Union defines the legal framework of Nearly Zero Energy Buildings (nZEB) in the Energy Performance of Buildings Directive (EPBD) which is regularly revised and updated. Same is true for the Energy Efficiency Directive (EED) and the Renewable Energy Directive (2009/28/EC) which indirectly supports the development of nZEB in Europe.
- Due to the principle of subsidiarity the EU member countries lay down their national building codes following the EPBD.
- In some countries like Austria the regional state governments themselves detail and modify these EU/national legal guidelines for nZEB in their own way.

❷ EXAMPLES (CASE STUDY A):



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

In zones where district heating is publicly promoted, strict limit values of the building energy demand could thwart the economic operation of those

❺ INFLUENCES ON OTHER ACTIONS

1.9, 1.16, 2.1, 2.9

REFERENCES USED

EU-directives and standards (see above), results from IEA EBC Annex 52/SHC Task40, OIB Richtlinie 6 - "Energieeinsparung und Wärmeschutz" (2015) and https://www.geq.at/ - Zehentmayer Software GmbH, accessed at 15th April 2018

❻ IMPORTANCE

Buildings defined and calculated following the limit values of the EPBD and national nZEB regulation can be benchmarked against each other. Minimum limits of energy demand or CO2-reduction goals can be formulated based on the legal framework and cannot be argued any more. The international agreed procedure is implemented.

❼ DIFFICULTY

- Loss of innovations by setting a technical framework
- Choosing the wrong benchmarks might lead to long-term failure
- The short-term social-economic costs could be high

❽ STANDARDS AND REGULATIONS

- Energy Performance of Buildings Directive 2010/31/EC (EPBD)
- EN standards like ISO 52016-1 (2017), ISO 52003-1 (2017)
- National as: Austrian OIB RL6

❾ MAIN DRIVER

Stakeholder B

❿ INVOLVED STAKEHOLDERS

Stakeholder B

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

- Political decision process EU/national/regional
- Energy Performance Certificate (EPC) calculation (tools like GEQ in Austria)
- Increased investments derive from a legal framework stimulating socio-economic development

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

- Qualitative goal: CO2-neutral European building stock
- Quantitative: Limit values for nZEB regarding the final energy demand as well as CO2-reduction

High: Best nZEB limit values of one single EU partner country
Medium: Medium nZEB limit values of one single EU partner country
Low: Worst nZEB limit values of one single EU partner country

ACTION: Funding Schemes for nZEB Buildings

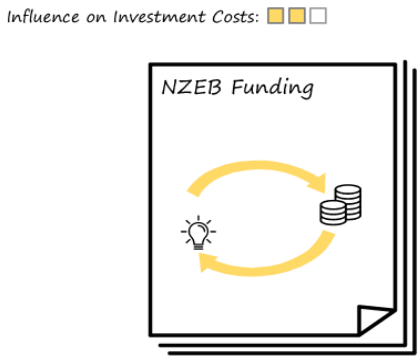
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Some new technologies and concepts helping nZEB uptake need support in the sense of market development and penetration. Therefor different EU countries and regions give subsidies to allow this uptake of new concepts in buildings.

For some reasons these funding schemes are very important to implement energy efficiency concepts and for showing frontrunners to learn from. The quality of the financial support is very different but it is worth looking for it, because at least for the higher planning effort of nZEB it could be crucial to have funding or not.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

Funding should be dependent on the specific needs and size of the nZEB project. Regional guidelines and political decisions could hinder proper funding schemes.

❺ INFLUENCES ON OTHER ACTIONS

1.11, 2.2

❻ IMPORTANCE

Help to overcome financial barriers in the beginning of a building's planning process, where normally not a lot of money is there to be invested. For example in Austria there exist funding schemes where housing associations can claim environmentally relevant extra costs in some nZEB projects, which make first steps easier.

❼ DIFFICULTY

- Funding schemes depend very much on politics
- In some market situations funding schemes are not interesting enough to drive nZEB developments
- A jungle of different subsidy and funding schemes decreases the efficiency of the instrument for a specific aim like nZEB

❽ STANDARDS AND REGULATIONS

- EU funding https://europa.eu/european-union/about-eu/funding-grants_en plus national funding services like https://www.foerderpilot.at/ in Austria
- COMMISSION REGULATION (EU) No 1407/2013 (De Minimis regulation) for enterprises

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Investors

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Indirect (loan with no/nearly no interest) or direct financing by national/regional authorities via grant application
- European initiatives trying to boost private investments: https://ec.europa.eu/energy/en/financing-energy-efficiency/sustainable-energy-investment-forums

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Qualitative goal: Experts on funding schemes should be available for advice

High: Different funding is available for energy efficiency, use of renewable energy and integration of energy flexibility in the building
Medium: Two different of these funding schemes are available
Low: Only one of these funding schemes is available

REFERENCES USED

EU-regulation and -funding service plus Austrian funding service (see above), accessed at 15th April 2018

ACTION: Development and Implementation of strategies for awareness raising
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Awareness raising activities should always accompany political decisions on a legal framework for energy and building performance goals. Otherwise stakeholders will not understand and hardly accept restrictions for the construction sector. Best strategy would be to break down the energy and CO2-goals / -requirements into easy understandable pieces for each stakeholder.
In a way, efficiency information such as energy performance certificates could also be used as a tool for awareness raising, but the potential of such certification is not very successfully exploited at the moment.

❷ EXAMPLES (CASE STUDY A)

Co-Benefits: User Acceptance

❸ CO-BENEFITS

user satisfaction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

1.13, 1.15, 1.19, 2.7

❻ IMPORTANCE

- Awareness raising campaigns are often accompanied by services which could be used to translate regulation into implementable measures, which makes it easier to be accepted by stakeholders
- A good starting point to activate the civil society and found organizations which help to implement energy requirements

❼ DIFFICULTY

- Could be misused for lobbying from market actors leading to different goals than insisted ones
- Could be a weak instrument for changing minds if not professional implemented

❽ STANDARDS AND REGULATIONS

No general standards exist for awareness raising campaigns, beside a lot of different ones of specific companies or organizations, also political parties like in Austria https://www.loc.gov/law/help/campaign-finance-regulation/austria.php

❾ MAIN DRIVER

Stakeholder A

❿ INVOLVED STAKEHOLDERS

Stakeholder A; Stakeholder B; Stakeholder C; Stakeholder D

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Better EU regulation initiative for including different aspects in regulatory decisions: https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
- Campaigning

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Qualitative feedback from the public

High: Number of articles and indications in broadcasting and TV>20
Medium: Number of articles and indications in broadcasting and TV 10-20
Low: Number of articles and indications in broadcasting and TV<10

REFERENCES USED

EU- and national regulation on campaigning (see above), accessed at 15th April 2018

ACTION: Regional efficiency improvement targets supporting nZEB
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Not only European, national and regional legal requirements - the "regulatory tools" - but also energy reduction goals that can be set by a local government, either at the citywide community level, or applied to its own publicly owned or rented building stock, can be very important to help nZEB development.
Municipal and city governments can and should introduce voluntary targets as a way to incentivize the private sector. They additionally can take government leadership by implementing frontrunner buildings and improving the public building stock.

❷ EXAMPLES (CASE STUDY A)

❸ CO-BENEFITS

Value Development

❹ CONFLICT OF AIM WITH OTHER ACTIONS

Could interfere with legal guidelines and technical nZEB standards

❺ INFLUENCES ON OTHER ACTIONS

1.18, 2.11

❻ IMPORTANCE

- Binding local targets like nZEB standards for buildings, maybe supported by local incentives, can strengthen political statements and activate local sources - companies and people.
- Lighthouse nZEB projects can serve as "knowledge-transfer" objects and test different technologies.

❼ DIFFICULTY

- Additional targets could increase the complexity of projects
- Local nZEB targets could in some cases lead to high municipal investment costs
- Undeliberated planning and unprofessional implementation of frontrunner projects could backfire the targets

❽ STANDARDS AND REGULATIONS

- klimaaktiv - Austrian voluntary building and energy certification system
- klimabuendnis.org - Existing tools and methods supporting municipalities, also on national level
- Servicepackage for public nZEB tendering and awarding for contracts e.g. https://www.umweltverband.at

❾ MAIN DRIVER

Stakeholder D

❿ INVOLVED STAKEHOLDERS

Stakeholder B

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- CO2-calculators like https://www.carbonfootprint.com/calculator1.html, http://www.energiewende-rechner.at/ and http://www.seap.at/Intro.aspx
- LCC-Tools like https://www.klimaaktiv.at/service/tools/bauen_sanieren/econcalc.html

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Analysis of the current building stock is done and targets for nZEB implementation are defined clearly.

High: Region/municipality beats the national nZEB goal by half
Medium: Region/municipality reduces the national nZEB goal by quarter
Low: Region/municipality has a CO2-analysis and an overall nZEB path

REFERENCES USED

Voluntary certification, calculators and tools (see above), accessed at 3rd May 2018

ACTION: Set long term regional targets for spatial planning

LIFE CYCLE PHASE: URBAN

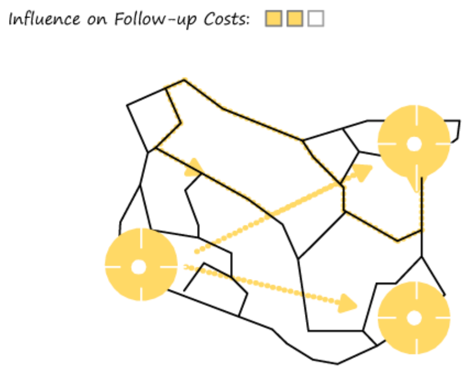
❶ DESCRIPTION OF THE ACTION

In order to achieve the nZEB goal, consistent concepts must be developed that include different urban development scale. EU member states agreed that all new buildings to be built from 2020 onwards will meet the near zero energy standard. New public-sector buildings must comply with this standard as early as 2019.

Urban regulations and targets influence the energy consumption of building structures and these regulations should cover both the macro and micro areas in order to achieve integrated planning.

This decay is intended to ensure that the sealing of areas does not increase any further, but rather that a "sensible" approach to soil as a resource is considered. Furthermore, urban development concepts that achieve a balance between building density and quality allow a high social standard, whereby energy consumption for transport can be reduced and non-motorized individual traffic can be optimized.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

1.9, 1.10, 1.12, 1.14, 1.19, 1.21, 2.10

❻ IMPORTANCE

The strategic planning of building structures makes it possible to optimally exploit the energy potential and to create the prerequisites for the planning and construction of almost zero energy areas / cities / buildings.

❼ DIFFICULTY

Often insufficient data basis

❽ STANDARDS AND REGULATIONS

The standards must be set up! There are right at the moment only regional specific guidelines which describe an optimized spatial planning process.

❾ MAIN DRIVER

Stakeholder C

❿ INVOLVED STAKEHOLDERS

Stakeholder J

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Develop a robust spatial evidence base to identify the energy profile of existing land uses and energy character in the urban area
- Develop an 'energy cadaster' to identify the capacity between demand and production.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Nearly Zero Energy and Carbon Areas
Medium: nearly Zero Energy Areas
Low: low Energy Areas

REFERENCES USED

http://www.special-eu.org/assets/uploads/SPECIAL_Pan_Euro-Guide.pdf, accessed at 28th June 2018

ACTION: Assessment of the energy efficiency and renewable energy potentials

LIFE CYCLE PHASE: URBAN

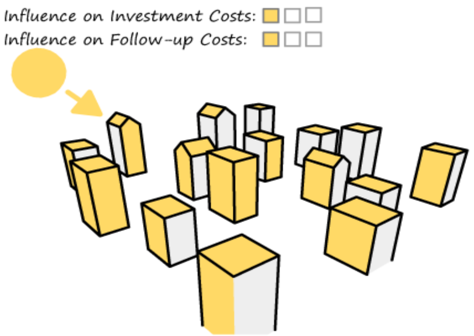
❶ DESCRIPTION OF THE ACTION

The potential of different renewable energy supply options may be divided into:

- Generation on building (e.g. Solar and Wind)
- On-site generation by on-site renewables (e.g. Solar and Wind)
- On-site generation by off-site renewables (e.g. biomass)
- Off-site generation (e.g. investment/production in wind mills, PV-plants etc.)
- Off-site supply (existing renewables in the grid)

If the share of renewables in the grid is high (off-site supply), the need for new on-site and/or off-site generation will be low (and vice versa).

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

State and municipality may have an agenda/strategy which is in conflict with sustainability.

E.g. they force (by law) to connect ot a district heating grid with low share of renewables.

REFERENCES USED

see standards above, and http://task40.iea-shc.org/data/sites/1/publications/Task40a-Net_Zero_Energy_Buildings_Calculation_Methods_and_Input_Variables.pdf, accessed at 29th June 2018

❺ IMPORTANCE

The share of renewables in the grid (off-site supply) will have a direct effect on the need for on-site and/or off-site generation.

❻ DIFFICULTY

- Local conditions may change (e.g. new adjacent buildings will result in more shading)
- The share of renewables in the grid is constantly changing

❼ STANDARDS AND REGULATIONS

- EN ISO 52000 Energy performance of buildings – Overarching EPB assessment
- EN ISO 52003 Energy performance of buildings – Indicators, requirements, ratings and certificates
- EN ISO 52016 Energy performance of buildings – Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads

❽ MAIN DRIVER

(Economic) Chambers

❾ INVOLVED STAKEHOLDERS

Landlords

❿ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

Desktop work - various tools to be used!

⓫ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Quantity goal:

- kWh/m2a_gross floor area (related to energy demand/load, on site generation)
- Share of renewables in percentages

High: 50 % better compared to national building regulations - meaning lower energy demand and higher share of renewables
Medium: 25 % better compared to national building regulations
Low: According to national building regulations

⓬ INFLUENCES ON OTHER ACTIONS

1,17

ACTION: Urban Masterplanning Allowing highly compact buildings

LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

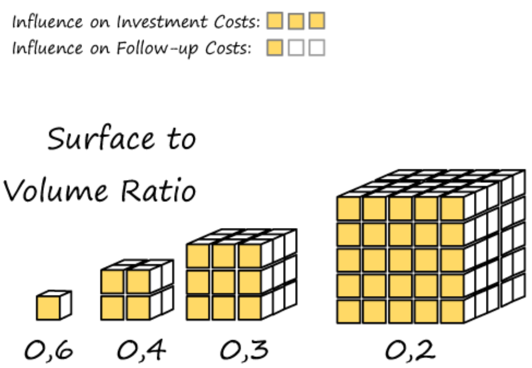
The compactness of structures is given by the ratio of the heat-emitting envelope surface (A) to the heated volume (V), the so-called A / V ratio. The smaller the A / V ratio, the lower is the specific energy input to heat/cool the building. The smallest A / V ratio has a spherical object followed by a cube.

Typical A / V ratios are:

- Detached single family houses 0.7 to over 1.0
- Semi-detached houses 0.6 to 0.9
- Row houses 0.4 to 0.6
- Apartment buildings 0.2 to 0.5

Primarily, the A / V ratio depends on the absolute size of the structure, secondarily on its shape. Basically, the rule of thumb is to build as large a volume as possible.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

See 'risks' - Daylight and ventilation goals could be influenced!

❺ INFLUENCES ON OTHER ACTIONS

2.2, 2.3

❻ POTENTIALS

With decisions on a quarter or urban master-planning a high potential of energy savings arise from compactness of the building's layout allowed to be built.

❼ RISKS

- Limits the architectural freedom of planning
- Very compact layout may cause challenges in offering daylight and fresh air in the inner parts of big-volume buildings

❽ STANDARDS AND REGULATIONS

Some national building codes include the surface/volume ratio in the calculation of limiting heat demand values, like in Austria.

❾ MAIN DRIVER

Stakeholder B

❿ INVOLVED STAKEHOLDERS

Investors

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

Mostly generated within the tools of energy certification calculations.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: A/V = < 0.3
Medium: 0.3 > A/V > 0.6
Low: A/V > 0.6

REFERENCES USED

Haas J. et al: Handbuch für Energieberater, 1994

ACTION: Optimize Building Orientation and Zoning
LIFE CYCLE PHASE: URBAN

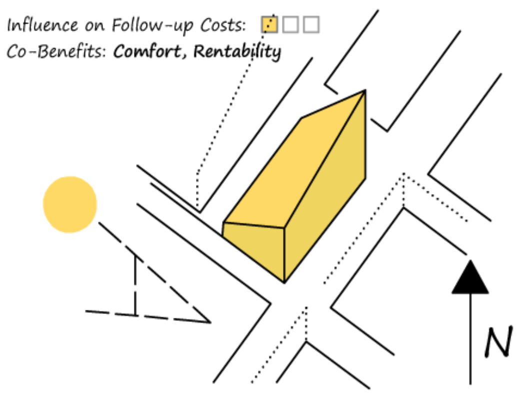
❶ DESCRIPTION OF THE ACTION

The orientation of a building and the orientation of the windows significantly determine the heat gain and losses during the heating season, but also cooling demand during summer. East and west oriented windows receive 60%, north windows 40% of the usable solar radiation of a south-facing window. Due to the low morning and evening sun during summer, the east and west facing windows have greater overheating problems than south windows.

The ability to maximize heat gains by orienting, zoning, and increasing the window area on the south side is often overestimated. Depending on the shape of the building and the proportion of the window area, the heat gain ranges from 4 to 8 kWh / m²GFA and year. Only with passive houses with an annual heating requirement of up to 15 kWh / (m²TFA.a) do these heat gains play a relevant role. For passive houses, a maximum deviation from the south of 10 ° should be maintained. For low-energy houses, the south-facing façade can deviate up to 30 °.

The zoning of living and recreation rooms should be oriented to the south, so that they can benefit from direct sunlight even in winter. On the north side, adjoining rooms, stairs and the entrance area should be arranged, the temperature level of which can be kept lower in winter.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

1.7, 1.14

❻ POTENTIALS

With decisions on a quarter or urban master-planning a high potential of energy savings arise from definition of possible orientation and zoning.

❼ RISKS

- Might somehow limit the owners freedom of functional use of the building
- There is a need for knowledge on how to use passive solar gains effectively (without causing active cooling measures) and reduce the overall final energy demand

❽ STANDARDS AND REGULATIONS

Some local building guidelines define building orientation or at least roof orientation.
Passive-house standard gives very good instructions to use passive solar gains.

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Stakeholder D

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Energy certification tools or PHPP for calculation of benefits.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Fixed detailed zoning concept with living rooms max. deviating 30° from south
Medium: Basic zoning concept
Low: No orientation and zoning concept of building area

REFERENCES USED

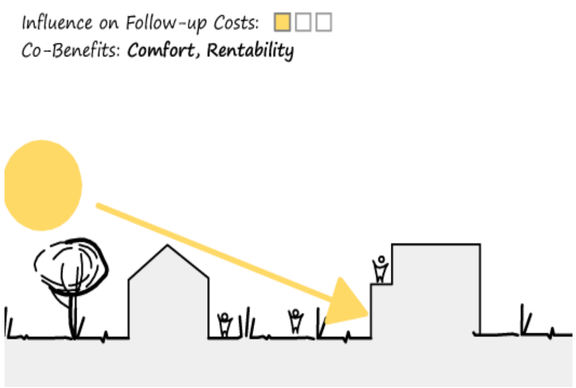
Haas J. et al: Handbuch für Energieberater, 1994, PHI Darmstadt - different sources at https://passiv.de/, accessed at 20th June 2018

ACTION: Optimize Solar Access in Urban Layout
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

The analysis of the passive solar potential calculates the solar radiation on the façade in order to determine the heating of the building by solar energy. Decisive factors are the orientation of the main or energy gain facade and the distances between the buildings, as well as the planting locations and growth heights of trees as a source of shade. The optimization and scenario development of the planning status serves as a basis for the preparation of the development plan and for coordination with all parties involved.
Active solar use optimizes solar energy production on roof and facade surfaces. Roof shape, roof orientation and roof pitch are considered as well as possible shadows. Each roof and facade has information on the solar energy potential for the use of photovoltaics and solar thermal energy.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

3.4, 3.5, 3.6

❻ IMPORTANCE

- passive gains and increased use of renewable energies
- Energy saving and thus reduction of energy costs
- Good marketing opportunities for the building plots
- Comprehensive planning options for municipalities
- Contribution to climate protection and sustainability

❼ DIFFICULTY

- Higher planning effort for the preparation of a development plan
- Data basis necessary

❽ STANDARDS AND REGULATIONS

Renewable Energy Directive 2009/28/EC

❾ MAIN DRIVER

Society

❿ INVOLVED STAKEHOLDERS

Stakeholder E

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

- Analysis of passive solar use (irradiation on main and energy gain facade)
- Potential analysis of active solar use (photovoltaics, solar thermal energy)
- Optimization and development of scenarios, recalculation of the active and passive solar potential
- Preparation of results data for different groups of actors
- Presentation of results with recommendations via interactive website as an information and marketing platform
- Economic efficiency calculation for the use of regenerative energy sources in heat and electricity supply

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Spatial planning fully follows the principles of solar access to buildings
Medium: Spatial planning takes solar access into account
Low: Spatial planning is not based on solar access

REFERENCES USED

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN

http://www.pv-financing.eu/wp-content/uploads/2017/05/04-SPE-PV-financing-full-lr.pdf

https://www.ipsyscon.de/fileadmin/user_upload/PDF/Loesungsflyer/SolarEnergetische_Bauleitplanung_LF.pdf, accessed at 20th June 2018

ACTION: Work with Urban Microclimate
LIFE CYCLE PHASE: URBAN

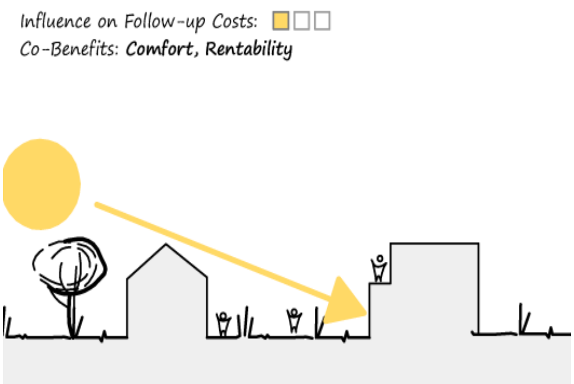
❶ DESCRIPTION OF THE ACTION

Urban structures are climatically very different from their surroundings. Distinctive are differences in temperature, wind conditions and precipitation distribution as well as a much higher degree of air pollution. The influence of built structures is most evident trough the formation of an urban heat island.
The newly developed thermal or urban climate zones further subdivide the urban climate on the basis of the following factors:

- surface roughness
- proportion of sealed surfaces
- sky view factor
- heat receptiveness
- albedo
- human heat production

The microclimatic and bioclimatic quality of the outdoor areas is of great importance for the well-being and a healthy living environment. Due to global climate change and the expected changes in the urban climate, the importance of this topic is increasing.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Health and well-being of residents and users (high air quality, avoidance of heat stress)
- Stability of ecosystems and thus securing the supply base
- Reduction of energy consumption by avoiding technologies for air conditioning and air cleaning in buildings
- Increased productivity of employees

❼ DIFFICULTY

Data basis

❽ STANDARDS AND REGULATIONS

- VDI 3785
- VDI 3787

❾ MAIN DRIVER

Stakeholder I

❿ INVOLVED STAKEHOLDERS

Municipalities; Investors; (Economic) Chambers; Citizen groups/NGOs; Society; Stakeholder A; Stakeholder B; Stakeholder C; Stakeholder D; Stakeholder E; Stakeholder F; Stakeholder G; Stakeholder H

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Urban climate evaluation by

- urban climate index of urban district
- urban ventilation concept
- urban climate consultant

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Urban Heat Index and ventilation concept are investigated to buildings
Medium: Urban Heat Index is calculated
Low: Urban climate is not considered important

REFERENCES USED

https://nachhaltigwirtschaften.at/resources/hdz_pdf/aspernplus_freiraum-mikroklima.pdf?m=1469659857

https://www.osnabrueck.de/gruen/stadtklima/stadtklima.html, both accessed at 20th June 2018

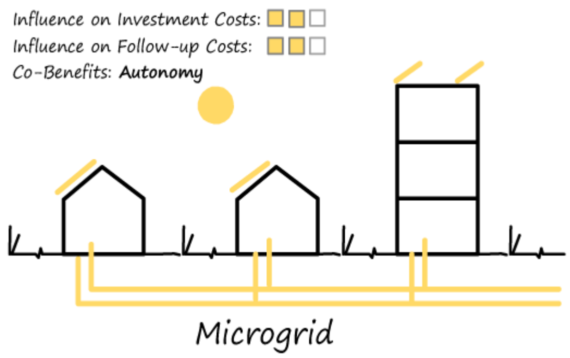
DGNB SQ16

ACTION: Consideration of Thermal / Electrical Microgrids on District Level
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

A microgrid on district level is an energy system, which, within a defined boundary, provides electricity as well as thermal energy for heating and cooling for several facilities.
Key drivers are: need of electricity in remote places, grid security and survivability, customer need for more reliable and sustainable service.
Examples of district energy microgrids, which serve building clusters, are those which implement combined heat and power (CHP).
Common CHP technologies are: microturbines, gas turbines, reciprocating engines, fuel cells.
University of California San Diego Microgrid: The microgrid project supplies electricity, heating, and cooling for 450 hectare campus with a daily population of 45,000.
It consists of two 13.5 MW gas turbines, one 3 MW steam turbine, and a 1.2 MW solar-cell installation that together supply 85% of campus electricity needs, 95% of its heating, and 95% of its cooling.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- The technology of microgrids reduces losses due to transport and distribution of traditional grids.
- Integrated system, more efficient than separate generation. This implicates lower emissions of pollutants.
- Suitable for the implementation of the concept pf energy flexibility and demand response.

❼ DIFFICULTY

Development and complexity of implementation of business models

❽ STANDARDS AND REGULATIONS

EEE 1547.4 - 2011: Guide for Design, Operation, and Integration of DR Island Systems with EPS

❾ MAIN DRIVER

Stakeholder D

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Specific planning tools and co-simulation tools

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Detailed concept of a thermal and electrical microgrid for a district communicating with the overall energy system
Medium: Concept of a thermal or electrical microgrid for a district
Low: No detailed concept for district energy microgrid

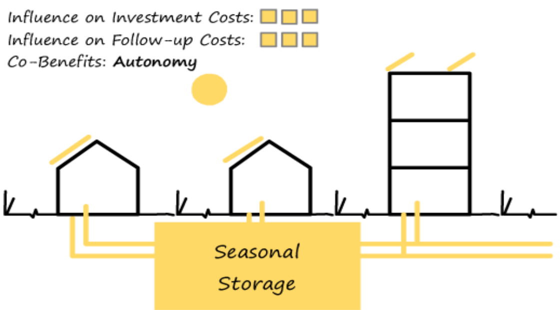
REFERENCES USED

se standard above and https://building-microgrid.lbl.gov/ucsd, accessed at 11th July 2018

ACTION: Consideration of Seasonal Storage on District Level
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION
Seasonal thermal energy storages (STES) are systems developed to face the problem of the temporary discrepancy between heating energy generation from renewables and building heating demands. Together with a higher integration of renewable and industrial waste energy sources, STES provide system flexibility and stability.

Three technologies are available:
- Sensible heat storage: Heat stored through enhancing of the temperature of a medium.
- Latent heat storage: Heat stored through phase change of a medium.
- Chemical storage: Heat stored through chemical reaction of a medium.

❷ EXAMPLES (CASE STUDY A)


❸ CO-BENEFITS
Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS
-

❺ INFLUENCES ON OTHER ACTIONS
-

❻ IMPORTANCE
Excess heat is stored and is used to compensate heat shortages. Seasonal storage allows solar energy to cover all heating loads.

❼ DIFFICULTY
- Specific heat, thermal conductivity, stratification
- Latent heat and chemical storage are not mature technologies

❽ STANDARDS AND REGULATIONS
First projects try to generate performance indicators for seasonal storage like https://www.aee-intec.at/index.php?seitenName=projekteDetail&projekteId=224&lang=en

❾ MAIN DRIVER
Owners

❿ INVOLVED STAKEHOLDERS
-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL
Specific planning tools and co-simulation tools

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)
High: STES are planned within the local district energy system
Medium: At least some demonstration to learn from integrating STES is considered
Low: No fixed plans for STES

REFERENCES USED
own project know-how

ACTION: Definition of Basic envelope attributes and Energy Targets

LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Even before the design of a building, basic envelope and energy related targets should be decided.

Setting the energy targets for the building envelope may be done in different ways:

1) Specific requirements for different building elements (thermal transmittance and air tightness)
2) Average U-value and air tightness for the building envelope including building elements, windows, thermal bridges etc.
3) Average U-value and air tightness for the building envelope in relation to floor area

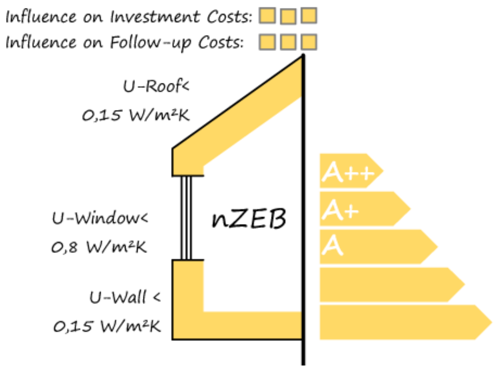
The first method allows for specific requirements but may give very different results as the architectural design of the building will still have a great impact.

By setting the requirement for the building envelope on average values, it is possible to handle the relation between window quantities and need for insulation etc.

The third option will give the projects the freedom to cope with architecture and building envelope in an integrated way. E.g. a compact building can have more windows etc.

❷ EXAMPLES (CASE STUDY A)

The example shows different transmission heat losses for different building systems and insulation quantities.



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

Could negatively influence the daylight conditions.

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

>70 % of the energy demand for heating in buildings designed with balanced mechanical ventilation with heat recovery will be due to transmission losses through the building envelope.

❼ DIFFICULTY

The state of knowledge is in general low.

❽ STANDARDS AND REGULATIONS

EN ISO 13789, EN ISO 6946, EN ISO 9972, EN ISO 10211

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

See standards and regulations, energy performance certification procedures

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

W/m2K, kWh/m2, etc.

High: Heating load <10 W/m² GFA or 50 % lower heating energy demand compared to national building regulations
Medium: Heating load between 10 and 30 W/m² GFA or 25 % lower heating energy demand compared to national building regulations
Low: Heating load >30 W/m² GFA or heating energy demand equal to national building regulations

REFERENCES USED

http://portal.research.lu.se/portal/en/publications/hygrothermal-conditions-in-exterior-walls-for-passive-houses-in-cold-climate-considering-future-climate-scenario(a21416d2-7d80-4b1e-b094-ad7e020e8449).html, accessed on 29th June 2018

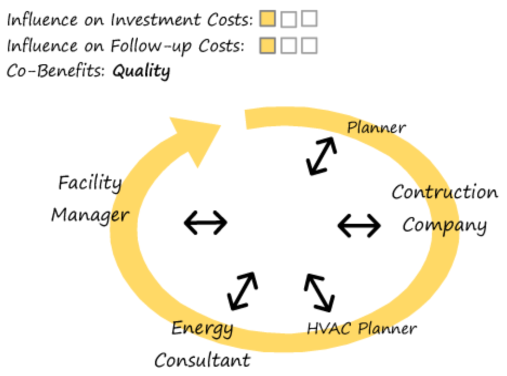
ACTION: Definition of Integrative Design Team
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

In order to develop a comprehensive concept for urban development, various institutions should work together to analyse the potential of the area and include it in the planning.

- Environmental engineers analyse the potential of the area (energetic specialist, city climate, protection of species, geology, water)
- Data specialist (geo information systems) analyse traffic, building standards, waste, noise
- Urban planners / architects analyse traffic / landscape planning
- Integral consultant and social planner could be involved

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

Could negatively influence the daylight conditions.

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Only through the cooperation of many planners, the area can be optimized in terms of its potential.

❼ DIFFICULTY

- Data security
- Data status / availability
- communication

❽ STANDARDS AND REGULATIONS

When setting up regulations for an energetic optimized spatial planning process it is necessary to analyse, calculate and plan in a integrated planner team

❾ MAIN DRIVER

Municipalities

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

With an integrated planning team for spatial planning you can receive a better utilization of energy resources from existing buildings.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Team of urban planner / architect + ecological planner + society planner
Medium: Urban planner / architect + ecological planner
Low: Urban planner / architect

REFERENCES USED

Leitfaden Energienutzungsplan
DGNB SQ 16

ACTION: Preparation of budget for renewables and estimate return on investment/ LCC
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION	❼ DIFFICULTY
Rough cost figures (cost/kWpsolar, cost/kWhsolar, cost/kWheat pump, etc) need to be defined in order to make rough estimates regarding investment in renewables and to enable trade of calculations between energy efficiency and investment in renewables. The investor also clearly needs to define expectations and boundary conditions, such as: discount rate, yield, etc. Tariffs for different energy carriers need to be defined. Furthermore, if an investor considers investing in renewables that export energy, the expected export capacity and export tariffs also need to be defined. Evaluations may only consider investment and energy cost reductions for renewables. However. They could also include co-benefits, such as: Publicpublicity value, increased property value etc.	o Predicting costs for investment and future energy tariffs is complex o Small changes in calculation period, yield etc. may have big effects o Different stakeholders/investors has different ways of analysing economy (it´s not physics) **❽ STANDARDS AND REGULATIONS** EN 60300, ISO 15686 **❾ MAIN DRIVER** Planners **❿ INVOLVED STAKEHOLDERS** -
❷ EXAMPLES (CASE STUDY A) - **❸ CO-BENEFITS** Energy Savings **❹ CONFLICT OF AIM WITH OTHER ACTIONS** Could compete with budget for energy efficiency measures. **❺ INFLUENCES ON OTHER ACTIONS** 1,5 **❻ IMPORTANCE** The LCC expectation from the investor is important and will have a direct effect on the possibilities to use renewable energy techniques.	**⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL** See standard **⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)** Monetary terms **High**: LCC/LCA on a detailed level, considering different technologies and scenarios **Medium**: Payback calculations to decide budget for renewables **Low**: No calculations (maybe no budget) **REFERENCES USED** Berggren, Wall 2017 - Profitable nZEBS - how to break the traditional LCC analysis.

ACTION: Connection request for PV / drilling permit for geothermal

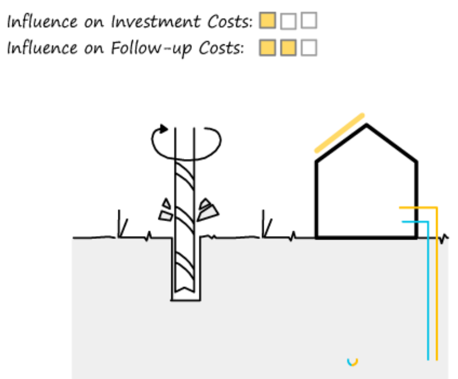
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

- Photovoltaics: The PV LEGAL project, financed by the Intelligent Energy Europe program, showed that administrative requirements can represent a considerable share of the development costs of a project, where photovoltaic systems are implemented onto a building. An efficient grid connection process is fundamental to lower the costs and increase the competitiveness of PV.
- Geothermal: A common EU-wide minimum standard to get a drilling permission for the use of geothermal energy has not been developed yet. Each member state has its own regulation. Therefore it is not possible to define a common action.

❷ EXAMPLES (CASE STUDY A)

- The European project PV LEGAL, ended February 2012, aimed at identifying and then reducing those legal-administrative barriers that affect the planning and deployment of photovoltaic (PV) systems across Europe.



❸ CO-BENEFITS

-

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

If planners are very early involved in the plans for using PV or geothermal energy in nZEB, the respective permissions to connect to the grid or to drill into the ground can be requested in time.

❼ DIFFICULTY

Main identified barriers are those related to permitting procedures, grid connection rules and technical standards.

❽ STANDARDS AND REGULATIONS

-

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The permission should be asked very early in the planning, best would be to define requirements for specific regional areas from authority side.

High: Permission for PV connection to grid and geothermal energy use before implementation
Medium: Permission for PV connection to grid and geothermal energy use during implementation
Low: Permission for PV connection to grid and geothermal energy use after implementation or not approved

REFERENCES USED

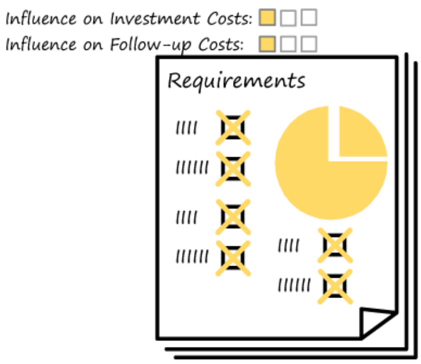
PV LEGAL https://ec.europa.eu/energy/intelligent/projects/en/projects/pv-legal, accessed at 30th July 2018

ACTION: Requirements Analysis
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

Requirements analysis, also called requirements engineering, is the process of determining owner and user expectations for a new product like nZEB. These requirements or functional specifications must be quantifiable, relevant and detailed. Requirements analysis is an important aspect of the project management. It can be used to detail and determine the expectations of owners but also users regarding urban planning or nZEB planning aspects.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

-

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

https://searchsoftwarequality.techtarget.com/definition/requirements-analysis, accessed at 8th Aug. 2018

❻ IMPORTANCE

Requirements analysis is a team effort that demands a combination of hardware, software and human factors engineering expertise as well as skills in dealing with people. Ensuring that the final planning of an area or on nZEB conforms to client needs. Good mediated and communicated process, not leading to mould user expectations to fit the requirements, but motivating to declare requirements.

❼ DIFFICULTY

- Could become costly process
- Demands communication effort

❽ STANDARDS AND REGULATIONS

- From software products and services side: 29148-2011 - ISO/IEC/IEEE International Standard - Systems and software engineering -- Life cycle processes --Requirements engineering
- Project management side: Quality management systems - Requirements (ISO 9001:2015), etc.

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: The expectations and requirements of the client (building owner, user, etc.) are clear and documented
Medium: The expectations and requirements of the client (building owner, user, etc.) are discussed before planning
Low: The expectations and requirements of the client (building owner, user, etc.) are not clearly communicated

ACTION: Apply Strategy towards efficient use of land
LIFE CYCLE PHASE: URBAN

❶ DESCRIPTION OF THE ACTION

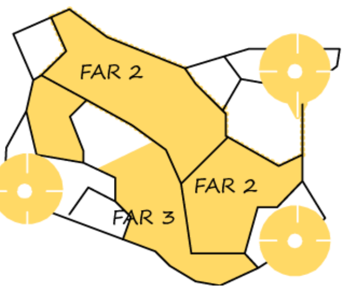
Land use should be limited as far as possible. This not only ensures the economical and careful use of fertile land, but also minimizes costs. The reuse or subsequent use of an unused area is important. Sealed area causes problems:

- Precipitation water cannot seep away, the groundwater level is sinking.
- Rainwater must be drained into the sewerage system. There it mixes with the wastewater and thus increases the costs for wastewater disposal.
- Evaporation decreases, the air becomes dry and the microclimate changes.
- Sealed surfaces heat up strongly. Therefore, the temperature in the cities is higher than in the open countryside.
- Loss of the soil as a natural resource and pollutant filter, as a habitat for animals and plants as well as a recreation and nature experience area for people.

Existing buildings should be assessed to get more storeys or the living area to be densified.

❷ EXAMPLES (CASE STUDY A)

Influence on Investment Costs: ☐☐☐
Influence on Follow-up Costs: ☐☐☐



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Positive effects for climate and the environment

❼ DIFFICULTY

- Ambitious planning for geometry and foundation
- Additional effort to convince current residents

❽ STANDARDS AND REGULATIONS

20/07/2016 - COM/2016/479

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

Lay foundations in the land use planning and legislation. The areas can be divided in to the following groups: natural environment, village space, urban space, brownfield sites, area integration, area loading (pollutants / explosive ordnance).

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Highest possible site density with green roofs for leaching water
Medium: Site density negotiations, no green roofs
Low: No negotiation on site density or green roofs

REFERENCES USED

https://www.ufz.de/index.php?de=35688, accessed at 2ßth June 2018
DGNB SQ16

ACTION: **Assessment of the Potential for Decentralized renewable power generation**

LIFE CYCLE PHASE: **URBAN**

❶ DESCRIPTION OF THE ACTION

Decentralized power generation means the generation of electrical power in small power plants or plants close to consumer. This type of generation is opposed to electricity generation in large-scale plants such as coal and nuclear power plants. The small power stations - combined heat and power plants, photovoltaic plants or small wind turbines, for example - feed energy directly into the low-voltage grid.

The decentralized generation of "green" power comprises in particular:

- Combined heat and power plants based on fossil and renewable fuels
- Wind turbines
- Photovoltaic systems
- Geothermal cogeneration plants and power plants

❷ EXAMPLES (CASE STUDY A)

-

❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Energy losses during power transport can be minimized by shortening the transmission paths. This means that energy can be fed into existing networks with almost no intermediate losses.

Centralized and decentralized power supply systems can co-exist and complement each other.

❼ DIFFICULTY

Usually higher investment and maintenance costs have to be expended.

❽ STANDARDS AND REGULATIONS

Country-specific initiatives based on the EPBD 2010, which implies decentralized energy generation as follows: "The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby."

❾ MAIN DRIVER

Construction company

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Local energy service companies should be established and/or involved by municipalities to develop decentralized generation of renewable power.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: There is the clear aim of supplying power from 100% local renewable sources

Medium: There is the clear aim of supplying power from 50% local renewable sources

Low: There is no specified aim of supplying power from 100% local renewable

REFERENCES USED

own experiences from projects and policy paper of the European Parliament http://www.europarl.europa.eu/document/activities/cont/201106/20110629ATT22897/20110629ATT22897EN.pdf, accessed at 6th Aug. 2018

ACTION: Definition of Allowed Thermal comfort ranges
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

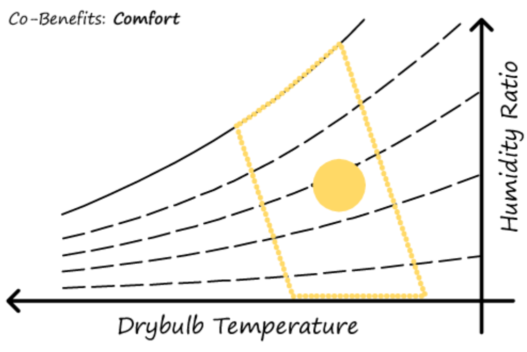
There are six factors to take into consideration when designing for thermal comfort. Its determining factors include the following:

- Metabolic rate (met): The energy generated from the human body
- Clothing insulation (clo): The amount of thermal insulation the person is wearing
- Air temperature: Temperature of the air surrounding the occupant
- Radiant temperature: The weighted average of all the temperatures from surfaces surrounding an occupant
- Air velocity: Rate of air movement given distance over time
- Relative humidity: Percentage of water vapour in the air

The environmental factors include temperature, radiant temperature, relative humidity, and air velocity. The personal factors are activity level (metabolic rate) and clothing.
Looking at the operative temperature, the levels of radiation and convection are important. The following values can serve as general orientation when it comes to comfortable temperature sensation:

- The vertical air temperature difference between 0.1 and 1.1 meters above the floor should be less than 3K.
- The asymmetry of the radiation temperatures (windows or other cold surfaces against interior walls or similar) should be less than 10 K.
- Surface temperatures of the floor between 19 and 26 ° C are perceived as pleasant.
- In summer, the room temperature should not exceed 30 ° C.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❻ IMPORTANCE

Thermal comfort is very important regarding the quality of the building's indoor environment, and so one of the key aspects for the users to be guaranteed. The property value is even higher when comfort ranges could be adhered.

❼ DIFFICULTY

- Complexity of the building services system and control could increase by strict comfort requirements, also raising the planning and maintenance costs of such comfort directed heating and cooling systems
- Narrowly interpreted comfort values do not allow energy flexibility and could raise the energy consumption

❽ STANDARDS AND REGULATIONS

- Standard EN 15251 specifies indoor environmental input parameters addressing indoor air quality, thermal environment, lighting and acoustics
- EN 13779 applies to the design and implementation of ventilation and room conditioning in non-residential buildings
- ISO Standard 7730 (ISO 1984) - Determination of the PMV and PPD Indices

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Tenants; Real estate fund; Investors; Society; Stakeholder D

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Categorization by Fanger's thermal comfort model
- Comparison of benchmarks for thermal comfort values (like in the former German standard DIN 1946-2:1994-01) by measurements

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

- Thermal comfort quality is high if the building services can provide different conditions to different users
- Quantitatively the thermal comfort could easily be defined by the three categories I - III of EN 15251 or by three different values of Predicted Percentage of Dissatisfied (PDD) of ISO 7730

High: cat. I (EN 15251)
Medium: cat. II (EN15251)
Low: cat. III (EN15251)

REFERENCES USED

standards (see above) and https://sustainabilityworkshop.autodesk.com/buildings/human-thermal-comfort, accessed at 15th April 2018

ACTION: Optimize Building Envelope (Compactness and Insulation)

LIFE CYCLE PHASE: PLANNING

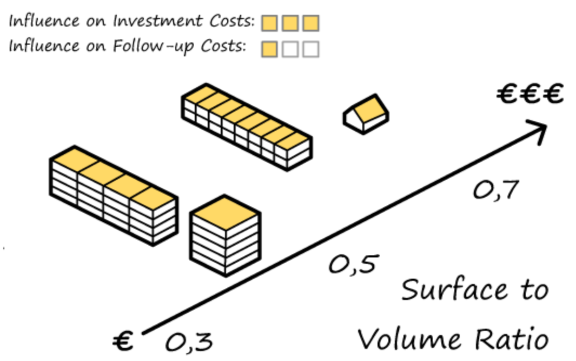
❶ DESCRIPTION OF THE ACTION

The building envelope is first of all a matter of design, secondly a matter of safety for the residents. The strategy of saving energy by the building's envelope is known from the passive house standard: A compact building form and good insulation reduce the transmission losses; an airtight building envelope reduces the ventilation losses.

Ideally, a simple structure is cost efficient (compact design), due to the relatively small envelope area in relation to the volume. The latter is expressed by the form factor as the ratio of enveloping area to heated volume - the smaller the form factor, the more favorable for the energy balance and construction costs of the building. Some passive house planners use the term "form factor" for the ratio of envelope area to treated floor area, so it makes sense to see what's behind the numbers.

Big and compact buildings have small form factors, single family buildings big ones.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Value Development

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Reduces the potential heat losses to the outside, makes comfortable wall heating systems work efficiently
- A compact and well insulated building has less overheating problems
- Thermal bridges caused by junctions of different building components are reduced

❼ DIFFICULTY

- Design variations are more restricted when thinking of compactness and insulation issues
- Know-how and experience is necessary to plan and implement compact and well insulated buildings

❽ STANDARDS AND REGULATIONS

- passive-house standards described at http://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm
- Some building codes like in Austria include limit values for the heating demand based on the form factor and so compactness of the building

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Owners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Heated envelope area to volume ratio calculation.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

- The most important qualitative goal is to raise comfort and lower operational costs for the building via reduced form factors and U-values by improving insulation.
- A lot of different quantitative goals exist - here are possible limit values for the average European climate

High: form factor < 0.4 for big-volume buildings (4 or more storeys), < 0.8 for single family houses; U-values opaque components < 0.2 W/m²K, transparent < 0.6 W/m²K

Medium: form factor < 0.6 for big-volume buildings, < 1.0 for single family houses; U-values opaque components < 0.35 W/m²K, transparent < 1.0 W/m²K

Low: form factor < 0.8 for big-volume buildings, < 1.2 for single family houses; U-values opaque components < 0.5 W/m²K, transparent < 1.4 W/m²K

REFERENCES USED

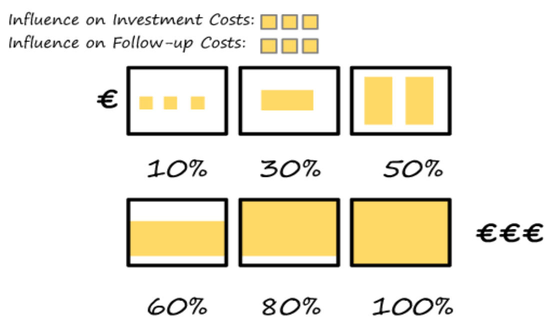
https://www.baunetzwissen.de/nachhaltig-bauen/fachwissen/planungsgrundlagen/bauphysikalische-planungsleitlinien-657243, http://howtopassivhaus.org.uk/form-factor, accessed at 7th May 2018

ACTION: Improve Window to Wall Ratio
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

For passive solar gains, the glazing and transparent components of a building should have a high total solar energy transmittance (g-value). On the other hand, the transparent parts of the building envelope create high losses (factor 5) compared to the opaque ones during cold seasons. A precise statement about which heat gains the building can use results in a simulation calculation with extensive consideration of the energetically relevant factors.
Mostly a window to wall ratio of 20 to 30% can be found talking about residential buildings in European climate. That could be totally different in commercial buildings and other climate zones. Corresponding standards for insulating glass range around U-values of 0.8 - 1.3 W/m²K.
Another important aspect - the energy balance of windows: A south-oriented window with a glazing U-value of 1.2 W/m²K and a g-value of 0.63 (means that 63 percent of the solar energy pass through the glass into the room) loses as much heat as it gains from the outside - the energy balance is zero. For the same window and the other orientations, the balance is negative. So generally for the south oriented windows a U-value of at least 1.2 W/m²K or lower and for all the other windows a U-value around 0.8 W/m²K or lower is the best solution in residential buildings.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Rental Income

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

One gets energy savings only by considering the optimal window to wall ratio and at the same time thinking of an optimal g- and U-value of the walls and windows. These energy savings are related to both the energy balance during summer and winter.

❼ DIFFICULTY

- Again design variations are more restricted
- A lot of know-how to follow all regulations and legal codes set on windows, doors, walls and buildings generally is necessary when planning an optimal window to wall ratio

❽ STANDARDS AND REGULATIONS

There are mainly minimum requirements in different national building codes regarding the ratio of window to net-floor area like in the Austrian national building guidelines "OIB Richtlinie 3" (2015) - page 6/7. These minimum requirements mostly refer to daylight or natural ventilation standards. Only the ASHRAE 90.1 - 2007 standard defines requirements for WWR.

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Owners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Window to wall ratio and energy balance calculations of windows.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

- Qualitative goal could be to increase comfort, reduce energy consumption and operational costs compared to buildings with a similar size in the respective region.
- Quantitative goals exist - here are possible limit values for the average European climate

High: window to wall ratio of 20-25% plus U-value of south-oriented windows < 1.2 W/m²K, the other oriented windows < 0.6 W/m²K
Medium: window to wall ratio between 12 and 20% or more than 30% plus U-value of south-oriented windows < 1.2 W/m²K, the other oriented windows < 1.0 W/m²K
Low: no extra planning of window to wall ratio plus U-values of windows < 1.4 W/m²K

REFERENCES USED

own studies and calculations

ACTION: Optimize Insulation

LIFE CYCLE PHASE: PLANNING

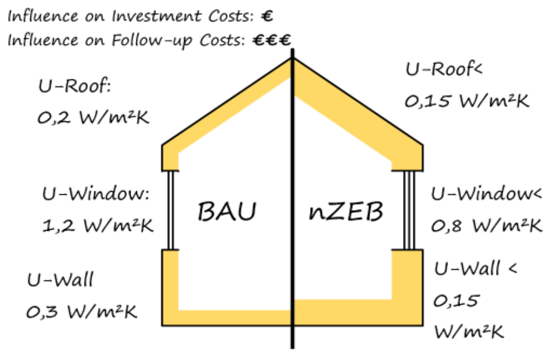
❶ DESCRIPTION OF THE ACTION

The heat transmission losses through external building components are in the focus of an energy-efficient design. The so-called envelope surface A separates the heated inner volume of the building from the outside space, from unheated building parts or from the soil. It covers both the transparent and the opaque areas of a facade, roof, etc. The heat transmission trough an external component is described by its U-value and indicates the potential heat that conducts through the area of 1 m² at 1 Kelvin [K] temperature difference between the out- and inside. The U-value of an external component, multiplied by the area of the component and the temperature difference between inside and outside, gives the potential heat flow to the outside.

Insulating materials have a low thermal conductivity λ and considerably reduce the component thickness as well as the U-value. That is the reason why they are currently used for upgrading the building envelopes when speaking about energy efficiency.

For example pressed straw as insulation material has a thermal conductivity λ of 0.055 W/mK and requires a thickness of 41 cm to achieve a passive house-compatible U-value. Vacuum insulated panels (VIPs) with λ around 0.002 W/mK reach the same U-value with a layer of 1.5 cm. The comparison of U-values and the subsequent choice of the construction are decisive criteria for the creation of energy-efficient buildings and thus also for a sustainable architecture.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❼ DIFFICULTY

- Knowledge on appropriate constructions is necessary to avoid thermal bridges and all related challenges, to apply airtight junctions and durable insulation etc.
- Insulation investments currently have a long payback time due to low energy costs
- In some cases insulation measures fail because of lacking space to the adjacent plot

❽ STANDARDS AND REGULATIONS

- National building codes stipulate limit values for specific building components.
- Indirectly a lot of voluntary green building rating systems like LEED support low U-values by setting energy demand targets. Papers and Regulations: http://ec.europa.eu/environment/gpp/pdf/thermal_insulation_GPP_product_sheet.pdf, https://www.eurima.org/regulatory/eu-legislation/directives.html

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Planners, Municipalities, Authorities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Various U-value and Psi-value calculators are available online!
- It is recommended to search for advice deciding on appropriate insulation technologies - there are a lot of energy agencies in the EU: https://www.managenergy.net/managenergy-agencies
- Brochures, giving advice on insulation topic and materials are also available on European level: https://www.eaetics.eu/files/dokumente-eae/5_Publications/Brochures/Buch_Waermedaemmung_engl.pdf (statement on why thermal insulation is necessary and answers to different claims), http://publications.jrc.ec.europa.eu/repository/bitstream/JRC108692/kjna28816enn_final.pdf (actual market overview), https://www.klimaaktiv.at/erneuerbare/nawaro_markt/daemmstoffe/daemmstoffbroschuere.html (German brochure of different insulation materials and their characteristics) ...

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

- Qualitative goals could be the application of more renewable materials like straw, cork, cellulose, or new

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Insulation measures raise the indoor comfort. The decision on the construction and the insulation materials for the external building components is crucial in a very early planning stage - it has a very high influence on:

- the decision of the heating system incl. the energy sources and heat dissipation
- the energy consumption during operation

technologies like prefabricated curtain walls with integrated insulation also for retrofit of buildings.

- Quantitative goals could be limit U-values like:

High: U-values of the windows < 0.8 W/m^2K, walls < 0.12 W/m^2K, upper ceiling < 0.1 W/m^2K and ground ceiling < 0.2 W/m^2K
Medium: U-values of the windows < 1.0 W/m^2K, walls < 0.2 W/m^2K, upper ceiling < 0.2 W/m^2K and ground ceiling < 0.4 W/m^2K
Low: U-values should at least follow national building codes/ standards

REFERENCES USED

see above!

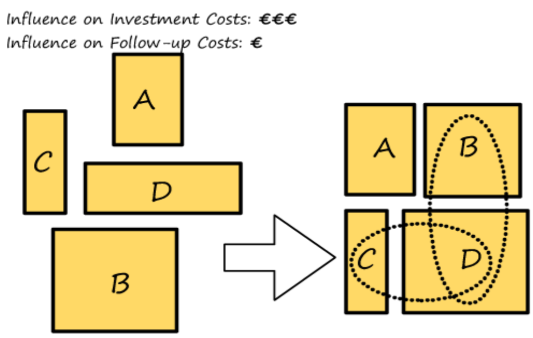
ACTION: Efficient Space Design

LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The purpose of an efficient space design is to identify those aspects that contribute to reach the highest functionality from a given space. The key aspects are the reduction of exceeding space (e.g. rethinking of a basement), the definition of the space/building function, the design of a balanced proportion between the used area and the built area, the definition of the use of the spaces according to the context, the orientation and the Window to Wall Ratio of the envelope.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- An efficient space design can lead to lower building and maintenance costs
- Positive effects on working (or studying) environment in non-residential buildings
- High energy saving potential exploiting the boundaries: orientation to maximize the solar gains during winter and to minimize them during summer

❼ DIFFICULTY

Building function can vary during the life-span. Space efficiency does not generally have high priority on the agenda in most building projects.

❽ STANDARDS AND REGULATIONS

There are no standards or regulation on this matter.

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Planners, Tenants/users

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

As a first step it is important to know the building context (boundaries, irradiance and potential shadows) in order to define the main use of the spaces accordingly. Once the concept design has been defined, it is important to have a rational approach to set-up the right spaces for the functions, and to reduce the un-necessary spaces.

Example: Cornell Climate Action Plan of the Cornell University set up a Space Planning and Management plan. Source: http://www.sustainablecampus.cornell.edu/initiatives/space-planning-and-management.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Qualitative goals could be: maximize the usable space on the footprint, define the use of spaces according to the orientation and to the Window to Wall Ratio of the zones

Quantitative goal could be: to reduce the S/V ratio (see action Planning 02)

High: Have a clear plan of the space design considering energy relevant zoning of the building

Medium: Have a plan of the space design

Low: Have no plan of the space design and building functionality

REFERENCES USED

knowledge from own projects

ACTION: Flexibility & Adaptability

LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The concept of flexibility & adaptability refers to the possibility to make changes quickly and with relatively little effort or cost.

In public buildings, adaptability can be associated, for example, with major changes in occupancy, usage or services.

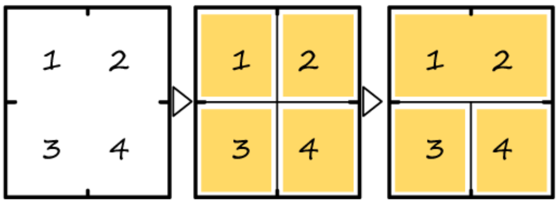
Flexibility is related to the configuration of working areas.

❷ EXAMPLES (CASE STUDY A)

Influence on Investment Costs: ■□□

Influence on Follow-up Costs: ■■□

Co-Benefits: **Resource Savings**



❸ CO-BENEFITS

Value Development

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Changes in the configuration can be done without having strong consequences on comfort and technical systems' efficiency.

❼ DIFFICULTY

Major challenges arise during the planning phase. A bigger effort is required.

❽ STANDARDS AND REGULATIONS

No standards or regulations are available.

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Planners, Tenants/users

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: The building is 100% flexible and adaptable to other functions and occupancy

Medium: 50% of the building's area is flexible and adaptable to other functions and occupancy

Low: The building is hardly or only with high costs flexible and adaptable to other functions and occupancy,

REFERENCES USED

Geraedts, R.P., 2001 "UPGRADING THE FLEXIBILITY OF BUILDINGS". Delft University of Technology, Faculty of Architecture.

ACTION: Optimize Solar Gains / Solar Control
LIFE CYCLE PHASE: PLANNING

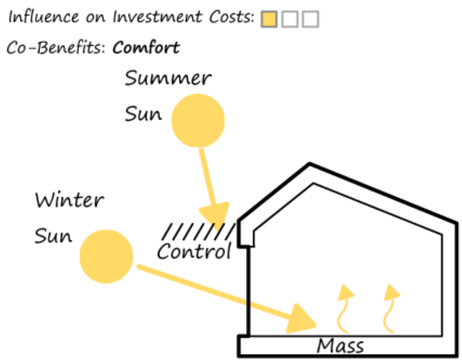
❶ DESCRIPTION OF THE ACTION

To take advantage of solar energy passively in the design of structures many criteria, such as e.g. the orientation of the building, the proportion of glass in the façade and the materiality of the building are playing a role. The size and the positioning, and especially the orientation of the window surfaces are particularly important for passive solar energy use.

Another criterion that must be taken into account when optimizing heat gains is the summer heat protection. Particular attention must be paid for the heating season, especially for non-residential buildings. Summer loads and cooling requirements of the building must also be considered.

Basically, it should be remembered that the sun occurs at steeper and shallower angles, depending on the season, and thus permeates more or less deep into the building. Also variable is the duration of sunshine and the radiation intensity, which is also influenced by the clouds.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

user satisfaction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Optimally used passive solar systems can reduce the heating and cooling demand by 30 to 50%.

❼ DIFFICULTY

Specific knowledge is necessary to create a good balance between passive heating and cooling measures over the year.

❽ STANDARDS AND REGULATIONS

The passive-house standards described at http://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm will give a lot of hints for the topic.

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Planners, Authorities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

During the planning phase, a detailed modeling or simulation of solar gains will lead to a high optimization of heating and cooling systems.

The passive-house characteristics are developed to cover the topic.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: A building which does not need heating energy on a sunny winter day or cooling on a hot summer day

Medium: A building which only needs few heating energy on a sunny winter day and no cooling on a hot summer day

Low: A building which needs a lot of heating energy on a sunny winter day and cooling energy on a hot summer day

REFERENCES USED

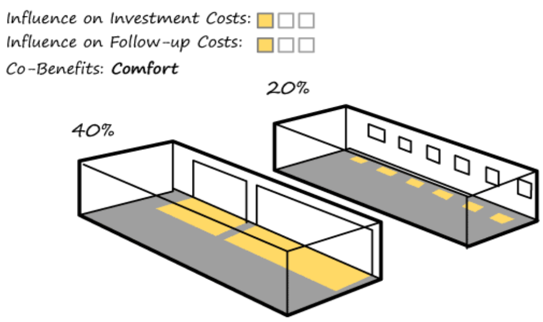
see source above

ACTION: Improve Daylight Factor
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Natural light is available depending on weather, day and season in quite different illuminance levels and fluctuates between 5,000 lux in winter up to 20,000 lux in summer. Daylight visually has the advantage that it contains all the spectral colors compared to artificial light. The change in light intensity and light color gives people a sense of the time of the day and the season, as well as continuous subconscious information about the outside climate. It stimulates the human metabolism, the formation of vitamins and the hormonal balance, as well as stimulates the soul through beautiful impressions such as a sunset, a rainbow or a stormy sky.
The Daylight Factor is a ratio that represents the amount of illumination available indoors, relative to the illumination present outdoors at the same time under overcast sky.
Sun protection systems determine the appearance of buildings and give architects extensive and differentiated freedom of design. The market today offers a multitude of shading elements and concept variants that range from classic systems such as sunblinds, roof projections and blinds to products such as electrochromic and thermochromic glass or holographic optical elements.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

see standards above

❻ IMPORTANCE

- Daylight significantly improves our health and wellbeing, makes us more productive and has a positive impact on the environment and business costs.
- In terms of sustainable planning, daylight has a clear advantage compared to artificial light.

❼ DIFFICULTY

- Daylight deprivation in buildings has been shown to have hugely damaging consequences.
- Artificial light requires electrical energy and the heat input with bulbs is significantly higher than with daylight.
- Prediction of illumination, planning knowledge

❽ STANDARDS AND REGULATIONS

- Building Code (or Building Regulation) requirements associated with ensuring adequate daylight have been introduced
- ISO 8995:2002 Lighting of indoor work places
- EN 12464-1:2002 Light and lighting – Lighting of work places – Part 1: Indoor work
- BS 8206-2 Lighting for buildings. Part 2: code of practice for daylighting

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Society, Owners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Daylight simulation:
Through a daylight simulation, the building can be optimized and the power consumption of artificial light can be significantly reduced. The result of this simulation is the distribution of illuminance in the room. It can u.a. examine the daylight distribution, the luminance, the efficiency of shading and light steering systems and the optimal interaction of artificial light and daylight. Through the precise calculation of the light beams sunscreen systems and light guide elements can be modeled.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Daylight Factor of over 5% in average of indoor rooms
Medium: Daylight Factor of over 3% in average of indoor rooms
Low: Daylight Factor below 3% in average of indoor rooms

ACTION: Energy performance Calculation

LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

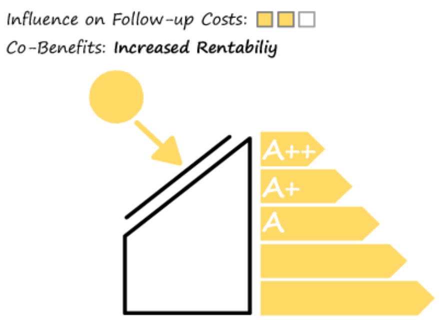
Energy performance calculation of the building is conducted, thanks to a calculation tool or simulation, during the planning phase to estimate the annual energy demand for space heating, cooling, electricity and domestic hot water.

The main features of the calculation method are provided by the European technical standard ISO 13790:2008 that includes:

- the heat losses by transmission and ventilation of the building when heated or cooled to constant internal temperature;
- the contribution of internal and solar heat gains to the building heat balance;
- the annual energy demand for heating and cooling to maintain the specified set-point temperatures in the building – latent heat not included.

Nevertheless, each country identified its own specificities in the calculation, defining specific boundaries, targets and energy performance classes tailored to the national context (See D2.1 Report on National Implementation of nZEBs).

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

An accurate energy performance calculation in the planning phase can lead to the adoption of the best design choices, from the energy efficiency point of view. Moreover, a positive impact on the real estate market has been recorded in countries with a long tradition of EPC.

❼ DIFFICULTY

- Special knowledge is needed to calculate the energy performance
- The values from calculation can vary in a big range due to user influence and quality of the implemented construction and building services system

❽ STANDARDS AND REGULATIONS

ISO 13790:2008: Energy performance of buildings - Calculation of energy use for space heating and cooling.

Energy Performance in Buildings Directive (EPBD 2010) and actual amendments (2016).

❾ MAIN DRIVER

Authorities

❿ INVOLVED STAKEHOLDERS

Society, Planners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

The thermal building simulation provides information on the cooling or heating power and the room temperatures that are set. For this purpose, the room or the building is modeled in the software used. In order to obtain meaningful results, the calculation model must correspond as closely as possible to the later building.

The climate data for the location are necessary for both the outside temperature and for the diffuse and direct sunlight. The use of the building specifies the necessary room temperatures and the internal heat loads. The building geometry and the component properties are needed for dimensioning the heat loss and storage. For the individual rooms, heat balances are compiled for the observation period in which all incoming and outgoing heat flows are received and for which an average air temperature is calculated. As a result, the thermal building simulation provides temperature profiles, temporal profiles of the heating and cooling power requirements and the heat storage processes.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: The building's energy performance is known by thermal building simulation

Medium: The building's energy performance is known by a simple certification tool or PHPP

Low: The building's energy performance is only estimated by comparison with similar ones

REFERENCES USED

see standards above

ACTION: Natural Ventilation

LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Natural ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure differences arising from natural forces. This natural ventilation of buildings depends on climate, building design and human behavior.

There are basically two types of natural ventilation that can be employed in a building: wind driven ventilation and stack ventilation. Both of which are caused by naturally occurring pressure differences. However, the pressure differences that causes wind driven ventilation uses the natural forces of the wind whereas stack ventilation is caused by pressures generated by buoyancy as a result in the differences in temperature and humidity. Hence, there are different strategies in the optimization of the two types of natural ventilation.

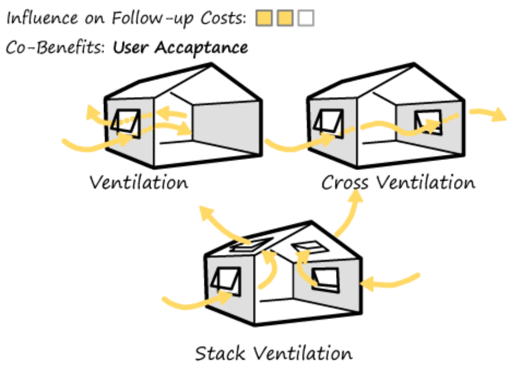
Factors directly influencing the airflow through openings:

- Wind speed and pressure
- Buoyancy (stack) pressure (interior temperature and humidity differences)
- Characteristics of openings ("effectiveness")
- Effective area of multiple openings

Indoor Environment Considerations/Requirements:

- Thermal Comfort
- Indoor Air Quality

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❼ DIFFICULTY

- Only in few cases natural ventilation is sufficient for establishing high indoor air quality
- It is very difficult to plan and calculate sufficiently dimensioned natural ventilation systems, because it is dependent on so many parameters

❽ STANDARDS AND REGULATIONS

- ASHRAE Standard 55 or ISO 7730 (thermal comfort)
- ASHRAE 62.1 and 62.2 or EN15242 / EN 13779 (ventilation rates, contaminant levels)
- New standardization projects for natural ventilation started in 2017 in the groups CEN/TC 156 (Ventilation for buildings) and ISO/TC 205 (Building design)

❾ MAIN DRIVER

Stakeholder A

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Computational Fluid Dynamics (CFD):

To be able to evaluate thermal comfort and indoor air quality CFD is often required.

The building flow simulation simulates the air exchange of the individual rooms or the flow through the building. The result is the pressure differences and volume flows of the interconnected rooms. Especially with natural ventilation concepts, flow simulations are an important instrument to prove the functionality of the concept.

Software: iDbuild (http://www.idbuild.dk/ for free, but results for only one room), Flovent, Fluent, ...

The calculation of the air flow rate can be done by using the methods described in the article by Yang T. and Clements-Croome D.J.: "Natural Ventilation natural ventilation in Built Environment", accessed at 18th May 2018

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

To be sure to have a good indoor air quality, thermal comfort and low energy consumption for ensuring the ventilation quality, a monitoring of the energy and ventilation related values is necessary. At least CO2-concentration, air change rate, temperature, rel. humidity and energy consumption should be measured.

High: Natural ventilation system guarantees IDA I to III of EN 13779

Medium: Natural ventilation system guarantees IDA III-IV of EN 13779

Low: Natural ventilation system does not guarantee any standard

❺ INFLUENCES ON OTHER ACTIONS	REFERENCES USED
- **❻ IMPORTANCE** o Natural ventilation can support mechanical ventilation systems to increase the indoor air quality and to cool the building by night and free cooling o It helps saving operating costs of the mechanical ventilation system by offering better indoor air quality	http://gbtech.emsd.gov.hk/english/utilize/natural.html, accessed on 17th May 2018; http://www.passivent.com/cross-flow-and-passive-stack-ventilation, accessed on 17th May 2018; https://www.wbdg.org/resources/natural-ventilation, accessed on 18th May 2018, and see above!

ACTION: Cooling Strategies
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The main heat flows into a building are:

- conduction through the building envelope
- ventilation (windows, doors)
- unintended infiltration (leakages)
- solar heat gains through transparent components (windows)
- internal heat generation (persons, appliances)

Preventing these heat gains means preventing from overheating.

Cooling is necessary if the heat gains within the building significantly exceed the heat losses. To avoid overheating and hold thermal comfort passive and active cooling measures can be taken.

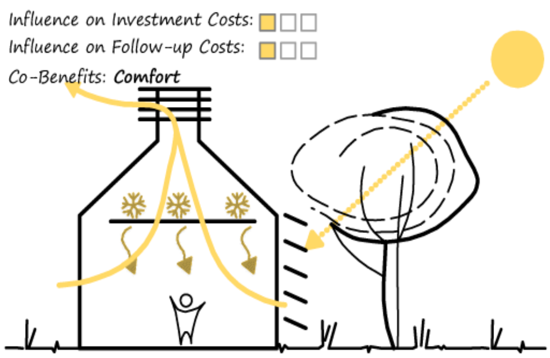
Passive Cooling:

- Natural ventilation (free / night ventilation)
- Activation of thermal mass
- Evaporative Cooling
- Others (shading, reflective surfaces, insulation, green roofs)

Active Cooling:

- Open or closed loop water-to-air heat exchanger
- Mechanical, or forced ventilation, driven by fans
- Use of chilled water or refrigerants
- Evaporative cooling and Ice storage

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2.4, 2.9, 2.10

REFERENCES USED

see standards above

❻ IMPORTANCE

- Building design with integrated passive cooling measures prevents buildings from bad summer comfort and eventual costs.
- In European climate it is normally not necessary to apply active cooling, except specific functionality of the building requires cooling.

❼ DIFFICULTY

- The lack of experienced planners and architects is a challenge when integrating passive cooling into design
- Similar to natural ventilation it is not simple to calculate the right cooling demand or hours with temperatures outside the comfort band.

❽ STANDARDS AND REGULATIONS

- ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality
- EN ISO 52016-1: 2018 02 01
- ISO 52016-1:2017: Specifies calculation methods for the assessment of e.g. the sensible heating and cooling load, based on hourly calculations
- EN 15251:2007 and Austrian standard B 8180 - 3

❾ MAIN DRIVER

Stakeholder C

❿ INVOLVED STAKEHOLDERS

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⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

All building modeling tools like TRNSYS, energy plus, Ida Ice are able to model cooling demand.

Following the former German standard DIN 1946-2, a qualitative approach would be to limit the overheating hours, with an operative indoor temperature above 26°C, by 10% of working hours per day.

To describe the thermal comfort band best, the adaptive model following EN 15251 fits best:

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The thermal comfort in summer could be quantified according to the European standard EN 15251 (see below). If these temperature bands cannot be reached by a curtain building, an active cooling strategy is necessary and related to more technological effort both simulation and appliances.

High: Operative indoor temperature between 23.5 - 25.5 °C

Medium: Operative indoor temperature between 23 - 26 °C

Low: Operative indoor temperature between 22 - 27 °C

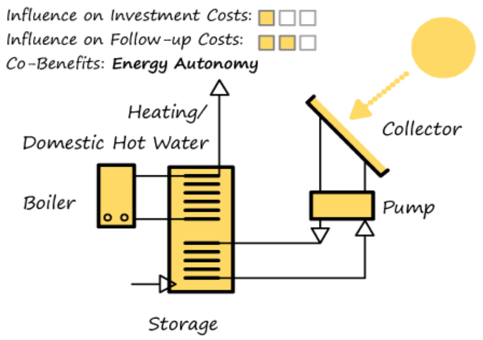
ACTION: Renewable Energy – Solar Thermal Systems
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The use of solar thermal systems for domestic water and heating support is a simple and effective way of renewable heat generation. The system technology is at a very high level of development - the need for maintenance and the susceptibility to malfunction are low. Two different solar thermal collector systems are used: the flat collector with absorber and transparent cover as a low-cost solution and the vacuum tube collector where the absorber is evacuated in a (vacuum) glass tube to reduce heat losses. For high-temperature requirements (industrial and commercial) and with limited space on buildings, the latter can be an advantage.

For meteorological reasons, a big solar thermal collector area including big buffer storage tank would be needed to cover the whole heat consumption during the European heating season. Depending on the size of the system and the energy-efficiency standard of the building, around 70% of the heating demand for domestic hot water and around 10 to 50% for the space heating can be achieved. It is important to think of how to use a possible solar surplus during the summer months in the planning phase. It is advisable to store the solar thermal heat in the heating storage tank. The domestic hot water preparation could be done by a fresh water supply system using the heat of the storage tank via an external heat exchanger. In this case, a combination with the space heating can be made relatively easy.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

❺ INFLUENCES ON OTHER ACTIONS

REFERENCES USED

internal studies of AEE INTEC, standards - see above

❻ IMPORTANCE

- Supports the heating system in replacing fossil fuels by renewable heat decentrally.
- Solar thermal systems work with a relatively high efficiency in relation to PV, and run with low costs.

❼ DIFFICULTY

- The investments costs are high related to other heating systems because of storage tank and backup heating system.
- Even if the effectiveness of solar thermal systems is higher than the one of PV - electricity can be used for more than "only" heating and so PV is more popular installed.

❽ STANDARDS AND REGULATIONS

- ISO 9806:2017(en): Solar energy - Solar thermal collectors - Test methods, and many more ISO standards under the direct responsibility of ISO/TC 180
- EN 12975: Thermal solar systems and components - Solar collectors
- The IEA Solar Heating & Cooling Program offers a lot of different publications, tools and project results at https://www.iea-shc.org/

❾ MAIN DRIVER

Stakeholder B

❿ INVOLVED STAKEHOLDERS

Stakeholder E

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

The technology is very simple: A solar thermal collector (panel), facing the sun, contains a dark absorber-sheet where heat water pipes are mounted. The collector is insulated underneath the sheet. Fluid circulates through these pipes by a low-energy pump and delivers heat to a water storage tank. When pre-fed with the solar hot water, the boiler or water heater is either not activated, or activated for less time than if there were no solar hot water system.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The performance of a solar thermal systems can be qualitatively planned in two ways: First, one can try to install a big collector area of up to 20 or 30 m² to increase the absolute amount of renewable energy, second one can optimize the specific performance per m² which would mean to reduce the collector area to an economic optimum of

High: Specific performance of a solar thermal system > 320 kWh/m²a

Medium: Specific performance of a solar thermal system 250 - 320 kWh/m²a

Low: Specific performance of a solar thermal system < 250 kWh/m²a

ACTION: Renewable Energy - Photovoltaics
LIFE CYCLE PHASE: PLANNING

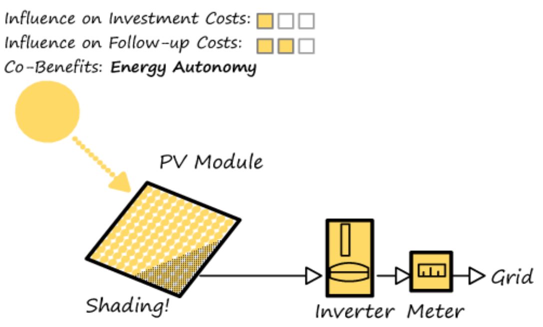
❶ DESCRIPTION OF THE ACTION

Photovoltaic solar panels, each comprising a number of solar cells, transform direct and diffused sunlight into electrical energy or "solar power". For solar power generation either grid-connected systems that are designed for a moderate year-round operation or island solutions, whose dimensioning is based on assumption of peak load and battery storage, are used:

Solitary operation:
If there is no grid connection, memory components are required for an independent operation. This makes economic sense if the installation of a grid connection would cost more than the PV installation, e.g. in the case of parking ticket or cigarette machines, display panels, congestion sensors or agricultural applications such as electric fences, irrigations, etc. The operation of larger units as buildings with an electrical consumption around 4,000 kWh/a is very expensive and therefore useful only in special cases such as alpine huts.

Grid-connected operation:
In grid-parallel operation the electricity generated from photovoltaic systems passes directly - i.e. without intermediate storage via batteries - into the AC installation of the associated house. An inverter converts the DC voltage into a 230 V AC voltage and into the house installation. The solar power is consumed in the household itself or fed as surplus into the grid of the local utility.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Rental Income

❻ IMPORTANCE

- Supports the electric energy system in replacing fossil fuels by renewable power - especially in synergy with wind power
- The investment costs of the PV modules decreased rapidly during the last years, even new business models like communal PV-plants helped to make them economical interesting

❼ DIFFICULTY

- In winter time, when the most electricity is consumed, PV-modules yield much less energy than during the sunny season
- The PV-modules run with a relatively low efficiency related to what the solar radiation would offer per m² - ratio 1:10

❽ STANDARDS AND REGULATIONS

- Publications of different standardization organisations like IEC Technical Committee TC 82: http://www.pvresources.com/en/standards/standards.php
- EN 61215 - Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (IEC 61215:2005)
- Different regional regulations control the use of PV-power (e.g. issues regarding commercial law when selling power to the market).

❾ MAIN DRIVER

Society

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

In the technical design of the photovoltaic system, the following aspects have to be considered:

- Orientation towards the sky: the maximum annual solar radiation only results from south orientation, 28 ° incination and freedom from shadows.
- Peak power: Each kWp has to be roughly calculated with a photovoltaic generator area of 10 m².
- Integration into the existing electrical installation: A second meter (or a new special meter), additional cables, an inverter and the photovoltaic generator on the roof have to be installed.

❹ **CONFLICT OF AIM WITH OTHER ACTIONS** -	⓬ **SPECIFICATIONS (QUALITY / QUANTITY GOAL)** A very effective way of quality assurance for PV-systems could be the promised warranties. The warranty conditions for PV panels typically guarantee that panels can still produce at least 80% of their initial rated peak output after 20 (or sometimes 25) years. So manufactures expect that their panels last at least 20 years, and that the efficiency decreases by no more than 1% per year. Rating: **High**: The warranties for the performance of the panels are given for 25 years, together with 10 years for the inverter **Medium**: The warranties for the performance of the panels are given for 20 years, together with 5 years for the inverter **Low**: The warranties for the performance of the panels are given for 15 years, together with 2 years for the inverter
❺ **INFLUENCES ON OTHER ACTIONS** -	
REFERENCES USED Warranties at https://www.solarpowerworldonline.com/2017/01/life-expectancy-solar-array/, accessed at 24th May 2018; standards - see above	

ACTION: Mechanical Ventilation
LIFE CYCLE PHASE: PLANNING

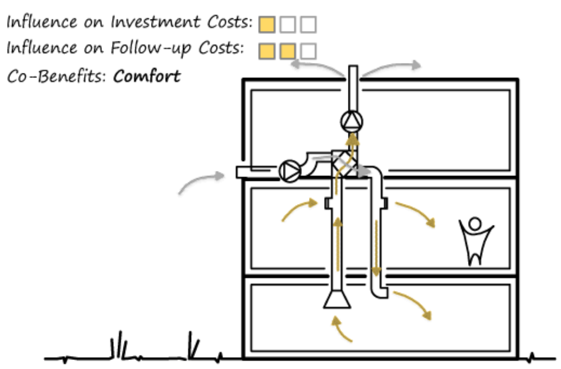
❶ DESCRIPTION OF THE ACTION

Sufficient ventilation is crucial for receiving high indoor air quality. In energy-efficient buildings nobody wants to have uncontrolled air infiltration by leakages in the construction. So there is a need of an airtight building envelope. The air change then has to be done by a mechanical ventilation system since the minimum hygienic air change can't be ensured solely by window, i.e. natural ventilation. The combination of low ventilation rate and thermal bridges in the construction increases the risk of mould growth.

So controlled mechanical ventilation can either be done by central exhaust or central balanced (supply and exhaust) ventilation systems. The latter uses different technologies of heat recovery: Crossflow heat exchanger with heat recovery (partially also moisture recovery) or rotary heat exchanger with moisture and heat recovery. Both exhaust and balanced ventilation can also be planned as decentralized systems.

A heat exchanger preheats the cold outside air by the warm air from the inside and supplies this preheated fresh air to the living rooms and bedrooms. By recovering the heat of the ventilation system the energy losses are highly reduced (up to 90% - around 150 - 200 liters of oil equivalent per household). The necessary space must be planned for the corresponding units and pipework.
The decision for a ventilation system has to be made because of the comfort increase, not the energy savings.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❻ IMPORTANCE

The indoor air quality can be increased efficiently by mechanical ventilation - so the CO_2-concentration in the indoor air can be held around or even below 1000 ppm. CO_2 is an indicator for polluted air, so if the concentration is low, also most of the other pollutants remain at a lower level.

❼ DIFFICULTY

- The investment costs of a mechanical ventilation system, although "well invested money", are the most critical in almost all construction projects - at least for residential buildings, the owners often claim high costs
- The running costs, including the ones for operation and filters, are also often part of criticism

❽ STANDARDS AND REGULATIONS

Various technical standards are known around Indoor Air Quality and ventilation system specifications (units, ducts, fire dampers etc.) like ISO 16814:2008 "Building environment design - Indoor air quality - Methods of expressing the quality of indoor air for human occupancy", standard ISO 7730, standards EN 13779 and EN 15251

❾ MAIN DRIVER

Planner

❿ INVOLVED STAKEHOLDERS

Owners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Ventilation should be controlled and have the capacity to address peak loads during the day and allow nighttime ventilation. Mechanical ventilation systems and hybrid systems are to be considered as adequate ventilation solutions. The system can be controlled by CO_2- or VOC-sensors or any other relevant sensors indicating the demand, it should be noise and vibration isolated and secure proper intake and exhaust avoiding cross-contamination.
Hybrid systems combine the mechanical system described above, which is using mechanical forces to draw the air, with the system that is using natural forces of wind and pressure difference. Hybrid systems allow reducing operation and maintenance costs but require that the ambient air is of a high quality. Both systems can be used for achieving nighttime ventilation that allows to increase the airflow to remove the accumulated heat once the temperature difference between outdoor and indoor air >3K.

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2,1

REFERENCES USED

see standards above and standards catalogue on "Ventilation and air-conditioning systems" at https://www.iso.org/ics/91.140.30/x/

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

To be sure to have a good indoor air quality, thermal comfort and low energy consumption for ensuring the ventilation quality, a monitoring of the energy and ventilation related values is necessary. At least CO2-concentration, air change rate, temperature, rel. humidity and energy consumption should be measured.

High: Ventilation system guarantees IDA I and II of EN 13779

Medium: Ventilation system guarantees IDA III of EN 13779

Low: Ventilation system guarantees IDA IV of EN 13779

ACTION: Domestic Hot Water

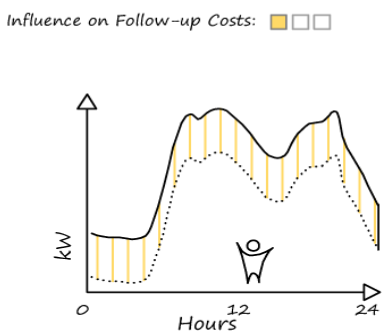
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The energy demand for domestic hot water heating can reach critical values in nZEB. This is because both the built construction components and the heating systems are efficiently planned but the domestic hot water demand depends strongly on the residents - and they are hardly predictable. So there is a need for a careful planning of the domestic water supply system, e.g. if it is supplied by the overall heating system or separately by electricity or partly by renewable energy like solar thermal or heat pump etc.

It is worth to think about the distribution and supply system very early. Questions like should extra pipes supply hot water storage tanks in every single flat, or should a central storage deliver heat permanently by a circulatory system or should hot water only be supplied decentralized per each flat may be clarified in the planning stage. The decision on that influences the dimensioning of the energy supply and heating system as well as space and load requirements.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy savings

❽ STANDARDS AND REGULATIONS

- DIN 1988-300:2012 and DIN 1988-3; NBN EN 806-3; EN 806 und EN 246; EN 12828: 2014
- European Technical Guidelines for the Prevention, Control and Investigation, of Infections Caused by Legionella species, June 2017 by The European Guidelines Working Group

❾ MAIN DRIVER

Planner

❿ INVOLVED STAKEHOLDERS

Owners

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

There are mainly two systems used to supply domestic hot water: Instantaneous water heaters with heat exchanger or storage and charge systems with tanks.

Instantaneous water heaters with heat exchanger provide hot water decentralized at that place where it is needed (flat, room, specific application) and only on demand. When a hot water tap is turned on, cold water travels through a pipe into the heat exchanger in the unit. The cold water is heated in the heat exchanger via district heating water or another waterborne heat source.

Another way of offering domestic hot water is a circulation line where a heat exchanger is placed centrally supplying hot water constantly to this circulation line which runs through the whole building. From this line every flat is supplied quickly when a hot water tap is turned on. As a result, the circulation line delivers a constant supply of hot water.

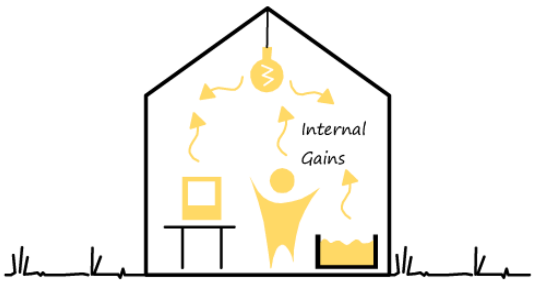
The storage and charge systems use storage tanks to store domestic hot water mostly fed by a solar thermal or other renewable heating system with legionella growth prevention e.g. through thermal disinfection. Like in the case of a

❹ **CONFLICT OF AIM WITH OTHER ACTIONS**	decentral heat exchanger and in contrast to the circulation line, stored hot water needs more time to reach the valves, but the advantage is the flexible use of energy sources.
-	⓬ **SPECIFICATIONS (QUALITY / QUANTITY GOAL)** The qualitative goals of lower energy demand for domestic hot water are to reduce the baths in favour of showers and at the same time use water-saving valves wherever possible. Qualitatively, following limit values could be targeted: **High**: Final energy consumption for domestic hot water ranges below 500 kWh/person.a **Medium**: Final energy consumption for domestic hot water ranges from 500-700 kWh/person.a **Low**: Final energy consumption for domestic hot water ranges above 700 kWh/person.a
❺ **INFLUENCES ON OTHER ACTIONS** -	
❻ **IMPORTANCE** o A moderate use of domestic hot water could save a lot of energy as well as money. In nZEB the energy demand for domestic hot water can reach higher values than for the heating energy demand o It is important to decide for a suitable water heating system very early in the planning stage	
❼ **DIFFICULTY** o There is a lack of knowledge and often unwillingness to install energy and water saving technologies by the professional companies regarding domestic hot water systems. o It is very hard to predict and calculate domestic hot water consumption for a specific building - detailed knowledge on the future users would be necessary.	**REFERENCES USED** own project information

ACTION: Plugloads and internal gains
LIFE CYCLE PHASE: PLANNING

❶ **DESCRIPTION OF THE ACTION**	❻ **IMPORTANCE**
Internal heat gains from occupants, equipment and lighting can have a high impact on the energy demand of a building. In particular in a nZEB, where the energy demand is very low, a correct estimation of the gains can lead to a significant increase of the design effectiveness. In particular, during the design phase, it is important to classify all the potential loads: occupants, lighting, equipment and ICT devices, and to assign the correspondent gain. The gains correspond to a reduction of the heating energy demand during winter, having a positive effect on the building performance and, on the other hand, they contribute to the load to be reduced during summer.	In non-residential buildings internal gains strongly affect the heating demand in winter. In the same way these play an important role in summer. A proper estimation of their entity can lead to relevant savings in winter and avoid overheating in summer. ❼ **DIFFICULTY** o Correct appraisal in the planning phase o Variable during the life span of a building, due to building layout or function change
❷ **EXAMPLES (CASE STUDY A)**	❽ **STANDARDS AND REGULATIONS** ASHRAE: Method of Test for Determining Heat Gain of Office Equipment Used in Buildings (https://www.ashrae.org/about/news/2015/new-ashrae-standard-provides-method-of-test-on-determining-heat-gain-of-office-equipment) ❾ **MAIN DRIVER** Planner ❿ **INVOLVED STAKEHOLDERS** Owners

Influence on Follow-up Costs:



❸ CO-BENEFITS

Energy savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

own knowledge of measured objects

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Mainly calculated within different calculation (EPC, PHPP) and simulation tools (dynamic thermal simulation).

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Calculation tool used in the planning phase maps all expected plug and internal loads
Medium: Calculation tool used in the planning phase maps all internal loads by default values
Low: No specific mapping of plug and internal loads during planning phase

ACTION: Storage facilities
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The more independent a building owner or a building complex of a community or company would like to be from specific energy sources and external energy grids the sooner investments in storage facilities will be made. They can foster both the resilience of a local energy system and the advantage to use energy sources when they are ecologically or financially interesting. In most cases they even help to become nZEB standard.

Different storage technologies are available - at the moment the most cost effective ones are water storage tanks for heating and pumped-storage power plants for electricity. But electro-chemical for power, chemical storage technologies and big water storage basins with hundreds of cubic meter for heating are evolving quickly. For example in Austria, known as one of the countries with a high number of storage facilities in buildings, the most installed storage facilities are hot water and heating buffer storage tanks with a volume between 200 and 1000 liters.

Electric batteries, for which the lithium-ion battery is the most common one at the moment, are currently more used to support photovoltaic systems, still less

❻ IMPORTANCE

- Storage facilities of buildings increase the flexibility and resilience of a local energy system.
- Storage technologies make the efficient use of renewable energy sources possible, e.g. solar thermal technologies heat is produced during the day and consumed mostly during nighttime, the storage technologies are the missing link.

❼ DIFFICULTY

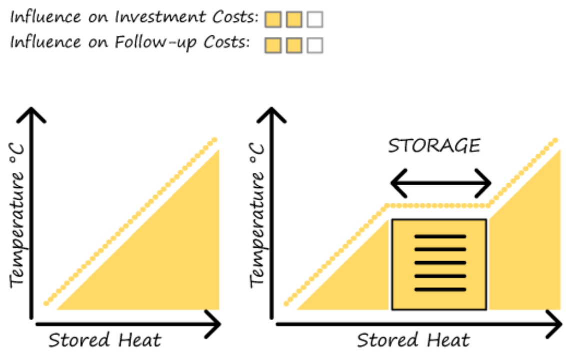
- Like all additional components storage technologies increase the investment costs of the building services.
- The use of storage technologies increases the energy losses of the whole system.

❽ STANDARDS AND REGULATIONS

- REGULATION (EU) No 812/2013: energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device
- REGULATION (EU) No 814/2013: ecodesign requirements for water heaters and hot water storage tanks
- Various standards on batteries from IEC like IEC 61960 for Li-ion, regulation on waste batteries and accumulators

playing a role in local load management of utilities and bigger consumers. But if the problem of short resources for the batteries would be solved, they could play a more important role to help energy flexibility in energy systems.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Role Model / Pioneering Role

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

Kemna R., Van Elburg M.: Special review study on categorization: Clause 7(2) of Commission regulation (EU) No. 814/2013 with regard to ecodesign requirements for water heaters and hot water storage tanks. FINAL REPORT, prepared by VHK for the European Commission; 11 July 2016; and see the sources above, accessed at 28th May 2018

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Currently a huge amount of money and activities run into the development of storage technologies - both thermal and electrical based - all over the world - see for example at https://www.renewableenergyworld.com/energy-storage/in-depth-technology.html

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

To increase the energy flexibility future energy systems will use different storage facilities of nZEB like buffer or hot water storage tanks, as well as batteries and possible other arising technologies. So using storage facilities one could learn about using alternative sources qualitatively; quantitatively different storage capacities could be rated like:

High: Thermal storage > 0,6 kWh/m²GFA or electrical storage > 0,2 kWh/m²GFA
Medium: Thermal storage < 0,6 kWh/m²GFA or electrical storage < 0,2 kWh/m²GFA
Low: No storage facilities except small like undersink hot water tanks or similar

ACTION: Construction Details – Heat Bridges

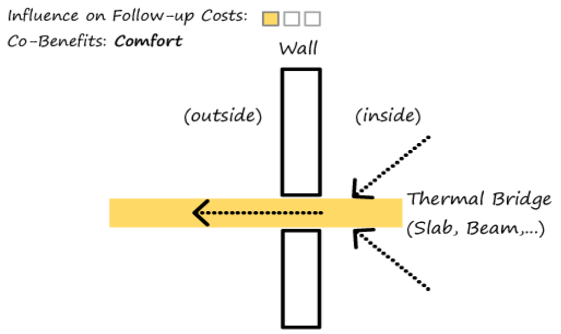
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Thermal bridges are localized areas in the heat-transferring envelope of a building where increased heat flow occurs. This is associated with lower inside surface temperatures.

- Material-related thermal bridges
  They occur where different materials with different thermal conductivity in the construction meet
- Geometry-related thermal bridges
  They arise when thicknesses of a building element changes or at building edges and building corners
- Thermal bridges due to planning and execution errors
  These are caused by leaks due to poorly executed construction work

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Lower running costs through reduced heat loss; Fewer defects; Reduced condensation; Improved comfort; Reduced carbon emissions; Verification of build quality

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Avoiding thermal bridging can result in decreased energy consumption due to winter heat loss and summer heat gain
- Near thermal bridges, occupants may experience thermal discomfort due to different surface temperatures - a second important reason to avoid them

❼ DIFFICULTY

- Due to their partly significant impact on the heat transfer, correctly modelling the thermal bridges is important to estimate overall energy use
- There is a risk of condensation in the building envelope due to the cooler temperature on the interior surface at thermal bridge locations which can ultimately result in mould growth

❽ STANDARDS AND REGULATIONS

ISO 10211:2017 Thermal bridges in building construction -- Heat flows and surface temperatures -- Detailed calculations

❾ MAIN DRIVER

Stakeholder A

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Nowadays thermal bridges losses in building design (standard or dynamic simulations) are generally evaluated using heat transmission coefficients from a database of usual cases.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Simulation of constructions, including thermal bridges

Medium: Detailing on the basis of already known standardized details

Low: Minimum national standard

REFERENCES USED

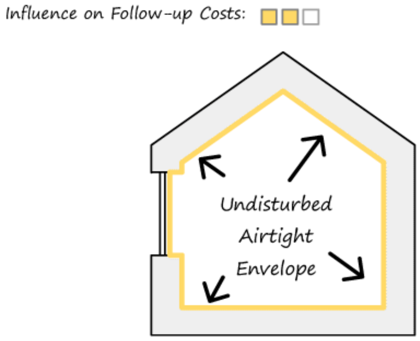
see standard above

ACTION: Air tightness
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

The airtightness of the building envelope is an essential element in the design of energy-optimized buildings. The airtight design requires a detailed planning, in the later execution of a careful implementation and possibly a qualitative final inspection. The production of the airtightness of the building envelope already begins with the planning by means of an airtightness concept. Just as with thermal insulation, the interruptions of which by thermal bridges are avoided as far as possible, the airtightness concept ensures that the components and connection joints are airtight. For the implementation of the planning detailed drawings of the connection points are helpful.
For solid inner walls, the airtightness is usually produced with the interior plaster. For multi-layered wooden structures, the airtight layer may be inside the wall.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Lower running costs through reduced heat loss; Fewer defects; Reduced condensation; Improved comfort; Reduced carbon emissions; Verification of build quality

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Airtightness of the roof and building envelope prevents damage caused by water vapour that is transported in air gaps
- Ventilation systems with supply and exhaust air duly operate only if the building envelope is sufficiently airtight
- Airtightness also results in better sound protection

❼ DIFFICULTY

- The connection joints between different materials or at construction corners and edges are problematicin planning and execution
- All employees and sub-contractors need to be suitably trained / qualified to carry out airtightness of the construction
- Design specifications need special attention during construction

❽ STANDARDS AND REGULATIONS

ISO 9972:2015 Thermal performance of buildings -- Determination of air permeability of buildings -- Fan pressurization method

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Air leakage is a large source of wasted energy and can lead to condensation-related moisture problems. The blower-door-testing methodology utilizes a combination of varying the building pressurization (50 Pa over- or negative pressure), smoke testing and infrared thermography to identify air leakage paths. Combined with calibrated door fans, air leakage can be quantified.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: n50 value has to be not higher than 0.4 h-1
Medium: n50 value has to be not higher than 0.6 h-1
Low: n50 value has to be not higher than 1.0 h-1

REFERENCES USED

own projects

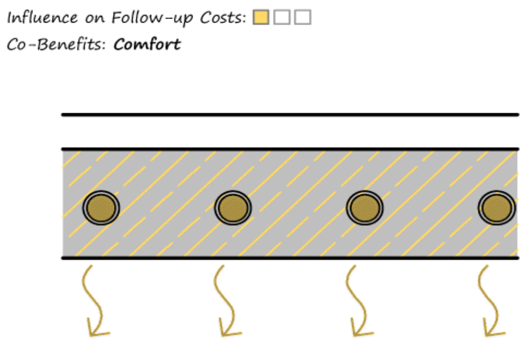
ACTION: Thermal Activated Building Elements
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Thermal component activation or concrete core tempering refers to heating or cooling systems in which water-bearing pipelines pass through walls, ceilings or floors and use the thermal masses of these components for temperature regulation.

Due to the considerably larger transmission surfaces compared to conventional radiators, the systems deliver significant power to the room even at low temperatures of the heating or cooling water (18° to 22°C or max. 27° to 29°C). Thus, it can be heated and cooled also with renewable energy at very low supply temperature level.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Increases the effectiveness of renewables; Improved comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

experience from own projects

❻ IMPORTANCE

Because the power of the activated thermal mass is limited due to the small temperature difference between the heating or cooling medium and the room temperature these elements should not be clad or suspended to ensure heat exchange with the room.

❼ DIFFICULTY

- If the building is to be heated and cooled exclusively by means of concrete core temperature control, the architecture, building physics and technology must be optimally coordinated and the heating and cooling load consistently limited
- In buildings with concrete core activation, the room temperature can not be adjusted individually or quickly

❽ STANDARDS AND REGULATIONS

ISO 13370:2017 Thermal performance of buildings -- Heat transfer via the ground -- Calculation methods

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

For the activation of construction elements the building can be divided into zones in order to be able to temper the various areas according to requirements. The zones should be differentiated according to orientation, floor, use or façade conception and should be regulated as required with varying flow temperatures and at different loading times. Thermally activated structures are best designed using thermal building and facility simulation. The laying of the pipes in the concrete core temperature control must be integrated into the course of the formwork, reinforcement and concreting work.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Core activation (low supply temperature >30°C)
Medium: Core activation (medium supply temperature >40°C)
Low: Floor heating system

ACTION: BIM systems
LIFE CYCLE PHASE: PLANNING

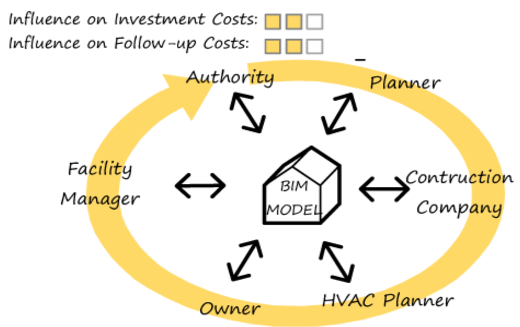
❶ DESCRIPTION OF THE ACTION

Building Information Modelling (BIM) refers to the optimized design and construction of buildings by means of suitable software. BIM is a smart digital building model allowing all the partners involved in a project - from architects and builders to building services and facility managers - to work together on and jointly implement this integrated model.

BIM is used to draw up an intelligent digital building model that can be examined and edited collaboratively by all the partners involved.

The data model digitally specifies all the relevant building data and combines and links them. The building is also geometrically represented as a virtual computer model. The BIM data are of a very high quality as they are drawn from a common data basis and are continually updated and synchronized. The immediate and continuous availability of all the current, relevant data ensures optimal information exchange between the partners and helps improve the efficiency of the planning process with regard to cost, deadlines and quality.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Role Model / Pioneering Role

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❼ DIFFICULTY

- High ratio of involved stakeholders is short on experience, BIM is mainly used by architects, less structural engineering and building services engineering
- Two different approaches possible -> open BIM vs. closed BIM
- Varying from country to country and from manufacturer to manufacturer, same properties / parameters can have different names

❽ STANDARDS AND REGULATIONS

- CEN/TC 442 - Building Information Modelling (BIM)
- ISO/TC 59/SC 13: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)
- ISO 16739:2013: Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

The BIM approach is still in development and every actor needs to adapt to this new environment. The cooperative planning method, the decision-making process, the treatment of common knowledge resources must be learned in order to actually create better cooperation between all stakeholders. For this, tools and services as well as common processes and standards are being developed. At present, some leading software manufacturers are mainly pushing "closed-BIM", that is, the collaboration of different actors within a software family (one manufacturer). However, because a building project requires around 50 different software applications by default, the "open-BIM" approach seems to be more effective in order to really enable a broad implementation of BIM. The organization buildingSMART (https://www.buildingsmart.org/) reinforces this "open-BIM" approach worldwide, including a common exchange format, the Industrial Foundation Classes (IFC), and related standards such as the Data Dictionary.

BIM has several dimensions that correspond to the different steps of the BIM implementation: 3-D for geometry, 4-D for time, 5-D for cost, 6-D for sustainability, and 7-D for facility management.

❻ **IMPORTANCE**	⓬ **SPECIFICATIONS (QUALITY / QUANTITY GOAL)**
○ Improved communication, intelligibility and visualization ○ Improved coordination and progress control ○ Improved planning and design quality ○ Reduction of project duration and guarantee of on-time delivery ○ Cost reduction (construction / operating costs)	○ BIM used in all life time phases of new and renovated buildings (design phase, tendering phase, construction phase, operational phase) ○ Improvement of quality in planning, construction and operation as a result of the use of BIM - evaluated e.g. in a quality assurance process **High**: BIM used in all planning phases of the nZEB **Medium**: BIM used in some planning phases of the nZEB **Low**: BIM used in only one planning phase of the nZEB
REFERENCES USED own knowledge and projects plus links above	

ACTION: Accession of Thermal Mass

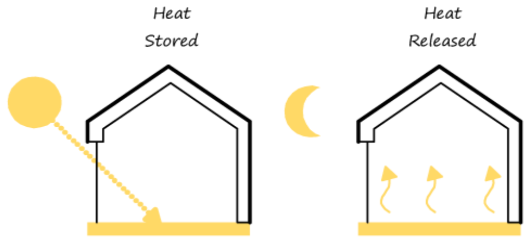
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Using thermal mass inside a building makes it possible to absorb and store heat energy. A lot of heat energy is required to change the temperature of high density materials like concrete, bricks and tiles. They have high thermal mass. Lightweight materials such as timber have low thermal mass. Appropriate use of thermal mass throughout homes can make a big difference to comfort.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs: ■□□
Co-Benefits: ***Comfort***



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Thermal mass, correctly used, moderates internal temperatures by averaging out diurnal (day–night) extremes
- Thermal mass must be integrated with sound passive design techniques. This means having appropriate areas of glazing facing appropriate directions with appropriate levels of shading, ventilation, insulation and thermal mass

❼ DIFFICULTY

- Poor use of thermal mass can exacerbate the indoor climate and can turn to energy and comfort liability. It can radiate heat all night during a summer heatwave or absorb the heat produced on a winter night
- The presence of exposed mass within buildings can cause problems with high acoustic reverberation

❽ STANDARDS AND REGULATIONS

- ISO 13789:2017(en) Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method
- ISO/DIS 52017-1(en) Energy performance of buildings — Calculation of the dynamic thermal balance in a building or building zone — Part 1: Generic calculation procedure

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Thermal mass must be exposed, not clad to function efficiently. This means that it is commonly associated with exposed concrete floors and walls. The effectiveness of thermal mass can however be enhanced by paint, selected to optimise the absorption and release of thermal radiation.
There are also more complex design strategies that utilise thermal mass, such as thermal labyrinths and other ground energy options.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Construction, specific heat capacity = 204 Wh/m²K
Medium: Construction, specificheat capacity = 110 Wh/m²K
Low: Construction, specificheat capacity = 60 Wh/m²K

REFERENCES USED

http://www.yourhome.gov.au/passive-design/thermal-mass, accessed at 20th June 2018

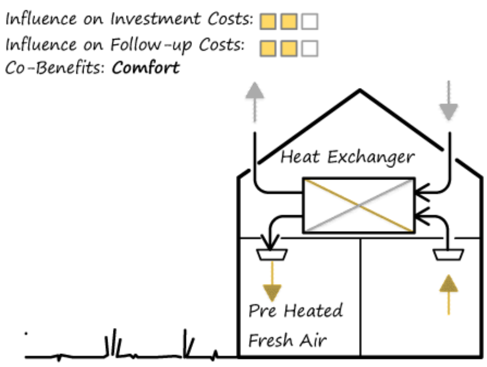
ACTION: Energy Recovery Systems
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

Energy-recovery techniques within heating, cooling and ventilation systems can provide the right building temperature and air quality. At the same time they can reduce heat losses, and hence energy consumption. The type of system to use varies depending on the application, but the most common is heat recovery within the ventilation system. Regarding heat sources in buildings, exhaust air and the wastewater are the main used ones.

Various types of heat recovery units are available for building ventilation (cross flow, rotary, twin coil, heat pipes, ...) with different efficiency.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Ventilation systems are fundamental in maintaining indoor air quality. Therefore significant energy savings can be provided by a correct design of the heat recovery within the systems.

❼ DIFFICULTY

The investment and running costs are higher if heat recovery is used within existing ventilation or heating systems, including more investments on filters.

❽ STANDARDS AND REGULATIONS

Ecodesign Directive (Directive 2009/125/EC)

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Tenants/Uses (association), Owners

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The European market of ventilation systems with heat recovery would require a growth factor of 8-10 in order to meet the nZEB construction market.

High: heat recovery efficiency > 85%
Medium: heat recovery efficiency < 85%
Low: heat recovery efficiency < 75%

REFERENCES USED

Atanasiu, B., & Attia, S. (2011). Principles for Nearly Zero-Energy Buildings: paving the way for effective implementation of policy requirements. Principles for nearly Zero-energy Buildings: Paving the way for effective implementation of policy requirements, 124.

ACTION: Heat Pumps
LIFE CYCLE PHASE: PLANNING

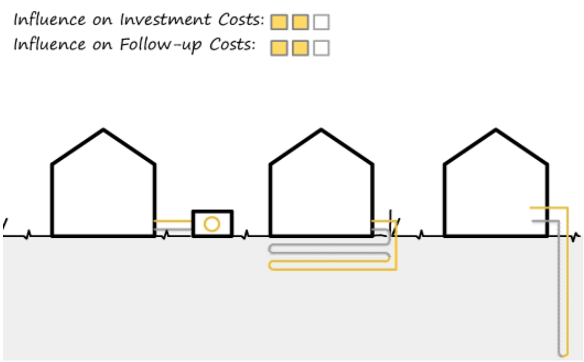
❶ DESCRIPTION OF THE ACTION

The operating principle of a heat pump uses electric power to generate a higher temperature level out of a heat source with a lower level. This thermodynamic cycle is called the Carnot Process.

Heat sources for heat pumps:

- Groundwater: this is the most reliable source of heat that provides a constant heat source temperature virtually year round. The required well installation is not possible or approvable at all locations and, above all, entails high investment costs. A case-by-case examination is required. With a suitable heat distribution (e.g. underfloor heating), good performance can be achieved.
- Geothermal probe: harnessing geothermal energy via a probe system is associated with higher investment costs, but is a reliable heat source depending on the location, which provides good annual work figures. Again, as with all heat pump systems, a heat distribution is necessary, which works with low flow temperatures.
- Ground collector plant: a ground collector plant is very area-intensive and is only possible or useful for new construction project with sufficient land size. In the winter months, a stronger cooling of the collector must be expected, so that the work figures at the end of the heating season decrease and thus suffers the effectiveness of the heat pump system. The solution, however, is cheaper than a geothermal probe.
- Heat source air: the use of an air heat pump has the advantage that no elaborate well or collector system has to be created. The main disadvantage is the poor number of jobs at low outdoor temperatures.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❻ IMPORTANCE

To reach nZEB standards, electric heat pump seems to be the most suitable technology, due to the expected increase of the renewable energy share in the national electricity mix and renewable on-site production.

❼ DIFFICULTY

- To run heat pumps, electricity is needed which is in many countries the most expensive and not really environment friendliest energy source at the moment - this should be taken into consideration when designing the heating system
- High flow temperatures in the heat distribution system make heat pumps very inefficient

❽ STANDARDS AND REGULATIONS

Many standards and guidelines regulate heat pump systems. Examples:

- EN 255-3: Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode
- EN 15450: Heating systems in buildings - Design of heat pump heating systems

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

The efficiency figure of a heat pump is the annual work rate, defined as the ratio of the heat produced to the electrical energy consumed, averaged over one year. For a high number of working hours of the heat pump, a small temperature difference between the temperature of the environmental energy (air or ground water or brine) and the one of the heating circuit is decisive. Heat pump systems are a very good choice in buildings, which manage with low flow temperatures of the heating system.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Heating demand of the building is < 30 kWh/m²GFA.a and flow temperatures below 35°C
Medium: Heating demand of the building is 30-50 kWh/m²GFA.a and flow temperatures from 30-40°C
Low: Heating demand of the building is > 50 kWh/m²GFA.a and flow temperatures above 40°C

REFERENCES USED

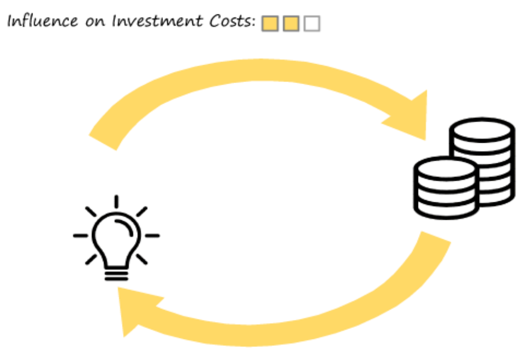
Haas J. et al.: Handbuch für Energieberater (1994) and own projects

ACTION: Apply For Funding
LIFE CYCLE PHASE: PLANNING

❶ DESCRIPTION OF THE ACTION

In the development of nZEB projects, not only technological and skills-related but also financial challenges could limit the implementation of interesting concepts. So there is a need to overcome these financial barriers to finalize the projects. Funding possibilities increase the probability to bring down nZEB projects. They are an important part of the portfolio the society or public organisations can give to change normal market behaviour.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

- Funding is often the dot over an i for a lot of new nZEB concepts to be realized.
- In Europe there are manifold ways of possibilities for funding - it is worth to contact professional advice to benefit from this big diversity.
- The process to get the funding mostly is connected to some quality assurance steps for nZEBs - could be very positive for the projects generally.

❼ DIFFICULTY

- The big diversity of funding schemes and possibilities confuses and makes it difficult to keep the overview, especially regarding requirements and quality assurance verification
- In some cases the amount of funding bears no relation to the time and effort of application - a great barrier for little companies not having personal resources

❽ STANDARDS AND REGULATIONS

The European Commission as well as every nation or region has a legal framework where funding schemes are based on, because otherwise funding could be seen as a market-distorting mechanism which is not allowed.

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

There are different ways and procedures of funding nZEBs:

- The classical way consists of direct grants or direct and indirect (via finance institutions) loan support from EU, governments, regions or municipalities
- Public private partnership models count on private investors who finance nZEBs with advantages for both sides, the owner and the investor, who again could be an affiliate of public organisations
- nZEBs could be funded in the frame of research projects to serve as frontrunner or lighthouse buildings to learn from
- The funding of nZEB in bigger companies could also happen internally by putting more resources into the conceptional process to come to an nZEB or to explore new technologies to get pioneer status
- Funding can for example also come from future users of the nZEB or sort of crowd-funding by advance cash for the planning and construction

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Funding is a qualitative way of supporting nZEB implementation. If trying to rate nZEB by claimed funding, one may come up with the following:

High: Funding from at least 3 different sources
Medium: Funding from at least 2 different sources
Low: Funding from only one source

REFERENCES USED

own sources and projects

ACTION: Efficient use of materials
LIFE CYCLE PHASE: PLANNING

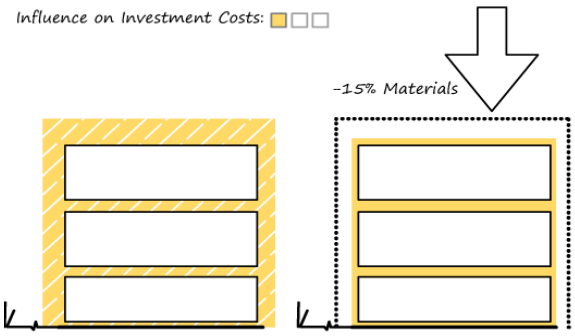
❶ DESCRIPTION OF THE ACTION

Efficient use of materials may drastically decrease the environmental impact, but also make savings in monetary terms.
Architects may consider the geometry and layout of the building. Not only to make it more compact and space efficient (Area to Volume ratio) but also to consider how to enable a resource efficient superstructure. E.g. short spans = less material.

Another example may be to set high quality requirements and tight tolerance requirements, resulting in lower usage of materials.

Early in the planning phase, the environmental impact of the building materials should be calculated in order to identify potentials (LCA-calculations).

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Cost savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

As buildings become more energy efficient, the relative impact from materials increases. In very energy efficient buildings, more than 50% of the environmental impact may be related to the use of materials.

❼ DIFFICULTY

It´s complex to do LCA-calculations early in the design phase.

❽ STANDARDS AND REGULATIONS

- ISO 129-1, EN 60300, ISO 15686
- LEED: NC-v4 MRc1: Building life-cycle impact reduction

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

See standards/ regulations

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Reduced use of material compared to baseline building (%)

High: 20% less used material compared to baseline building
Medium: 10% less used material compared to baseline building
Low: Less used material compared to baseline building

REFERENCES USED

Certification systems and standards above

ACTION: **Energy Flexibility – Demand Response**
LIFE CYCLE PHASE: **PLANNING**

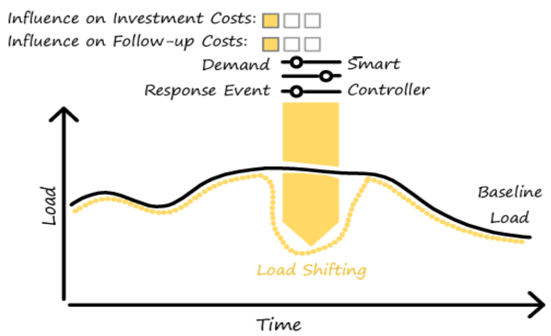
❶ DESCRIPTION OF THE ACTION

Energy systems based on fluctuating renewable energy sources are characterized by intermittent generation. Their rapid increase challenges the stability of both thermal and electric grids. A mitigating effect of the stress put on the grid by variable renewable energy sources (VRES) penetration can be played by buildings, which are gradually moving from standalone consumers to interconnected prosumers (both producers and consumers) able to provide and store renewable energy and actively participate in demand response.

Based on the initial definition of the IEA EBC project Annex 67 (Energy Flexible Buildings), building Energy Flexibility represents "the capacity of a building to manage its demand and generation according to local climate conditions, user needs and grid requirements. Energy Flexibility of buildings will thus allow for demand side management/load control and thereby demand response based on the requirements of the surrounding grids".

In this regards, the concept if flexibility is connected to the demand response aims to reduce the peak demand in grids by adjusting the power consumption strategy of the building energy systems. This demand response is often obtained through the implementation of energy storage systems.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

By utilizing energy flexibility, reduce energy from fossil sources, increase the use of renewable energy sources in the overall energy system and so reduce greenhouse gas emissions associated with new building construction.

❼ DIFFICULTY

A shared methodology for the evaluation of energy flexibility is still under development.

❽ STANDARDS AND REGULATIONS

Clean energy for all europeans. COM(2016) 860 final. Brussels, 30.11.2016. Including 2016 amended EPBD.

❾ MAIN DRIVER

Energy Providers

❿ INVOLVED STAKEHOLDERS

Designers

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

Still work in progress

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Smart control and storage systems are included and communicating in the building energy system
Medium: Storage possibilities are integrated in the building energy system
Low: Simple control system but no storage facility exist in the building

REFERENCES USED

Annex 67 www.annex67.org, accessed at 6th Aug. 2018

ACTION: Tenant Design and Construction Guidelines
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

The guidelines will help the future tenants/users/building owner to design and build sustainable interiors and adopt green building practices.
I.e. helping them in future build-outs, interior changes etc.

The guidelines could include:

- A description of the sustainability features already included in the building.
- Information regarding:
  - Water reduction
  - Electric lighting and daylighting
  - HVAC
  - Energy metering
  - Indoor air quality and thermal comfort

❷ EXAMPLES (CASE STUDY A)

Influence on Investment Costs: ■□□
Influence on Follow-up Costs: ■□□

❸ CO-BENEFITS

Energy Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

These guidelines are not only helpful for recent users of the building, but also relevant for the "second generation" of occupants.

❼ DIFFICULTY

Developing guidelines may be easy - it may be harder to encourage the tenants to follow the guidelines.

❽ STANDARDS AND REGULATIONS

- LEED CS-v4 SSc7: Tenant Design and Construction Guidelines
- BREEAM NC 2017, 5.0 Management (Commissioning, handover and aftercare)
- EN ISO 7730 Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

See standards and regulations

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Quality goal: Guidelines are made and documented

High: Detailed guidelines + verbal introduction of the guidelines
Medium: Guidelines introduced
Low: No guidelines

REFERENCES USED

own projects

ACTION: Energy performance guarantee
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

Energy performance guarantees are similar to energy performance contracts and often part of service contracts, where the owner/occupant pays for a specific service like retrofit measures and gets a guarantee for a better performance or lower energy bill. Energy performance guarantees can so be incorporated into contracts with service providers, contractors or product suppliers (ESCO), transferring some or all of the performance risk to the supplier/ service provider.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs:

❸ CO-BENEFITS

Value development

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Energy performance guarantees reduce / outsource project risks, which can be valuable for large and complex retrofits or energy saving investments.

❼ DIFFICULTY

Transaction costs, financial expert involvement and long negotiation phase could hamper the process to get to these guarantees.

❽ STANDARDS AND REGULATIONS

No regulations or standards are available, but EU-projects like https://ec.europa.eu/energy/intelligent/projects/en/projects/eurocontract#partners to promote EPC

❾ MAIN DRIVER

Tenants/Users (association)

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

Energy Performance Contracting (EPC) is a form of 'creative financing' for capital improvement which allows funding energy upgrades from cost reductions. Under an EPC arrangement an external organisation (ESCO) implements a project to deliver energy efficiency, or a renewable energy project, and uses the stream of income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the costs of the investment. Essentially the ESCO will not receive its payment unless the project delivers energy savings as expected.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: High amount of >50% of all building services are contracted by EPC
Medium: Some building services are contracted by EPC
Low: No energy performance guarantees are integrated in the building services implementation

REFERENCES USED

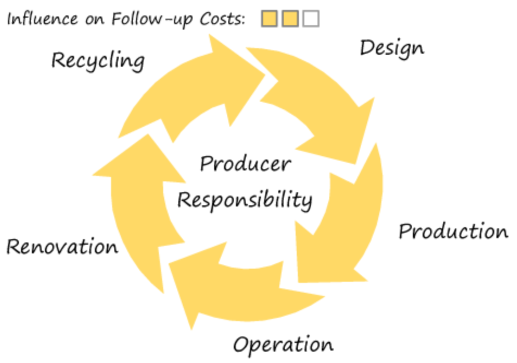
Energy Performance Contracting - https://e3p.jrc.ec.europa.eu/articles/energy-performance-contracting and http://www.sustainable-procurement.org/, accessed at 27th July 2018

ACTION: Extended producer responsibility
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

Buildings use large amounts of materials and produce a lot of waste. Extended Producer Responsibility (EPR) policies are based on the principle that producers are responsible for the treatment or disposal of their products at the end-of-life. EPR uses financial incentives to encourage manufacturers to design products that respect the environment, holding producers responsible for the costs of handling their products at the end of their useful life.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

Energy shortages and pollution prevention are concerns at regional and global levels, while material shortages occur in some regions.

❼ DIFFICULTY

Set up of regulatory, economic or information instruments.

❽ STANDARDS AND REGULATIONS

- OECD: Extended Producer Responsibility. Updated Guidance for Efficient Waste Management. Published on September 20, 2016.
- EPD (Environmental Product Declaration) - standards EN ISO 14025 and EN 15804

❾ MAIN DRIVER

Authorities

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Some consulting organisations like in Austria offer a kind of chemicals and ecological building product management, where EPR is the basis of the materials used and declared (e.g. http://www.bauxund.at/index.php?id=81).

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Encourage the production of commodities that have a minor environmental impact.

High: A construction product plan is established where all used material follow the EPR policy
Medium: A construction product plan is established where at least the material for building components follow the EPR policy
Low: There is no construction product management, EPR policy is not used

REFERENCES USED

Information at http://www.expra.eu and http://www.oecd.org/env/waste/factsheetextendedproducerresponsibility.htm, accessed at 27th July 2018

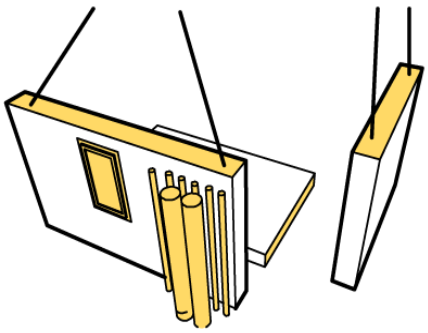
ACTION: Prefabrication of multifunctional Building Elements
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

Constructing a nZEB evokes different sources of errors and interface problems. For example the installation of a heavy triple-glazed passive house window into the wall is not a simple task and requires knowledge of how to do it without causing thermal bridges, leakages etc. One answer to such kind of possible errors in building constructions is prefabrication, means the assembling of bigger elements like wall, ceiling or even heating or ventilation systems, in a more controlled way with lower possibilities to make errors.
Such prefabricated building elements do not only have the advantage of quick, qualitatively high and precise assembling, they can even provide different functionality such as integrated renewable energy generation, ventilation ductwork, insulation and transparent components - all in one prefabricated wall-element. Another example are solar thermal collectors in roof elements where they produce hot water but at the same time protect the building from the weather.
There is a growing market for the use of prefabricated multifunctional building elements in nZEBs. The EU and different national programmes support the development of these, because they believe in the increase of quality and functionality for constructions.

❷ EXAMPLES (CASE STUDY A)

Co-Benefits: **Construction Time, Quality**



❸ CO-BENEFITS

Value Development

❹ CONFLICT OF AIM WITH OTHER ACTIONS -

❻ IMPORTANCE

- Prefabricated construction and HVAC elements increase the construction and functional quality of the nZEB buildings.
- The possibilities to include different functions in one element decreases prizes.

The working conditions for processing the elements is mostly much better than on site.

❼ DIFFICULTY

- A lot of know-how and special equipment is needed to design and construct such elements.
- This and the lack of knowledge on the costumer's side may lead to higher launching, convincing and organisational investments than normally calculated for construction works.

❽ STANDARDS AND REGULATIONS

- IEA EBC Annex 50 developed a "10 steps guide" for prefabricated element walls under https://nachhaltigwirtschaften.at/resources/iea_pdf/iea_ecbcs_annex_50_anhang5-10stepsguideline_aee-en_1-3.pdf?m=1469661023
- Regulations or standards on quality management like ISO 9000-standards or quality assessment ISO 15504

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

The development of prefabricated elements for nZEB is mainly done within research and company projects and partnerships. Holistic roof and façade solutions, which, through a high level of prefabrication, feature good integration possibilities of energy façades and roofs and also complete integration possibilities for energy distribution systems (plug-and-play concept), do exist in many countries. Ongoing research is trying to integrate more of the HVAC system too.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

When it is about quality of a prefabricated element, measures like heat/sound/fire protection or services quality for installation could be rated. For easy quantitative rating of a nZEB integrating prefab elements one could use the following:
High: At least 3 different prefabricated elements can be found in the nZEB
Medium: At least 2 different prefabricated elements can be found in the nZEB
Low: At least one prefabricated element can be found in the nZEB

REFERENCES USED

IEA EBC Annex 50 project results under https://nachhaltigwirtschaften.at/en/iea/technologyprogrammes/ebc/iea-ecbcs-annex-50.php; PREFABRICATED SYSTEMS FOR DEEP ENERGY RETROFITS OF RESIDENTIAL BUILDINGS under http://bpie.eu/wp-content/uploads/2016/02/Deep-dive-1-Prefab-systems.pdf, accessed at 28th May 2018; and above mentioned standards

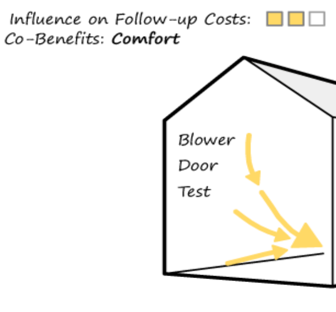
ACTION: Air Tightness Measurements
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

nZEBs are constructed in an airtight way, so that there is are no uncontrollable leakages and air exchange with the surrounding when windows and doors are fully closed. This is first of all because of the ventilation energy losses in winter, but also to get balanced pressure conditions when a mechanical ventilation system will be operated.

The building envelope is measured for its airtightness by using the differential pressure method, the so called 'blower door' test. Using this method the remaining air exchange rate can be determined. To do this, air is forced or sucked out into the building under investigation by means of a fan. The fan is usually used with a frame in the opening of an open window. The previously used door (this is where the name comes from) is no longer used as often as the front door should also be checked for windproofness. Due to the generated positive pressure, air flows through leaky constructions to the outside, which can be localized with smoke. With a measuring and control unit, the desired pressure differences can be adjusted and the delivered volume flows can be determined.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

The ventilation concept of a nZEB should be very good adjusted to the airtightness measures taken for the building, so that for example possible air gaps in window frames for exhaust or hybrid ventilation do not disturb the airtightness of the building.

❺ INFLUENCES ON OTHER ACTIONS

-

❼ DIFFICULTY

- For little buildings it is very easy t do the testing, but for big buildings it is difficult to decide which parts of the buildings are to be tested in one run.
- It is costly to get leakages airtight, so there should be put more emphases on that in the planning of the construction before.

❽ STANDARDS AND REGULATIONS

- Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:2015)
- Thermal performance of buildings and materials - Determination of specific airflow rate in buildings - Tracer gas dilution method (ISO 12569:2017)
- Different national procedures regarding energy performance certification

❾ MAIN DRIVER

-

❿ INVOLVED STAKEHOLDERS

-

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Blower Door Test:
For leak detection and measurement of the air change rate, the building is brought to a pressure difference of 50 Pa to the environment/ outside. While this pressure difference is kept constant, the entire building can be inspected for leaks. The leakages found are logged and can be improved using this protocol.

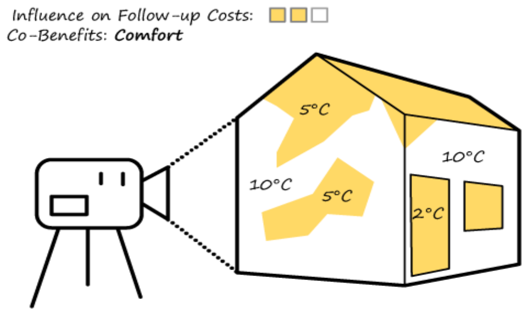
Air exchange rate:
The air exchange rate n indicates how often the air volume of a building is renewed on average. The unit of the airtightness of a building is the air exchange rate 'n50'. This figure is given by the air flow rate per hour when maintaining a pressure difference of 50 Pa divided by the volume of the building. The smaller the number, the more tight the building. For buildings without ventilation and air conditioning systems, an air change rate of $n50 = 3$ and of buildings with air handling systems of $n50 < 1.5$ is required. Passive-houses should not exceed a value of $n50 = 0.6$.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

❻ **IMPORTANCE**	It should be clear from the beginning and for all construction workers where to put emphases to get the envelope airtight as well as possible. The quantitative aims could be: **High**: For the air change rate the n50-value should be < 0.6 per hour **Medium**: For the air change rate the n50-value should be < 1.5 per hour **Low**: For the air change rate the n50-value should be < 3 per hour
o The air tightness measurement is a very important quality assurance measure to guarantee the promised functionality of the building envelope. o It is very important to do the testing before the envelope is really finalised, otherwise there is no possibility to optimize the airtightness afterwards.	
REFERENCES USED klimaaktiv standards as on https://www.klimaaktiv.at/english/buildings/Buildings.html, accessed at 5th June 2018, and standards - see above	

ACTION: Thermography infrared **LIFE CYCLE PHASE: CONSTRUCTION**	
❶ **DESCRIPTION OF THE ACTION** Thermographic investigations are carried out in the form of temperature and heat measurements in all areas of heating, ventilation, air conditioning and refrigeration. In the field of building physics, for example, they serve to determine thermal bridges. Especially in the case of component connections, heat-bridge-related heat losses and lower room-side surface temperatures occur, which can lead to mould fungus formation. Modern devices feature 12-bit high-speed colour systems with real-time temperature measurement and display and are equipped with built-in data logging systems. This allows the thermal images to be analysed and documented via PC. From the small colour handycam to the long-wave Stirling cooled real-time camera to the Focal Plane Array system, all thermal and geometric resolution performance requirements are available. Pictures can be taken by a hand-borne camera but also using a drone that carries the camera along the building surface. Low level infrared thermography can be done using a simple thermographic camera at the appropriate weather conditions. High level infrared thermography is usually offered as a service by technical offices for building physics. In this case, the outcomes are not only photographs but also an analysis and interpretation of the results in form of a thermographic report.	❻ **IMPORTANCE** o Infrared thermography helps to reveal heat bridges and deviations in surface temperature o It is a fast, low cost and non-destructive investigation method o One image covers a large area and can include inaccessible places (via drones) o Images can be stored as photograph for documentation ❼ **DIFFICULTY** o A special camera is needed o Heat bridges can only be identified in the heating season (heating on, cold outside) o Differing emissivity and reflections from other surfaces limit the accuracy o The results show only the surface and not temperature inside the walls ❽ **STANDARDS AND REGULATIONS** o DIN EN 13187, Wärmetechnisches Verhalten von Gebäuden – Nachweis von Wärmebrücken in Gebäudehüllen – Infrarot-Verfahren o ASTM C1060, Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings o ASTM C1153, Standard Practice for the Location of Wet Insulation in Roofing Systems Using Infrared Imaging ❾ **MAIN DRIVER** - ❿ **INVOLVED STAKEHOLDERS** -

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

user satisfaction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

REFERENCES USED

Thermographical report for the case study Kapfenberg out of own project "e80^3"; Wikipedia article on Thermography, accessed at 20th June 2018

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Infrared Thermography here is mainly used in three occasions:

- Investigation in case of mould and other structural damages
- Control at the handing over of the construction
- Baseline investigation before doing a renovation

It can be financed by the assicuration in case of damage, and paid back by future energy savings and prevention of damage in other cases.

Infrared thermography is a standard procedure in case of damage.
It is however not often used for quality assurance and pre-renovation analysis, since it has not yet been included in the standard procedure.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

In the first heating season all facades should be tested.
An engineering office for building physics should take pictures with a calibrated camera and write a report, including photographs, calculated surface temperatures and interpretation, as well as boundary conditions like outdoor and indoor temperature, date, hour of the day, camera type

High: Comprehensive thermographical report available on building envelope
Medium: Comprehensive thermographical report available on high-risk parts of the building
Low: Thermographical documentation (only photographs) on high-risk parts

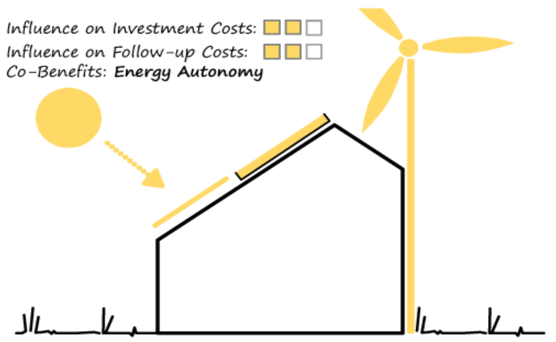
ACTION: Installation renewables
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

Integration of renewables in the building for various applications such as water heating, heating/cooling and electricity production is an important aim, pursued by the EU and many regions in Europe.
Renewable energy technologies are: wind generators, photovoltaic systems, solar thermal water heating, biomass heating, biomass CHP, and different source heat pumps.

The Renewable Energy Directive (RED 2014/53/EU) established an overall policy for the promotion of the energy production from renewable sources. It requires the Member States to fulfill at least 20% of its total energy consumption with energy from renewables by 2020. Also, it requires that at least 10% of transport fuels come from renewable sources. The 20% target was updated in November 2016. The new target requires at least 27% of energy from renewable energy sources in the final energy consumption of the EU by 2030.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Resource Savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

-

❻ IMPORTANCE

The main goals of installation of renewable energy technologies are to reduce the use of fossil resources and lower CO2-emissions.

❼ DIFFICULTY

- Technical feasibility studies have to be done: geometry, orientation, position, etc.
- Economic viability: capital and maintenance costs, payback time

❽ STANDARDS AND REGULATIONS

Renewable Energy Directive (RED) 2009/28/EC and a lot of technology-specific standards on renewable energy systems

❾ MAIN DRIVER

Authorities

❿ INVOLVED STAKEHOLDERS

Owners

⓫ METHODOLOGY/TECHNOLOGY/BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The European Union Member States should fulfill at least 20% of its total energy consumption with energy from renewables by 2020.

High: 100% of the building's final energy supply comes from renewable energy sources
Medium: 50% of the building's final energy supply comes from renewable energy sources
Low: National minimum requirements for renewable energy sources in building codes

REFERENCES USED

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0053, accessed at 27 July 2018

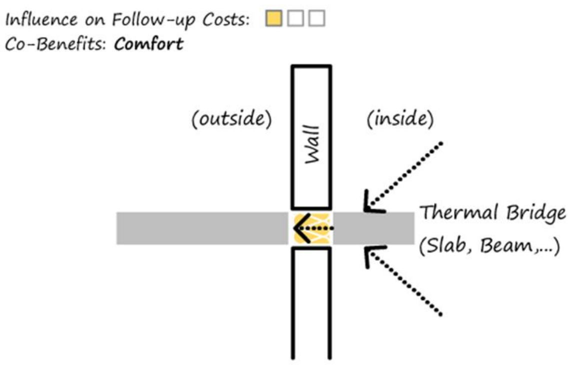
ACTION: Eliminate Heat Bridges
LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

Thermal bridges are areas of the building envelope with a much lower thermal resistance than the adjacent wall and ceiling parts. They generally occur in the vicinity of structural connections, for example in the case of balcony projections or roof / exterior wall connections and other component connections. Thermal bridges cause heat losses and lower room-side surface temperatures, which can lead to condensation and mould formation, depending on the room air humidity.

Using simulation tools (e.g. HTflux), the resulting lowest room-side surface temperature can be calculated as well as the humidity level that offsets condensation and the thermal bridge loss coefficient. The unit of the thermal bridge loss coefficient is W/(m K), that means lost Watt per running Meter and Kelvin temperature difference between the in- and outside.

❷ EXAMPLES (CASE STUDY A)



❻ IMPORTANCE

- The absence of heat bridges reduces thermal energy loss
- Elimination of heat bridges helps to avoid structural damage

❼ DIFFICULTY

- Heat bridges need to be detected before they can be eliminated: Measurement/Calculation before Elimination
- For repair works it might be necessary to enter the apartments
- Elimination of heat bridges might require adaptations in the building design

❽ STANDARDS AND REGULATIONS

- Restrictions for thermal bridges are usually regulated in the national building code, via maximum energy consumption and minimum allowed surface temperature to avoid damage by condensation
- ISO 10211:2017 Thermal bridges in building construction -- Heat flows and surface temperatures -- Detailed calculations

❾ MAIN DRIVER

Planner

❿ INVOLVED STAKEHOLDERS

Construction company; Authorities; (Economic) Chambers; Citizen groups/NGOs

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Thermal bridges can be caused by geometry, construction and inadequate insulation.

Evaluation of thermal bridges by:

- Blower Door Test
- Thermal Bridge Calculation Software; product information for building components
- Infrared Thermography

Possible measures:

- Fill cracks and holes in walls and around window frames with insulating material
- Insulate protruding building elements additionally
- Integrate loggias into the thermal envelope
- Avoid alcoves for radiators and radiators in front of windows
- Use components with low risks for thermal bridges (e.g. prefabricated, pre-insulated etc.)

Avoiding and eliminating thermal bridges will pay off by reducing heat losses and avoiding damage to the building structure.

❸ CO-BENEFITS Quality assurance and construction value	**⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)** Thermal bridges should be avoided by accurate planning, implementation and quality check on site of all corners, angles and breakthroughs. Quality goals for thermal bridges can be expressed via the effective U-value of a component (for heat loss) and the minimum acceptable inner surface temperature (protection from moisture). **High**: Complete absence of thermal bridges by verification on site **Middle:** Thermal bridges minimized by inspection of most important ones on site **Low:** Thermal bridges only checked by verification of planning or national minimum standards of proof
❹ CONFLICT OF AIM WITH OTHER ACTIONS Avoiding thermal bridges might lead to smoother facades and reduces possibilities for the architect to express the character of the building. **❺ INFLUENCES ON OTHER ACTIONS** 2.3, 2.4, 2.18, 2.22, 2.26	**REFERENCES USED** Passive house Institute, PHPP calculation scheme, https://passipedia.de/grundlagen/bauphysikalische_grundlagen/waermebruecken/wbdefinition, accessed at 20th June 2018 DIN 4108 German standard on thermal bridges Ö8110-2 Austrian standard on thermal bridges for protection from condensation

ACTION: Construction checklists
LIFE CYCLE PHASE: CONSTRUCTION

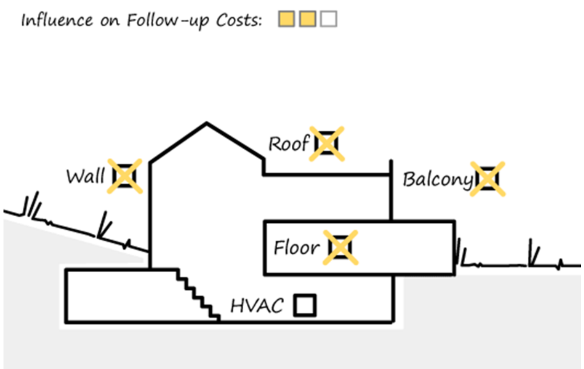
❶ DESCRIPTION OF THE ACTION

An energy-efficient house provides cosy warmth in winter and a pleasant climate in summer. For everything to work well, special rules must be followed: Modern insulation methods, alternative heaters and solar systems must be perfectly installed and coordinated. Many craftsmen make mistakes here, which can lead to serious defects in the house - even often at first after years.

Especially in view of the increasing complexity of projects and the many different actors involved in planning, but above all in implementation, quality assurance measures are of essential importance. In particular, the "invisible" defects, which can lead to major impairments in use and for the user, can only be detected by measurements - and thus remedied before commissioning. Furthermore, the planned energy performance can only be achieved if the building envelope has the appropriate impermeability. Here, too, a measurement is required for verification. Such a quality assurance based on measurements must be planned at an early stage and the corresponding responsibilities defined.

- Inspection of building quality
- Measurements to prove correct execution
- IBM for correct functioning of the HVAC
- Monitoring for optimization and early detection of errors

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Quality assurance and construction value

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2.2, 2.3, 2.4, 2.14, 2.18, 3.1, 4.7, 4.9

❻ IMPORTANCE

- Quality assurance
- Prevention of construction defect's
- Assurance for a high energetic performance

❼ DIFFICULTY

- Identify the critical points in the construction process
- Communication with construction companies

❽ STANDARDS AND REGULATIONS

Basis is the ISO-9000-family, plus EN 14001 Environmental Management and EN 16001 Energy Management Systems
Quality assurance in renovation: http://www.iee-square.eu/InformationPublications/Reports/SQUARE_QASystem_EN.pdf

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Real estate fund; Construction company; Planners; Investors; (Economic) Chambers

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

1. General Building Checks
2. Early Stages Construction
3. Flooring and Framing
4. Plumbing
5. Roofing
6. Exterior Envelope
   ecterior cladding
   weather tightness
   window joinery
   gutter downpipes
7. Behind the Wall
8. Interiors
9. Kitchens
10. Bathroom
11. Heating and Air-Conditioning
    supervising construction process
    technical pre check
    detailed commissioning
12. Outdoor

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Construction supervision by energy experts, architects and measurements for quality control
Middle: Construction supervision by energy experts and architects
Low: Construction supervision by the architect

REFERENCES USED

http://www.buildingguide.co.nz/construction/construction-checklist/
https://www.espazium.ch/baumngel-kosten-jhrlich-milliarden
DGNB 2018
Construction Checklists (Eric A. Berg),
http://www.iee-square.eu/Implementation/QAsystems.asp, all accessed at 28th June 2018

ACTION: Green Power and Carbon Offsets

LIFE CYCLE PHASE: CONSTRUCTION

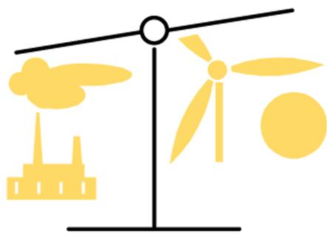
❶ DESCRIPTION OF THE ACTION

- As stated by EPA (United States Environmental Protection Agency): "Green power is a subset of renewable energy and represents those renewable energy resources and technologies that provide the highest environmental benefit". EPA defines green power as electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources. Customers often buy green power for its zero emissions profile and carbon footprint reduction benefits. (Source: https://www.epa.gov/greenpower/what-green-power)

- Carbon offset allows individuals and companies to invest in environmental projects around the world in order to balance out their own carbon footprints. (https://www.theguardian.com/environment/2011/sep/16/carbon-offset-projects-carbon-emissions).

❷ EXAMPLES (CASE STUDY A)

Co-Benefits: ***User Acceptance***
Co-Benefits: ***Pioneer Role / Role Model***



❸ CO-BENEFITS

CO_2-reduction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

1.9, 2.7, 2.12, 2.13, 2.24, 2.27

❻ IMPORTANCE

- Green power plants are an important part of the renewable energy goals of the EU
- Purchasing carbon offsets allows to compensate for the emissions of greenhouse gases, limiting their accumulation in the atmosphere. Carbon offset represents an important connection between economic considerations and environmental issues

❼ DIFFICULTY

- Lack of regulations, also on green power certificates etc.
- Dislocation of responsibility

❽ STANDARDS AND REGULATIONS

- CDM: Clean Development Mechanism
- JI: Joint Implementation
- EUA: European Union Allowances
- VCS: Verified Carbon Standard
- Gold Standard
- VOS: Voluntary Offset Standard

❾ MAIN DRIVER

Tenants/Users

❿ INVOLVED STAKEHOLDERS

Owners; Citizen groups/NGOs; Society; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Using 100% green power for the building's electricity demand or equally balancing with carbon offset
Middle: Using 50% green power for the building's electricity demand or equally balancing with carbon offset
Low: Sometimes carbon offset model is used for green power balancing

REFERENCES USED

Info from https://carbon-clear.com/what-we-do/carbon-offsetting/carbon-offsets-our-projects, accessed at 27th July 2018, and see above

ACTION: Indoor Air Quality Assessment

LIFE CYCLE PHASE: CONSTRUCTION

❶ DESCRIPTION OF THE ACTION

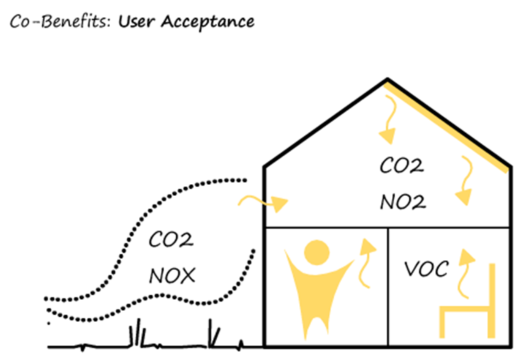
The indoor air quality in new buildings without any ventilation concept could be very bad. For this reason and to increase the indoor air quality, a certain air exchange is necessary. As a guideline, fresh air volume of 25 - 30 m³/h per person is to be offered to rooms when used.

Accordingly, the air change rate provides information about indoor air quality; it indicates how often the room air is completely replaced by fresh air per hour. Reference values are:

- Apartments: Air change rate of 0.3 - 0.5 per hour
- Offices: Air change rate of 1.0 - 2.0 per hour
- Meeting / class rooms: Air change rate of 4 to 12 per hour

Air velocities are not constant in their natural as well as in mechanical form and, with their degree of turbulence, as well as the indoor air quality, have a considerable influence on the perception of the users. Humans can perceive room air flows of 0.1 to 0.2 m/s as pleasant and will accept them in this range.
Humidity is not directly perceived by humans, only a very high relative humidity, 65% or more during summer is perceived as uncomfortably humid. Dry air can cause persistent skin irritation and irritation of the nasal mucosa. At a relative humidity less than 35%, the dust is very favored and plastics are electrically charged.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2.10, 2.11, 2.14

❻ IMPORTANCE

- Stuffy indoor air with high CO2-/VOC- and fine partides-concentration reduces the ability to concentrate when working or learning, it can cause health problems - so the measurement and assessment of the indoor air quality is of high importance
- Air quality and comfort sensors are not costly anymore

❼ DIFFICULTY

- Know how is needed for the assessment and quality check of the indoor air - this leeds to additional costs
- Measures to increase the indoor air quality like mechanical ventilation can cause higher investments if not considered from the beginning

❽ STANDARDS AND REGULATIONS

- ASHRAE Standard 55 or ISO 7730 (thermal comfort)
- ASHRAE 62.1 and 62.2 or EN15242 / EN 13779 (ventilation rates, contaminant levels)
- Some voluntary building certification systems offer guidelines for IAQ

❾ MAIN DRIVER

Citizen groups/NGOs

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Owners; Construction company; Authorities; Planners; Municipalities; Citizen groups/NGOs

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

There are various measurement instruments for the assessment of the indoor air quality on the market. Organisations like RHEVA offer gudelines how to assess and building certification systems how to rate the quality.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

To assess indoor air quality one can take key performance indicators from IDA I and II of EN 13779, air velocity below 0.2 m/s or relative humidity in the range of 39 to 55%. But to assess these parameters one should do measuremnts like:

High: Operative temperature, air velocity, relative humidity and VOC- or CO2-concentration are measured

Middle: Operative temperature and CO2-concentration are measured regularly

Low: Room temperature and relative humidity are measured temporarily

REFERENCES USED

Stefano P. Corgnati, Manuel Gameiro da Silva: REHVA Guidebook n° 14, "Indoor Climate Quality Assessment - Evaluation of indoor thermal environment and indoor air quality"; and standards see above

ACTION: Operations and Maintenance Plan
LIFE CYCLE PHASE: Operation

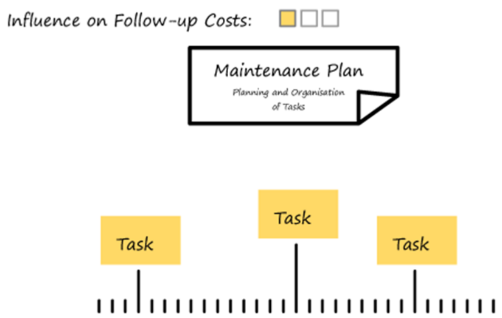
❶ DESCRIPTION OF THE ACTION

An operation and maintenance plan ensures that the building performs as intended in the planning phase. It usually relates to energy and indoor quality but may also include other performances.

The operation and maintenance plan should include:

- Life expectancy of different building elements and installations
- A plan for recurring operation and maintenance meetings and regular necessary routines like changing filters of ventilation units
- Routines to follow when tenants/users are complaining (e.g. about indoor temperature)
- Important set points and key performance indicators (energy use, water consumption, indoor temperature, supply air temperature etc.)
- A plan for recurring controls of the set points and performance indicators

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Value development and quality assurance

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

3.1, 3.3, 3.9, 4.2, 4.4, 4.7, 4.8

❻ IMPORTANCE

A building that is not operated as intended may drasticaly reduce the life/service time for different elements and components. It may also increase the energy use and reduce the indoor air quality.

❼ DIFFICULTY

The plan needs regular adjustments and documentation - responsibilities are to be defined clearly.

❽ STANDARDS AND REGULATIONS

- EN 13306 Maintenance terminology
- EN ISO 41001 Facility management - Management systems - Requirements with guidance for use
- EN 13460 Maintenance - Documentation for maintenance

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

See standards and regulations

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Qualitiy goal: Plan is made/documented

High: Detailed plan exists, responsible person implements measures and updates it
Middle: Detailed plan exists and facility management tries to follow it
Low: Handover documentation and maintenance collection exist, but no detailed plan how to operate it

REFERENCES USED

Standards above and own experience of CRAVEzero partners.

ACTION: Documentation and Recommendations

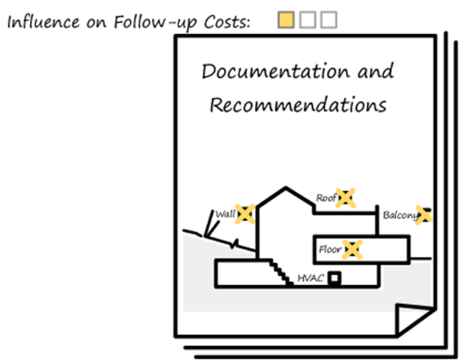
LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

A change of perspective over the entire life cycle of the building is regarded as mandatory prerequisite for sustainable development. Since buildings become complexly equipped, the challenges of planning and design are met. In order to be able to control the building technology at all and to exclude damages due to incorrect use, care and maintenance, a complete and always up-to-date documentation of the building, services and the plant technology is absolutely necessary.

In practice, incomplete and poorly structured documentation often leads to additional costs in building operation. Necessary documents are usually missing and lead to costly rework. Usage-oriented building documentation is not only an essential success factor for the efficient management, it is only possible through the transparent consolidation of all necessary data and plans of a building. For example, if the service life of a component is noted in the documentation, maintenance and spare parts procurement can be better planned as a result to be. Impairment due to maintenance arrears is avoided, which ensures the value of the building. Operators can download the information as a basis for working in their own processes and in communication among each other. An integrated information management is therefore an important tool throughout the entire lifecycle of the planning process.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Value development and quality assurance

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

3.10, 4.1, 4.5, 4.6, 4.9

❻ IMPORTANCE

- Knowledge about building components / obscured materials
- Quality documentation

❼ DIFFICULTY

Additional costs for quality checks and documentation should be recognised.

❽ STANDARDS AND REGULATIONS

EN ISO 16739

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Construction company; Authorities; Planners; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- Green Building Certification
- commissioning documents
- measurement records
- acceptance protocol
- energy pass / performance certificate
- material building pass
- Building Information Modeling BIM 7D

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Green building certificate including BIM for Facility Management

Middle: Commissioning + component documentation + material passport

Low: Commissioning + component documentation

REFERENCES USED

http://www.gesundes-haus.ch/architekturarbeiten/das-digitale-bauwerksmodell-ist-die-zukunft.html

https://edoc.hu-berlin.de/bitstream/handle/18452/2953/161.pdf?sequence=1, both accessed at 20th June 2018

ACTION: Occupant and operator Training

LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

User behaviour has a decisive influence on building energy consumption and a good indoor climate. Convincing building concepts are characterised by the fact that the user is enabled to have a large degree of influence without losing sight of the fact that up to 15% of energy costs can be saved by changes in the behaviour of the user. These changes can only be achieved through targeted information and motivation and through building technology tailored to individual needs.
The expected behaviour of users should therefore be taken into account right at the start of planning. A user profile has to be created in advance; it could, for example, include the behaviour at the workplace in non-residential buildings and in handling the electrical lighting or a switchable sun protection, as well as information on draughts or natural ventilation. Whether the building concept is ultimately successful depends crucially on the active participation of the users.
After the realization of the building, the users should be informed in detail how they should or can behave, because the energy savings and optimizations achievable through structural or technical aspects of a building are difficult to achieve without sufficient instruction and are often strongly minimized due to ignorance. An understandable preparation of the information for the following user generations in the form of an attractively designed user manual would be ideal.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs:

❸ CO-BENEFITS

Energy savings and CO2-reduction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

3.1, 3.3, 3.9, 4.1, 4.2, 4.4, 4.5, 4.6

❻ IMPORTANCE

The user has a very large influence on the energy efficiency of the building due to his behaviour. If the user behaves "correctly" and operates the technical systems like planned for, energy can be saved.

❼ DIFFICULTY

Additional costs for quality checks and documentation should be recognised.

❽ STANDARDS AND REGULATIONS

Formulations must be created that require the processing of data and technologies that enable the user to make optimum use of the building.
Some first drafts for user and operator training where implementet in green building certificates and European projects like from the Passive House Institute Germany.

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Construction company; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- DGNB user guide
- DGNB operator guide

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: User manual / operator guide + training, additional annual evaluation from monitoring data and optimization strategy development with user / operator
Middle: User manual / operator guides actively distributed plus training
Low: User manual + operator guide is available

REFERENCES USED

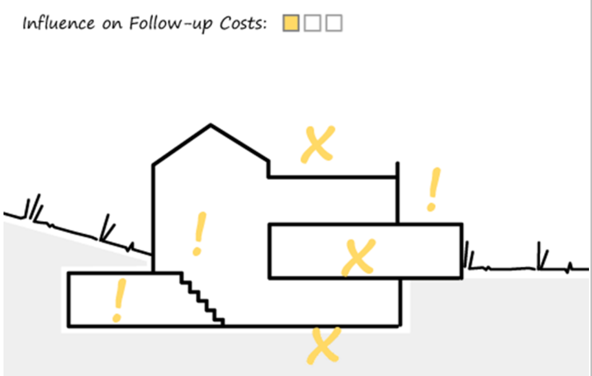
DGNB 2018
https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/effizienzhaus_plus_broschuere_bf.pdf
http://passiv.de/en/05_service/03_literature/030300_user-manual/030300_user-manual.htm, both accessed at 20th June 2018

ACTION: Problem Dedection and Optimisation
LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

When building a new nZEB or renovating existing buildings to nZEB standard, a very important action to check the operation is the monitoring of different functionalities and so check all functions of the building services important to reach nZEB standard in operation. Continuous comparison between planned consumption (adjusted with the real weather data) and real consumption should be made. Automatic alerts should be sent by advanced control and integrated problem detection, when the energy consumption of a particular system is not like planned (too high), or to detect leaks, system problems etc.
The documentation and alert management is very important also to run the system on an optimised level.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Energy and resource savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

4.2, 4.3, 4.7, 4.8

❻ IMPORTANCE

HVAC systems account for almost 50% of the energy consumed in buildings. With low investment costs, it is possible to reach energy savings and so cost savings by optimizing energy performances of the HVAC systems.

❼ DIFFICULTY

Problem detection and optimization procedures can be costly looking at the investment only.

❽ STANDARDS AND REGULATIONS

- For specific technologies like EN12097: Cleanliness criteria for ventilation systems
- Monitoring: M&V (Measurement and verification) or IPMVP (International performance and verification) protocols

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Construction company; Authorities; Planners; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- DGNB user guide
- DGNB operator guide

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Quality assurance process, using regular energy measurements, control algorithms and optimization by responsible
Middle: Regular energy measurements and check by person
Low: Simple energy measurements and annual check

REFERENCES USED

own project results

ACTION: Problem Advanced Energy Metering
LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

'LEED v4' green building certification introduces the concept of Advanced Energy Metering, which requires, in addition to monitoring energy consumption and on-site production from renewable sources, to perform separate monitoring of energy consuming devices, which represent more than 10% of the total energy consumption.
In relation to electricity, it is necessary to monitor both consumption and demand. The installed sensors will have to monitor the consumption with an interval of one hour and be connected to a Business Management System, BMS, able of storing all metered data for at least 36 months.
The data must be remotely accessible. All meters in the system should be capable of reporting hourly, daily, monthly, and annual energy use. The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs: ■□□
Co-Benefits: ***User Motivation***

❸ CO-BENEFITS

CO_2-reduction

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2.9, 3.2, 4.7

❻ IMPORTANCE

As indicated by the U.S. Green Building Council (USGBC): "The intent is to support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use."

❼ DIFFICULTY

Lack of ICT infrastructure and monitoring sensors, which to install in retrospect could be cost intensive.

❽ STANDARDS AND REGULATIONS

- Green building certification like LEED v4
- Protocols of M&V (Measurement and verification) like http://task40.iea-shc.org/Data/Sites/1/publications/STA-MV-protocol-for-Net-ZEBs-Final.pdf (within IEA SHC Task 40) or IPMVP (International performance and verification)

❾ MAIN DRIVER

Utilities

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

- DGNB user guide
- DGNB operator guide

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

A broad implementation in new constructions has to be pursued, in order to monitor the effectivness of energy efficiency measures adopted.

High: All energy consuming facilities of the building are measured and connected to the BMS
Middle: All important energy consuming facilities of the building are measured and controlled
Low: Most important energy consuming parts of the building (heating, electricity and domestic hot water) are measured and yearly checked

REFERENCES USED

Info at https://www.usgbc.org/node/2612855?return=/credits/new-construction/v4/energy-%26-atmosphere, accessed at 27th July 2018

ACTION: User Information on Energy Expenditure
LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

User behaviour has a decisive influence on the building's energy consumption and operational costs. The users should be informed in detail how they should behave or can, because the energy savings and optimizations achievable through structural or technical aspects of a building are difficult to achieve without adequate instruction and are often greatly minimized due to ignorance.
Optimal would be an understandable preparation of the information for the subsequent user generations in the form of an appealingly designed user manual.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs:
Co-Benefits: ***User Motivation***

❸ CO-BENEFITS

Energy and resource savings

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

4.2, 4.3, 4.7, 4.8

❻ IMPORTANCE

Up to 15% of the energy costs can be saved by behavioural changes of the users.

❼ DIFFICULTY

To activate the energy saving potential time and effort on communication is necessary.

❽ STANDARDS AND REGULATIONS

- EN ISO 52003 Energy performance of buildings – Indicators, requirements, ratings and certifcates
- LEED CS-v4 SSc7: Tenant Design and Construction Guidelines
- BREEAM NC 2017, 5.0 Management (Commissioning, handover and aftercare)

❾ MAIN DRIVER

Citizen groups/NGOs

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Authorities; Municipalities; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

IT solutions for future information

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Quality goal: Common energy expenditure is communicated to users.

High: At least daily informed users of buildings by displays, apps or similar
Middle: Monthly informed users
Low: Yearly information about energy expenditure

REFERENCES USED

Experience from CRAVEzero partner organizations

ACTION: System Test Procedures
LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

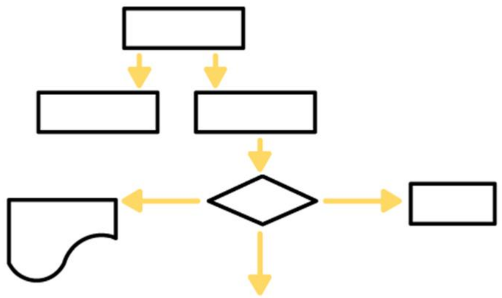
To run a nZEB optimally, specific system test procedures can help for quality assurance measures. Test pocedures may be divided into the following:

- Self controls: Usually carried out by the person who does a specific operation/work. The self control has a limited scope. E.g. control of measured air flow at an air duct.
- Tests: Usually carried out by a third party. The test has a limited scope. E.g. air tightness test of building envelope.
- Coordinated test: Usually conducted to ensure a specific function which requires several different entrepreneurs/actors. The test has a wide scope. E.g. fire saftey functions depends on severel different components, delivered and installed by different entrepreneurs.
- Commissioning: The commissioning includes controlling of self controls, tests and coordinated tests.
- After the above is approved, the building is commissioned according to specifications from the planning phase.

This may include operating time schedules for ventilation and lighting, set point temperatures for the heating control, etc.

❷ EXAMPLES (CASE STUDY A)

Influence on Follow-up Costs:
Co-Benefits: ***User Acceptance***



❸ CO-BENEFITS

Value development and quality assurance

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

3.3, 3.9, 4.2, 4.6, 4.8

❻ IMPORTANCE

A building not commissioned in a correct way will not perform as planned in the planning phase - system tests help to understand why.

❼ DIFFICULTY

- Identifying important aspects for tests
- Planning for tests - a lot of knowledge needed

❽ STANDARDS AND REGULATIONS

E.g. from SQUARE project: http://www.iee-square.eu/default.asp

❾ MAIN DRIVER

Owners

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Authorities; Planners; Municipalities; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

-

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

Tests and quality assurance procedures are targeted durign and after commissioning.

High: Specifications are made and system test procedures are written down and carried out regularly
Middle: Specifications are made and some tests carried out regularly
Low: System test procedures are made but lack implementation

REFERENCES USED

from own project results like above

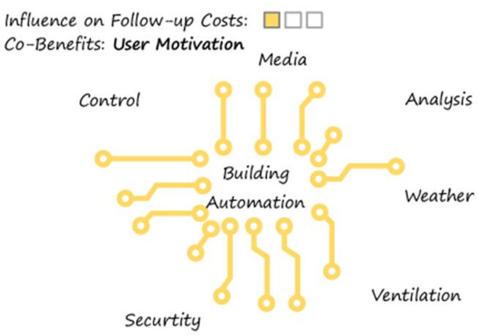
ACTION: Building Automation

LIFE CYCLE PHASE: Operation

❶ DESCRIPTION OF THE ACTION

By equipping buildings with bus systems, there are numerous possibilities to automatically control and regulate the life processes in the house, as well as to use energy sparingly. For this purpose, in addition to the normal electrical installation, a two-core, shielded 24-volt cable is routed through the building. This bus line connects all devices with each other for decentralized communication and compares data streams via integrated chips in the connected switches and devices. The reported states of the devices can thus be reacted. This development was driven by advances in electronics and computer technology and the increasing need for comfort (remote control of many functions, intelligent blinds controls, automatic room temperature control, light control), security (presence and motion detectors, wind detectors, burglary, fire and smoke detection systems, etc.) and above all - from an ecological point of view and in view of increased energy prices - energy and cost savings.
Especially for heating, for the lighting and hot water supply, energy can be saved. Although the initial investment is higher than conventional technology, the higher cost of energy saving over the lifetime of the building pays off. Additionally load management and demand response actions can be implemented.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

CO_2-reduction and increased energy flexibility

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

4.1, 4.2, 4.4, 4.6

❻ IMPORTANCE

Energy consumption can be optimised, and adjusted to the demand. Significant energy savings can be reached.

❼ DIFFICULTY

Investment cost and maintenance effort.

❽ STANDARDS AND REGULATIONS

EN 15232:2012 - Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management

❾ MAIN DRIVER

Planners

❿ INVOLVED STAKEHOLDERS

Owners; Authorities; Municipalities; (Economic) Chambers; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

Examples of electricity savings in buildings using building automation:

- Daylight-dependent lighting control (depending on the light from the outside, the lighting is automatically controlled so that, for example, a constant brightness is achieved at the workplace).
- Light scene control (lowering the brightness and switching on or off certain lights / lighting groups depending on the task or life process).
- Economical decentralized water heating with electronic instantaneous water heaters, which provide as much hot water as is really needed.
- Options for remote control and / or remote inquiry (for example, query whether electrical appliances such as stove or iron were turned off and possibly remote control power off).
- Central functions like ones that influence device groups or the whole building from a push-button, the door lock or also via time control; e.g. automatically shut down "all lamps", shut down all heating circuits to frost protection or lower shutters when closing the building.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

High: Fully integrated building automation system with predictive and self-learning control possibilities
Middle: Building automation system with control possibilities of most important applications
Low: Not bus-connected control system with only basic control possibilities

REFERENCES USED

own project results

ACTION: Hydraulic Balancing
LIFE CYCLE PHASE: Operation

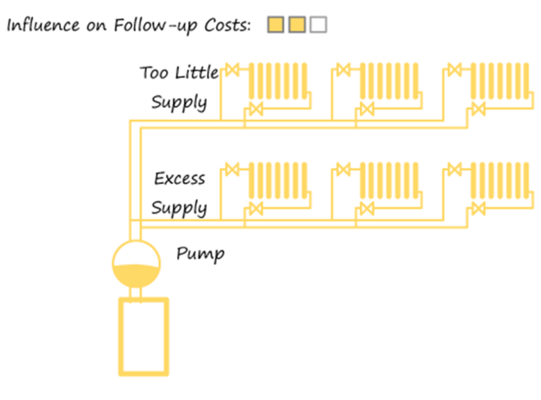
❶ DESCRIPTION OF THE ACTION

When centralized heating systems are used in nZEBs, the heating pipe networks have significant line lengths with numerous pressure-reducing branches, bends and fittings. The flow and heat transfer, with increasing distance from the boiler system and pump, are increasingly low. For radiators that are at the end of a heating line, this can lead to a shortage. Because of these comfort problems with sparsely supplied radiators or heating surfaces mainly occurring within long lines, a hydraulic compensation has to be done.

The so got uniform supply of all heating surfaces with heat energy from a central heating system can lower the network temperatures and thus reduce transport losses. The adjustment can be made on strands or directly on the heating surfaces and can be controlled by installing and adjusting control elements.

For heating systems with utilization of condensing technology, the calorific value gain increases due to the lower return temperatures from calibrated systems. The uniform supply of all heating surfaces increases comfort and cosiness without the need for excess temperatures in the heating network.

❷ EXAMPLES (CASE STUDY A)



❸ CO-BENEFITS

Comfort

❹ CONFLICT OF AIM WITH OTHER ACTIONS

-

❺ INFLUENCES ON OTHER ACTIONS

2,24

❻ IMPORTANCE

- About 5-10% energy savings can be achieved by hydraulic balancing.
- The comfort of exposed dwellings, far from the heating unit of a nZEB, increases.
- Further advantages: Noise in the heating system is avoided, and the auxiliary energy consumption for the necessary pumps is lower.

❼ DIFFICULTY

- Knowhow and experience with hydraulic balancing is needed to achieve it properly.
- Could be costly when neglected in the warranty phase.

❽ STANDARDS AND REGULATIONS

- DIN 18380: German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - Installation of central heating systems and hot water supply systems
- EN 14336: Heating systems in buildings - Installation and commissioning of water based heating systems

❾ MAIN DRIVER

(Economic) Chambers

❿ INVOLVED STAKEHOLDERS

Tenants/Users; Owners; Citizen groups/NGOs; Utilities

⓫ METHODOLOGY/ TECHNOLOGY/ BUSINESS MODEL

A hydraulic balancing can be done mainly in two ways:

- First limiting the flow through the radiators next to the boiler / heating source by manipulating the valves.
- Second connecting the radiators by the so called "Tichelmann" pipe system - where every radiator has the same length of flow and return pipes to the boiler.

⓬ SPECIFICATIONS (QUALITY / QUANTITY GOAL)

The quality of the operation of a central heating system is to a high share depending on hydraulic balancing and right control of pumps and flow/return temperatures. So one could rate a system like:

High: Hydraulic balancing is made within the commissioning phase of a nZEB

Middle: Hydraulic balancing is made within the warranty phase of a nZEB

Low: Hydraulic balancing is not considered during planning and warranty, but later

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ANNEX II: TERMINOLOGY

Life CYCLE Phases

1) Political Decision and Urban Planning
   a) Regional Planning
   b) Urban Design
   c) Preparation and Brief

2) Planning
   a) Concept Design
   b) Authorisation Planning
   c) Technical Design

3) Construction
   a) Tender/Construction Contracts
   b) Construction phase
   c) Commissioning/ Handover

4) Operation
   a) Operation
   b) Monitoring
   c) Maintenance

5) Renovation
   a) Small Renovation
   b) Deep Energy Retrofit
   c) End of Life

Life CYCLE COSTS

1) **(Infrastructure Costs? / Urban Planning Costs?)**
2) Planning Costs
3) Construction Costs
4) Operating Costs
5) Maintainace/ Repair Costs
6) Renovation Costs
   - Image
   - Role model / Pioneering role
   - Creative quality
   - Durability
   - user satisfaction

7) Disposal Costs

8) Non Construction-Costs
   a) Land and Enabling Works
   b) Finance
   c) Externalities

9) Income
   a) Rental Income
   b) Third Party Income
   c) Disruption

Stakeholders

- Society
- Authority/ municipality
- Real estate fund
- Profit developer/ investor
- Landlord
- Client/ Owner
- Tenant/user
- Masterplanner
- Architect
- Civil and structural engineer
- Building services engineer
- Planning consultant
- Construction company
- Facility manager
- Other additional project role 1
- Other additional project role 2

Co-Benefits

- Resource savings
- Value development
- Lettability
- Rental income
- Comfort

Terms and Definitions

ACQUISITION COST

all costs included in acquiring an asset by purchase/lease or construction procurement route, excluding costs during the occupation and use or end-of-life phases of the life cycle

CAPITAL COST
initial construction costs and costs of initial adaptation where these are treated as capital expenditure

DISCOUNTED COST
resulting cost when the real cost is discounted by the real discount rate or when the nominal cost is discounted by the nominal discount rate

DISPOSAL COST
costs associated with disposal at the end of its life cycle

END-OF-LIFE COST
net cost or fee for disposing of a building at the end of its service life or interest period

EXTERNAL COSTS
costs associated with an asset that are not necessarily reflected in the transaction costs between provider and consumer and that, collectively, are referred to as externalities

MAINTENANCE COST
total of necessarily incurred labour, material and other related costs incurred to retain a building or its parts in a state in which it can perform its required functions

NOMINAL COST
expected price that will be paid when a cost is due to be paid, including estimated changes in price due to, for example, forecast change in efficiency, inflation or deflation and technology

OPERATION COST
costs incurred in running and managing the facility or built environment, including administration support services

REAL COST
cost expressed as a value at the base date, including estimated changes in price due to forecast changes in efficiency and technology, but excluding general price inflation or deflation

NET PRESENT VALUE
sum of the discounted future cash flows

Acronyms

CHP	Combined Heat and Power
PV	Photovoltaic
COP	Coefficient of performance
DHW	Domestic hot water
DSM	Demand side management
HVAC	Heating, ventilation and air conditioning
nZEB	Net zero energy building(s)
nZEB	Nearly zero energy building(s)

RES	Renewable energy sources
max	Maximum
min	Minimum
CoC	Cost of Capital
LCC	Life-Cycle Costs
LCCA	Life-Cycle Costs Approach
WLC	Whole-Life-Cycle Costs
NPV	net present value

ANNEX III: REFERENCES

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ANNEX IV: ACKNOWLEDGEMENT

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