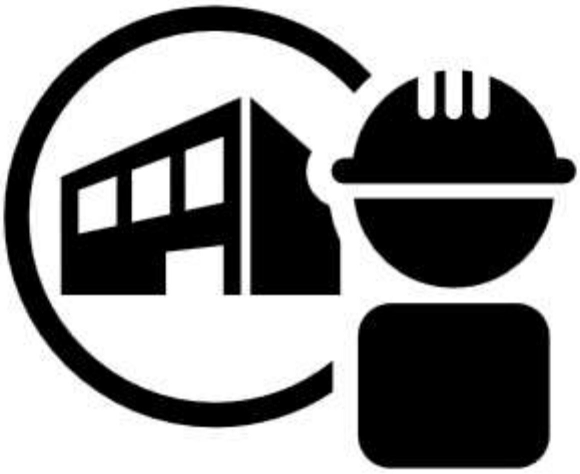
D7.3: Prototypical implementation – Part 2



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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D7.3: Prototypical implementation – Part 2

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FOREWORD

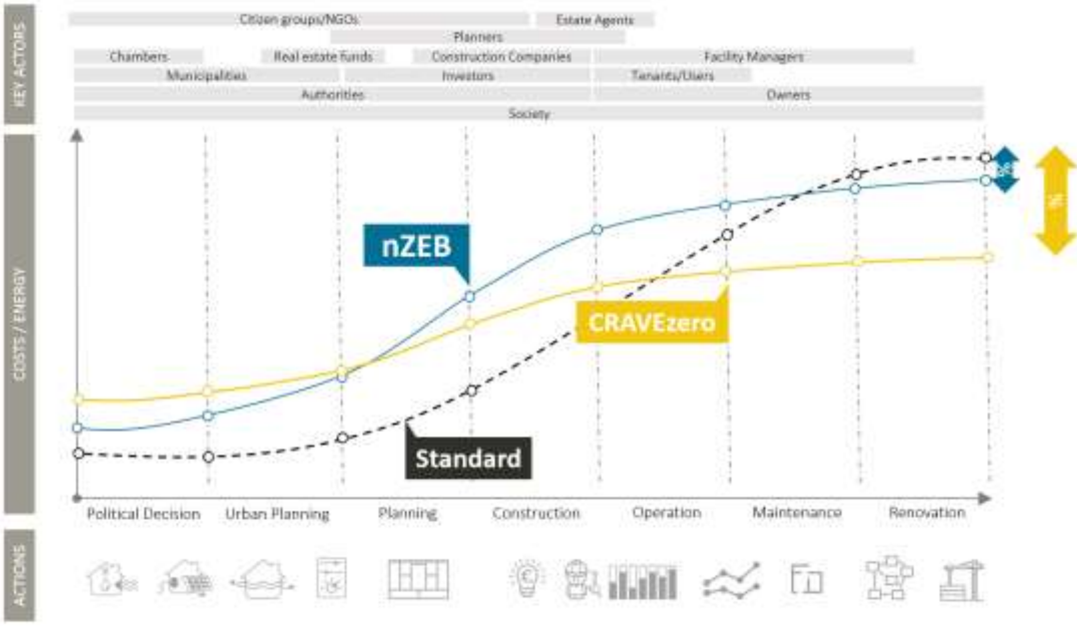

Figure 1: CRAVEzero approach for cost reductions in the lifecycle of nZEBs.

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 [1]. These will be significant 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 realized 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.

This report summarizes the outcomes of work package "Prototypical implementation" of the CRAVEzero project. The industry partners ATP Sustain, Bouygues Construction, Köhler & Meinzer, Skanska, Moretti and 3i have applied the "CRAVEzero methodologies" to six ongoing projects, in order to optimize their design workflow and to achieve efficient nZEBs, taking the whole life cycle of the projects into consideration. In this way, the CRAVEzero approach can demonstrate the results of its application and the replication potential for planning and construction of low life cycle cost (LCC) nZEBs. This deliverable covers the remaining four out of the six prototypical implementations in the CRAVEzero project.

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EXECUTIVE SUMMARY

The objective of work package 7 is to provide the methodological framework for the implementation of the CRAVEzero approach. The idea is to collect all the methodologies and approaches developed within the project and then to test them, implementing those methodologies to case studies/ongoing project developments by the project partners: ATP sustain, Bouygues, Skanska, Moretti, 3i and Köhler & Meinzer.
This deliverable builds upon the methodologies as published in the CRAVEzero pinboard (http://pinboard.cravezero.eu/) and Deliverable 7.1, and like Deliverable 7.2 is devoted to the application of the CRAVEzero methodology. The objective is to test and display how the CRAVEzero approach has been implemented in four more case studies, called "prototypical implementations", which have applied and tested some of the developed methodologies.

The tools are available on the pinboard:

- **Business Model Repository and Canvas:** It offers the possibility to browse through existing business models or to create new ones.
- **Case-study dashboard – Frontrunner buildings:** The idea of this interactive dashboard is to allow users of the pinboard to dig into the data from frontrunner buildings and discover insights and search for optimal solutions that can also be applied for their nZEB developments.
- **Process Map:** The Process Map is a process tool that enables the project team to integrate additional tasks and actions for achieving the nZEB building standard into their own planning, construction and execution routine.
- **Life Cycle Tracker Tool and process management**: An excel tool which intends to provide assistance to consider the relevant aspects and actions of individual planning phases in the realization of nZEBs.
- **Life Cycle Cost Tool:** A tool for the life cycle cost calculation was developed and is available in two versions: a complete version with all functionalities and freedom to customize and a reduced online version, which permits to do a preliminary LCC calculation.

The Industry Partners, ATP sustain, Köhler & Meinzer, Bouygues and Skanska applied a set of tools and methodologies to four case studies. These buildings, differently from those of D7.2, are nZEB front- runner projects that are currently either in the planning phase or already under construction.

"Case study 4" - ATP Sustain

The building is a compact office building, 18 m deep, 130 m long and 14 m high, with four floors and an underground car park, planned as a timber construction. The proposed building services have been planned to have either a Balanced mechanical ventilation system - for approx. 50 % of the areas, such as meeting rooms, restrooms and other internal rooms (KfW55[1] standard) or a supply and exhaust air system for 100 % of the areas (passive house standard), depending on the final building standard selected. Within the framework of the preliminary design, two building standards - the passive house and the KfW55 house - should be compared by the planning team. The focus was on reducing life cycle costs and optimizing thermal comfort.
To do that, LCC comparison of variants methodology has been applied. In this project no comprehensive LCC analysis was carried out, but only a differential cost analysis of the relevant sub-areas.
Calculation 1: The architects planned a building for the client with the necessary insulation thickness for the building standard "KfW55" and in this context also estimated the expected costs for the building. In this first variant, a supply and exhaust air system for approx. 50 % of the areas (meeting rooms. sanitary rooms and other internal rooms) was considered.
Calculation 2: The owner wanted to examine, which differences in the calculation will result, if a complete supply and exhaust ventilation system (passive house

[1] KfW is a german Efficiency House Standard (new construction and refurbishment). A KfW Efficiency House 100 meets the requirements of the Energy Saving Ordinance (EnEV). The EnEV sets out specifications which are used to calculate the transmission heat loss and the annual primary energy demand of a so-called reference building for each construction or renovation project. Compared to the reference building of the EnEV, a KfW55 house only requires 55 % of the primary energy. If a client decides to implement this KfW standard in his new building, he can receive certain promotional measures from KfW. However, KfW bases its calculations on the outdated EnEV standard 2009 instead of the more recent EnEV 2014 (with changes in 2016).

standard) with air humidification is considered. **Calculation 3**: The third building variant took into account a building envelope with a quality similar to passive house, but with a ventilation system similar to the first calculation.

Results: The calculation results show that the passive house only with a large PV system and without air humidification pays out the additional investment compared to a KfW55 house over the life cycle. Due to the changed view of a building - towards a life cycle approach - a building project is no longer measured solely by its investment, but also by its life cycle performance. As a result, supposedly more expensive investments can become cheaper over the life cycle. Nevertheless, by considering the variants as a whole in this approach, some of the differences that can be worked out in a component or building component comparison cannot be depicted because very rough parameters are used.

After the LCC variants comparison a CO_2 emissions analysis was carried out in order to further expand the understanding of the implication of the selected design choices.

Variant 3, as already determined for the LCC analysis, results being a good compromise between life cycle costs and CO_2 emissions.

Luisengarten Ambiente – Köhler & Meinzer

„Luisengarten Ambiente“ consists of two residential complexes with 10 units each, 2,060 m² net floor area (NFA), built in 2019, gas-fired CHP for heating, owner community as operator of the PV, battery storage, KfW55 standard. Two buildings are considered one unit. They share the underground parking, a CHP-plant for energy production, the DHW system and a PV system with battery storage. Main goals of the project are a high-quality building and a low energy consumption level, the owner community becomes an operator and benefits from the profits generated, a new billing model for electricity generation by CHP and PV, which constitutes a new Business Model (BM.).

Business model analysis: By participating in CRAVEzero project, Köhler & Meinzer had the opportunity to view its activities from a different perspective. The intuitive approach for a more or less consciously chosen BM was shifted to a more rational and theoretical one. The main findings which helped to develop a BM are:

- Focus on building and using on-site renewable energy based on a well-insulated building envelope and efficient building services, rather than theoretically saving on expensive measures for insulating the buildings beyond nearly zero-energy building level.
- Concentration of subsidies on the energetic improvement of existing buildings.
- Focus more on efficiency potential in terms of hot water and electricity consumption.

In the whole contemplation several “Key Activities, Value Propositions” and effects for the “Customer Relationship” have been identified and integrated in the new business model:

- “Customer satisfaction” versus how is it possible to influence the behavior in the sense of an economical use of energy?
- “Prosumer”: change from a classical understanding of being a “patronized consumer” to a producer of energy.
- Win-win-situation for clients, when the customer not only has to pay more, but also receives added value that is worthwhile for him/ her in an overheated real estate market.
- Increasing acceptance for nZEBs and technologies if the customer is involved in energy issues.
- Economical one-stop solution with manageable effort for the client and the property management.
- Meeting of national requirements and regulations, ecological and economic aspects.

La Distillerie – Bouygues

The project consists of a new mixed usage sustainable district with a net floor area of 62,000 m². The municipality wanted to redevelop an existing contaminated land into an urban land with an equivalent area of agriculture using green roofs and a landscaping arrangement. The project will include several typologies of buildings as follow: commercial, offices, private and social dwellings, hotels, kindergarten and a farm.

Main goals and the priorities of the design are the energy autonomy, no consumption or usage of the agricultural field, privileging urban farming. The implemented methodology for this case study is the CRAVEzero process map. The purpose of this prototypical implementation project was to demonstrate that a structured process can offer opportunities either to build at lower cost for the same performance or to enhanced performance at same cost. For this reason, the methodology related to optimized nZEB processes will be used during the political decisions and urban planning phases. In fact, a series of decisions and actions should be taken with the support of the process map at the indicated timing in order to minimize the cost of the whole project. Some examples of the investigated actions are:

- Action 1.01: Definition Political and legal framework for nZEBs
- Action 1.07: Funding Schemes for nZEBs
- Action 1.15: Assessment of the Potential for Decentralized renewable power Generation
- Action 1.16: Consideration of Thermal / Electrical Micro-grids on District Level
- Action 1.14: Assessment of the energy efficiency and renewable energy potentials
- Action 1.18: Preparation of renewables budget and estimate return on investment/ LCC
- Action 1.13: Definition of Basic envelope attributes and Energy Targets
- Action 109: Requirements Analysis

Regarding the planning phase some of the analyzed actions are the following:

- Action 216: Definition of Allowed Thermal comfort ranges
- Action 2.06: Flexibility and Adaptability
- Action 2.02: Improve window to wall ratio
- Action 2.18: Mechanical ventilation
- Action 2.22: Renewable Energy - Photovoltaics
- Action 2.17: Natural ventilation
- Action 2.07: Improve daylight factor
- Action 2.05: Efficient space design
- Action 2.15: Energy performance calculation
- Action 2.09: Plug loads and internal gains
- Action 2.08: Domestic hot water
- Action 2.24: Storage facilities

The main goal of this application is to reduce cost and time due to wrong or late decisions towards the achievement of nZEB target. Furthermore, all actions will be listed in order to be integrated smoothly in the company's processes.

Ön - Skanska

Skanska's prototypical implementation is a project named Ön. It is a well-insulated and airtight building, with balanced ventilation with heat recovery, ground source heat pump, waste water heat exchanger and photovoltaic panels. Goals are net ZEB and Skanska Deep Green standard, low CO_2-emissions from construction phase, good comfort and indoor environmental quality. The process described in this report therefore largely follows a regular project process as it appears in Skanska's ordinary workflow. This methodology presents many similarities to the CRAVEzero approach. Therefore, in this implementation the methodologies applied and assessed are the process map, life cycle tracker and process management tool. The CRAVEzero life cycle management and process tracker tools complement the Skanska Deep Green pre-study templates very well, since these tools collect detailed and tailored actions for nZEB planning. The tools developed could be used for many purposes in Skanska's perspective and as an example they could be used as one of many sources for Skanska green development division to refine and create new tools and information leaflets regarding design and construction of energy efficient Deep Green NetZEBs. The advantages related to the CRAVEzero methodology are that it is very informative and addresses all nZEB stakeholders. However, due to the unique conditions in each country, region and municipality regarding legislation, rules, processes and authorizations, it's impossible to develop a general tool that works 100 % in all regions/countries for all stakeholders.

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1. INTRODUCTION

The objective of work package 7 is to provide the methodological framework for the implementation of the CRAVEzero approach. The idea is to collect methodologies and approaches developed within the project and then to test them implementing those methodologies to case studies/ongoing project developments by the project partners ATP sustain, Bouygues, Skanska, Moretti, 3i and Köhler & Meinzer. In this way, the CRAVEzero approach can be assessed, evaluating the results of its application and the replication potential for planning and construction of low LCC nZEBs.
This deliverable builds upon the methodologies as published in the CRAVEzero pinboard (http://pinboard.cravezero.eu/) and Deliverable D7.1, which is devoted to the pinboard description. The CRAVEzero pinboard is a structured framework, which collects and organizes all major methodologies, results and tools developed along the project activities to build reliable and viable low life cycle cost nZEBs.
Deliverables D7.2 and D7.3 are devoted to the application of the CRAVEzero methodology. The objective is to test and display how the CRAVEzero approach has been implemented in six ongoing planning/construction processes provided by the industry partners, the so-called "prototypical implementations".
This deliverable follows the structure established in D7.2, presenting four more prototypical implementations from the project partners ATP sustain, Köhler & Meinzer, Bouygues and Skanska. However, in this deliverable no nZEB concepts or products have been developed like those proposed by 3i and Moretti in Deliverable 7.2. D7.3 focuses on specific planning processes and nZEB buildings currently in the design phase or under construction, where the above-mentioned Industry Partners apply and test CRAVEzero approach in their workflow.

Table 1: Overview of the applied methodologies/tools.

	ATP	Köhler & Meinzer	Bouygues	Skanska
Typology	Office building	Multi-family house	Mixed	Residential
Net floor area	4,000 m^2	2,070 m^2	62,000 m^2	7,000 m^2
Methodology 1	Variants comparison through LCC analysis	Optimization technology set	Process map	Process map
Methodology 2	CO_2 analysis	New BM		Life cycle process tracker and management tool
Phase of implementation	Planning	Construction	Urban planning	Urban planning, pre-study
Advantages	LCC analysis as support to decision making process	Awareness on pursued goals	Holistic and a structured approach	Overview of actions and dependencies
Disadvantages	Complexity	High degree of abstraction	Only energy aspects	

1.1. CRAVEZERO TOOLS: THE PINBOARD

A brief overview of the main features of the Pinboard is required to better understand the prototypical implementations carried out by project partners.
Please visit https://www.cravezero.eu/pboard/PinboardMain/PinboardMain.htm for more information.

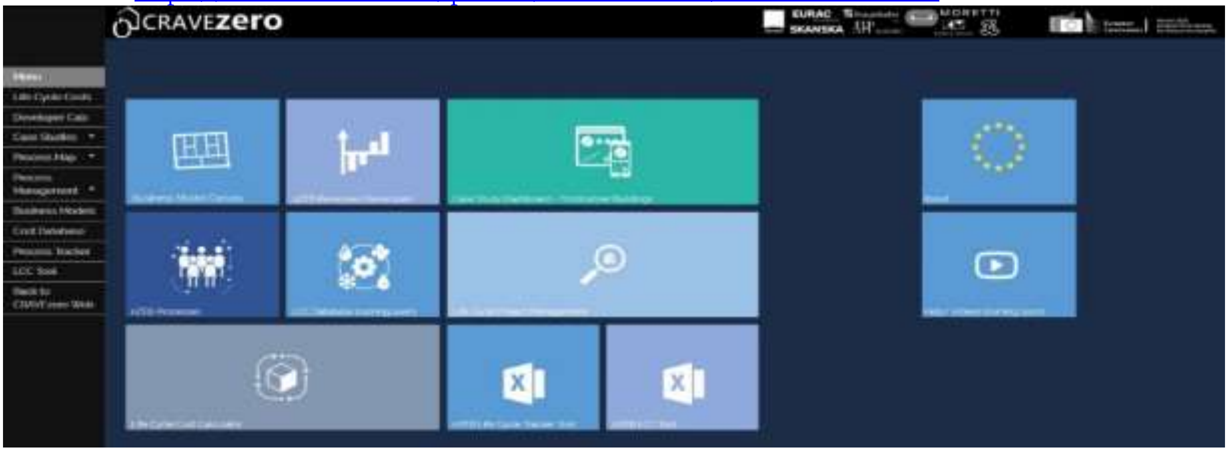


Figure 2: Pinboard landing page on CRAVEzero website (cravezero.eu).

Business Model Repository and Canvas

It offers the possibility to browse through existing business models or to create new ones. The business model repository collects 60 existing nZEB business models, where the life cycle phases are indicated. The business model canvas is a tool which helps to understand a business model in a straightforward, structured way. It is also possible to create a business model from scratch thanks to the Business Model Canvas creator.

Case-study dashboard – Frontrunner buildings

Within the dashboard, users can add and remove data, change visualization types, and apply filters to the assessed case studies. The idea of this interactive dashboard is to allow users of the pinboard to dig into the data and discover insights and look for optimal solutions that can also be applied for their nZEB developments.

Process Map

The Process Map is a process tool that enables the project team to integrate additional tasks and actions for achieving the nZEB building standard into their own planning, construction and execution routine. It gives an initial overview of the complexity and the possibilities of influencing the planning and construction process in order to develop an nZEB.

Life Cycle Tracker and process management

An excel tool was developed, which is intended to provide assistance to consider the relevant aspects and actions of individual planning phases in the realization of nZEBs. The tool "CRAVEzero-lifecycle-tracker" consists of four phases from urban planning to operation to renovation and more than 50 key actions along the entire process. All measures necessary for a specific project to achieve the nZEB standard were defined and systematically selected with the interest groups involved.

Life-cycle cost tool

A tool for the life-cycle cost calculation was developed and it is available in two versions: a complete version with all functionalities and freedom to customize and a reduced online version, which permits to do a preliminary LCC calculation. The ISO 15686-5:2017 [2] groups the costs: the LCC analysis deals with the activities connected with the design, construction and operation of the building. End-of-life costs have not been implemented in the tool yet.

2. “CASE STUDY 4” - ATP SUSTAIN

2.1. GENERAL DESCRIPTION

Brief description / main features
The building is a compact office building with four floors and an underground car park, planned as a timber construction. The building is 18 m deep, 130 m long and 14 m high.

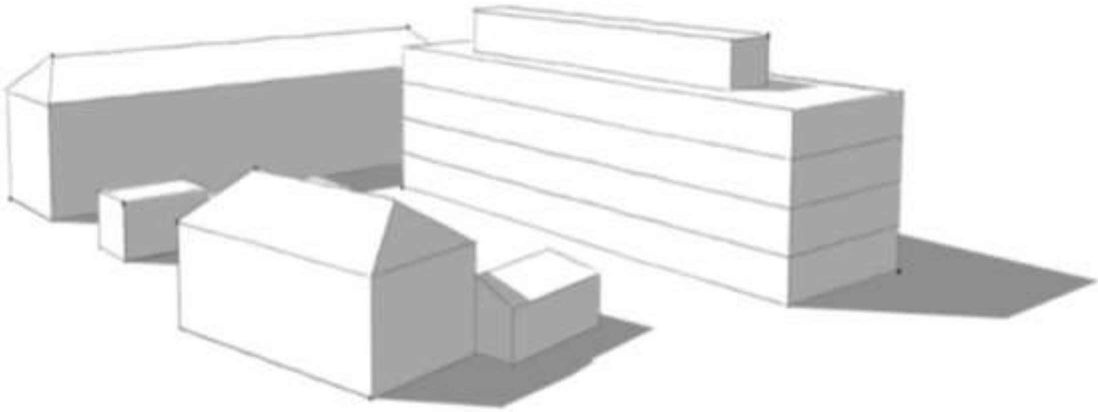


Figure 3: 3D drawing of the building.

Energy concept
Two targeted energy standards are object of evaluation: KfW55 and Passive House Standard. Two variants of building services have been planned respectively: a Balanced mechanical ventilation system - for approx. 50 % of the areas, such as meeting rooms, restrooms and other internal rooms (KfW55) or a supply and exhaust air system for 100 % of the areas (passive house). The building is planned to be heated and cooled by a groundwater heat pump. For the KfW55 variant, heating and cooling are planned via underfloor systems. The cooling supply in the case of passive house standard will be realized via the ventilation system. DHW will be supplied decentral via electric instantaneous water heaters at the respective standpipes.

Table 2: General project information ATP case study.

General project information	
Project name	“Case Study 4” - ATP sustain
Location	Bavaria, Germany
Planning team	-
Architect	-
Building owner	-
Net floor area	4,000 m²
Construction date	2023
Building typology	Office Building
Current status	Design phase

2.2. GOALS DEFINITION

Main goals and the priorities of the design
Two building standards - the KfW55 and the passive house standard - should be compared by the planning team at pre-design stage. The focus was on reducing life cycle costs and optimizing thermal comfort. The KfW55 house describes an increased building quality in Germany. These increased quality criteria are supported by the KfW Bank (Kreditanstalt für Wiederaufbau) in terms of favorable loans and a repayment subsidy. The subsidized standard is made up of the requirements for primary energy demand and transmission heat losses. These requirements may not exceed 55 % of the characteristic value according to the requirements of the national standard (EnEV).

Main constrains for the design
In the planning process, two critical points have been primarily discussed:

1. Investment costs for a passive house are higher than the costs for a KfW55 house. These concerns of the owner should be analyzed and dispelled by a variant analysis of the life cycle costs. This analysis should lead to the break-even point of the investment costs/ life cycle costs.
2. The building envelope quality of a passive house implies that the building can be heated and cooled exclusively via the ventilation system. The owner and his employees regard this point as very critical, because in the rural area of the building location they are used to open the window to achieve the room comfort in terms of air quality. This user behavior can lead to increased energy consumption of the building, which could outweigh the advantages of a passive house compared to a KfW55 house. Furthermore, the client has already had negative experiences with the indoor air humidity provided by ventilation systems.

Focus on CRAVEzero approach application

- **CRAVEzero applied methodologies:** LCC comparison of variants (Whole Life Cycle Costs).
- **Is this/these methodology(ies) replacing another one used within your company or is it a new one?** ATP has already implemented LCC analysis in its workflow. However, the integration of this CRAVEzero method into the company's planning process is investigated.
- **Phase of implementation:** The investigation is carried out at the beginning of the planning phase.

Table 3. Characteristics of the basic project variants.

	KfW55	Passive house
Orientation	East-West	
Design	Office building with core zone and a modular grid element of 1.35 m	
Window area	50 % window area share of all facade surfaces	
Quality thermal envelope	Wall: U=0.20 W/m²K Roof: U=0.17 W/m²K Floor: U=0.28 W/m²K Windows: U=1.1 W/m²K	Wall: U=0.15 W/m²K Roof: U=0.10 W/m²K Floor: U=0.20 W/m²K Windows: U=0.8 W/m²K
Air tightness	0.8 1/h	0.47 1/h
HVAC System	Heating: Groundwater heat pump DHW: Decentralized instantaneous water heater Ventilation: Balanced mechanical ventilation system for meeting, sanitary and other internal rooms without a window (50 % of the building area) Cooling: Direct cooling with groundwater	Heating: Groundwater heat pump DHW: Decentralized instantaneous water heater Ventilation: Balanced mechanical ventilation system Cooling: Via ventilation system
Lighting	LED lighting 8 W/m² (office and meeting)	LED lighting 6 W/m² (office) daylight-dependent regulation
PV	No PV	300 m² PV

Targeted performances: Low life cycle cost, high thermal comfort (especially indoor air quality, indoor air humidity)
Selected business model(s): LCC optimization, CO_2 (from Energy consumption) optimization
Selected reference case: KfW55 building (possible calculation of national standard as ref. case).

Variants - main features: Variants of the whole building have been analyzed (examining LCC, construction and technology.

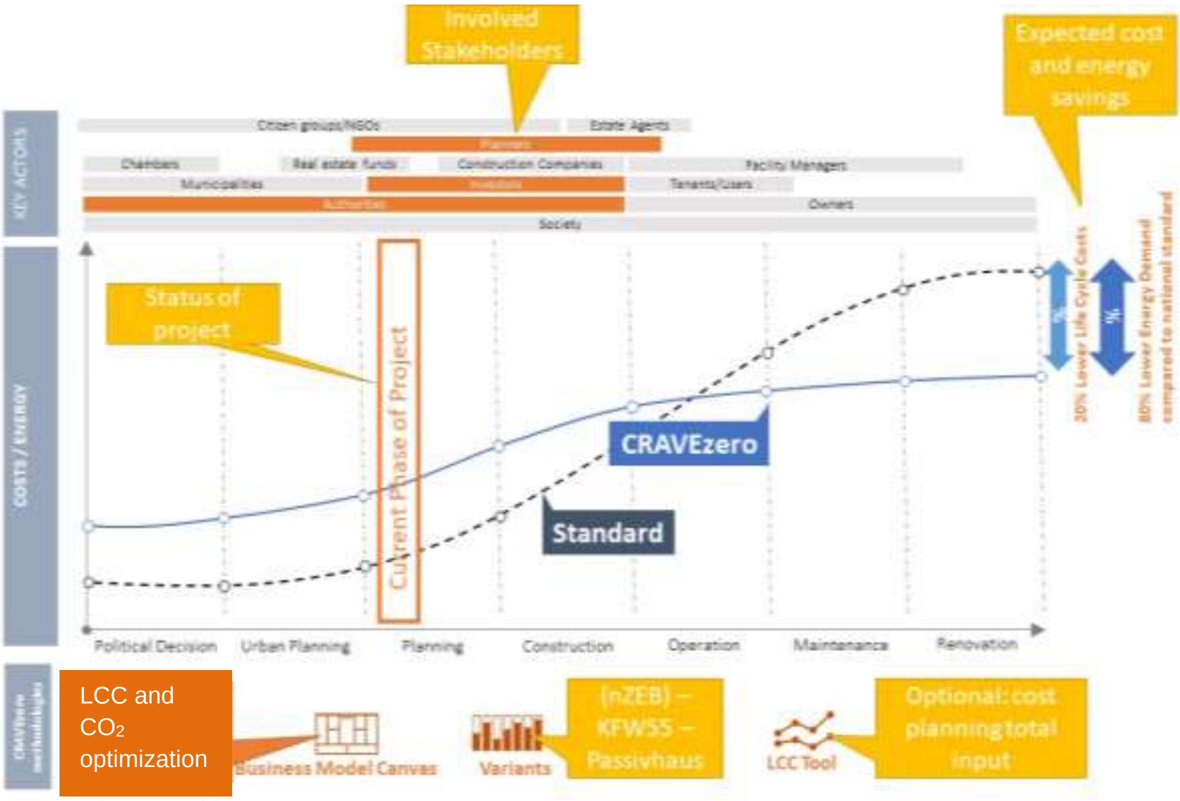
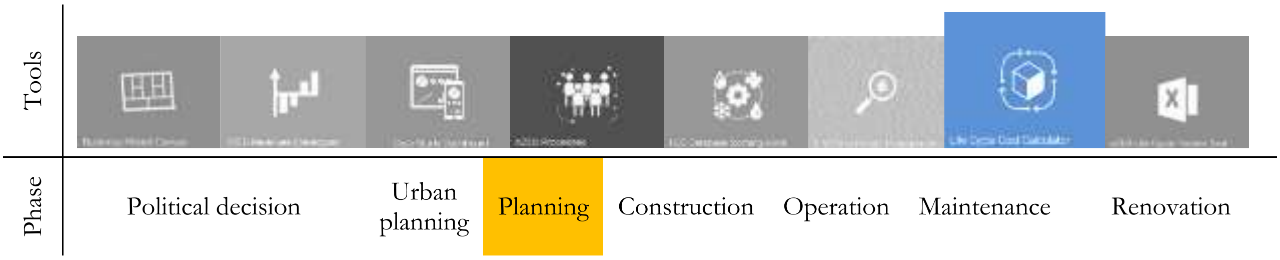


Figure 4. Graphical representation of the prototypical implementation most relevant features – ATP.

2.3. PROTOTYPICAL IMPLEMENTATION OF ATP PROJECT



2.3.1. DOCUMENTATION: LIFE CYCLE COST ANALYSIS

Objective of the study

Within the framework of the project tender, the client requested the analysis of three variants:

1. Variant 1: Passive House Standard
2. Variant 2: KfW55 Standard
3. Variant 3: Self-defined variant, which lies between the KfW55 and the passive house, in terms of envelope performance.

The results of this analysis will be used to evaluate the building operation, taking into account the user behavior. The influence of the ventilation system on the building operation needs to be investigated as well.

General project boundary conditions

An office building with a net floor area of approx. 4,000 m² was designed for the client. Within the framework of the basic evaluation, the building quality of a passive house was defined from the building standard of the company. The responsible construction team, on the other hand, is critical of the technology of a ventilation system in the office building at the rural building site. For this reason, a life cycle cost study should be carried out as part of the planning, in which the building should be designed as a passive house and compared to a KfW55 house variant.
For the planning of the building the KfW55 house variant was taken as a basis and then the passive house was calculated as a variant.

Methodology

The building envelope performance and the technical equipment are relevant for the life cycle cost calculation carried out in the planning phase. Moving to a level of detail which considers the single component, different lifetimes and their life cycle performance need to be taken into account.
In this analysis no total life cycle cost analysis was carried out, but only a differential cost analysis of the relevant sub-areas. The following parts / components were selected for this analysis:

- Windows/doors
- Insulation external wall (since this is a wooden construction, the entire external wall structure was included in the investigation)
- Roof insulation
- Insulation of the base plate
- Ventilation
- PV
- Operating energy

These areas have been evaluated from the two above-mentioned building standards (KfW55 house and passive house) and compared in a life cycle cost calculation. Furthermore, based on the results of the first variants comparison, more variants were then defined in the course of a client meeting with all planners, which were then calculated and presented to the client again.

The calculation of the life cycle costs was an integral cooperation of the planning department's architecture, costs, building services and building physics.

Calculations

Calculation 1: Architects planned a building for the client with the necessary insulation thickness for the building standard KfW55 and in this context also estimated the expected costs for the building. The increase in the insulation thickness, the increased thermal quality of the windows and the requirements for the building services to meet the passive house standard were only examined in the building physics and the building services design. The changes made for the passive house standard were then assessed by the cost department in terms of additional costs. This resulted in the following additional investment costs for the passive house standard:

Table 4. Additional investment costs for a passive house.

Groups of costs DIN 276[2] [4]	**Additional investment costs for a passive house**	
	Costs per m²	**Total costs**
KG 330 - External wall	+ 50 €/m²	+ 59,250 €
KG 334 - Window	+ 300 €/m²	+ 342,000 €
KG 354 - Ceiling coverings (insulation underground car park)	+ 20 €/m²	+ 23,900 €
KG 360 - Roof	+ 70 €/m²	+ 83,650 €
KG 431 - Ventilation system		+ 335,300 €
KG 442 - PV		+ 60,000 €

From the calculation performed according to DIN V 18599 [3], the following relevant energy demand data can be obtained:

Energy source	**Energy demand differential for passive house operation**
Electricity	- 58,113 kWh

		Area [m²]	Unitary price [€/m²]	Construction costs [€]	Maintenance %	Maintenance costs [€]	Lifespan [year]
	BUILDING ELEMENTS						
A1	Roofs	1.195	180	215100	0,45%	968	40
A2	Ceilings			0	0,00%	0	40
A3	Floors			0	0,00%	0	40
A4	Walls	1.185	300	355500	0,45%	1600	40
A5	Windows	1.140	1.150	1311000	0,45%	5900	25
A6	Shading Systems			0	0,00%	0	40
A7	External Doors			0	0,00%	0	40
A8	Internal elements (next to heated areas)	1.195	140	167300	0,45%	753	40
A9	Structural elements			0	0,00%	0	40
A10	Other elements			0	0,00%	0	40
	BUILDING SERVICES						
B1	Heating system				0,0%	0	0
B2	DHW system				0,0%	0	0
B3	Cooling system				0,0%	0	0
B3	Distribution system				0,0%	0	0
B4	Mechanical ventilation system			948.000	2,1%	19529	25
B5	Electric/Hydraulic system				0,0%	0	0
	RES						
C1	PV panels				1,5%	0	25
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0
C1	PV panels				0,0%	0	0
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0
C1	PV panels				0,0%	0	0
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0

Figure 5: Inputs into the LCC tool for the calculation of life cycle costs for the KfW55 house.

[2] DIN 276 is a standard used in architectural engineering for determining the project costs the fee for architects and engineers.

		Area (m²)	Unitary price (€/m²)	Construction costs (€)	Maintenance %	Maintenance costs (€)	Lifespan (year)
	BUILDING ELEMENTS						
A1	Roofs	1.195	250	298750	0,45%	1344,375	40
A2	Ceilings			0	0,00%	0	40
A3	Floors			0	0,00%	0	40
A4	Walls	1.185	350	414750	0,45%	1866,375	40
A5	Windows	1.140	1.450	1653000	0,45%	7438,5	25
A6	Shading Systems			0	0,00%	0	40
A7	External Doors			0	0,00%	0	40
A8	Internal elements (next to heated areas)	1.195	160	191200	0,45%	860,4	40
A9	Structural elements			0	0,00%	0	40
A10	Other elements			0	0,00%	0	40
	BUILDING SERVICES						
B1	Heating system				0,0%	0	0
B2	DHW system				0,0%	0	0
B3	Cooling system				0,0%	0	0
B3	Distribution system				0,0%	0	0
B4	Mechanical ventilation system			1.283.300	2,1%	26436	25
B5	Electric/Hydraulic system				0,0%	0	0
	RES						
C1	PV panels			60.000	1,5%	900	25
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0
C1	PV panels				0,0%	0	0
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0
C1	PV panels				0,0%	0	0
C1	Inverters				0,0%	0	0
C1	Other elements (please specify)				0,0%	0	0
	OTHERS						
D1	Building automation, measuring, management systems				0,0%	0	0
D1	Fire and security systems				0,0%	0	0
					0,0%	0	0
					0,0%	0	0
					0,0%	0	0
	humidivication				2,1%	0	25

Figure 6: Inputs into the LCC tool for the calculation of life cycle costs for the Passive house.

The following results were obtained from the life cycle cost calculation based on the CRAVEzero LCC tool.

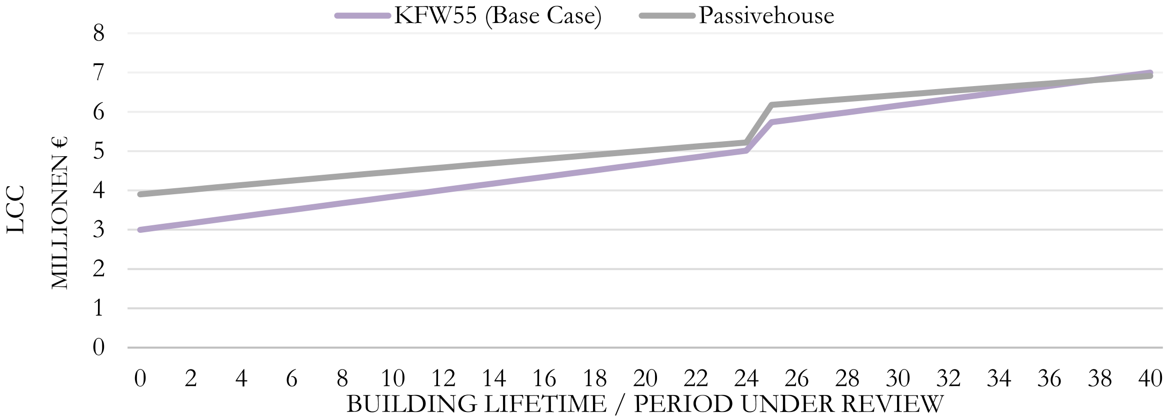


Figure 7. Life cycle cost – KfW55 (base case) and passive house comparison.

The calculation of the life cycle costs showed that the additional investment for the passive house standard in this specific project only pays off after about 37 years.

These results led to a discussion whether the examined variants present the same level of comfort for the building users. The building owner was very critical of the fact that the comfort and satisfaction of the users in the passive house variant decreased due to the drier air and the "prohibition" to open the windows. For this reason, a further variant evaluation with air humidification for the passive house was discussed.

Calculation 2: The owner wanted to examine, which differences in the calculation outcome will result, if an air humidification system in the passive house is also considered. In addition, the PV area in the investigated variants should also be adjusted to achieve a better comparability of the results.

Table 5. Characteristics of the 2 variants, passive house variant with humidification system.

	KfW 55	Passive house
Orientation	East-West	
Design	Office building with core zone and an extension grid of 1.35 m	
Window area	50 % window area share of all facade surfaces	
Quality thermal envelope	Wall: U = 0.20 W/m²K Roof: U = 0.17 W/m²K Floor: U = 0.28 W/m²K Windows: U = 1.1 W/m²K	Wall: U = 0.15 W/m²K Roof: U = 0.10 W/m²K Floor: U = 0.20 W/m²K Windows: U = 0.8 W/m²K
Air tightness	0.8 1/h	0.47 1/h
HVAC System	**Heating:** Groundwater heat pump **DHW:** decentralized instantaneous water heater **Ventilation:** supply and exhaust air system for meeting rooms, sanitary rooms and other internal rooms without a window (approx. 50 % of the building area) **Cooling:** direct cooling with groundwater	**Heating:** Groundwater heat pump **DHW:** decentralized instantaneous water heater **Ventilation:** supply and exhaust air system **Cooling:** via ventilation system
Lighting	LED lighting 8 W/m² (Office and meeting rooms)	LED lighting 6 W/m² (Office rooms) Daylight regulation
PV	Approx. 150 m² PV	Approx. 150 m² PV
Humidification	-	Humidification system

This results in the following changed investment costs and energy consumption for the planned building.

Table 6. Additional investment cost and energy consumption for the passive house variant with humidification system.

Groups of costs DIN 276	**Additional investment costs for a passive house**	
	costs per m²	**total costs**
KG 431 - humidification		+ 15,000 €
Energy source	**Energy demand differential for passive house operation**	
Electricity	- 27,680 kWh	

Following results were obtained for variants based on the parameters of this second calculation.

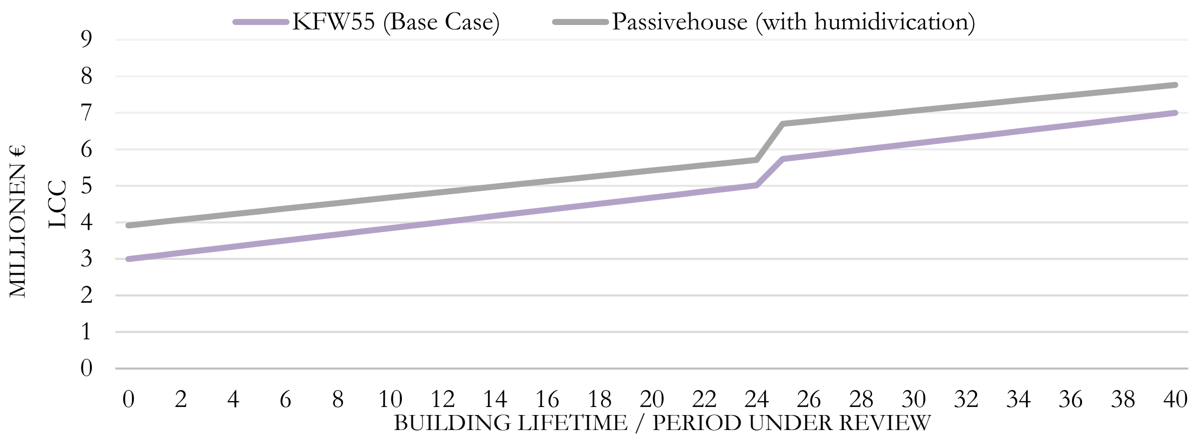


Figure 8. Life cycle cost – KfW55 and passive house (with humidification) comparison.

If air humidification system is taken into account in the life cycle cost calculation of the passive house variant, due to the increased energy demand, no amortization of the additional investment costs over 40 years can be achieved. Furthermore, the calculated variant of the passive house with air humidification according to the calculation rules of the Passive House Institute - heating demand < 15 kWh/m²a - no longer meets the requirements. Based on these results, it was decided in the client meeting to investigate a further third variant of the building.

Calculation 3: In this case the building envelope performance will lie between the requirements of a

KfW55 and a passive house. A complete ventilation system such as the first KfW55 variant should be avoided. The building owner accepts that the heat losses through the window ventilation in the office space are increased.

Table 7. Characteristics of building variant 3 of the ATP-case study.

Building variant 3	
Quality thermal envelope	Wall: U = 0.18 W/m²K Roof: U = 0.11 W/m²K Floor: U = 0.18 W/m²K Windows: U = 0.8 W/m²K
Air tightness	0.35 1/h
HVAC System	Heating: Groundwater heat pump DHW: decentralized instantaneous water heater Ventilation: supply and exhaust air system for meeting rooms, sanitary rooms and other internal rooms without a window (approx. 50 % of the building area) Cooling: via ventilation system
Lighting	LED lighting 6 W/m² (office and meeting)
PV	Approx. 150 m² PV
Humidification	-

These data lead to the following additional investment costs of variant 3 compared to the KfW55 house.

Table 8. Additional investment costs for variant 3.

Groups of costs DIN 276	Additional investment costs for variant 3	
	Costs per m²	Total costs
KG 330 - External wall	50 €/m²	59,250 €
KG 334 - Window	300 €/m²	342,000 €
KG 354 - Ceiling cladding (underground car park)	20 €/m²	23,900 €
KG 360 - Roof	70 €/m²	83,650 €
KG 431 - Ventilation system		- €
KG 442 - PV		35,000 €

The LCC analysis produced the following results:

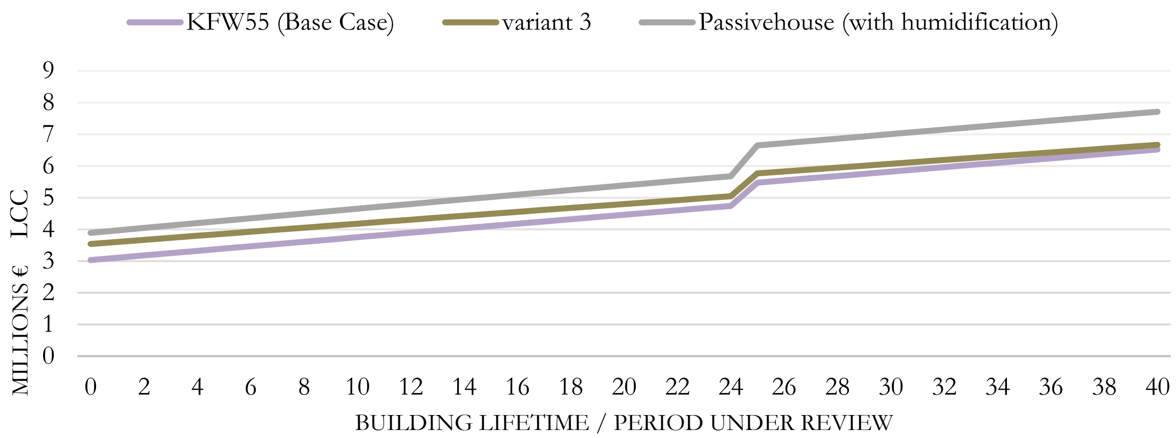


Figure 9. Life cycle cost – variants comparison

The third variant showed that the life cycle costs are closer to the costs of the basic variant. However, even here there is no amortization of the life cycle costs in the 40-year period under consideration.

Results

The calculation results show that the passive house only with a large PV system and without air humidification pays out the additional investment compared to a KfW55 house over the life cycle. On the basis of these findings, it was suggested to the owner that, in addition to examining the life cycle costs, he should also carry out an ecological study of his variants. This would involve measuring the environmental impact of the building for its construction and operation. This study could reveal major differences in environmental impacts between the KfW55 house and variant 3.

2.3.2. DOCUMENTATION OF CO2 EMISSION AND CO2 COSTS

Due to the different building technology and energy sources in the building variants, different levels of CO_2 emissions are produced in the operation phase. In Germany, databases on the impact on resource consumption and the ecology of products and energy sources are provided. General parameters for ecological quality are described in the database ÖKOBAUDAT [5] or in product-specific or manufacturer-specific EPDs (Environmental Product Declaration).
Within the building services variants described in the previous chapter, electricity is the only energy source. This data set reports the environmental impacts of the electricity mix in the life cycle phase B6 (operational energy use in the utilization phase of a building) divided in the following categories:

- Global warming potential (GWP)
- Depletion potential of the stratospheric ozone layer (ODP)
- Acidification potential (AP)
- Eutrophication potential (EP)
- Potential for tropospheric ozone formation (POCP)
- Abiotic resource extraction potential - Elements for non-fossil resources (ADP substances)
- Potential for abiotic resource extraction - fossil fuels (ADP fossil fuels)

In this chapter, only CO_2 emissions (category GWP) are assessed in relation to the national targets (55 % CO_2 reduction by 2030).

Table 9: CO_2 characteristics of electricity (Source: Ökobaudat)

	kg CO_2 eq.
Electricity	0.532

Germany has also decided to tax CO_2 emissions from 2021.

Table 10: CO_2 Pricing Strategy Germany[3]

Year	**€/t. CO_2**
2021	25.00
2026	55.00-65.00[4]
2030	180.00[5]

Based on these values, the CO_2 emissions and their cost-specific effects on the life cycle are evaluated in the following paragraphs.

CO_2 Calculation 1

Based on the energy consumption of calculation variant 1, the following CO_2 emissions can be calculated for the different energy standards. This calculation does not take into account the influence of the increased use of materials for the higher insulation standard.

[3] www.bundesregierung.de

[4] https://www.bundesregierung.de/breg-de/themen/klimaschutz/co2-bepreisung-1673008

[5] Fassade 20 – Konferenz Fassadentage Augsburg; André Hempel

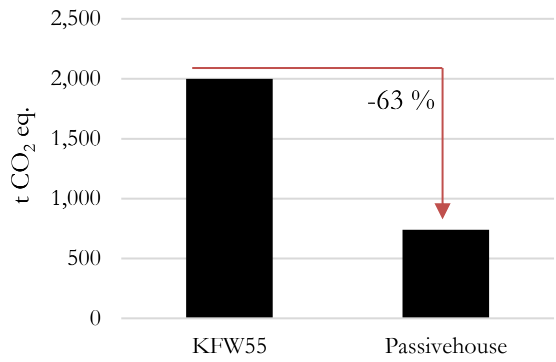


Figure 10: CO_2 emissions for building operation over 40 years.

By reducing the energy consumption in the passive house standard, CO_2 emissions can be reduced by 63 %. If costs due to the CO_2 emissions in the building operation are calculated, in 2030 (seven years of building operation) 0.8 % for passive house and 1.0% for KfW55 additional costs arise due to the CO_2 emissions. For the further CO_2 price increase, a constant price increase as in 2030 is assumed for the calculations (annual price increase of approx. 29 €/t CO_2).

On the basis of the assumed price increase for the emitted CO_2 from the year 2030, additional costs for the CO_2 emissions are due after 40 years of building operation: 350,000 € for the KfW 55 and 130,000 € for the passive house. It is important to notice that specific emissions of electricity of today (2020) are used. These will most likely decrease during the operation phase of the building and therefore the emission reduction will be even higher.

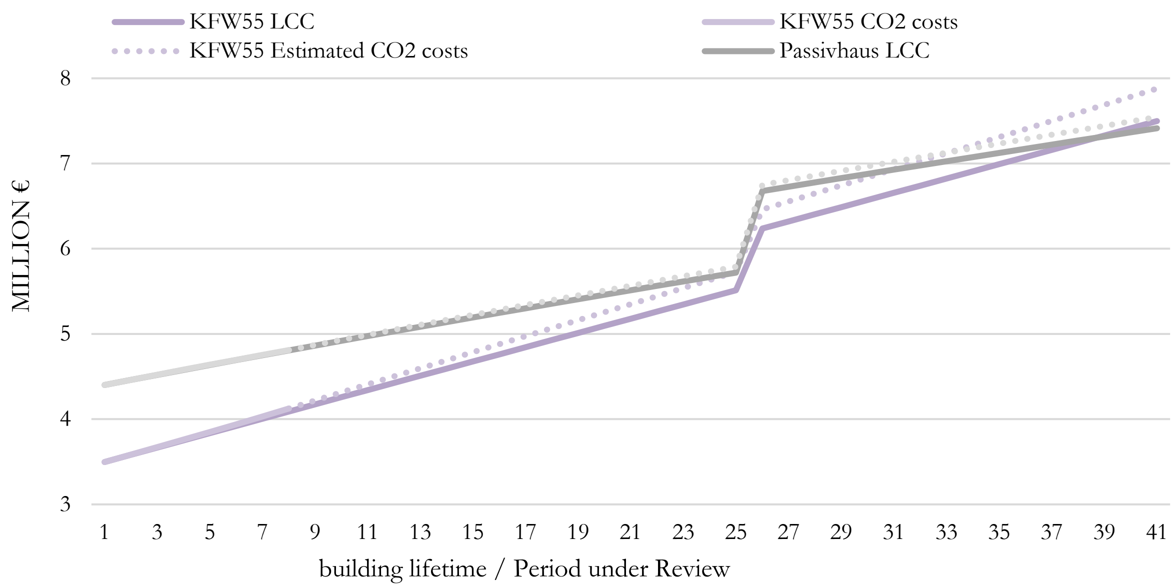


Figure 9: Life cycle costs of the building variants, including and excluding CO_2 costs, calculated over 40 years.

Considering the costs of CO_2 emissions, the breakeven point for investment costs is shifted from 37 years to 31 years.

CO_2 Calculation 2

As in variant 1, the CO_2 emissions are calculated on the basis of the energy consumption of the building operation phase.

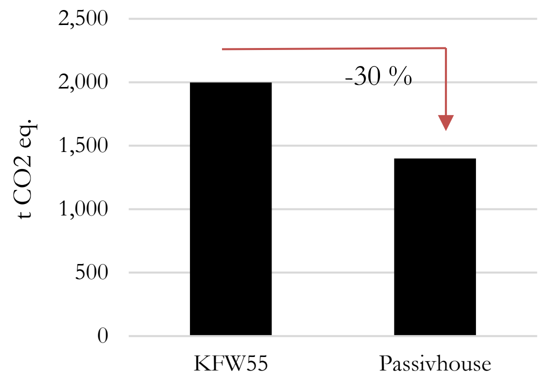


Figure 11: CO_2 emissions for building operation over 40 years

Due to the higher electricity consumption of the passive house with an air humidification, only 30 % (instead of 63 % in variant 1) of CO_2 emissions can be saved compared to the KfW55 house.

For the life cycle costs of the two compared variants, the following results are obtained under the boundary conditions defined in chapter 2.3.1 and the CO_2 prices described in Table 10.

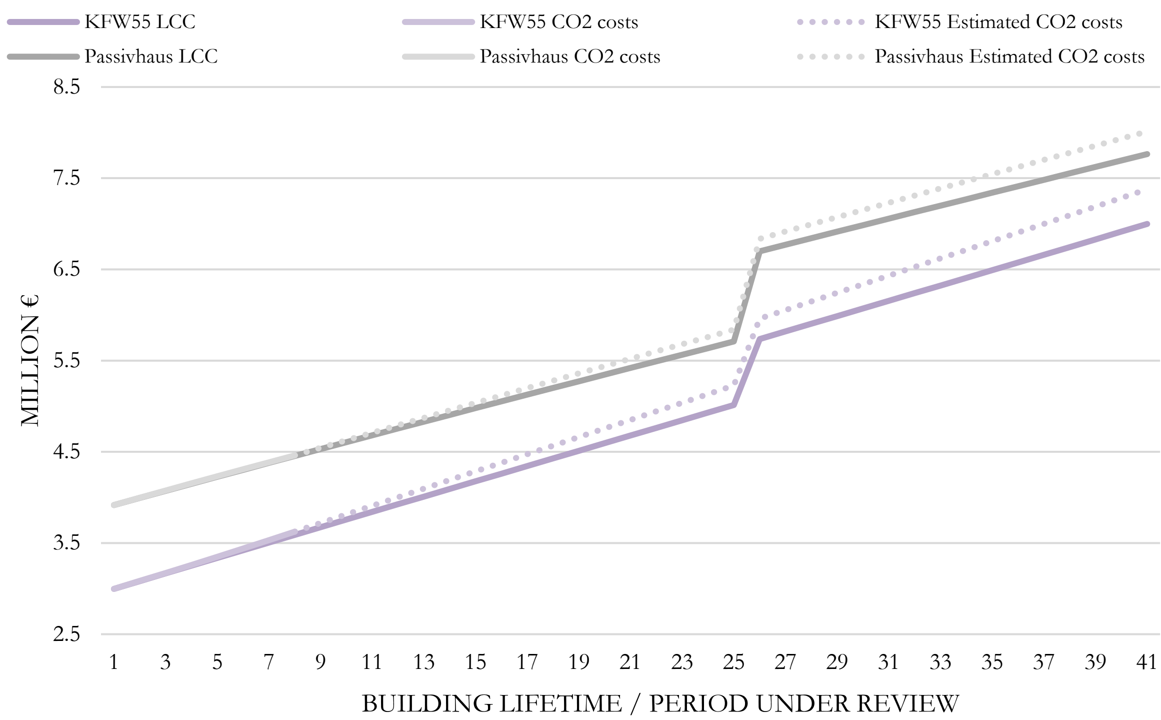


Figure 12: Life cycle costs of the building variants, including and excluding CO2 costs, 40 years.

As in the LCC calculation of variant 2 without costs for CO_2 emissions, there is no break-even point in the 40-year assessment time frame. Nevertheless, the difference of the cumulated costs in the year 40 is smaller than in the LCC without CO_2 costs.

CO_2 Calculation 3

In calculation variant 3, a self-defined building standard (envelope and building services, deviating from the building standards KfW55 and passive house), were evaluated.

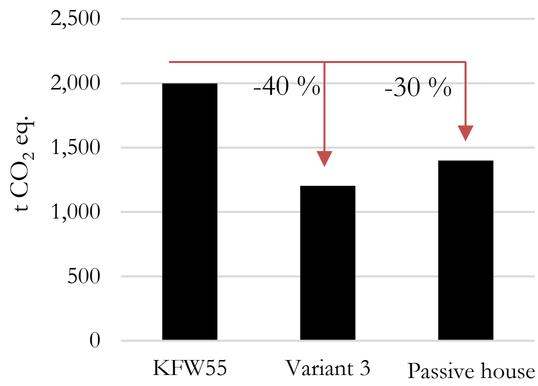


Figure 13: CO_2 emissions for building operation over 40 years

By adapting the building services in variant 3 and the resulting reduced electricity consumption, 10 % of CO_2 emissions can be saved compared to the passive house variant with air humidification. This reduction of CO_2 emissions cannot achieve the same results (23 % higher CO_2 emissions) as a regular passive house without humidification.

For the life cycle costs of the three compared variants, the following results are obtained under the boundary conditions met in previous chapter and the CO_2 prices described in Table 10.

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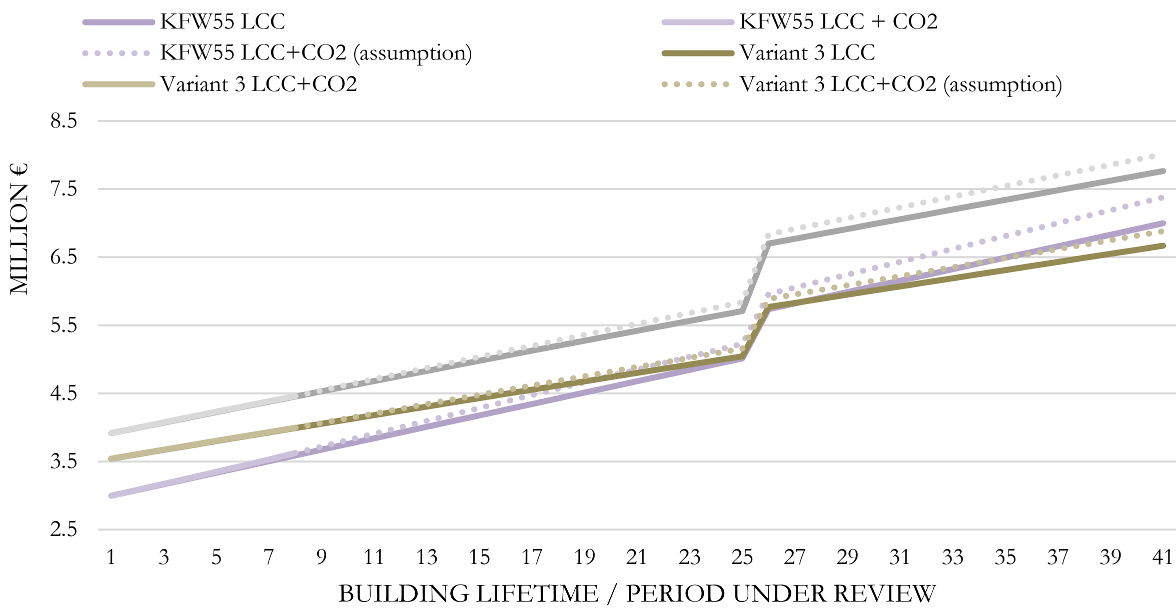


Figure 14: Life cycle costs of the building variants, including and excluding CO_2 costs, 40 years.

With building variant 3, a breakeven point in investment costs can be reached after only 19 years compared to the KFW 55 house variant. The passive house variant with air humidification remains the most expensive variant over the 40 years of consideration.

Results

Based on the evaluation of the CO_2 emissions and the specific costs for the CO_2 emissions, it can be summarized that the CO_2 emissions are lowest by operating a classic passive house without air humidification. Furthermore, the life cycle costs including the CO_2 pricing can achieve a shift of the break-even point by six years. Variant 3 is a compromise between life cycle costs and CO_2 emissions. Compared to the passive house variant with air humidification, CO_2 emissions could be reduced by another 10 % and at the same time the break-even point could be reached after 19 years.

2.3.3. DISCUSSION

The life cycle cost calculations have been carried out during the preliminary planning and design phase. The calculation results serve as a basis for decisions on the building energy standard.

Boundaries of application
The calculation was carried out for an observation period of 40 years. For the calculation, the relevant cost groups, which are subject to change due to adjustments of the energy standard and the building services equipment, were collected and compared. The energy price for electricity, which is the only energy source used in this energy concept, is 0.2 €/kWh for this calculation. The following percentages have been used to determine the life cycle costs according to the net present value method for the evaluation of payments in the future.

Table 11. Boundary conditions ATP LCC analysis.

Boundary conditions	
Interest rate	1.5 %
Inflation rate	2.0 %
Inflation energy price	2.0 %
Energy price increase	5.0 %

The assessment of the maintenance and repair costs of the components was calculated, analogously to the calculation boundary conditions, from the DGNB[6] certification system with 0.35 % for maintenance and 0.10 % for servicing in relation to the investment costs. For the evaluation of the building services installations, the approach of VDI 2067[7] [6] was applied.

If a similar methodology is already integrated in the standard workflow, which are the main differences between the two methodologies?
As part of the standard procedure in company *ATP*, energy concepts are assessed on the basis of their difference in life cycle costs. Only the relevant investment costs or additional investment costs are collected and compared. An overall building analysis is currently not carried out. Furthermore, only the cost difference in year 0 (additional investment costs) and the cost difference at the end of the period under review (life cycle difference costs) are evaluated. The analysis period is usually 50 years, as in the BNB[8] (Bewertungssystem Nachhaltiges Bauen) and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) certification system.

Goals from the application of the methodology
The aim is to be able to evaluate the added value associated with any additional investment, resulting for instance from an optimized building standard or a more expensive but more durable building service in the life cycle. This makes it possible to make decisions that are not evaluated on the basis of investment costs.

Difficulties and critical points of the implemented features
When assessing the life cycle costs in the planning process, a variety of problems arose. The changed view of a building due to the focus on the life cycle entails closer cooperation between the different planning participants, since the results influence each other directly. Furthermore, the differences in the calculations must be clearly pointed out during the calculation, and possible standardizations have to be made, to avoid comparing not comparable aspects. This point must be considered, for example, when considering the PV area in calculation 1.

Advantages of the applied methodology
Due to the changed view of a building - towards a life cycle approach - a building project is no longer measured solely by its investment, but also by its life cycle performance. As a result, supposedly more expensive investments can become cheaper over the life cycle.

Disadvantages of the applied methodology
By considering the variants as a whole in this approach, some of the differences that can be worked out in a component or building component comparison, cannot be depicted because very rough parameters are used. Analyzing closer individual components, an experienced builder-owner, who has already gained experience from other buildings in operation, can give a contribution as close to reality as possible.

[6]DGNB:https://static.dgnb.de/fileadmin/dgnb-system/de/gebaeude/neubau/kriterien/03_ECO1.1_Gebaeudebezogene-Kosten-im-Lebenszyklus.pdf

[7] VDI 2067 - "Cost-effectiveness of technical building systems"

[8]BNB:https://www.bnb-nachhaltigesbauen.de/fileadmin/steckbriefe/verwaltungsgebaeude/neubau/v_2015/BNB_BN2015_211.pdf

How easy is the methodology to be implemented in the normal workflow?
This method is already part of the ATP sustain's workflow. For the input of the values and the evaluation of the results, expert knowledge is currently still required.

Target/s achieved
In the course of the evaluation and the selection of the variants to be investigated, a result was obtained, which allows the client to argue that he may deviate from the building standard for this building. However, it should be noted here that the passive house performs worse than variant 3, which was defined by the client and the planning team, only because of the humidification system. Furthermore, it must be taken into account that the passive house was calculated under the assumption of an ideal operation. If the users of a passive house open the windows despite the ventilation system, the operating advantage may be worse than the calculation results.

Upcoming projects

Table 12. Upcoming nZEB projects – ATP sustain.

	Project	Location	Building use / Typology	Client
1	DRV Karlsruhe	GER, Karlsruhe	Office	Deutsche Rentenversicherung
2	Bauamt Weilheim	GER, Weilheim	Office	Staatliches Hochbauamt Weilheim
3	Ceratizit	GER, Kempten	Office & Production Building	Ceratizit Logistik GmbH
4	Kathlisches Siedlungswerk	GER, München	Housing	Katholische Siedlungswerk München GmbH
5	Magdas Großküche	AT, Wien	Industrial kitchen	Caritas Wien
6	Aspern TZ2	AT, Wien	Office	WWFF Business Sercice Center GmbH
7	DOC Zagreb	HRV, Zagreb	Outlet Center	Designer Outlet Croatia d.o.o (UJEA Centntres)

ATP Sustain is also pursuing the approach of developing strategies for existing buildings to be climate-neutral by 2050 within the framework of DGNB GIB certification. In accordance with the DGNB certification standards, this goal can only be achieved by continuously improving existing buildings.

Table 13. Upcoming projects on existing buildings – ATP sustain.

	Project	Location	Building use / Typology	Client
1	Landshuter Allee 8-10	GER, Munich	Office	LaSalle Investment Management Kapitalverwaltungsgesellschaft mbH
2	Campus D	GER, Munich	Office	LaSalle Investment Management Kapitalanlagegesellschaft mbH
3	Denkraum München	GER, Munich	Office	LaSalle GmbH
4	Dutchman Office	GER, Hamburg	Office	LaSalle GmbH
5	Solo West	GER, Frankfurt am Main	Office	LaSalle Investment Management Kapitalverwaltungsgesellschaft mbH „Sondervermögen LaSalle E-REGI“

3. LUISENGARTEN AMBIENTE – K&M

3.1. GENERAL DESCRIPTION

Brief description / main features
"Luisengarten Ambiente" are two residential buildings with 10 apartments each, 2,060 m² NFA, their construction started in 2019, gas-fired CHP heating, owner community as operator of the PV and CHP, battery storage, KfW55 standard. Unlike in the Luisengarten Parkcarré (with the case study Hauptstr. 131 investigated in deliverable D2.2), the buildings of Luisengarten Ambiente are not connected to a central CHP plant. Here always two buildings are considered as one unit. They share the underground parking, a CHP-plant for energy production and the DHW system and a PV system with battery storage. The plants therefore remain of a manageable size. The roofs are not completely covered with PV panels, because, starting from a certain system size, the administrative requirements for the owner community become too onerous and confusing.

Figure 15: Rendering Luisengarten Ambiente project.

Energy concept
CHP system und PV for high self-consumption rate of heat and electricity, thermal-bridges-optimization, KfW55 standard.

Table 14: General project information of Luisengarten Ambiente

General project information	
Project name	Erna-Hötzel-Weg 1 and 3 (Luisengarten)
Location	Germany, 76344 Eggenstein-Leopoldshafen
Planning team	Köhler & Meinzer GmbH Co KG
Architect	Alex Stern
Building owner	Real estate developer, later owner community
Net floor area	2,070 m² (2 x 1,035 m²)
Construction date	Started in 4/2019
Building typology	Multi-family home with hipped roof, standardized building concept with customized nZEB technology sets
Current status	Construction phase

3.2. GOALS DEFINITION

Main goals and the priorities of the design
High-quality building and low energy consumption, owner community become an operator and benefits from the profits generated, a new billing model for electricity generation by CHP and PV.

Main constrains for the design
Zoning plan, compliance with the parameters specified in the energy calculation, otherwise there are no restrictions regarding the technology, building elements or the equipment.

Main characteristics of the building

Table 15: Building envelope/structure Luisengarten Ambiente.

	KfW 55
U-Value Wall	0.20 W/m²K
U-Value Roof	0.15 W/m²K
U-Value Floor	0.20 W/m²K
U-Value Window	0.9 W/m²K (g=0.5)
Air tightness	Optimized, considering thermal bridges
Shading	All windows with shutters

Table 16: HVAC systems and RES Luisengarten Ambiente.

Heating	CHP-plant local net, gas condensing boiler for peak load cover
DHW	CHP-plant local net, gas condensing boiler for peak load cover
Ventilation	Natural
Cooling	-
RES	PV with battery storage

Targeted performances: KfW55 standard or better for higher government repayments, generation plant owned by the community of owners easy billing.
Selected business model(s): community of owners becomes the plant operator, new billing model for self-generated PV and CHP plant electricity, tenant electricity model.
Selected reference case: Hauptstr. 131.
Variants - main features: New technology set with local CHP and PV (with storage). Innovative billing system for the owners.

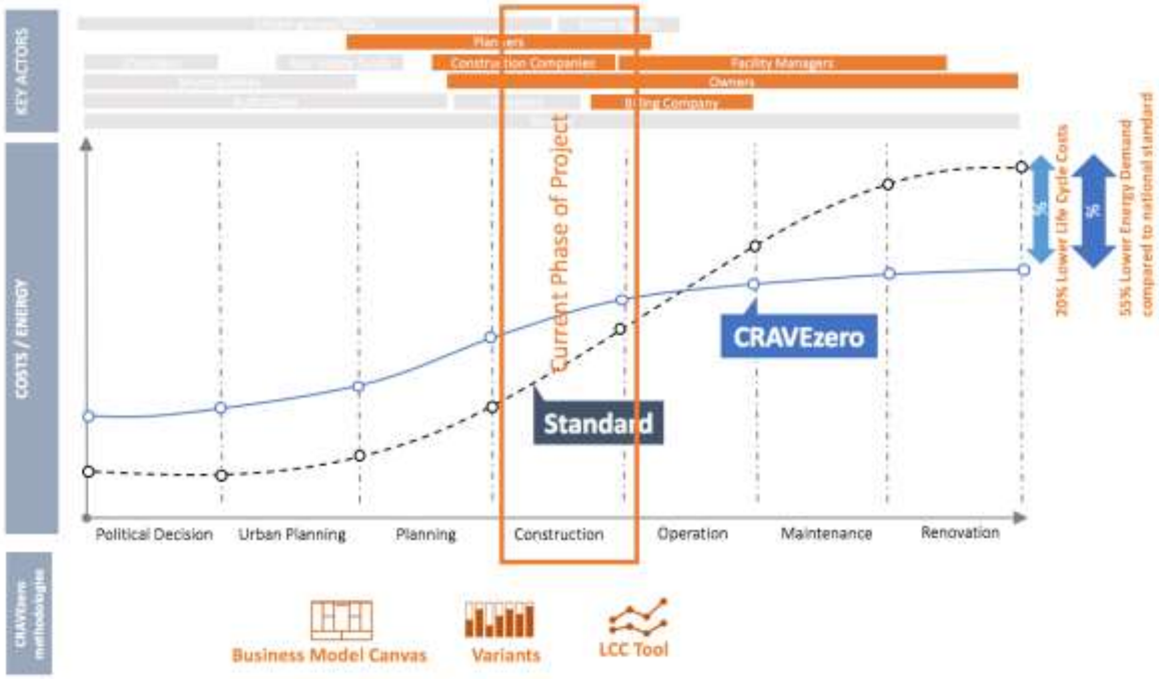
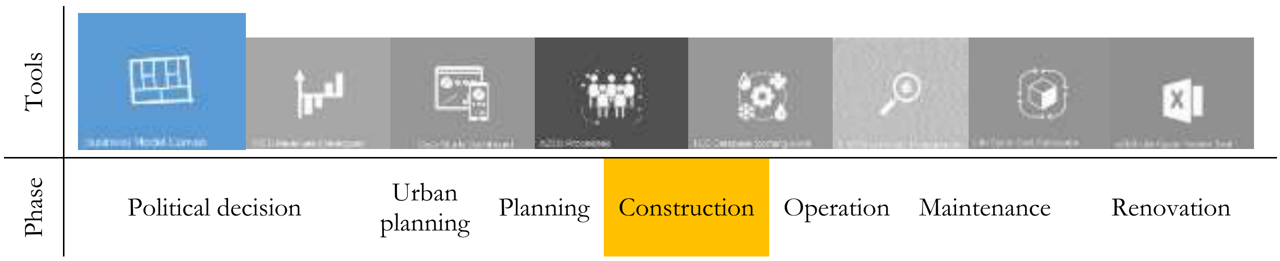


Figure 16. Graphical representation of the prototypical implementation most relevant features – K&M.

3.3. PROTOTYPICAL IMPLEMENTATION OF K&M PROJECT



3.3.1. DOCUMENTATION: BUSINESS MODEL ANALYSIS

General conditions for nZEB business models

Both the national and the EU regulations on the sustainable contribution of the residential and construction industry to climate neutrality are becoming stricter. The discussion about the consumption of fossil fuels and CO_2 emissions through media coverage and research contributions to climate change has reached public awareness (at least from the German perception). This current situation allows different stakeholders in the nZEB-market to create or expand their interests and business models.

Not only one-sided profit maximization arises, but also win-win-situations can be created, which in turn promote the nZEB-thoughts and implementations. This effect is reinforced by the fact that nZEB technologies are in many cases not the main price drivers in the price spiral due to the increasing level in real estate prices. In relation to the total price the nZEB building technologies are profitable from a LCC perspective (sales or purchase value, depending on the stakeholder perspective). In some cases, as in the case of photovoltaics, some technologies are experiencing price erosion that makes them even more interesting and usable in a large scale. Manufacturers, installers, operators as well as planners, real estate developers are equally benefiting from these efforts to develop creative business models and technologies, to make them ready for the market and also to promote them accordingly.

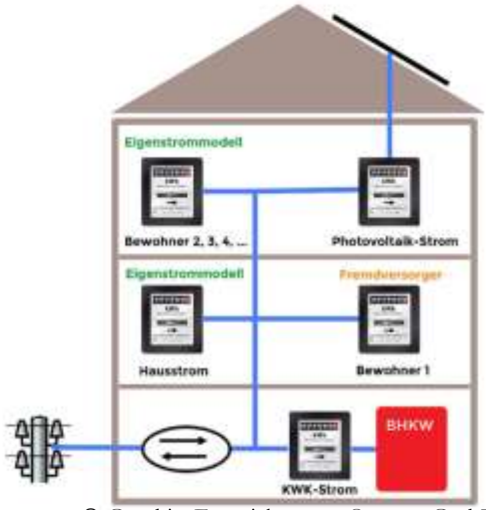
K&M approach to a new BM

As a regional operating housing company in Germany Köhler & Meinzer is always dependent on reacting to the market situation. By participating in

the CRAVEzero project, K&M had the opportunity to view our activities from a different perspective.
The intuitive approach for a more or less consciously chosen BM was shifted to a more rational and theoretical one. In K&M contribution to the CRAVEzero project among others our Key Resources and Key Activities have been recognized. The advantage of mapping and controlling the entire process of project realization of buildings, which are already in compliance with nZEB criteria, was identified as a strength. This includes all planning and execution stages, beginning with the planning and district development, over the architectural building planning, the control of the used house-technical energy concepts, and the construction management of the objects up to their marketing.
Since K&M now also act as property manager for the owner communities of more than 400 apartments, the company found in this administrative activity a broad and comprehensive database of operating and maintenance costs of the objects that have been built in the last decades.
At the beginning from the year 2008 our multi-family dwellings during the CRAVEzero project have been analyzed. (deliverable D6.1, chapter 4 contains a detailed analysis of these case studies). In an extensive questionnaire, a large number of building parameters have been recorded. Depending on the ascending year of construction, the buildings reflect the state of the national energy saving regulations (e.g. with regard to the thickness of the insulation material, thermal bridges optimization and the technical solution sets used). This made it possible for us to evaluate the impact of the individual variables with regard to the actual heating energy requirement, not only per building but also up to the individual apartments located therein and to draw conclusions for the orientation of our own business model.

Process steps

During the preparation of the deliverable D6.1 on parametric models, in chapter 4 "Lessons learned" K&M had the opportunity to prove almost every possible combination of heating and DHW generating technologies available on the market. The company had an intensive discussion phase on the technology sets used so far and the experiences made with these sets. The real data for heating energy consumption in the individual buildings, the maintenance costs and our experience in the daily practice of the respective technology sets were compared. In addition (with our Key Partners), several rounds of experts and appointments with external specialist consultants took place, in which technology sets and business models were presented and rated. This also included LCC analyses focusing on the profitability of each technology. The support from Fraunhofer ISE as a scientific partner was also helpful.
An extremely big issue in the implementation of renewable energies, that are to be fed into a public grid, is the billing with the regional energy supplier and the tax authorities. For this reason, the focus in all meetings was also on a viable manageability for a community of apartment owners or, like in our cases, for the property management contracted with it. All these considerations resulted in premises as the basis for developing further project steps and key factors for a business model.



© Graphic: Energiekonzept Ortenau GmbH

Figure 17. Tenant electricity model.

Findings and Consequences for the BM

The analysis carried out in the study brought a wealth of findings. In addition to those mentioned above, one of the key findings of our investigation is the fact that the user behavior of the building occupant has a significantly greater influence on its heating energy consumption than the quality of the thermal envelope or the efficiency of the building services. This finding contradicts the theoretical models and the legislative intentions behind the energy saving concept. Nevertheless, K&M has to deal with these circumstances in every-day business and also has to find sensible strategies and concepts that take these facts into account. It was and remains a constant adaptation effort to accommodate contradictory issues in a project or a business model. Our derived premises and concepts are briefly summarized below.

Findings and Key Activities/Resources for the adaptation of the Business Model

- Focus on renewable on-site energy production: The main influencing factor for the energy consumption of a building is the user. The user can operate a standard EnEV house as a passive house or a passive house in a poor EnEV standard. From a certain point, the theoretically achievable saving potential has no relation to the energy used, which e.g. is required for the manufacturing, transport and recycling of the insulation. Therefore, the focus should be on building and using on-site renewable energy based on a well-insulated building envelope and efficient building services, rather than theoretically saving on expensive measures of building beyond nearly zero-energy building level.

- Concentration of subsidies on the energetic improvement of existing buildings: Due to the high minimum standard of the German EnEV and the user behavior described above, the actual difference in heating energy consumption between buildings meeting a good thermal standard and passive house envelopes is very low. Therefore, focus should be on an effective cost-benefit ratio of subsidies and promote energy improvements in the building stock.

- Consideration of ecological effects: It is important an overall ecological and economic analysis of all components and implemented technologies (taking life cycle analysis of building elements into account) to avoid measures with negative environmental impacts.

- Focus on hot water and electricity: Nearly all energy-saving regulations and laws apply to the space heating of buildings. Current standard well-insulated houses consume more energy for domestic water and electricity than for heating the homes. Therefore, focus should be more on efficiency potential in terms of hot water and electricity consumption.

In the whole analysis several "Key Activities, Value Propositions" and effects for the "Customer Relationship" were identified. These will be taken into account and conveyed into a new project:

- "Customer satisfaction" versus how is it possible to influence the behavior in the sense of an economical use of energy?
- "Prosumer", change from a classical understanding of being a "patronized consumers" to a producer of energy, clients get a higher awareness in the thematic group of energy using, nZEB buildings and technologies.
- Win-win-situation for clients, when the customer not only has to pay more, but also receives added value that is worthwhile for him in an overheated real estate market.
- Increasing acceptance for nZEB-buildings and technologies if the customer is involved in energy issues.
- Economical one-stop solution with manageable effort for the client and the property management.
- Meeting of national requirements and regulations, ecological and economic aspects.

In current project "Luisengarten", consequences for K&M company with the aim to build a sustainable low-energy building, where economic, ecological and social aspects are balanced, have been drawn. It was helpful to compare most of the above-mentioned information for the Luisengarten Ambiente project, which is currently being carried out, to decide which business model and technical solution set should be used. The adaptations implemented in the current project are described below.

Actual project „Luisengarten Ambiente"

As indicated above „Luisengarten Ambiente" consists of two residential buildings with 10 apartments each, 2,060 m² NFA, built from 2019, gas-fired CHP, gas boiler, owner community as operator of the PV and CHP, battery storage, KfW55 standard

Total consumption of electrical power	60-65,000 kWh/a
Electrical power PV	35,000 kWh/a
Electrical power CHP	30,000 kWh/a
Battery storage	27 kWh

Figure 18. Detailed rendering of Luisengarten Ambiente project.

Instead of theoretically saving additional heating energy by further increasing the insulation thicknesses with the economic (and also ecological) consequences described in the study, K&M wants to invest in the production of renewable energy based on the insulation standard according to KfW55. The buildings will receive a PV system with a capacity of 30 kWp. To achieve the highest possible self-consumption, the system is supplemented by a battery storage with a capacity of 27 kWh.
In this study, no significant heating energy savings through the introduction of decentralized ventilation units with heat recovery were detected . In the described project, this technique was discarded and the saved costs have been invested in the construction of a gas-powered CHP plant buffered by a gas-based peak-load boiler. The CHP takes over the base load of the heat supply of the residential complex and also generates additional electrical energy. Just like the PV power, this should be consumed on site as much as possible. The billing of this tenant electricity model, which is very complicated by law, is carried out by an external service provider (see D5.2 "Existing Business models" BM No. 55).
PV system, CHP and electricity storage are in the ownership of the condominium community. The owners become energy producers and are less susceptible to price increases by energy suppliers. The proceeds from the sale of the electricity to the users are credited to the maintenance account of the condominium community. This construction is the consequence of the unacceptably high heat price in the contracting model analyzed.

Results
The implementation of the described process started in October 2017 with data compilation and evaluation as well as meetings and expert hearings. The shell construction phase has started in September 2019, so that the installation phase will begin shortly. The new business model has not yet been actively promoted or highlighted as a special feature. It is not currently necessary to use the common distribution "channels". As mentioned above, the costs for heating or heat generation are so low and the energy costs overall so moderate that consumers in the overheated real estate market are happy to get an apartment at all. However, this perspective may change quickly if the energy costs (especially for electricity) will rise again as previously announced. K&M hopes that the preferred solution will provide the best and added value for customers ("Value Proposition"). The business model with an improved involvement of the customer and potential savings due to the energy generation and consumption on site by the owner could easily be integrated into our normal workflow. The expected success ("Revenue Stream") of the adapted business model will turn out in a medium to long-term perspective and will certainly depend on the general price development in the energy sector or the increased public awareness of sustainable energy production. A factor that should not be

underestimated are the qualitative co-benefits (see Deliverable D6.4), which as a by-product have a positive impact in many areas. These are not to be repeated here in detail, but they not only promote the perception of the company but also, in particular, the acceptance of the CRAVEzero concept and nZEB technology sets.
The results are nevertheless extremely positive. Our study and the interaction of communication in meetings and with external consultants lead us in an almost optimal solution for the current situation. Since other projects are already being considered also with the input from Fraunhofer ISE, K&M will, with certainty, develop new perspectives from it again. Our business model and our "lessons learned" are in this way a snapshot in an ongoing process.

3.3.2. DISCUSSION

Phase of implementation
The investigated BM is currently in the implementation phase. The technical solution set (CHP with PV and gas condensing boiler for the peak load) will be installed soon. Since all apartments have already been sold and the concept was not actively promoted, the effects can only be assessed in a subsequent evaluation.

Boundaries of application
As K&M is "master of the process" there are only few restrictions. Creativity is required to find the best possible strategy based on the results found.

If a similar methodology is already integrated in the standard workflow, which are the main differences between the two methodologies?
The BM that has been adopted so far has "emerged" over the past years and decades. The adjustments to the needs of the market were carried out continuously, but were not the subject of complex considerations. For this reason, it was a new approach for us to consider the approach of the theoretical model of the Osterwalder Canvas[9], the results of the CRAVEzero project and the results of our data analysis in order to draw the appropriate conclusions for our BM.

Goals from the application of the methodology
- Improvement of the BM, adaptation of key factors and technology sets.
- Improve customer acceptance of sustainable energy systems.
- Customer participation in the yields of energy generated on-site.
- Enabling self-consumption of electricity generated on site.

Difficulties and critical points of the implemented features
See above "boundaries of application".

Advantages of the applied methodology
The Osterwalder Canvas is a tool with a broad basis for identifying the topics and key factors on which you want to focus. Although in some cases, terms are used with a very high degree of abstraction, the display helps to become aware of these topics and to achieve the desired goals via a jointly defined catalogue of measures.

Disadvantages of the applied methodology
See above "boundaries of application".

How easy is the methodology to be implemented in the normal workflow?
Since the constant improvement of the BM is part of the company strategy, the use of the method was not new in terms of contents. The type of information acquisition and processing and the abstract framework had to be taken into account.

Target/s achieved
Our study and the interaction in meetings and with external consultants lead us to an almost optimal solution for the current situation. The chosen technical solutions set in combination with the external support for the planning and billing promise a win-win situation for customers and us.

How satisfied are you with the results obtained
The results are extremely positive. A number of co-benefits are expected, which are usually not likely to be measured quantitatively but, as already mentioned, represent a qualitative improvement in customers' perception of nZEB technologies, generation of renewable energies, personal energy consumption and, last but not least, our BM itself.

[9] Business Model Canvas is a strategic management and lean startup template for developing new or documenting existing business models.

Lessons learnt

BM and our "lessons learnt" are a snapshot in an ongoing process.

Which part of the CRAVEzero methodology will be further implemented within the company?

The advanced model remains in our workflow. It will certainly be adapted to future developments and continuously expanded also from the point of view that the technology sets, the national regulations or the BM offered by external partners may change or appear and thereby open up new perspectives.

Upcoming projects

Table 17. Upcoming nZEB projects – Köhler & Meinzer.

	Project	Location	Building use / Typology	Client
1	Luisengarten, Erna-Hötzel-Str. 1-3	Eggenstein	Multi-storey apartment building	Real estate owner community
2	Luisengarten, Erna-Hötzel-Str. 5-7	Eggenstein	Multi-storey apartment building	Real estate owner community
3	Luisengarten, Erna-Hötzel-Str. 9-13	Eggenstein	Multi-storey apartment building	Real estate owner community
4	Luisengarten, Erna-Hötzel-Str. 8-12	Eggenstein	Multi-storey apartment building	Real estate owner community
5	Weissachrün	Bretten	District with apartment building (63 apartments)	Real estate owner community, property owner
6	Multiple single-family houses, semi-detached house.	Rastatt, Eggenstein.	Single-family houses	Owner
7	Luisenstraße 2	Eggenstein	Apartment building	Property owner

4. LA DISTILLERIE – BOUYGUES

4.1. GENERAL DESCRIPTION

Brief description / main features: The project consists of a new mixed usage sustainable district with a net floor area of 62,000 m². The municipality wanted to redevelop an existing contaminated land into an urban land with an equivalent area of agriculture using green roofs and a landscaping arrangement. The project will include several typologies of buildings as follow: commercial, offices, private and social dwellings, hotels, kindergarten and a farm.

Energy concept: Resilience by an energy autonomy.

Table 18: General project information La Distillerie.

General project information	
Project name	La Distillerie
Location	Villeneuve d'Ascq, France
Planning team	Linkcity
Architect	Sempervirens / Atlante Architecte
Building owner	(confidential)
Net floor area	62,000 m²
Construction date	2022
Building typology	Mixed: commercial, offices, individual housing, collective housing, hotels, parking and farm.
Current status	Master plan already defined. Starting of preliminary design.

4.2. GOALS DEFINITION

Main goals and the priorities of the design

- Energy autonomy.
- No consumption or usage of the agricultural field.
- Urban farming.

Main constrains for the design

- Pollution.
- Architectural integration of RES.

Focus on CRAVEzero approach application

- CRAVEzero applied methodologies: nZEB processes.
- Is this methodology replacing another one used within your company or is a new one? New methodology.
- In which phase will this/these methodology be implemented? Urban Planning.

Main characteristics of the building

Planning not available yet.

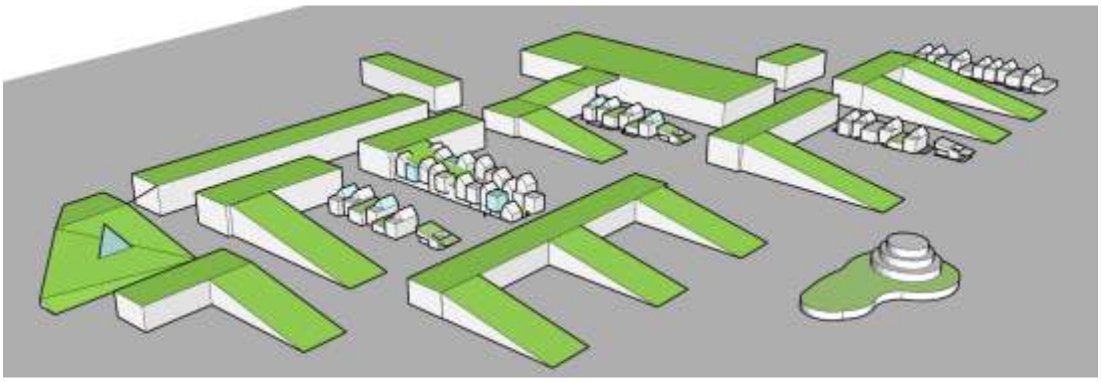


Figure 19. Urban planning of La Distillerie.

Targeted performances

Energy autonomy E=0.

Selected business model(s)

- 4: Urban planning-Bouygues Construction
- 9: Daylight optimization
- 15: Monitoring
- 16: PV contracting: Helios
- 30: Energy supplier-PV-Systems, storage and electrical cloud service
- 31: Wastewater heat recovery system - EHTECH
- 32: Vendor of solar hybrid modules
- 35: Public financing support for nZEB buildings, renovation and renewable energies
- 48: Digital boiler - Stimergy

- 50: Collective self-consumption - Sunchain
- 55: Renewable energy systems: CHP-Plants (Combined heat and power plant)

Selected reference case

The new French thermal/energy regulation RE2020[10].

Variants - main features

Optimization of building structure and envelope to respect the new energy regulation.

Variants of single elements/technologies

- Heating source: centralized or decentralized, heat pump or biogas.
- Electricity production: hydrogen or PV panels.
- Water management.

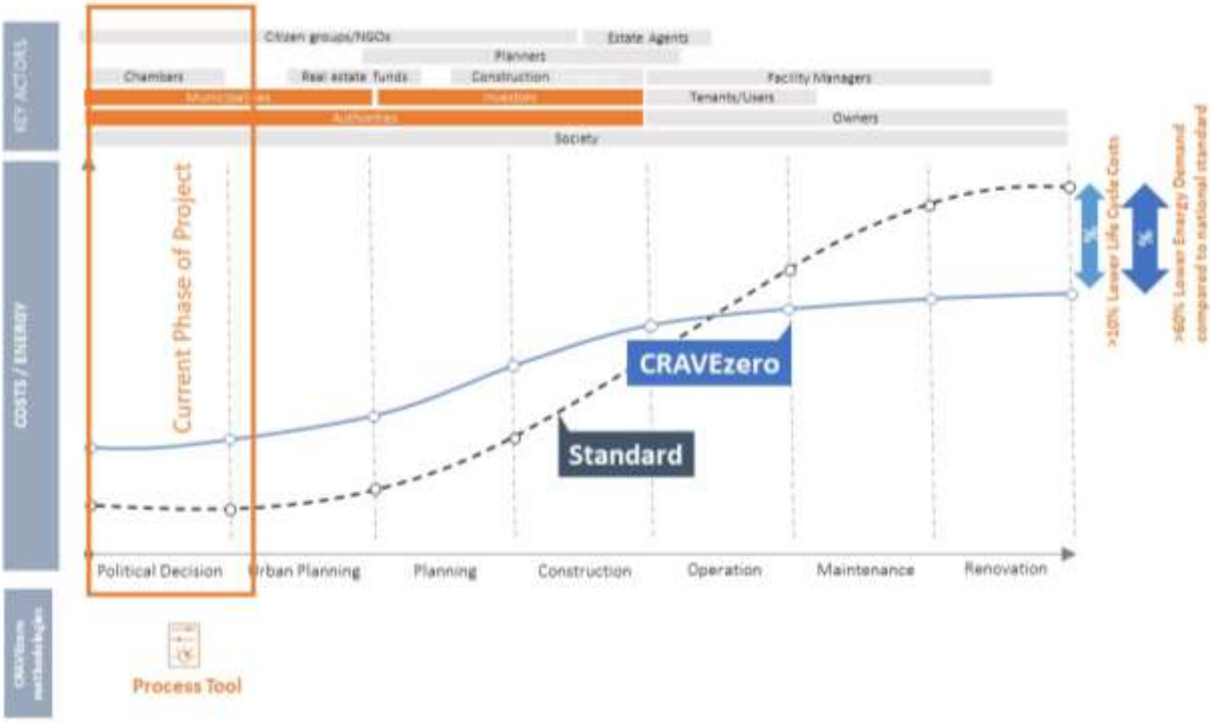


Figure 20. Graphical representation of the prototypical implementation most relevant features - Bouygues

[10] The RE 2020 is the french thermal regulation which will be applicable to all new constructions from the end of 2020.

4.3. PROTOTYPICAL IMPLEMENTATION OF BOUYGUES PROJECT

4.3.1. DOCUMENTATION: PREDESIGN AND PROCESS ANALYSIS

Objective of the study

The client is a private investor and the owner of the land. He is not aware of nZEB concept and role in the upcoming regulations of Member States but is sensitive to energy performance in a very broad way and therefore not fully able to define KPI for the energy part.

The purpose of the project was to demonstrate that a structured process can offer opportunities either to build at lower cost for the same performance or to enhance performance at same cost.

The project consists of redeveloping an agricultural field into a sustainable district. It will include several typologies of buildings such as: commercial, offices, private and social dwellings, hotels, kindergarten and a farm. An optimized selection of new technologies and renewable energy sources will be integrated as well. The energy goal is to achieve a resilient energy autonomy. Within the framework of the project development, "nZEB process analysis" was selected to optimize the cost and time of the actions sequence.

General project characteristics

The project consists of a new mixed district with a net floor area of 62,000 m². The main constraints set by the municipality is to redevelop an existing contaminated land (waste storage area) into an urban land with an equivalent area of agriculture using green roofs and a landscaping arrangement. For this reason, the methodology related to optimized nZEB processes will be used during the political decisions/urban planning and planning phases. In fact, a series of decisions and actions should be taken with the support of the process map with the right timing in order to minimize the cost of the whole project.

Applied methodology

In the regional planning, "Métropole de Lille" has defined the development scheme (schéma directeur) for energy performance goals, based on the new French energy regulation "RE2020" which clarifies the nZEB in terms of performance and planning application. "Villeneuve d'Ascq" municipality asked for an energy autonomous district without specifying the exact level.

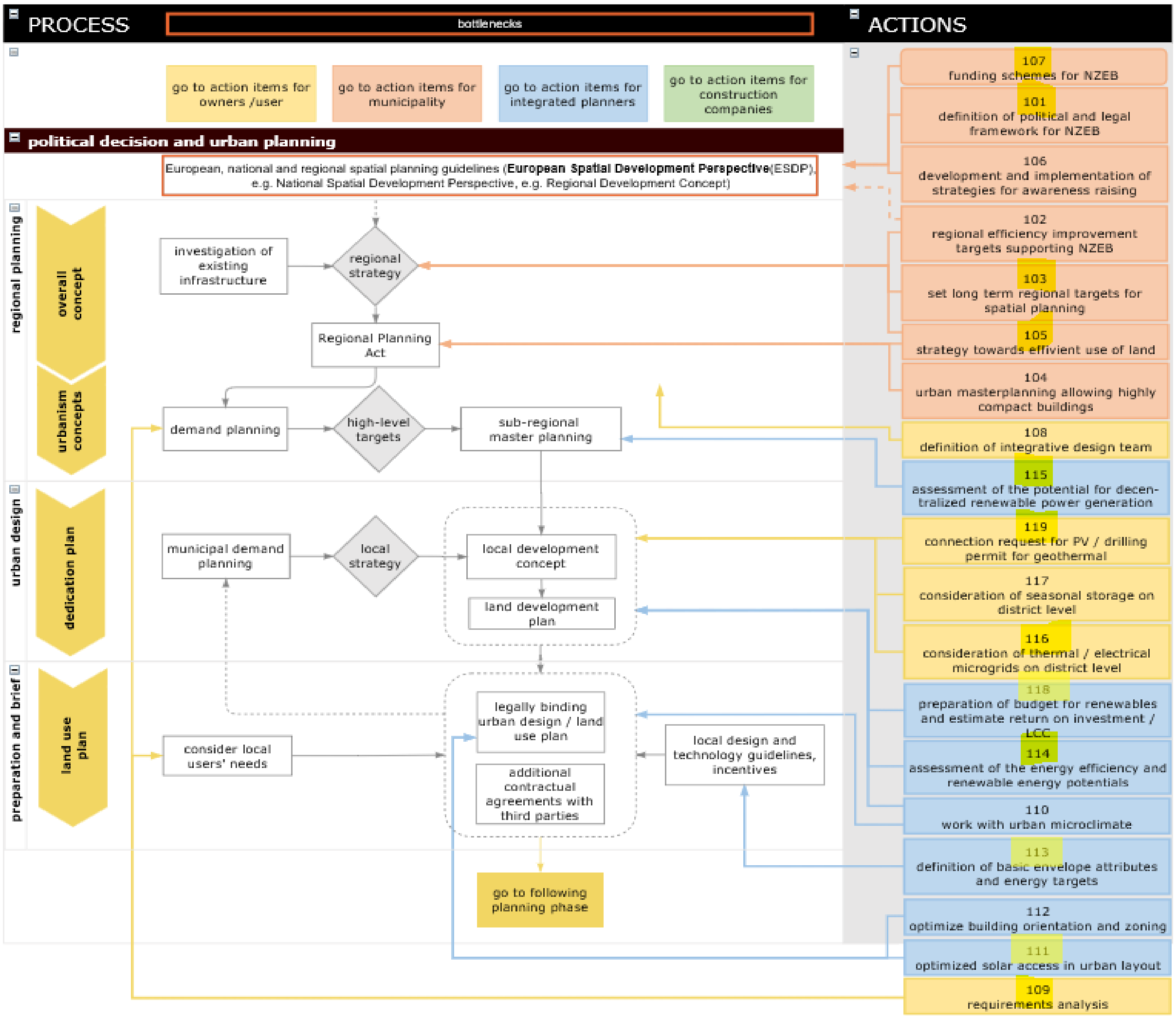


Figure 21. Political decision and urban planning process map.

As one can see in the above screenshot Figure 21, land owner/user, municipality and planners will be the main players during the urban planning phase. A batch of actions was selected to optimize the process during the regional planning, urban design and the final brief before passing to the planning phase.

Action 1.01: Definition political and legal framework for nZEBs:

In our case, a new energy/carbon emission regulation should be applied starting 2021. So, this action is represented in CRAVEzero concept under the Action 1.01. As per each country, some guidelines and norms should be respected and followed to develop a new project. The new regulation define the nZEB KPIs as follow:

- The heating consumption (primary energy pe) should be less than 12 $kWh_{pe}/(m^2*a)$.
- The total energy consumption of regulated and non-regulated usage should be less than 100 $kWh_{pe}/(m^2*a)$.
- The renewable production should cover the regulated consumption (Approx. 50 %).

The specification of this application is “low” since the goal is to reach the minimum regulation’s requirements. Some investigations will be made to enhance the specifications to a higher value by installing shared RES.

Action 1.07: Funding schemes for nZEB buildings:

After the first analysis of existing subsidies dedicated to renewable energy sources, action will be undertaken to check specifically the possibility to finance a biogas installation based on agricultural waste. Region and municipality can finance feasibility studies on new technical solutions available on land. Since hydrogen storage is considered as a prototype technology, some specific funds need to be identified to validate the implementation. The specification of this action is “low” to “medium” depending on available funds.

Action 1.05: Strategy towards efficient use of land:
The main client's goal is to maintain the same green cultivated area as in the current status. Therefore, the integration of green roof will be mandatory with some agricultural areas to achieve the preset goal. Some agri-photovoltaic concept will be integrated on the ground to produce centralized renewable energy without affecting green areas (soil artificialization). Buildings will be constructed on some dead areas due to waste storage in order to optimize the use of land. The specification of this action is "high" due to the integration of green roof and rainwater management. It is foreseen to use the collected/ stored rainwater for irrigation purposes.
In accordance with the regional strategy, a deep investigation will be done to search for a possibility to connect to an existing near urban heating network in order to minimize costs and determine the percentage of renewable provided by this network. With the above-mentioned actions, a region-planning act could be elaborated and detailed as per project goals.

Action 1.15: Assessment of the potential for decentralized renewable power generation:
On this project, a specific study will detail the potential, benefit and cost of several renewable energy production such as urban heating, photovoltaic panels, biomass, geothermal and wind turbine. Regarding the heating distribution solution, it is planned to invite the energy service company to participate to the assessment of the cost. The specifications of this action is "high" since our goal is to achieve an energy autonomy.

Action 1.19: Connection request for PV / drilling permit for geothermal:
Moving to the urban design phase, the local strategy and the sub regional master planning will allow the planner to create a local development plan and concept. For this reason, the owner will ask public bodies for the feasibility/permit of PV connection and geothermal drilling. Photovoltaic connection: The project will request some technical and administrative steps to check for the cost and feasibility of a PV connection to the grid supplier (Enedis). This step will be done for both cases, centralized or decentralized photovoltaic plants. Geothermal drilling or pumping: As a first step for the permit, the user should validate the feasibility with the help of the local French institution BRGM, which is the responsible public body for geothermal activities in France. This process will clarify the potential of the energy recovery. The specifications of this action is "high" since photovoltaic and geothermal renewable sources will be required in the project.

Action 1.16: Consideration of thermal / electrical micro-grids on district level:
To finalize the local development concept, thermal micro-grids should be considered as an alternative solution if urban heating is not available in this area. On the other hand, the option to integrate an electrical micro-grid on a district level will require further negotiation with the grid supplier "Enedis" since it is quite complicated to manage within the actual French regulations. The specifications of this action is "low to medium" since the implementation of thermal/electrical micro-grids is not sure.

Action 1.14: Assessment of the energy efficiency and renewable energy potentials:
After defining the local development concept (Actions 1.15, 1.19 and 1.16), the planner will check the potential of different renewable energy supply options as per the site constraints. The objective is to define the percentage of onsite/offsite RES generation. For onsite generation, the planner will propose a repartition between centralized and decentralized energy production on district and building level. This subdivision should respect the main goals of the program. The specification of this action is "high" since more than 50 % of the demand will be generated on-site.

Action 1.18: Preparation of budget for renewables and estimate return on investment/ LCC:
After getting results of actions 1.15, 1.19, 1.16 and 1.14, an estimated budget will be calculated to select the best batch of available renewable solutions based on the lowest time of return on investment. The specification of this action is "high" since we will choose the most valuable scenarios based on a detailed whole life cycle cost calculation.

Action 1.13: Definition of basic envelope attributes and energy targets:
The main influences on investment cost are building envelopes and energy targets. These topics cannot be treated until a local development concept and a main plan are elaborated clearly. So, the planner will optimize the energy performance of the envelope with respect to renewable energy sources in order to attain the required and most valuable energy level. The specification of this action is "medium" since the new energy regulation is quite demanding on energy performance.

Action 1.11: Optimize solar access in urban layout:
The master plan takes into account the solar access to each building due to the sufficient distance between buildings and their low height. The specification of this action is "medium" since it was taken into consideration for large buildings and not for the small ones.

Action 1.09: Requirements analysis:
Arriving to this final stage of the urban planning, action 1.09 will consider the local stakeholder needs and the demand planning. Therefore, this document will clarify all the engineering requirements by showing quantifiable and relevant specifications. This analysis will be the result of all decisions and reports stated in the already mentioned actions. The specification of this action is "high" since the expectations and requirements are clear and documented for the client.

PLANNING PHASE

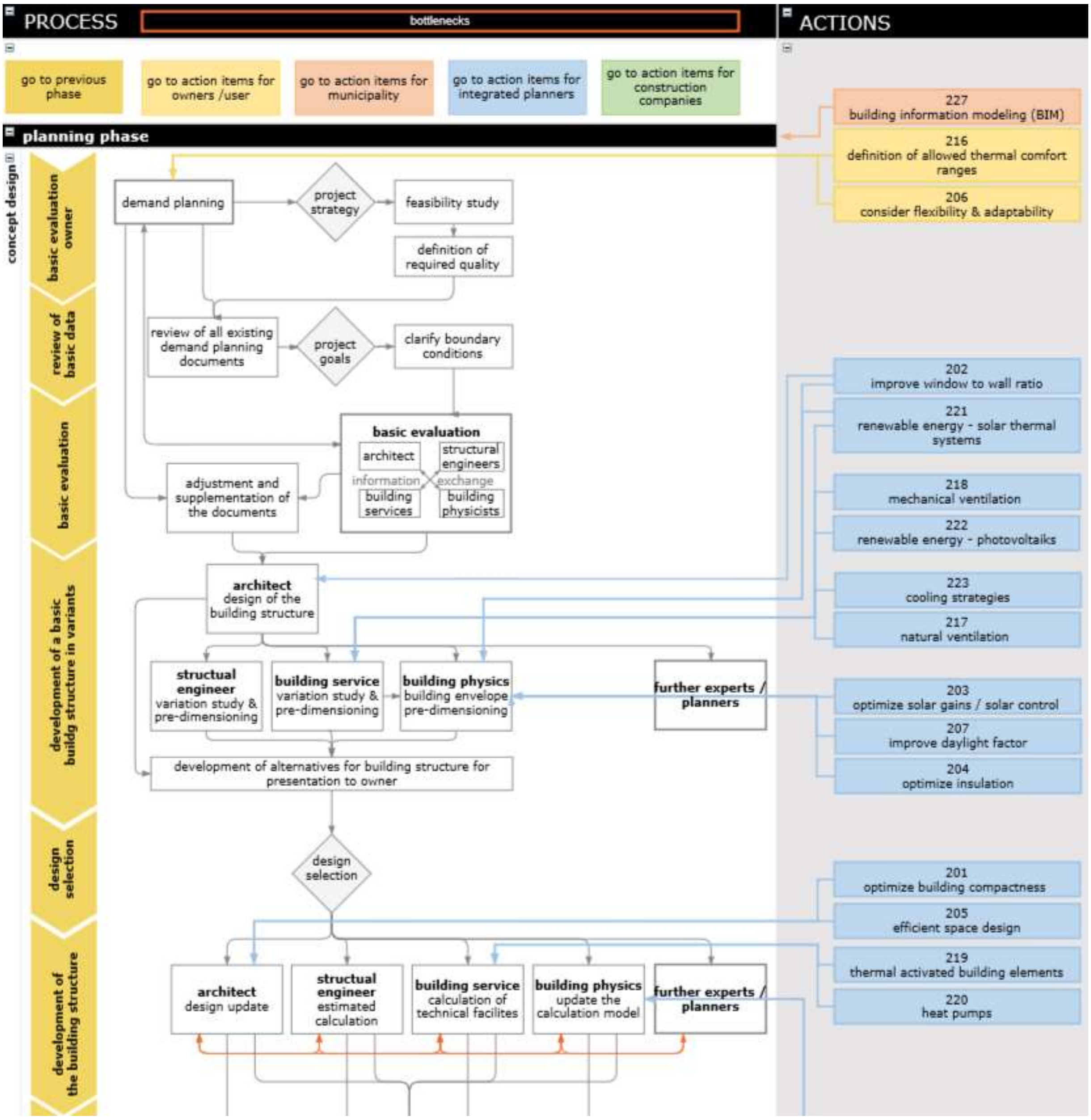


Figure 22.Process map of the planning phase – part 1.

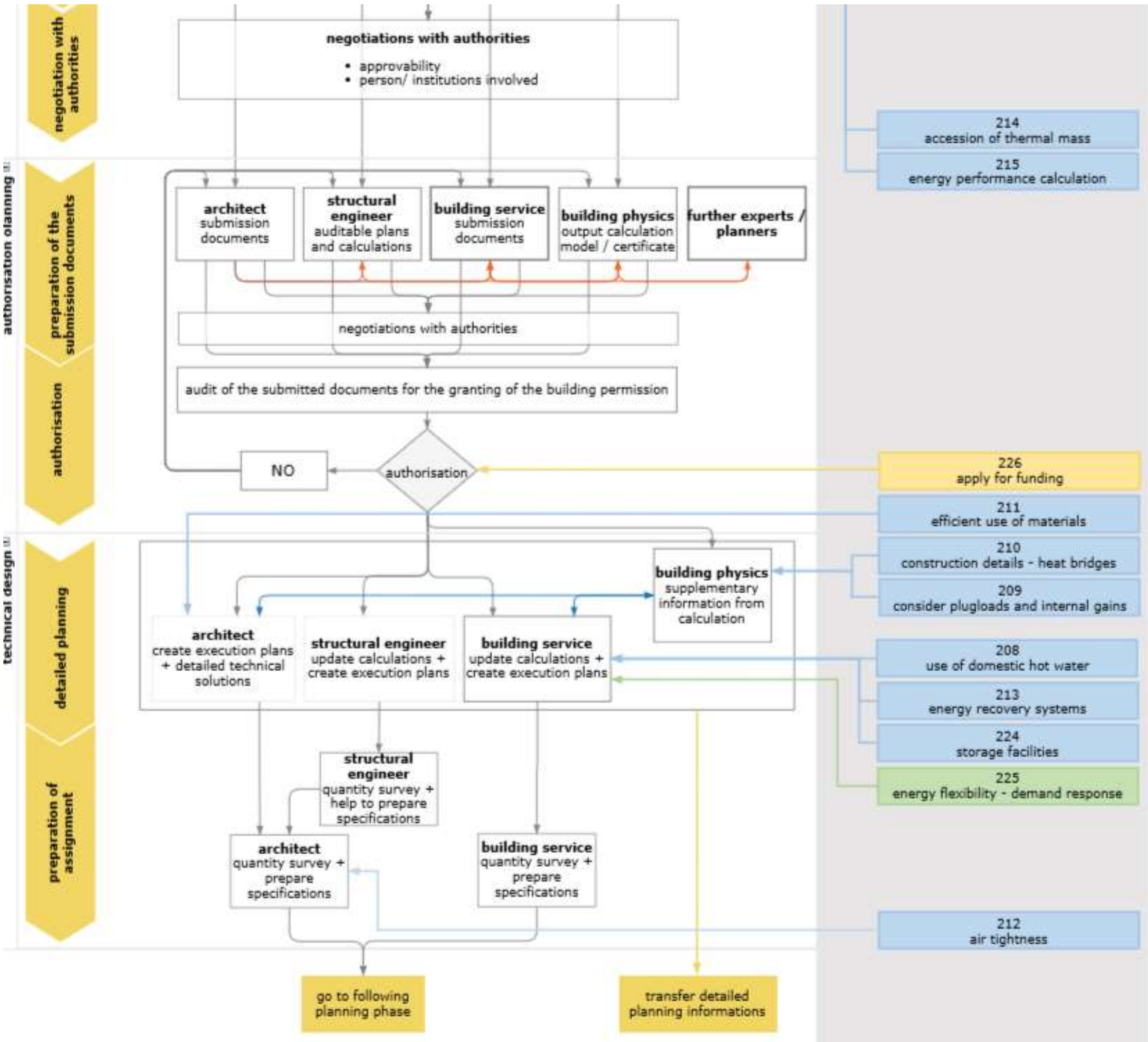


Figure 23. Process map of the planning phase – part 2.

Action 2.16: Definition of allowed thermal comfort ranges:

To start the concept design phase, the demand for a planning should take into consideration the definition of the required thermal comfort ranges in order to follow nZEB procedures. This subject is rarely discussed with clients, but it will be used from now on to optimize the thermal design and facilitate the labeling. The specification of this action (medium or high) will depend on the typology of the building: residential, offices.

Action 2.06: Flexibility and adaptability:

In addition to action 216, flexibility of buildings to make quick modifications and adapt the new configuration is required. This flexibility is taken in a vertical perspective instead of horizontal. This action is related to market prices. The specification of this action will be "medium" due to its partial flexibility and adaptability.

After applying these actions, we will be allowed to identify the project strategy, goals and start a basic evaluation of the concept with the help of architects and specialists. Through the following actions, we'll be able to select the most optimized variant, start to develop in detail the design and negotiate with the referred authorities.

Action 2.02: Improve window to wall ratio:

The main goal of window to wall ratio optimization is to maximize the natural sunlight and reduce the energy consumption. Due to the new French thermal regulations, maximizing renewable energy will be the main criteria to respect in order to build new construction. The ratio will definitely differ with respect to the location (South or North), direction (which façade) and shading effects. In this project, the specification will be medium with a ratio of 17 % and an average of window's U-value equal to 1.1 W/m²K.

Action 2.18: Mechanical ventilation:
The mechanical ventilation is required by the French regulation. But the indoor air quality will depend on the occupation, type of activity and client's budget. The specification of this action will be "medium" in residential houses since the ventilation system will guarantee a CO_2 level of 800 ppm (ppm: parts per million) and "high" in offices with a CO_2 level of 600 ppm.

Action 2.22: Renewable energy – photovoltaics:
As per the new French environmental regulation, a percentage of renewable energy is specified. So, after doing a market benchmark, photovoltaic panels are the best source of on-site renewable energy due to their cost/efficiency ratio. The energetic efficiency of using photovoltaic panels with a heat pump to produce hot water is higher than using solar thermal panels. Leasing option is quite known in France through investors and can motivate the client to install renewable energy with a low capital cost. So, the specification of this action will be "high" with a 25-30 years of warranty and 10-15 years for inverters.

Action 2.17: Natural ventilation:
In residential apartments, this action will be partially used due to local regulations to extract air through mechanical systems all over the year. So, natural fresh-air systems will be used through trickle vents installed on window blocks. In offices, the ventilation system will be totally motorized using mechanical fans. So, the specifications of this action will be "low" for offices and "medium" for residential buildings with respect to the percentage of natural ventilation.

Action 2.07: Improve daylight factor:
Action 2.02 and 2.07 are strongly related and indicate a medium specification with a daylight factor of 3 % in all rooms.

Action 2.04: Optimize insulation:
Action 2.02, 2.04 and 2.07 will define the envelop performance of the building. To achieve an nZEB and limit heat losses, an efficient wall, roof and floor insulations are required. The specifications of this action will be "qualitative" to reduce the combustible mass of facades due to fire regulations and "highly quantitative" with a super high envelop efficiency.

Action 2.05: Efficient space design:
This nZEB district consists of offices, commercial stores, markets and residential buildings. So, an efficient space design will maximize the usable and living areas by defining the usage of areas as per window location and orientation. The specifications of this action are "medium" since we're locating the working places near windows to optimize the daylight usage.

Action 2.19: Thermally Activated Building Elements:
Due to the high envelop performance and the small temperature difference between floor and room, floor heating[11] will be an efficient solution. The specifications will be "low".

Action 2.20: Heat pump:
If district heating is not available, a geothermal/ aerothermal heat pump will be the best option for space heating and domestic hot water production. It will be alimented by photovoltaic panels with a coefficient of performance equal to 3. The specifications of this action will be "high" since we have an efficient envelop. The heating demand will be less than 30 kWh/m^2_{GFA} and the flow temperature equal to 35°C.

Action 2.15: Energy performance calculation:
Thermal dynamic simulations will be necessary in this project in order to calculate the overall energy consumption and try to compensate it with the on-site renewable energy production in order to achieve an nZEB performance. The specification of this action will be "high".
Once this action is confirmed, we'll be allowed to move to the "authorization" planning phase.

Action 2.26: Apply for funding:
There are a lot of funding schemes and grants in France to encourage renewable energy, green roofs and eco/social-friendly construction. So, searching for funds in this early stage will help us to benchmark and apply for most of them. The specification of this action will be "high". Once the concept and authorization planning are finalized, we'll be able to move to the detailed planning and design.

Action 2.11: Efficient use of materials:
Carbon footprint is an important criteria during the detailed design phase due to the new French regulation RE2020. The specification of this action will be "medium" since reduction of used material

[11] Although not properly part of this category, underfloor heating was included in TABS.

will be less than 10 % compared to baseline building.

Action 2.10: Construction details – heat bridges:
Heat bridges will be taken into consideration before thermal dynamic simulations. Thermal bridges will be reduced between roof/façade corners, floor/ceiling level, window/structural openings and ground floor/façade corners. The specification will be "medium" since the study will be based on a known standardized standard.

Action 2.09: Plug loads and internal gains:
The percentage of occupancy and internal gains will affect the residential and office heating demand. The yearly activity profile of the building will be taken into consideration during thermal simulations in order to optimize the energy production. The specifications will be "medium" since default values will be used for internal loads.

Action 2.08: Domestic hot water:
This action will be achieved before the thermal dynamic simulation. We can't strongly act and optimize this system since it's already defined in the French regulation with a value of 45 l/day/person. Using a heat pump as a production source will help to minimize the primary energy consumption. The specifications will be "medium" with a yearly consumption between 500 and 700 kWh/person.

Action 2.24: Storage facilities:
Nowadays electrical storage is quite complicated and expensive in France as per capital and operational costs. Thermal storage will be more efficient to store the excess of the photovoltaic electricity into tanks using heat pumps. This stored thermal energy will aliment the apartments during peak hours. It could be a storage on a district or a building level. The specifications of this action will be high since we'll be using 0.6 kWh/m^2_{GFA} of thermal storage no electrical storage planned.).

Action 2.25: Energy flexibility – demand response:
Energy management system is very essential on a district level since we can optimize the energy consumption, distribution and storage with respect to the energy production in order to achieve nZEB goals.
This flexibility is very important to balance between the different typologies of building. The specification of this action is "high".

4.3.2. DISCUSSION

Phase of implementation

The test of this methodology implementation is only for political and urban planning phases and the planning phase. The project is currently starting a first round of decision and studies. The client was very interested in the batch of questions and general analysis of his project. The fact that the methodology is well documented and clearly followed gives us a very professional image from our company to manage those energy targets and decisions. Even if some KPIs are not defined yet by the client, he knows that this should be clarified as soon as possible.
He was very interested to apply later on the nZEB process tool to optimize the next steps like planning, construction and even operation phases.

Boundaries of application

We decided to disregard some actions listed on the process chart. The reasons to unselect those actions are stated as follows:

Action 1.06: Development and implementation of strategies for awareness raising:
Since Bouygues is playing the role of developer, planner and construction company, communication for environmental awareness (energy and CO_2 emissions) is already included in Bouygues processes. All other stakeholders will be consulted after the preliminary results of the above actions.

Action 1.02: Regional efficiency improvement targets supporting nZEB:
Currently, the municipality and the "Métropole de Lille" did not introduce any target supporting nZEB other than the future French energy regulation RE2020.

Action 1.04: Urban master planning allowing highly compact buildings:
Due to the current master plan and massing design adapted for suburban areas, a compactness ratio cannot reach an efficient value. Another constraint due to urban farming and green roofs, limits the height of the building and therefore their compactness.

Action 1.08: Definition of integrative design team:
The current stage of design does not require an integrated design team since some major choices have not been taken. So, the constitution of this team will be postponed until the availability of results.

Action 1.17: Consideration of seasonal storage on district level:
Seasonal storage on district level could be considered at a later stage if the district heating network is not available and the feasibility study of thermal micro-grid is validated.

Action 1.10: Work with urban microclimate:
The project is located in a suburban area, and therefore heat island effect is not a major issue. In addition, the main goal of this project is to increase green areas that will enhance the microclimate conditions.

Action 1.12: Optimize building orientation and zoning:
The architect did not adopt this action.

Action 2.21: Renewable energy – solar thermal systems:
Solar thermal systems are not selected due to their high investment and maintenance costs. The usage will be only to produce hot water.

Action 2.23: Cooling strategy:
It will not be applied in this project due to its location in the north of France.

Action 2.01: Optimize building envelope (compactness and insulation):
The compactness of building envelope is not considered as a criterion in this project. The client prefers to stick to the architectural concept without optimizing the south façade area with respect to the building volume.

Action 2.14: Accession of thermal mass:
It's not adopted in this project.

If a similar methodology is already integrated in the standard workflow, which are the main differences between the two methodologies?
Currently the workflow does not integrate a specific energy strategy methodology. The only existing guidance are based on the application of the French thermal French regulation (RE 2020). The client experienced this new methodology in a very participative way. Even local authorities were interested in this approach as they knew all the questions and the studies to be sorted out but not the proper timing to answer to them. The impact and order of magnitude mentioned in the information data sheet of each action was considered as very helpful to prioritize decisions and actions to be undertaken.

Goals from the application of the methodology
The main goals of this application is to reduce cost and time due to wrong or late decisions in order to achieve nZEB target. On the other hand, it will list all to do actions in order to be integrated smoothly in the company's processes. Our goal is to implement this methodology during the whole process life of the project.

Difficulties and critical points of the implemented features
The main difficulty was the language and some technical expressions since some local stakeholders do not understand English. The fact that the tool was online and not downloadable is an issue for project tracking and changes follow-up. The person in charge of managing this nZEB processes is also requiring some hyperlink to documentation of the decision and reports of each action.
A missing part of energy connection and relationship between mobility and buildings could be added for further improvement.

Advantages of the applied methodology
- Applicable in Europe, well defined and detailed.
- It gives a holistic approach in a structured manner.
- It helps the client to take the right decisions in the right time. The documentation for each action is well understood and not too long to read.

Disadvantages of the applied methodology
It should be related to other construction subjects (circular economy, eco design...) and not only energy. Generally speaking, energy is only a part of a complete development and construction project. Other aspects like citizen involvement, mobility, biodiversity, digitalization and resilience are also interacting with energy topics.

How easy is the methodology to be implemented in the normal workflow?
It is not business as usual and needs extra effort of explanation to apply the methodology properly. Client and local authorities are to be induced in this process and trained.
The methodology is quite similar to some environmental certification schemes like LEED, BREEAM, HQE, DGNB.

Target/s achieved
The target of going through all the question was achieved and a list was retained of selected items customized for this specific project. This list clearly

defines the strategy to be followed to match the constraints of this development.

How satisfied are you with the results obtained
The client is now convinced of the benefit of this approach and wants to apply it on the coming phases of his project, which are the detailed urban planning phase and also planning/design of the construction. Thanks to the robust sequence of processes there is no action left aside and each of them is well detailed and explained by examples, advantages and inconvenient.

Lessons learnt
Several actions were taken into account at a very early stage compared to the existing business development in order to proceed in a very structured and clear process. The client still needs to be educated on the applied process and it takes more time than the common approach. This needs to be taken into account in resources for accompanying the client.

Which part of the CRAVEzero methodology will be further implemented within the company?
As the phases of the project were at an early stage, the rest of the CRAVEzero tools couldn't be used. For the coming phases of this project, all methodologies will be applied through different phases since Bouygues is involved in the whole development and construction process as a global player on the whole life cycle of a building.

Upcoming projects

Table 19. Upcoming nZEB projects – Bouygues.

	Project	Location	Building use/ Typology	Size	Client
1	Les Tanneries	Dijon	Residential, Hotel, Elderly House	26,000 m² of residential private and social 6,000 m² hotel	Private and public
2	Les Fabriques	Marseille	Residential, offices, commercial, hotel, public realm, apparthotel	250,000 m² of mix-used buildings	Private and public
3	La chocolaterie à Noisiel	Ile de France	Housing, convention and business center, museum of chocolate.	160,000 m² of mix-used buildings	Private and public
4	O'Mathurins	Ile de France	Housing and offices	85,000 m² dwellings 100,000 m² office buildings	Private
5	Quartier Flaubert	Rouen	Housing, kindergarten, elderly housing and offices	16,500 m² office buildings 300 dwellings	Private

5. ÖN – SKANSKA

5.1. GENERAL DESCRIPTION

Brief description / main features: Skanska aspires to go beyond regulation's compliance and to push toward future-proof Deep Green NetZEB buildings – buildings intended to accommodate future environmental demands and conditions. The proposed project, named "Ön", is a 7,000 m² residential building. It is planned to be a well-insulated and airtight structure, with balanced ventilation with heat recovery, ground source heat pump, waste water heat exchanger and photovoltaic panels.

Energy concept: NetZEB standard. The strategy focuses on passive, active, and renewable design solutions, which results in sustainable robust buildings with minimal environmental impact.

Table 20: General project information of Skanska's case study

General project information	
Project name	Ön
Location	Umeå, Sweden
Planning team	Nya Hem Riks, Skanska Residential Development Nordic
Architect	Winroth architects
Building owner	Housing cooperative
Net floor area	7,000 m²
Construction date	2021
Building typology	Residential, housing cooperative owned
Current status	Pre-study, preliminary design

5.2. GOALS DEFINITION

Main goals and the priorities of the design
NetZEB, low CO_2-emissions from construction phase, good comfort and indoor environmental quality, front-runner/demonstration.

Main constrains for the design
No district heating system available on-site and narrow property makes it hard to design buildings with low heat loss shape factor.

Focus on CRAVEzero approach application

- CRAVEzero applied methodologies: process map, life cycle process management tool and workshop regarding co-benefits.
- Is this/these methodology(ies) replacing another one used within your company or is a new one?
  As energy management engineer in Skanska whom manage energy design in preliminary design phase - this is useful new tools.
- Phase of implementation: planning phase, preliminary design.

Figure 24. Ön pre-design stage plan.

Main characteristics of the building

Table 21: Building envelope/structure

Component	Performance	Notes
Wall	U < 0.13 W/m²K	CLT frame focused on lowering heat bridges.
Roof	U < 0.09 W/m²K	Garage below ground with minimum temperature 5 degrees wintertime.
Floor		
Window	U 0.7-0.8 W/m²K (g =0.55)	Window sizes and bright floors are optimized regarding daylight factor, orientation, solar heat gains and heat losses.
Air tightness	0.2-0.3 l/s m² external area	
Shading		Passive external shading and balconies shading larger windows facing south.
Structural elements		CLT frame for low CO_2-emissions
Facade		Double shell facade in form of fully glazed balconies

Figure 25. Ön pre-design 3D rendering.

Table 22: Ön HVAC systems and RES

Heating	Ground source inverter heat pump with a low supply temperature heating system. Control system which optimizes COP according to the nZEB needs from boreholes and storage tanks
DHW	Ground source heat pump with hot water storage tanks. Energy efficient taps and shower heads will be installed instead of bathtubs.
Ventilation	Balanced ventilation with low SFP: 1.4-1.5 kW/m³/s air. Using the return air of the flats to heat garage and also store heat in garage's concrete frame. Effective kitchen volume hoods reducing need of high return air ventilation flows in kitchen. Air supply in floors blowing on convector heating units with low supply temperature.
Heat recovery	Ventilation HRV-unit with flat plate heat exchanger with temperature efficiency of 83-85 %. Waste water heat exchanger pre-heating cold water for DHW production and recovering >15 % of energy from DHW.
Cooling	Geo-HRV-solution used in summer by cooling supply air with geothermal boreholes.
RES	Photovoltaic panels covering all roof parts facing east, south and west. Some of the south facing facades will also be covered with PV. Minimizing shading of PV by designing roof with hoods, chimneys and roof hatches placed at north side of the roof area. PV will both be integrated into the facade materials and also used as passive solar shading above windows.

Targeted performances
NetZEB and Skanska Deep Green. The project is also aiming for Skanska Sweden's own definition of "Climate Neutral Building".

Selected business model(s)
Business model of Ön - "CONSTRUCTION & PROJECT DEVELOPMENT COMPANYpdc".

Selected reference case
A residential project in Umeå, where building performance are compliant with laws, regulations, codes and standards in Sweden and Umeå.

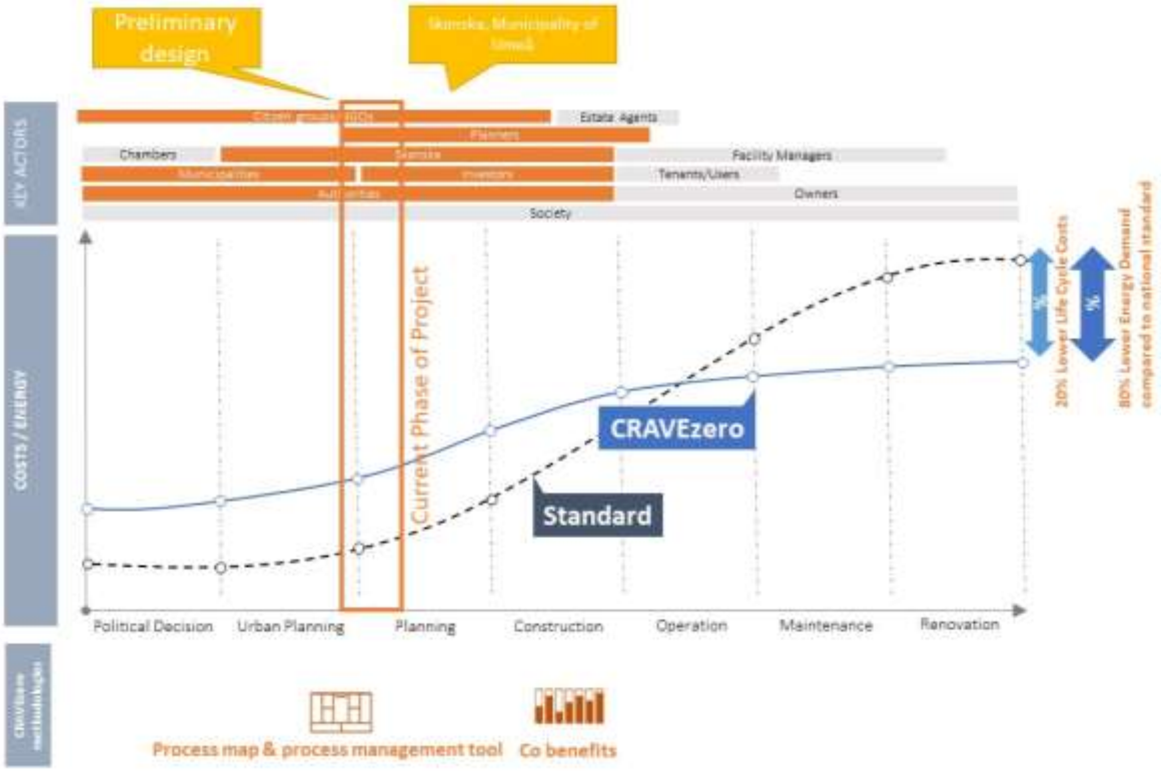
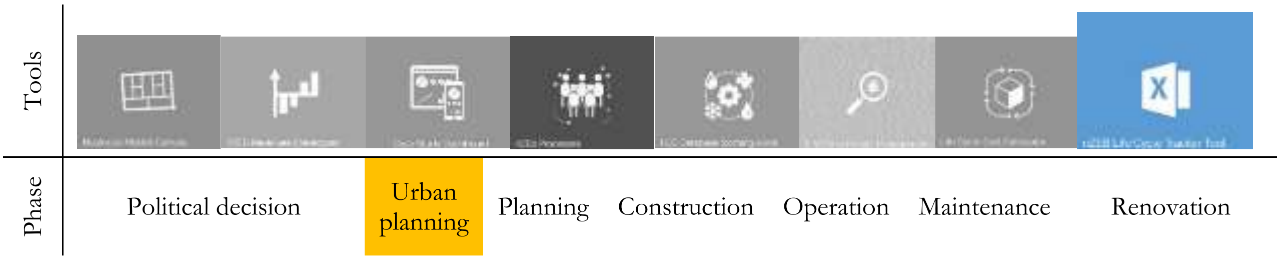


Figure 26. Graphical representation of the prototypical implementation most relevant features – Skanska.

5.3. PROTOTYPICAL IMPLEMENTATION OF SKANSKA PROJECT



5.3.1. DOCUMENTATION: PREDESIGN AND PROCESSES ANALYSIS

Skanska's green vision, strategy and goals

Skanska's near zero energy building commitment relates to the long-term environmental performance of buildings delivered by Skanska's construction and development projects. In keeping up with the Skanska *Care for Life value*, Skanska promotes green solutions and seeks to conduct operations in green ways. Another part of the strategy is significantly reducing Skanska's carbon emissions footprint by 2030, in line with the Paris international climate agreement. Skanska uses Green Key Indicators to measure green performance. These cover three areas: increasing the level of green business; management support and training employees on green subjects; and supporting teams to deliver projects with improved green profiles. As defined in the *Skanska Color Palette* shown in Figure 27, Green refers to when construction processes and/or building and infrastructure performance are beyond compliance, but do not have a near-zero environmental impact.

Skanska Color Palette

Through Skanska's Journey to Deep Green, Skanska goes far beyond compliance. Every Skanska project benefits from the Color Palette. Since 2009, the Skanska Color Palette has defined Skanska's vision of Green and Deep Green projects according to four priority areas: energy, carbon, materials and water. The Skanska Color Palette sets the strategic green direction for projects and is used to define goals and develop action plans, driving continuous improvement.

Figure 27. Skanska Color Palette.

The Color Palette rates the performance of projects across resource efficiency: energy, carbon, materials and water. On the Color Palette regarding energy performance, the Vanilla zone is the starting point, where energy performance is compliant with laws, regulations, codes and standards. In the Green zone, projects are beyond compliance, but do not have a net-zero energy performance. In the Deep Green zone, they have a net-zero primary energy performance. This includes the total energy balance for the building, i.e. heating, DHW, cooling, operational electricity and generated renewable energy onsite and offsite.

A Deep Green project is a way of working, a methodology, rather than a certification model. The process described in this report therefore largely follows a regular project process as it appears in

Skanska's ordinary workflow. Energy and climate measures are at the top of the environmental agenda among Skanska's customers. A Deep Green project may therefore provide market benefits in a bidding process or in a zoning process. Skanska claims that energy efficient and climate smart buildings create the conditions for lower operating costs as well as increased attractiveness resulting in higher property value. Through trust, transparency and increased internal cooperation between different units, Skanska fulfills the customer's goals and continues to develop and maintain the position as leader in sustainable construction in Sweden. The Deep Green NetZEB projects go first and are pioneers in their overall thinking and requirement levels, being part of Skanska's business with a normal profit demand, and not treated as single demonstration projects.

Many tenders in Sweden contain high sustainability goals. The requirements to be fulfilled are increasingly aiming at Deep Green NetZEB level. Both, companies and municipalities, have begun to sharpen their sustainability goals, which in many cases match targets in the Color Palette. A relevant co-benefit regarding systematic approach and development of Deep Green NetZEB buildings is the positive image the company sets up and which helps to win more projects.

The proposed project "Ön" has a dedicated team which is responsible for the operative Deep Green planning. In the preliminary design stage, Ön's business- and project developers are the main stakeholders but also project leaders of the Skanska construction division are involved, providing through the Sustainable Business Development division different types of support about both environmental and energy issues. A "Deep Green Portal" on Skanska's intranet has been set up, where employees and support divisions can find tools and process information regarding the Deep Green goals and overall process (Figure 28). This report focuses on the preliminary design phases, idea and feasibility study phase.

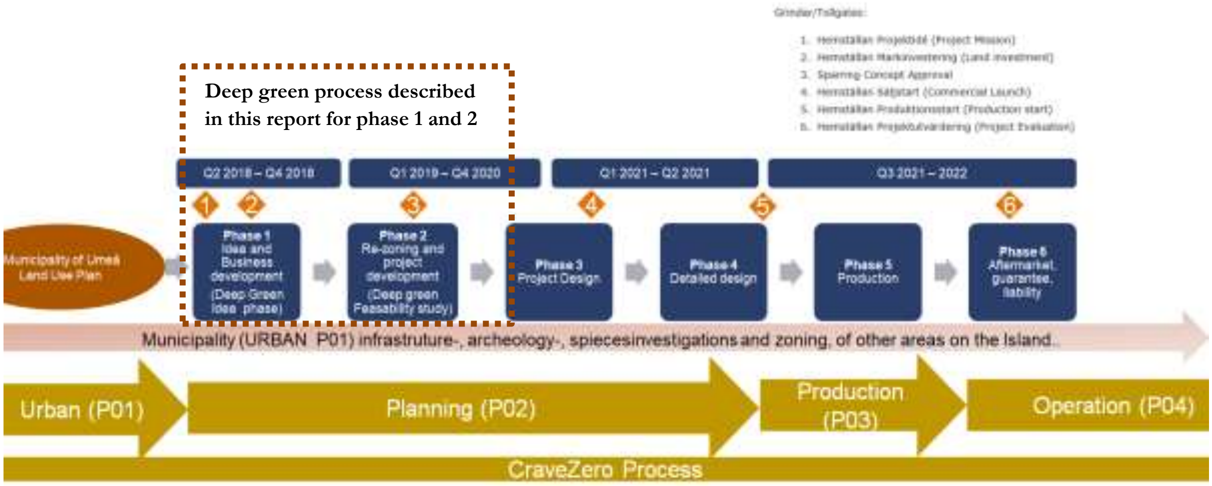


Figure 28. Process of Ön project in Umeå.

Phase 1 - Idea phase

In the initial phase of the Deep Green projects, the focus is on green solutions, ideas and design. Including energy and climate as top priority at this phase, creates the right conditions and framework for concepts and design of a Deep Green NetZEB. Skanska Sweden has developed different Deep Green tools for project teams to be implemented at this stage, *Deep green sales leaflets, Deep green process information sheet, The Color Palette for residential buildings* and a *Deep Green mini pre study template.* Skanska uses reference projects and study visits in this phase to inspire project teams who are interested in reaching Deep Green and Skanska always tries to employ some people with experience from Deep Green projects in new projects with high ambitions.

Many similarities with the CRAVEzero methodology can be found in this phase, regarding different proposed actions such as action 2.02 "Optimize building envelope", 2.03 "Improve window to wall ratio"," and 2.08 "Improve Daylight factor". In fact, a prerequisite for meeting the criteria according to Skanska's definition of Deep Green is early cooperation with an energy specialist. This implicated that during the first phase the roofing design, roof tilting to optimize PV production is analyzed. Another topic which is important at this phase is solar shading and window position taking into account solar gains and daylight.

During the idea phase Skanska's sustainable business development division can support project teams with general Deep Green topics, for example:

- Deep Green Insight Sales
- Deep Green workshops
- Internal and external communication
- Sales leaflets and reference sheets / reference documents
- Finding and evaluating new green innovations
- Packaging Green Solutions

The Deep Green mini pre-study is often carried out at phase 1, before the architect has made the first concept design drawings and corresponds to the process "basic evaluation owner" referencing to the CRAVEzero process map (Figure 29).

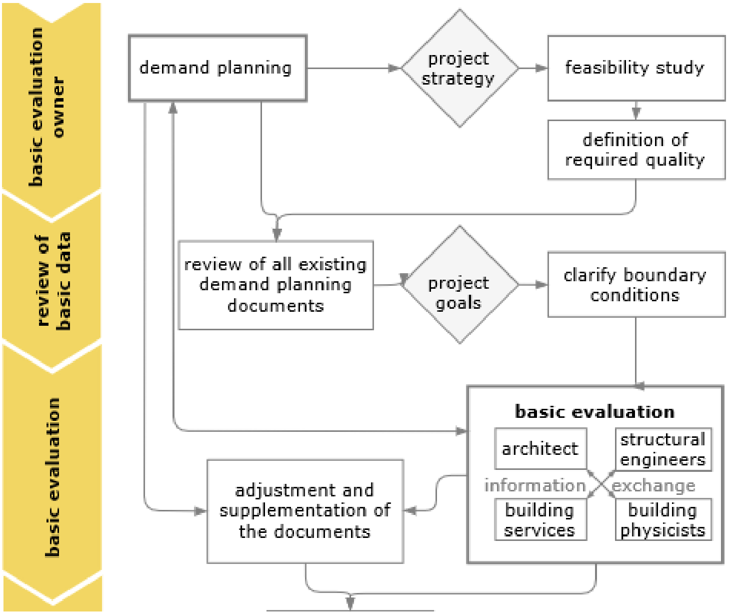


Figure 29. Part of CRAVEzero planning process equivalent to Skanska's Phase: Idea phase.

The mini pre-study analysis and simulation methodology is based on specific energy performance simulations with an IDA-ICE[12] model of an earlier built, similar Skanska reference project. In the case of Ön, the reference project is the apartment building *Solterassen* in Umeå. The mini pre study consists of approximately 30-40 hours of work for a Skanska Technology energy specialist and the purpose of the mini pre study is to give the business developer and project developer a good decision basis to go further in the planning process of the Skanska Deep Green NetZEB but is also used to provide energy-related information before the architect starts sketching.
The mini pre-study consists of different steps. First, a short technical description and the energy requirements of reference building are presented. The reference building should preferably be a building that the team has experience of, with known cost structure. The building must correspond to a building that meets current laws and regulations. The reference building's energy performance and placement in Skanska's Color Palette is presented. After this, a passive house design approach is implemented to the reference building with purpose of minimizing heating and cooling demand. Actions to reduce heat loss form factor and window to wall ratio are considered. Measures regarding building envelope and minimization of the building envelope heat transfer loss are adopted. When the passive house design approach has been implemented, HVAC and active design measures are used with purpose to further minimize energy demand, often with extra focus on reducing electricity and DHW consumption. Measures with free cooling from air, ground and different kind of energy recovery systems from exhaust air or waste water are proposed. All measures are simulated and quantified in the IDA ICE model of the reference building. Finally, renewable energy production measures are proposed to reach NetZEB standard. From

[12] IDA Indoor Climate and Energy (IDA ICE): whole-year detailed and dynamic multi-zone simulation application for study of thermal indoor climate as well as the energy consumption of the entire building.

Skanska's point of view, this methodology corresponds with many steps found in the overall CRAVEzero methodology. But much more detailed actions can be found in the tools CRAVEzero Process Tracker, Process map and Life Cycle management tool.

All improvement measures for the specific project and the journey from a reference building to a Deep Green building are illustrated through a line of energy efficient measures from "vanilla" to "Deep Green" in Skanska's Color Palette. A rough estimate of the resulting investment cost and energy savings potential of proposed measures to go from energy performance of the reference building to Deep Green energy performance is presented with the payback period. In an in-depth Deep Green pre study, which may be carried out in the feasibility study phase, life cycle cost studies and effects on higher property value may also be carried out and analyzed with regards to alternative solutions.

Figure 30. Focus pyramid in preliminary design of Skanska Deep Green NetZEB projects.

Phase 2 - Feasibility study phase

Once completed the feasibility study phase, clear targets and measures for Deep Green can be achieved. This part of Skanska's Deep Green process is aligned on many points with the CRAVEzero process. The energy framework contains an early estimate carried out by an energy specialist, including proposals for green technology solutions such as renewable energy, energy efficient ventilation, insulation etc. It also includes a plan for energy monitoring and verification of energy performance. A design is selected based on the feasibility study and the early solutions are then implemented into the system design stage. Involved at this stage could be architects, HVAC/ installation coordinators, energy specialists, structural engineers and key persons from Skanska's Deep Green central support team. The Skanska feasibility study stage corresponds well to the CRAVEzero process map "Development of a basic building structure in variants", see Figure 31.

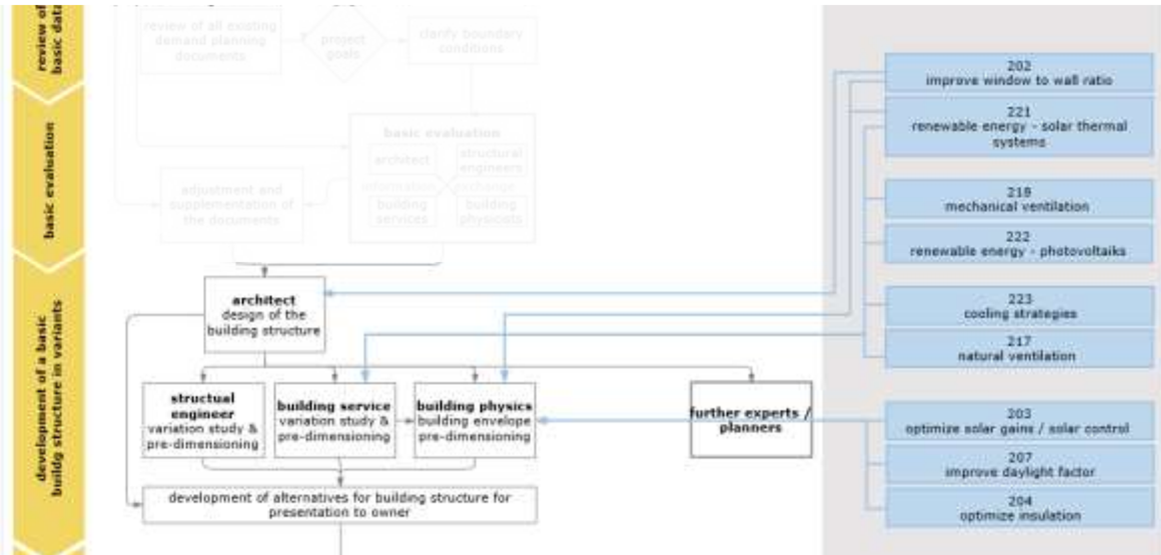


Figure 31. Part of CRAVEzero process map equivalent to Skanska's feasibility study phase.

To ensure goal achievement for the entire Deep Green approach a *"Deep Green target document"* is prepared for each project with Deep Green aspirations. The target document is used as a basis if there is a tender calculation and is used as a guideline in the planning phase. The document is also used as a tool during calculation stage or when communicating with external parties and is based on a simpler analysis and positioning of all environmental areas in the Skanska Color Palette.

It is recommended that energy specialists from Skanska's own internal consultant department Skanska Technology get involved early through an energy framework and continue to be involved as an energy coordinator throughout the whole planning phase. This is also something that is described in the CRAVEzero methodology and CRAVEzero process map (the energy specialist is named *building physicist)*. Skanska also recommends that the energy specialist is involved during construction phase and commissioning and becomes the resource that monitors the energy measurement accuracy after the final inspection of the building and final commissioning. Skanska Technology also has a *Solar support team* which can provide support about possible solar energy solutions during the feasibility phase. Skanska's sustainable business development division can help with a so called Deep Green review and formulation of target documents. Green business partners, supported by Skanska's central Deep Green support team, guide and help the project to coordinate the Deep Green process at this early stage.

The central green support team helps with the development of project ideas and gives views on proposed design based on the Deep Green matters. If a tender competition material is produced, either green business partners or someone in the central green support team is involved to include suggestions on Deep Green goals and measures in the tender proposal. It is also recommended to include a business partner when meeting with an architect, and if an energy specialist is appointed, he or she can advantageously be included in this meeting.

Green business partners provide support for the application for in-depth pre studies of Deep Green buildings within Skanska Sweden's *Green Concept Lab internal green subsidy fund*. If the application is granted internally, the local business partner can assist with contact and description of the assignment to Skanska Technology's Energy Specialist group who can perform an in-depth pre study. This in-depth pre study is based on the same concept as the mini pre study, but with the preliminary architectural design documents as a basis. The in-depth pre study is often performed with use of an IDA ICE Energy model of the building.

Skanska has developed different tools and materials for project teams to use at the feasibility design phase: *Information leaflets regarding solar PV, "Think before" - Solar PV information leaflet, Deep Green guidelines for buildings - the preliminary design phase, Standardized system solutions presentation.*

An in-depth Deep Green pre study is ongoing at project Ön. In the pre study different strategies are investigated with focus on both passive design measures or active design measures and installations.

CRAVEzero Life Cycle Management Tool and CRAVEzero Process Tracker at Project Ön

The CRAVEzero life cycle management tool is a web-based tool that provides a cost-efficient, economical approach to the planning and implementation of nZEBs. The life cycle management complements the Skanska Deep Green pre study templates very well, giving new insights. In project Ön the tool has ensured that the project developer, energy specialist and architect have considered all important parameters in the preliminary design stage of the project.

In this project some actions that can be found in the *CRAVEzero Process Tracker and Life cycle management tool* correspond well with actions that have been analyzed in Skanska's Deep Green process and pre studies. Examples of important actions that can be found in the CRAVEzero methodology that will be carried out in the design of Ön are: action 2.01 - Thermal comfort, action 2.02 - Optimize building envelope, action 2.03 - Improve Window to wall ratio, action 2.04 - Optimize insulation, action 2.09 - Energy performance calculation, action 2.12 - Solar thermal systems, action 2.13 - Photovoltaics, action 2.14 - Mechanical ventilation, action 2.15 - Domestic hot water, action 2.16 - Plug loads and internal gains, action 2.18 - Heat bridges, action 2.19 - Air tightness, action 2.23 - Energy recovery systems, action 2.14 - Heat pumps (For in depth description of the actions, see CRAVEzero deliverable D3.1).

Even if many of the proposed actions are already considered in the Skanska pre-study methodology, the CRAVEzero life cycle management tool helps project developer or energy engineer to plan different actions in an efficient way and it also works as an information-checklist regarding different

NetZEB actions at preliminary design stage of a building. The Process Tracker also displays different dependencies between actions, which helps to prepare questions and plan meetings minimizing conflicting objectives between different chosen actions and speeding up processes.

Actions that have been chosen in the preliminary design stage of project Ön and analyzed based on the CRAVEzero methodology are: action 2.05 and 2.07, Efficient space design and Optimize solar gains / solar control.

Action 2.05 - Efficient space design

In the life cycle management tool, start date and deadlines for your chosen actions can be specified. The definition of quantative or qualitative targets can be specified as well.

Figure 32. Defining the characteristics of Action 5 in CRAVEzero process management tool.

The qualitative target of action 2.05 in the project of Ön is to have a clear strategy of the space design considering energy relevant zoning of the building. Having this qualitative target, the architect has designed the spacing based on three types of "climate zones", see Figure 33.

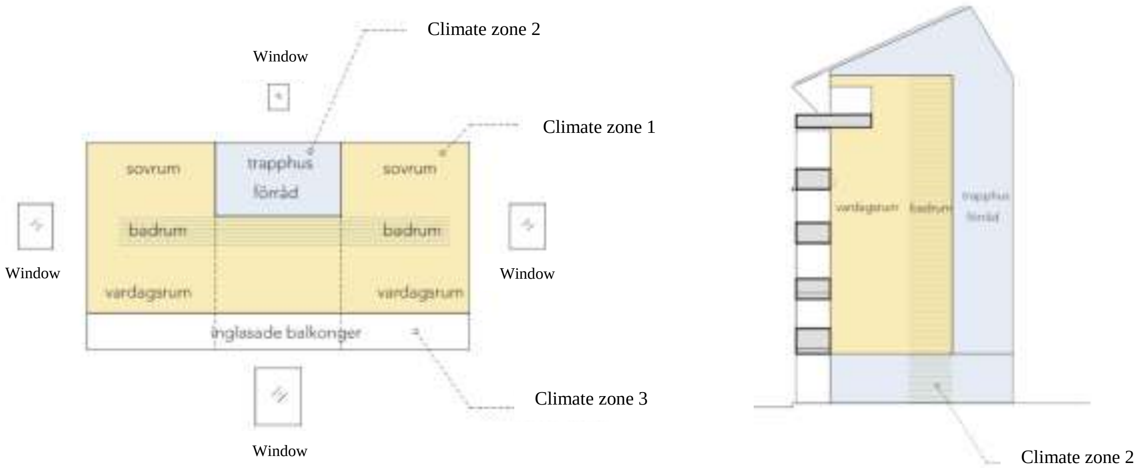


Figure 33. Efficient space design and optimization of solar heat gains of a floorplan in Ön project.

<u>Climate zone 1</u>: Tenant living areas with good thermal comfort and indoor temperatures ranging between 20-23°C. Larger windows facing south resulting in good daylight factor despite shading facade-covered glazed balconies.

<u>Climate zone 2</u>: Property-related zones with stairs, elevators and storages with smaller window sizing, lower indoor temperatures <17°C due to low degree of tenant presence.

<u>Climate zone 3</u>: Semi air tight glazed balconies which work as a double shell facade and solar collector in wintertime and passive solar shading in summer when sliding glazing elements are opened. The glazed balconies are creating a microclimate and extend the summer period.

Action 2.07 - Optimize Solar Gains / Solar control

Figure 34. Defining the characteristics of Action 7 in CRAVEzero process management tool.

The qualitative target of action 7 in the project of Ön is to design a building which needs low amount of energy for heating in a sunny winter day and no cooling load on a sunny summer day. Setting this qualitative target, the architect has designed the buildings, balconies and window design as described in Figure 33 and Figure 35. When designing roofs and facades, factors such as maximization of solar PV production and creating eye-catching architectural design have been taken into consideration.

Figure 35. Solar heat gain design of project Ön, Umeå.

The orientation of the buildings has been optimized taking into account maximization of solar lighting into climate zone 1 and 3 during winter. The window sizing is designed to catch as much sun as possible during winter and the opened glazed balconies work as passive solar shading during summer. Daylight optimized smaller window sizes are proposed to the north, lowering U_m-value without compromising loss of solar heat gain. The design is making a good balance between passive heating and cooling measures over the year relative to the conditions given at the site regarding solar access in the urban layout.

5.3.2. DISCUSSION

The CRAVEzero methodology and the process tools have a wide span of application and address many stakeholders in the process of designing and building a nZEB. The tools developed could serve many purposes of Skanska's approach, like being adopted as one of many sources for Skanska green development division to refine and create new tools and information leaflets regarding designing and construction of energy efficient Deep Green NetZEBs. The process tools can also be used directly in specific Skanska projects to find inspiration and a better understanding about important tasks and dependencies between the different NetZEB actions.

The Skanska Color Palette sets the strategic green direction for internal projects and is used to define goals and develop action plans, driving continuous improvement regarding energy and environmental performance. The CRAVEzero methodology has a similar purpose but goes much deeper and tries to explain the complex processes, dependencies between stakeholders and different actions that could be made to reach the nZEB goals. The pros related to the CRAVEzero methodology are that it is very informative and addresses all nZEB stakeholders. However, because of the unique conditions in each country, region and/or municipality regarding legislation, rules, and authorizations, it is impossible to develop a general tool that works 100 % in all regions/countries for all stakeholders. On the other hand, the methodology helpful when forming country- or company-specific methods.

Another difficulty is that every stakeholder has its own unique goals and tasks, and it is hard to develop a universal tool that fits perfect for all stakeholders in all different phases of a nZEB.
The advantage of the CRAVEzero methodology and the process tools is that involved stakeholders get a very good overview of all actions and dependencies that affects a nZEB-project through the whole life cycle. If every stakeholder has a better insight of other tasks and actions, it creates a common understanding and in the long run less misunderstandings and risk for double work. Regarding this specific issue the CRAVEzero methodology and the process tools give good insights and valuable inputs. Most of the CRAVEzero tools and the methodology could easily be reshaped to fit unique conditions in different countries, regions and corporations. A big effort was done, and with just some adjustments the tools could be very pedagogical and well-functioning in different kinds of organizations and companies around Europe.

It is not possible to replace entire parts of Skanska's Deep Green processes with parts of the CRAVEzero methodology, but there are many things to learn from the CRAVEzero methodology and many things that could be found in the methodology that Skanska could use to improve action plans and tools regarding nZEB processes and design. Many of the developed tools give inspiration and new insights that may lead to new methods and actions that will be incorporated into Skanska's drive towards building more nZEBs and Deep Green buildings.

Regarding the implementation of the process management tool in project Ön it worked very well. By using the tool and explaining action 2.05 and 2.07 and the goals to the architect in the feasibility study design phase, considering the conditions at the site, the project Ön has obtained an efficient space design and optimized solar gains which may not have had without the integration of CRAVEzero process tools.

Upcoming projects

Table 23. Upcoming nZEB projects – Skanska.

		Project	Building use/Typology		Area [m²]
Under construction	1	Gottorps hage, Etapp 1	Residential project development	Single family houses	
	2	Solträket och Havsbrynet		Apartment buildings	14,894
	3	Sjömarkenskolan idrottshall		Other	796
	4	Villa Kviberg	Commercial Development	Retirement home	5,406
	5	Tolered	Residential project development	Apartment buildings	
	6	Maltren	Commercial Development	Retirement home	3,618
	7	Östermalm	Commercial Development	Office building	3,500
Design phase	8	Skärgårdskyrka	Commercial Development	Retirement home	
	9	Överbyggnaden E45	Commercial Development	Office building	
	10	Fader Berström	Residential project development		
	11	Villabacken etapp 2	Residential project development		
	12	Bunkeflo etapp 2	Residential project development	Apartment buildings	
	13	Hjärup Västerstad	Residential project development	Apartment buildings	
	14	Ön	Residential project development	Apartment buildings	7,000
	15	Äppelgården	Commercial Development	Retirement home	5,100
	16	Borstahusen	Residential project development	Single family houses	5,200
	17	Täbz park	Residential project development	Apartment buildings	13,000
	18	Rotorfabriken	Residential project development	Apartment buildings	

6. CONCLUSIONS

Life cycle costing

The case study presented by ATP demonstrates one of the main functions of the life cycle costing implementation underlined within the CRAVEzero project: the variants appraisal function.

In fact, in this specific implementation the company had to select the most cost-efficient solution between two mutually replaceable nZEB design alternatives which present different energy performances and investment costs. In this way LCC analysis is a tool which supports the decision making process, undertaking financial options evaluation.

The intrinsic flexibility of this approach is proven in that the variants evaluation can be performed analyzing relevant elements only, as shown in ATP implementation. This characteristic eases the methodology integration in the company/ planner/ designer workflow who often struggles with time constraints and thus can be stopped by the input effort required by a complete LCC analysis.

Furthermore, analyzing the variants single elements, it is possible to evaluate them in terms of extra-costs generated. For instance, in this specific project the calculation showed that the additional investment for the passive house standard pays off after about 37 years only.

Business model analysis

Köhler & Meinzer's BM was developed after a deep analysis devoted to nZEB technology-sets optimization. Findings derived from the experience (i.a. the extreme relevance of user behavior, the need to concentrate subsidies on energetic improvement of existing buildings, the important role played by DHW and electricity) have been translated and integrated into this new BM.

Furthermore, as underlined several times, to make nZEB investments cost-effective and profitable, ultimately appealing for the market, it is key creating win-win situations for the involved stakeholders. In this case the client is directly involved in energy issues, moving away from a "consumer" perspective towards a "prosumer" one, where the client itself is the producer of energy. Furthermore, where on the one side national requirements and regulations are met, on the other side the client receives an added value on the real estate market. All these elements together showcase how it is possible to develop a comprehensive nZEB proposal which can tackle the present market challenges.

Process analysis

In deliverable D7.2 a first implementation of the process analysis was illustrated. In that case CRAVEzero process map was integrated as a support for the company's own process map, as the cost-efficient achievement of nZEB standard requires a dedicated approach (actions and tasks).

In this second part of the prototypical implementation (D7.3), Bouygues confirms the key role of nZEB processes analysis by implementing CRAVEzero process map in the urban planning and planning phase of an nZEB life cycle. The company attests the general applicability of the methodology since it goes beyond country specific regulations. In a moment where there is a growing but also required attention towards nearly zero-energy buildings, this methodology provides a structured and clear process to achieve nZEB targets. On the one hand, this process gives support with the challenges of nZEB design; on the other hand, it helps the company to give the client a clear vision of the nZEB pursued targets.

In Skanska implementation a further application of process analysis methodology was carried out, focusing on the pre-design stage of a project. It is clear that having a well-organized and transparent process and defining relevant actions in the first step is key for achieving cost-efficient nZEBs.

The process tools raise awareness and promote a better understanding on important tasks and dependencies between the different nZEB actions. As a result of integrating in a company's workflow this methodology, targets such as optimization of design phase and team members' expertise, a reduced risk, control over costs and energy performance, and the establishment of measurable success criteria can be achieved.

Outlook and upcoming projects

In Table 12, Table 17, Table 19 and Table 23 companies provided a list of the most relevant nZEB projects in their pipeline. The high replicability grade of CRAVEzero methodologies will permit an easy and straightforward implementation in the indicated upcoming projects. In the same way more companies can profit of the developed CRAVEzero methodologies boosting a step forward the market uptake of nZEB buildings.

7. REFERENCES

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8. APPENDIX – FEEDBACKS PINBOARD

The CRAVEzero Pinboard went through a beta-testing phase, where the tools have been tested by the project partners in order to collect feedback for improvements. All the comments and remarks are listed below. Its implementation is planned for the final project phase.

	The Pinboard - General Remarks
1	The pinboard offers a variety of structured process steps and evaluation options.
2	I see a problem with cost calculation tools (LCC): Despite the fact our company can refer to a large reliable cost database of realized objects, we don´t even trust these figures when calculating new projects because of rapidly increasing prices. We are calculating on actual offers. So I won´t rely on a database where I can´t verify the figures.
3	In the first page “CRAVEzero Pinboard” is not clear you have to click. In the landing page I would add a sentence such as “click to continue”
4	The sidebar menu could be adjusted in order to reflect the order of the tools displayed in the landing page
5	When a tool is used, the corresponding tab in the sidebar could be highlighted
6	by clicking on “cost database” the website directs to the page Life Cycle Tracker Free Downloadable Excel tool
7	The pinboard is not adaptive - not suitable for mobile devices
8	"Menu" on the left sidebar should maybe be renamed to "Home"?
9	When the pointer hovers over different clickable menus, the pointer should change into a hand. That is not the case in several cases
10	For each tool: Who is the intended user? This should be stated - easier to understand if the specific tool is suitable for "me"
11	Confusing with different names/namings in the pinboard and menu
12	The icons on the screen and the line in the menu on the left, guide to the same pages. I would leave only the icons and remove the menu on the left. Is useful only the Menu line, I think. Simplify the left menu tab or delete it as it is a repetition of the tiles on the right.
13	Give more easy understanding name for each tile (Case study dashboard Frontrunner Buildings could be replaced by for example: "Solutions used for exemplary nZEB", Life Cycle project Management replaced by "Action plan to manage a nZEB project from start to end".
14	Describe the sequence of tool usage.
15	Reduce size of the "About" tile
16	For the Help" tile, the video is too quick to have time to read the subtitles and to follow the screen evolution (Oral explanation instead of subtitles)
17	Pictos partly still too incomprehensible (example processes - picto persons)
18	Separation of BM Canvas in database (<60) and tool (own BM)
19	Each module could have a concise headline (Benefits of the module) (e.g. Processes: How to implement in your process)
20	(Download Excel or Draw.IO) in a "tool box"?
21	Structure of the pinboard from rough to fine (case studies, BM, processes, tools (toolbox) ...)
22	Would it be interesting to put in all modules the link of the deliverable about that topic? In this way if the user want more information can read directly the deliverable without losing too much time to look for the right one

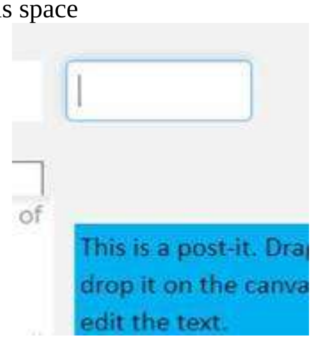
23	Logos can be read very unclearly on the first page and also on following pages - e.g. that of AEE INTEC
24	The subtitle on the initial page, but also some titles of the individual pages reach into the graphics on the right of the initial screens and are not so easy to read at the end
25	The font size and type of the texts under the "Step" headings of the individual tools could be even better matched?

Pinboard Module I: The Business Model Canvas

1	Light gray writing on a white background is difficult for anyone over the age of 50 to read
2	I think it is problematic to describe BM of real existing companies and to name them with Internet address (30. Energy supplier ....)
3	“About” and “Business Model Canvas”: to me it is not clear that are buttons. Since at the beginning and at the end there are already links to the canvas I would remove the link in the tab
4	The title “Step 2” is repeated 2-times
5	The post-it is difficult to be managed: when deleting the text with the mouse it changes position; not possible to remove post-ist
6	Post-its gets stuck in all canvases if I edit one
7	Empty models (6-9, 15, 21-22, 29, 33)
8	Very small box for Customer segment
9	In tha page of BM I would eliminate the voices “About” and “BMC” leaving only the text of the description and the user can access to the BMC using the button at the top
10	When you print is not possible to print only the Canvas?
11	It can be useful to identify in the dropdown menu for every BM the lifecycle phase/phases. And maybe it could be useful to ordinate the BM for phases
12	During the creation of a new BM it can be useful to copy text from other BM in the dropdown menu
13	Rename BM drop list with clear objective description.
14	Classification of each BM again 3 criteria : Better, Faster , Cheaper
15	The phase of project is not shown
16	What is the purpose of the top right empty box?
17	Print out layout not optimized for printing. (Landscape instead of portrait)
18	For new BM a drop list of LC phases could be nice to have.
19	Make the name of the BM even more appropriate - the content or goal of the BM model should be recognizable from the description.
20	Some BMs still describe projects and should be described as general BMs and then refer to a case study or a link (company or similar) if necessary
21	Concrete description of the BM idea and success factors
22	Unification of the way the BM are written
23	Advantages (strengths and key factors) in mirror points (easier to read)
24	Graphic at each BM (where possible) for ease of understanding
25	At Activities and Cap. Please integrate reference to the "Action Item
26	Vision display - Instead of a drop down menu a kind of dashboard with name and icon, which are then grayed out depending on the filter settings. This way you have a complete overview of the BM

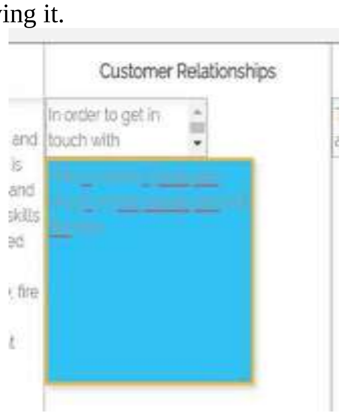
27 I tried to print a BM – the visualization is not perfect: if possible delete the right and left parts. It is not possible to read all the text when printed.

28 It is not very clear why is present this space



29 It would be nice to filter the BMs (for stakeholder or process phase?)

30 The space Channels is always empty for all BMs – if we decided to don't fill it in maybe it is better to shade it or write somewhere that it is not considered. Otherwise someone might think that we forgot it

31	After i drop the post-it in a space I don’t read more the description. Don’t know if it is possible to solve this problem and how. Is it so important to drag and drop it on the canvas? Maybe we can leave the post it on the right without moving it. 
32	In the text under "Overview" it should read "You can create your own new Business Model
33	On "BM Canvas" I can only drag the post it to some fields - on very full ones it cannot be placed, or I don't see it then?
34	If I have placed a Post it on a field of a certain BM, and then click on another B; from the list, the Post it sticks to the field of the previous BM - probably shouldn't be, should it?
35	If you go to "Create your own BM" and print your own BM, the way it is printed is very "rudimentary" and not laid out - is this better - e.g. landscape format and without the sidebar etc.?
36	Life cycle phase (for the new BMs, instead of typing the life cycle phase, it’d be nicer to just choose one of the options we prepare, and the user getting the same looking chart with the existing models)
37	Post-its for ‘Create your own BM’
38	‘Save’ function for the new BMs besides the ‘Print’ button

Pinboard Module II: nZEB revenues and co-benefits Calculation (for project Developers)

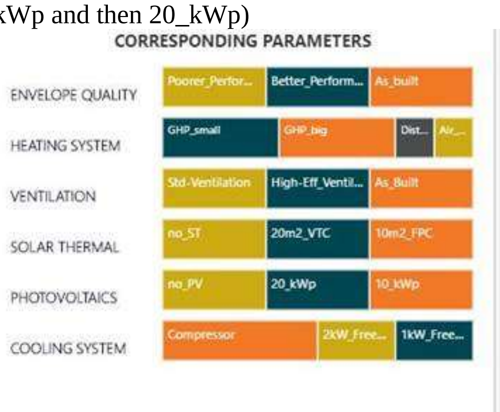
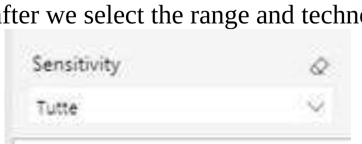
1	General internal remark: Missing tutorial, "Start page for the tool" in progress
2	The minimum energy standard for any actual reference building is so high that, compared to the high-efficiency building, no statements can be made regarding staff turnover and absenteeism
3	General internal remark: Missing tutorial, "Start page for the tool" in progress
4	Global parameters – general: the sliders show a help window on the top. This makes the multiple selection difficult since the help window covers the next slider.
5	Complicated to have drag-bars, change to manual input?
6	Why number of employees in a residential building?
7	Why "X" in front of input - is it possible to remove?
8	Is it possible to choose what to include in calculations - or do I need to include everything?
9	Possible to change input based on if it´s residential or not?
10	Press clippings doesn't seem to affect the calculations?
11	Of course, each input needs explanations
12	Not possible to include increased value of property for "High quality nZEB"?
13	Which is the function of the blue X buttons?
14	"Excepted Sales year of property" : Indicated the number selected by the cursor of year like for % in "Expected yield"
15	How it is possible to adjust the Expected Yield without changing the Rents to tenant ? Indicate the financial formula

16	"Number of employees " correspond to the people within the building ? If yes, to be blocked in case of residential
17	"Treated floor area": Heated, cooled and ventilated ? Put a control box if rentable area is > to Treated floor area.
18	Indicate the definition of each m^2 : GFA; GLA, treated area...
19	Block the "bank loan duration " in case of equity selection or enable a mix equity + bank loan as it is very frequent.
20	CO^2 "follow up cost" : Is this a carbon Tax ? If yes then give access to exact value after giving default assumption.
21	"Added value" Indicate at each line the figure selected by the cursor.
22	"Reduced vacancy" compare to which references ? How it is calculated ?
23	"Maintenance cost": this could increase some times with technologies used in nZEB. Introduction of negative % ?
24	Block the module "only for office building" when residential is selected
25	Energy Price increase "power" replaced by "Electricity"
26	Enlarge cell for "global parameter for office only" and add € where cost are mentioned
27	Days per year mean Working days per year ?
28	Explain the calculation of "Employer & social cost" ?
29	Graph with title and definition of the m^2: GFA GLA ? And x-axis title
30	What difference between 2 and 3 and what is results 4 ? How it is calculated.
31	Financial: e.g. with rents there could be differences between Reference and NZEB building - therefore input option in each case
32	Financial: Rentable area must also be entered twice, as differences in ref. to nzeb arise when the building line or building boundary is limited (thicker insulation material means thicker walls, see Gerold publication)
33	Energy: both entries are also available, but for Ref. without PV (in DE because of EEWärmeG but possibly necessary)
34	Graphic should show comparison between Ref and nZEB more clearly (sum line in comparison of intersecting lines and possibly number table in addition or in the background)
35	Result printable
32	Structure of reference building and nZEB analog Lifecycle cost web tool
33	It is not possible to move the indicator because the text covers it 
34	Is the number of emplyees important in case of a residential building? Added values (only for office buildings) à maybe it is better to disable them when i select the residential building, otherwise they change the result if I select them anyway. 
35	General internal remark: Missing tutorial, "Start page for the tool" in progress

36	Some terms like "number of employees" and some in the "Reference Building" Finance part I don't understand in this context, but as you write the previous line, there will be a guide to read about it ...
37	Why are all numbers grouped on the right and funding on the left?
38	In the second graphic, "Cumulative savings total" should not be a red dot, but a red line in the label
39	hq nZEB should be explained somewhere or in parenthesis next to the heading
40	In the results table for item 10 "Reduced CO2 emissions" the 10 is unreadably small
41	With Global parameter "Average gross monthly wage per em" the word after em is missing.
42	Under "Global Parameters - General" the unit "% per year (without inflation" is not displayed until the end

Pinboard Module III: Interactive Case Study Dashboard

1	In the third graph, German terms appear under life cycle costs
2	Behind the arrow button German terms appear
3	Page 1: Net present Value… (isn't it costs…)
4	Page 2: What is included in heating demand?
5	Page 2: Parenthesis is missing on heating demand in figure
6	Have a look at the dynamic axis's - I believe it would be better to lock them, easier to see/track/compare changes/results
7	Shouldn't all case studies start in "Overview"? (Not the case)
8	In the start page in the title of Step 1 there is an error in the word dashboard. Also in the description text of step 2 there are two words with a "-" in the middle
9	Is possible to visualize a "hand" on the buttons at the top (help, Solallen, etc)?
10	You can move through the pages also with the buttons at the top, non only at the bottom of the dashboard, like is described in the start page
11	In the Dashboard I can not find the print option described in Step 1, is possible only screenshot?
12	Is not clear how to export dashboard data
13	Name is different between tile and tool.
14	Definition or information for "Sensitivity"
15	Definition or information of CO² Follow-up cost, clarification of the "High-CO², Low-CO²…)
16	Envelope: More detail on each parameter : "200 mm of Mineral wool external". Same for the other parameter.
17	Same remarks for user behavior
18	Graphics: M² to be defined (GFA or GLA or Treated area ?)
19	Graphics: when cursor shows black tag some units are missing: for investment cost (page 1)
20	Graphics: Indicate PE as Primary Energy.
21	Graphics: Indicate "Heating demand" in kWh/m².yr instead of kWh/m²a
22	Graphics: Indicate definition of self sufficiency (page 2)
23	Graphics: Define statistics Vocabulary such as IQR, WHISKER…
24	Graphics: Define "average heating and cooling load" is it for the entire building ? Does it correspond to maximum demand ?
25	Graphics: Define page 3 the LCC duration and applicable m². information about NPV comparison.
26	Graphics: Define For Les Héliades, the mean LCC in "Benchmark results cost" is not equal to the average LLC in "LCC Cost"
27	Graphics: Page 3 "economic efficiency LCC : Change format of "Average Of investment cost from 1,75 K to 1750 €/m²

	Description of the application (Why?) - What is the benefit for the user - Maybe also different filter options depending on the stakeholders (analogous to Process Map)
	O_2 emissions instead of demand, right? & point out that these are the CO2 emissions of the red energy and not the grey energy.
	Application as video example with explanation of the effects
	Abbreviations partly not self-explanatory, and background information about the names eff_user, PHPP user, std user (PHPP user is also misleading, since Gerold found out that the real PHPP user does not always behave like that)
	More clearly identify what is input and output/result
	Corresponding parameters to the foreground if necessary
28	User Behavior: What questions should I ask myself as a developer to select the user behavior?
29	What is the benefit of looking at external buildings? This would have to be described or the typological characteristics would have to be clearer in order to select a building similar to "my developer building".
30	Benchmark results costs as an example: all scales that are next to each other are standardized optically for comparability!
31	It would be nice to call the parameters in a clear and easy way and sort them on base of importance (photovoltaics : no_PV, 10_kWp and then 20_kWp) 
32	User behavior: efficient, not efficient, PHPP, standard what is the difference? Is it possible to describe different behaviors?
34	If i select to cancel all selections à it selects them all. Opposite effect
35	It would be nice to print the page after we select the range and technologies 
36	It should be “Step 1 - How to use the interactive dashboard” without l at the end
37	At Step 2 “All variations of the life cycle cost and performance optimization are shown at the beginning for the building. Selecting, for example“ the commas are too unnecessary.

Pinboard Module IV: CRAVEzero Process Map

1	Correlation between action items for municipality and BIM ?
2	No pdf-document behind the button "BIM" 227
3	No pdf-document behind the button "solar gains" 203
4	In the landing page is called “nZEB processes” and in the sidebar “Process Map”
5	Caption of the tabs (ProcessMap, Urban Planning…): spaces between the words “Process Map” and “End of Life”
6	Actions descriptions should open in new tab or pop-up?

7	Link to "End of life" in side bar is not working
8	bottlenecks are not described
9	I would remove the buttons in the start page: ProcessMap, Urban Planning etc. and go directly to the Process Map
10	If you click on the grey button “Go to Process Map”, the map opens on the Planning phase, instead if you click on the link at the bottom of the page, the map opens on Construction phase.
11	Is possible to give a short description in the Process Map also for bottlenecks, linking the descriptions that are in the deliverable (like as the Action Item)?
12	Some bugs of display appear when clicking on the minimized Button top left. When printing no words appear
14	Replace "planning" by "Design and conception"
15	Template "End Of Life" is different than other Processes. Why ?
16	Urban planning chart : Clarification: information for "Dedication plan"
17	Action 108 :arrow not connected to a task
18	General comment on the chart: add some info box on each part of the chart. Ex: Land plan development ; what is the purpose of this document...
19	For bottleneck actions provide some info box with additional information
20	409 action; missing counterpart for aerolic balancing
21	For Energy Performance Guaranty during operational phase a missing action to describe the contractual process with gain and/or penalty
22	Irreversible component: change to "non demountable equipment"
23	Print option does not include "actions" and "bottleneck"
24	General description + Video
25	Download Draw.IO
26	Printability Action items
27	Reference to BM in the Action Items
28	Reference to LCC Tool in Action Item
30	In "Step 6" of the description of how to proceed, it says "The detailed description of the action item contains information on the topics listed below:" and the first item "- Description of the action" is not below but right next to the colon - change it if necessary?
31	” By moving the cursor over the individual bottle-necks, further information on the individual bottleneck is displayed.” – does not work
32	“Step 3 - Process Structure” – Proces**s!**

Pinboard Module V: Process management

1	Shouldn't "Specification be in the end as it is the final result of the action?
2	Is it possible to change the "check-button" at the actions which shows/hides explanations? As it is right now it is not intuitive
3	It is confusing that this sometimes is called process management and sometimes Life cycle management tool
4	Operation and end of life is not working - not possible to reach

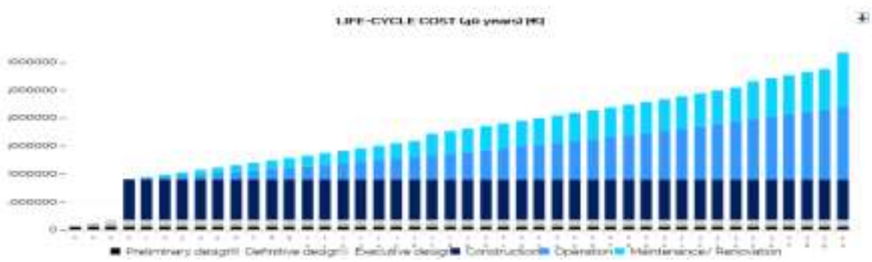
Pinboard Module VI: CRAVEzero Life Cycle Management Tool

1	I was not able to choose a different phase apart from P01 Urban Planning

2	The screenshots with the explanation on how to use the tool are not readable, and it is difficult to use them as a support for the use.
3	It would be more intuitive to select the actions to be included in the process rather than the contrary. Nevertheless, the tool is anyway usable without too many difficulties also in the current version
4	See comments for Process management
5	Why is it called LCC Web tool???? It is not a LCC tool
7	It is possible to move through different phases only using the menu on the left. For other tools there were also buttons inside the tool, I find this way is more useful
8	The calendar is in German language
9	The Gantt chart on the right is divided in months, if any activity takes only some days? Is possible to resize it if needed?
10	Construction phase is not included?
11	Would be possible to print only the part of the tool and not all the page?
12	Add on top of the page the different phase as for "Process Map"
13	Print option is not adapted for a proper output
14	Change "Deselect nZEB…" by "Select nZEB action to be excluded from the process."
15	Some Actions are not suppressed when selected : 1.5, 1.7, 1.6, 1.8,
16	Drop menu for "Main driver" with multiple selection : Client + Consultant
17	For planning date selection, change from German to English
18	The graphic representation is unclear when zoom in is used : see attached Screenshot:
19	Export to excel or Planning software exchange file format.
20	Correlation matrix, Operation and End of life planning are not available
21	Standardized name of the tool
22	Guidance to all phases above not available (only in menu guidance can also be used in planning phase etc.)
23	Point 1) why don't you click on what you are interested in?
24	detailed description action items in the web tool necessary
25	Partly there are already dates in it - would have to be removed in the template
26	Since project management tools are available for most projects, the table could be used to coordinate the interfaces between, for example, the client and project controller
27	Once Cat I has been selected, this applies to all other criteria anyway, since I have already defined the highest standard. This could be done automatically, because it doesn't help to select CAT III for another criterion, does it? -> Action Items that have a direct dependency on each other.
28	Print button is not working on my pc
29	Names of months are not in English
30	The layout at 1) Deselect (cells with points 1.1 ... are differently sized and arranged) and 2) Define (calendar after the "Status" column has a small number confusion) could be improved, otherwise perfect
31	Currently only the "Urban Planning" phase is active - later the others will be active as well, right?
32	Under 1) Deselect, 1.5 to 1.8 cannot be "deselected

Pinboard Module VII: CRAVEzero Life Cycle Cost Web-Tool

1	Numbers of the life cycle cost table are situated out of the left frame (first numeral can´t be read)
2	In the sheet “General project information /energy cost” the labels “input is available” and “no input” are kind of misleading. Another possibility is to use “input provided” and “no input provided” or something similar.

3	In section “Boundary conditions (economic)” and in the price increase for energy costs it is not possible to select decimals. This option should be provided.
4	In sheet “Construction cost” since only global costs are required, I would remove area and unitary cost, using the column construction cost as input.
5	In sheet “Construction cost”, the section building services, the cost classes show a type error: B1, B2, B3, B4, B5, B6 are the correct classes.
6	In sheet “Construction cost”, C1 should be called “RES” and the maintenance percentage should be an input.
7	In sheet “Construction cost”, below section C1, a section D1 could be inserted with the label “Others”.
8	In general, internal links to access different sections of the pinboard through the sidebar on the left side not always work properly. Once I go out of the LCC tool, I can’t open it again.
9	The pictures in the first page with the explanation of the tool are not readable. It is better to have a more specific focus on some parts then a general screenshot
10	Why different width for reference case and variant?
11	Why need for project data input twice? (e.g. they should be located at the same place, constructed the same year?)
12	Why different ways to give input data (sometimes manually, sometimes with bars, sometimes wit +/-) confusing
13	Energy consumed from PV? (This is a complex simulation…)
14	y-axis should be the same for both cases
15	Results "numbers" are in different orders
16	Like the first point of other modules
17	Is not possible to print some page?
18	The name is different from Tile
19	Cursor of "Construction Year" not fixed when selected
20	Project information: Change "Nation" by "country"
21	Building geometry vs Building Surfaces and volumes: why
22	The input data's should be the same between Reference case and nZEB variant for the geometrical data
23	Slow/lag input capacity on the various input case
24	the shape factor is rounded in the column of nZEB variant and with 10 decimal number
25	Define the monthly rent : including or not the energy and maintenance cost ?
26	Why only 3 rent row? 
27	Is The rentable area equal to threated area?
28	What is the difference between Energy Carrier N12 and N17 in "Energy cost"
29	Change "Average fuel price " by "Average energy price"
30	Not possible to change the "Reference Period for life cycle"
31	Graph not clear
33	In visual diagrams: Show % of all pie parts See attached screen shot:

34	Menu navigation and structure very successful - user is guided (hint - this should partly be the template for other modules as well).
35	Leave the reference building and nZEB as headline (like in Excel when you fix the top rows), so that the input is correct at the bottom
36	Allow to enter interest rate and other percentage values in decimal places - Since 1% jumps are mostly unrealistic.
37	A case study can be provided to better assess what added value the results can bring at what stage. For this purpose also create a storage facility (log in etc.)
38	Input facilitation Check all entries (identical to reference)
39	Core question from our point of view: What is the cost of a nZEB more? With this in mind, the input would have to be changed and, for example, only include the shell for KGR 300 (no A09 structural elements, A02 and for A03 only the base plate) and for KGR 400 the systems relevant to the nZEB question. The evaluation would thus only show how large the difference is over the service life and would not claim to be complete LCC. -> Call Klara with Federico da complex topic
42	It would be nice to print the result

Pinboard Module iX: Life Cycle Tracker (Excel Tool Download)

1	I´m sorry, we are using apple computers in our office, the excel tool unfortunately doesn´t work
2	Different name in side bar = confusing
3	Having a hard time understanding who should use this and how. Furthermore. What is the difference between this one and "Process management"?
4	In the start page between the phases described there is not the construction, instead there is the renovation phase
5	D114
6	Sort by themes the various actions to be more easily selected
7	Add "Press Ctrl" to select multiple actions
8	Missing Legend for cost (-€, -€€…)
9	Indicate that you have to double click to access to other menu.
10	Are the Default value robust and reliable, or should we clear all of them.
11	Missing action for geothermal for "Action P02 Planning"
12	Spreadsheet Action View : Problem of display when clicking on "Color " and "Filter" buttons
13	Add N° of action in each box in Spreadsheet "Action View"
14	Integration of the tool into the toolbox.
15	Reference to the complex tool in the Web tool area for an editing option in expert mode or offline.
16	The macro and virtual basic don't work and i can't use the tool.
17	Once called "Life Cycle-", but then also "Process tracker tool" - should always be called the same?

Pinboard Module X: Life Cycle Cost Tool (Excel Tool Download)

1	I´m sorry, we are using apple computers in our office, the excel tool unfortunately doesn´t work
2	Why did you decide to separate the two LCC tools in two sections: "Life Cycle Cost Calculator" and "nZEB LCC Tool"? Maybe this separation and the different caption can be misleading.
3	Wrong link for download
4	Very, very complex input data
5	Not possible to hide variants
6	Why need for project data input twice? (e.g. they should be located at the same place, constructed the same year?)
7	window to wall ratio equation is wrong (it is window to total thermal envelope area)

8	Comments are in the way…
9	Potential price, by which area?
10	Tab functions are not working
11	Should some cells be locked?
12	When clicking on Hide Variant 1 or 2, bug as follow
13	Glazing area corresponds to only transparent surface or including frame?
14	Air thingness : Change "1/h" by "V/h"
15	See comments on Module 7 for input data.
16	This Tool is overlapping with Module 7
17	Very time consuming to fill in all the data. Automatisation with PHPP export file to be studied
18	Integration of the tool into the toolbox.
19	Reference to the complex tool in the Web tool area for an editing option in expert mode or offline.

WHISHLIST FOR THE PINBOARD
(Functionalities, future applications that would be "nice to have" in the future

1	In order to make the pinboard accessible to a wide circle of users it is necessary, as discussed in Paris, to translate it in different languages. For many, the specific English terms are a major obstacle
2	Adaptive - suitable for mobile devices
3	Clearly highlight who is the potential user for each tool
4	Same naming/wording for different modules
5	Consequent type of input data (not mixing manual input, drag-bars etc.)
6	One tutorial per tiles.
7	For BM, possibility to export (Excel, Word file, for existing and blank models) : Delete post-it form BM tool…
8	For module 2 , give a short description of info for each criteria.
9	Use of the Case study dashboard for my own new project.
10	Webinars
11	Pinboard more lively (video teaser that runs or similar)
12	Hotline or similar? Feedback from users possible? How do we avoid that the tools are understood as gravestones?
13	Further development of the tools
14	Put a button with the link to the deliverables section or possibility to read them directly online on the pinboard
15	Would it be interesting to write the number of views? Of course nota t the beginning but when the number is big enough. In this way if we reach an interesting number the user will trust our project more.
16	See General Remarks.
17	"Nice to have" for all tools would be completely "De Fault" filled out nZEB reference buildings, which you could take and only enter or add more changes, then in some "typical" cases you would be faster in filling out