

## D7.1 CRAVEzero pinboard

“A modular framework to build an effective low life cycle cost nearly zero energy building”



## 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.

CRAVEzero - Grant Agreement No. 741223

[WWW.CRAVEZERO.EU](http://WWW.CRAVEZERO.EU)

Co-funded by the Horizon 2020  
Framework Programme of the European



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# **D7.1 CRAVEzero pinboard**

**“A structured framework to build an effective low life cycle cost  
nearly zero energy building”**

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February 2020

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# FOREWORD

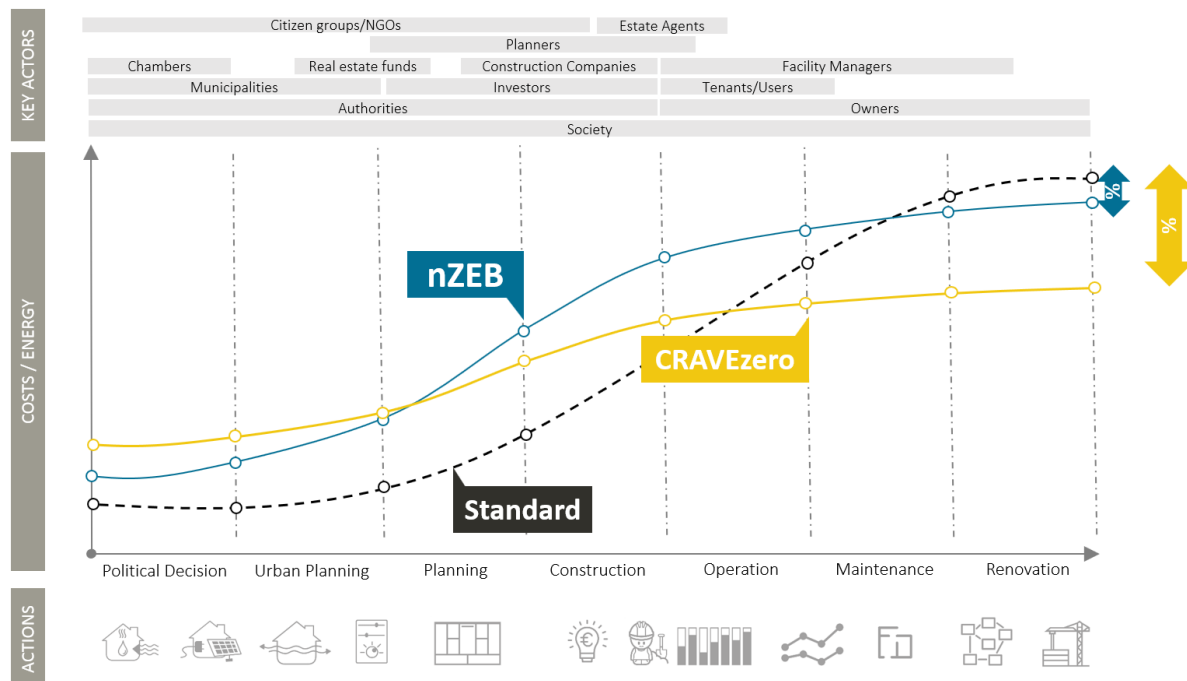


Figure 1: CRAVEzero approach for cost reductions in the life cycle of nZEBs.

Cost optimal and nearly zero energy performance levels are principles initiated by the European Union's (EU) Energy Performance of Buildings Directive, which was recast in 2010 and amended 2018. These will be 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 implemented nZEBs have clearly shown that nearly zero energy target could be achieved using existing technologies and practices, most experts agree that a broad scale shift towards nearly zero energy buildings requires significant adjustments to prevailing building market structures. Cost-effective integration of efficient solution sets and renewable energy systems, in a form that fits with the development,

manufacturing and construction industry processes, as well as with planning, design, and procurement procedures, are the major challenges.

The report presents a documentation for the "CRAVEzero Pinboard" which can be accessed via <http://pinboard.cravezero.eu/> or <http://www.cravezero.eu/pinboard/Pinboard-Main/PinboardMain.htm>.

All the project results will be included in the "CRAVEzero pinboard" – an interactive web-based structured framework supporting in developing low LCC nZEBs.

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# The CRAVEzero Pinboard



Co-funded by the Horizon 2020  
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Coordinator



[WWW.CRAVEZERO.EU](http://WWW.CRAVEZERO.EU)

nZEB Toolbox: [PINBOARD.CRAVEZERO.EU](http://PINBOARD.CRAVEZERO.EU)



# 1.THE PINBOARD STRUCTURE

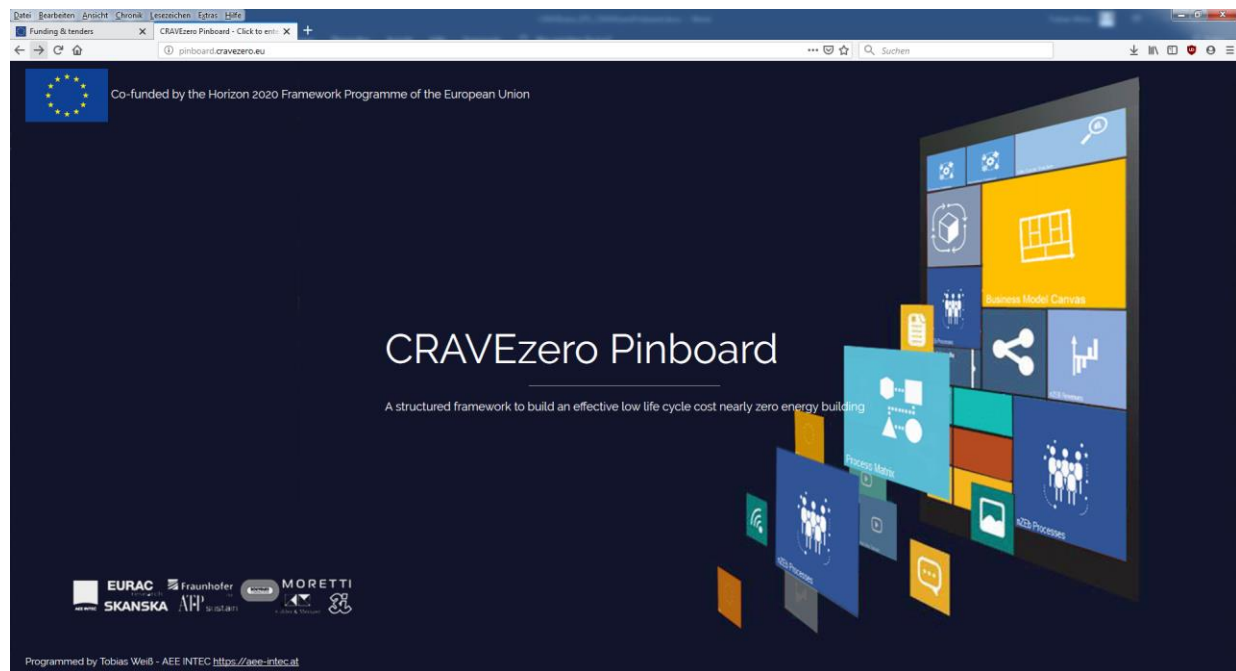


Figure 2: The CRAVEzero pinboard <http://pinboard.cravezero.eu/>

**The report presents a documentation for the “CRAVEzero pinboard”.  
An interactive web-based structured framework supporting in developing low LCC nZEBs is available here: <http://pinboard.cravezero.eu/>**

The CRAVEzero pinboard is a structured framework organizing all required information and tools to build:

- an effective low life cycle cost nZEB business model
- reliable life cycle cost databases with cost reduction potentials in processes
- technologies, methodologies, robust solutions and business models for low LCC nZEBs.

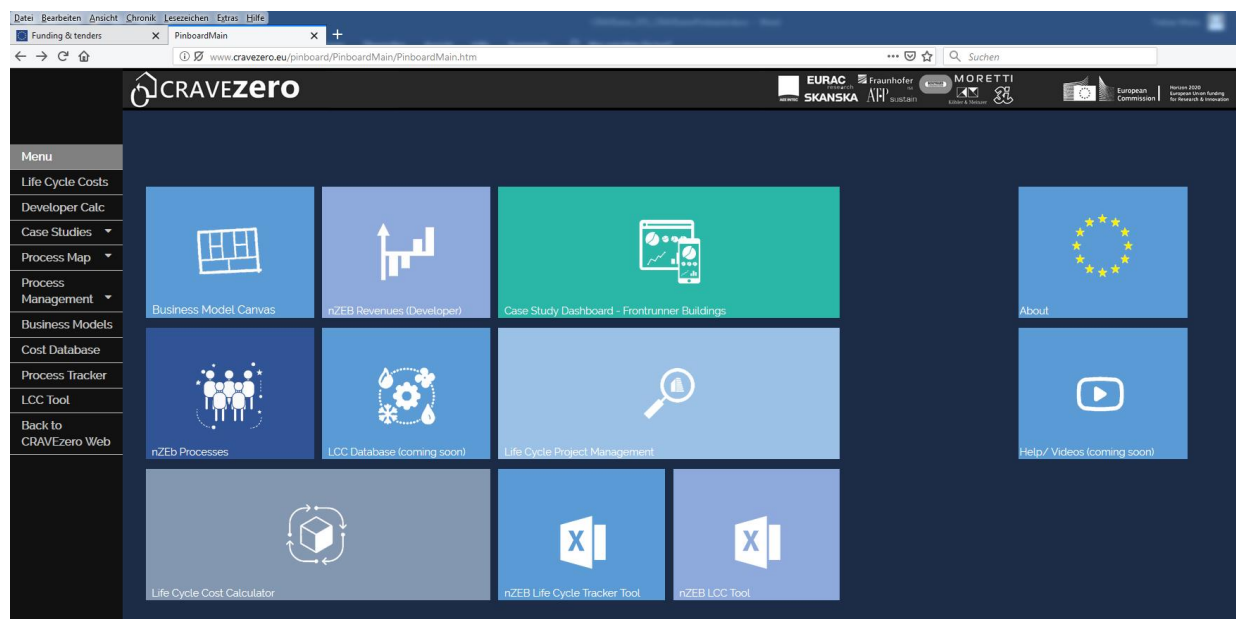


Figure 3: CRAVEzero pinboard overview – page

## User Interface

The tools and applications, which have been developed in the course of CRAVEzero, can be accessed via the CRAVEzero pinboard in two different ways:

### 1. Navigation Menu (Sidebar)

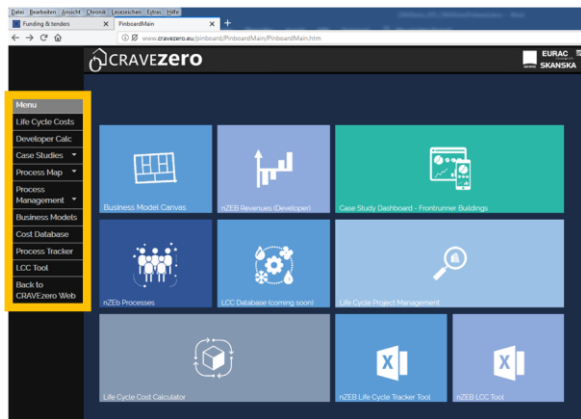


Figure 4: CRAVEzero Pinboard navigation by menu

### 2. Navigation by pinboard modules

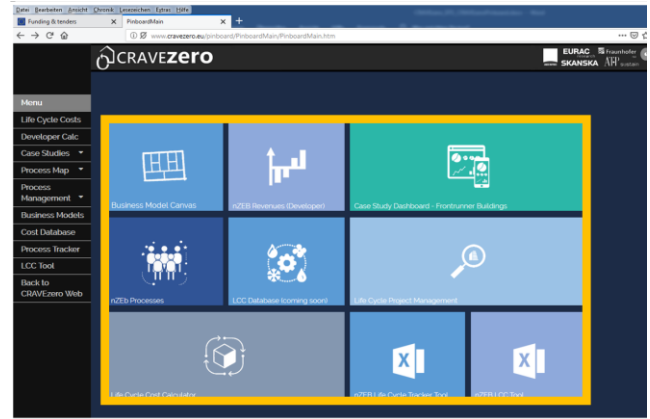


Figure 5: CRAVEzero Pinboard navigation by modules

By using the side-menu on the left side, it is possible to navigate back and forth through the tools, or to return back to the CRAVEzero website.

By hovering the mouse over the modules, a tooltip appears on the respective module. Clicking the left mouse button will open the selected module.

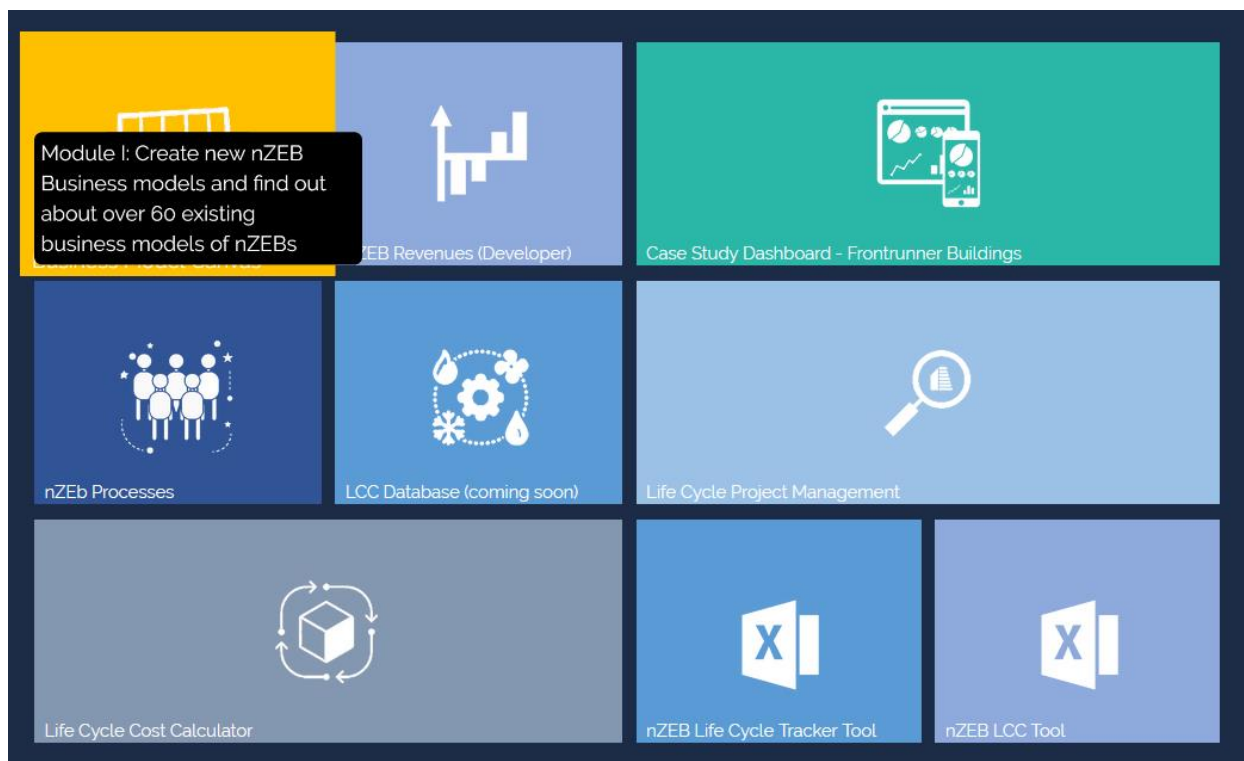


Figure 6: CRAVEzero Pinboard module description



General information about the project CRAVEzero can be found in the module “about” on the top right side.

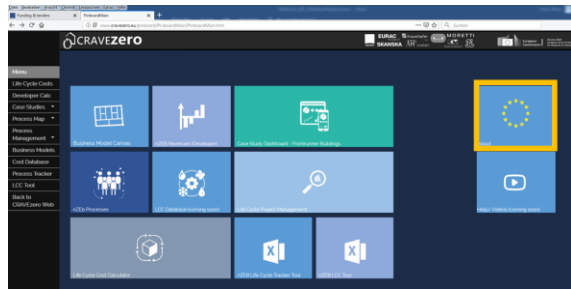


Figure 7: CRAVEzero Pinboard - further project information

Help and further explanatory videos for the different modules can be found under “Help/Videos”.

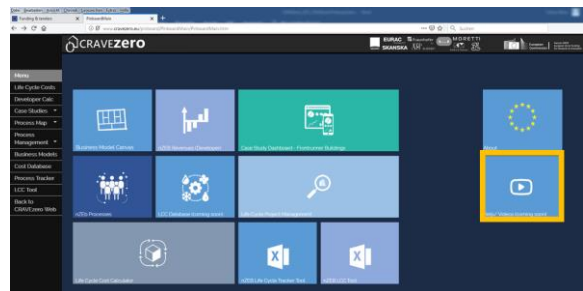


Figure 8: Further information and explanation videos about the tools

## 2. MODULE I: THE BUSINESS MODEL CANVAS



### Overview - The nZEB Business Model Canvas

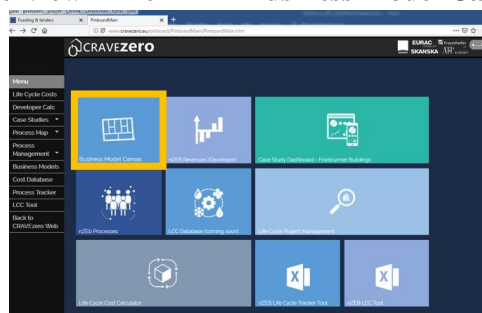


Figure 9: Pinboard selection of the Business Model Canvas

On the start screen it is possible to choose how to work with the canvas.

There are two possibilities:

- select the existing or new business models identified
- create a new business model

### Step 1 – How to use the nZEB Business Model Canvas

Business Model Canvas is a strategic management template for documenting existing nZEB business models. With the dropdown menu on top the left side you can browse through 60 existing nZEB business models. The life cycle phase of the business model can be seen next to the dropdown menu. The information of each business model will be displayed according to the Osterwalder Business Model Canvas structure: It is a visual chart with elements describing a firm's or product's value proposition, customers, and finances. The Business Model Canvas is a great tool to help you understand a business model in a straightforward, structured way. This canvas provides insights about the customers, what value propositions are offered through what channels, and how a company achieves earnings due to nZEBs.



Figure 10: Business Model Canvas dropdown menu and life cycle phases

## Step 2 – The 9 Boxes of the Canvas

Osterwalder's canvas has nine boxes - the name of each is given in bold below.

- **Strengths and Key Factors:** The most important activities set for a company's value proposition.
- **Activities and Capabilities:** This component provides an overview of the activities and the capabilities that are necessary to ensure that the BM becomes viable.
- **Business model maturity:** The core model that most people use to explore and articulate the motivation, offerings and capabilities required to pursue an enterprise is the business model maturity.
- **Value Propositions:** The collection of products and services a business offers to meet the needs of its customers. The value propositions may be "Quantitative – price and efficiency" or "Qualitative – overall customer experience and outcome"
- **Customer Relationships:** To ensure the survival and success of any businesses, companies must identify the type of relationship they want to create with their customer segments.

- **Channels:** A company can deliver its value proposition to its targeted customers through different channels.
- **Customer Segments:** To build an effective business model, a company must identify which customers it tries to serve.
- **Cost Structure:** This describes the most important monetary consequences while operating under different business models.
- **Revenue Streams:** The way a company obtains an income from each customer segment. There are several ways to generate a revenue stream.

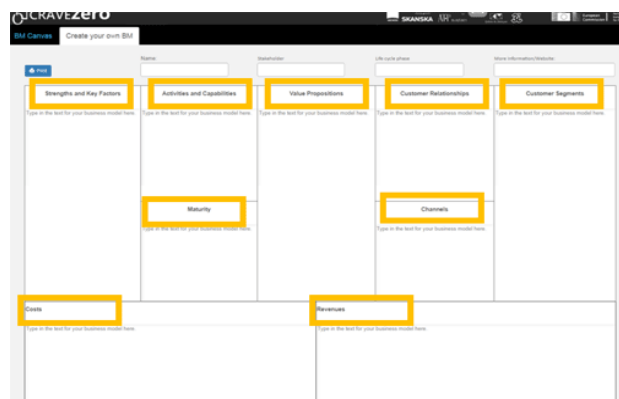


Figure 11: 9 Boxes of the Canvas

Note: You can also drag&drop or edit "notes (blue boxes)" from the right side of the Canvas into the canvas itself.

### Step 3 – Create a new nZEB Business Model Canvas

By selecting "Create your own BM" in the top-menu of the canvas you can create your own business model.

“Business Model Canvas creator” is a lean start-up template for developing new or documenting your existing nZEB business models. The Canvas helps you to focus on your business model segment by segment.

Start by filling in the boxes and print out your Canvas!

**Link:**  
[http://www.cravezero.eu/pinboard/Canvas/BM\\_Canvas.htm](http://www.cravezero.eu/pinboard/Canvas/BM_Canvas.htm)

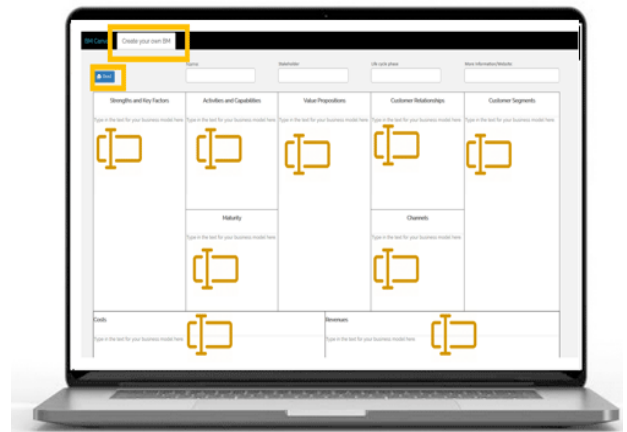


Figure 12: Create a new nZEB Business Model Canvas

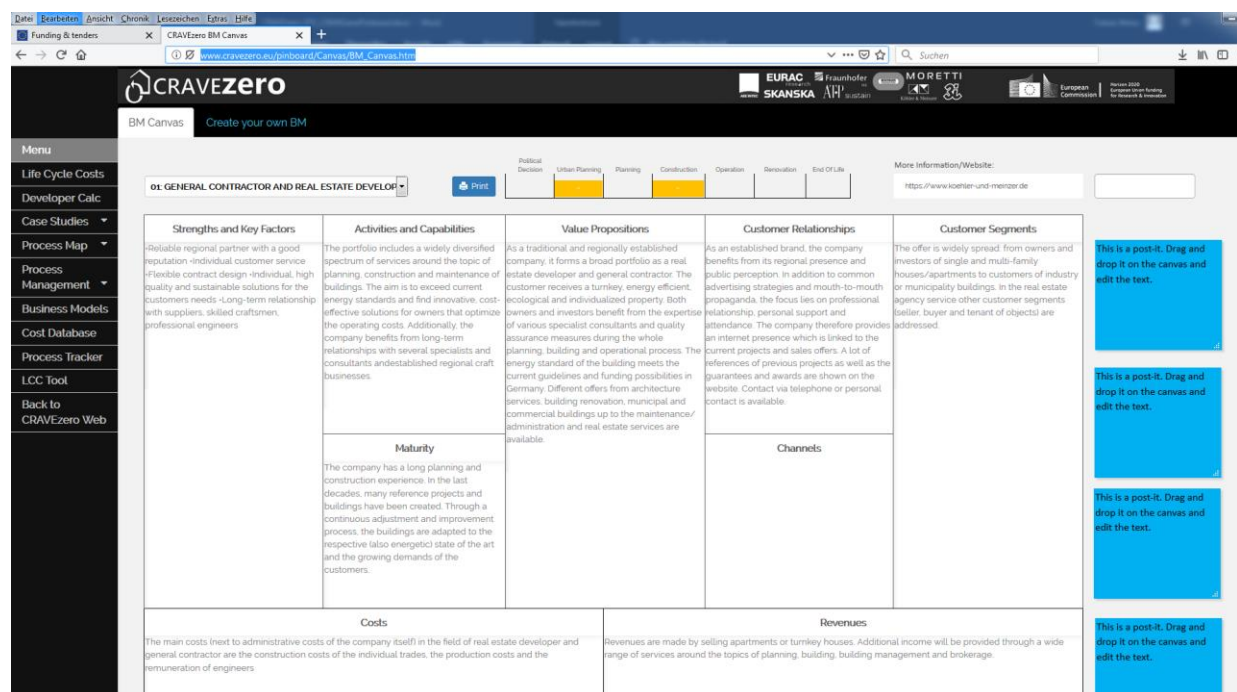


Figure 13: Example of a Business Model Canvas

### 3. MODULE II: NZEB REVENUES AND CO-BENEFITS CALCULATION

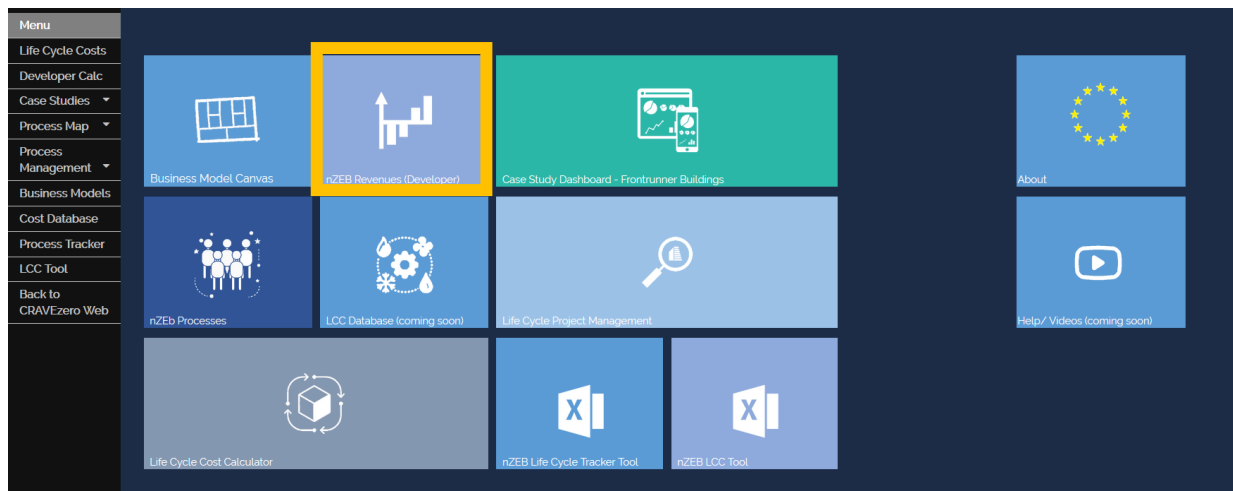


Figure 14: Pinboard selection of the nZEB revenues and co-benefits Calculation

#### Getting started with the nZEB Revenues and Co-Benefits Calculation

To get an overview of the influence of individual co-benefits on the payback time it is necessary to know the building data

#### Step 1 – How to use the interactive dashboard

The dashboard consists of three tabs for the project details and a tab for the results.

1. The first tab "Reference Building" asks for general information about the building. These are subdivided into Financial and Energy.
2. The second tab "High quality nearly zero energy building" deals specifically with information concerning the quality of the building. A distinction is made between the following factors:
  - Financial
  - Energy
  - Added Values
3. General information about the location and the conditions can be given in the grey area "Global Parameters - General".

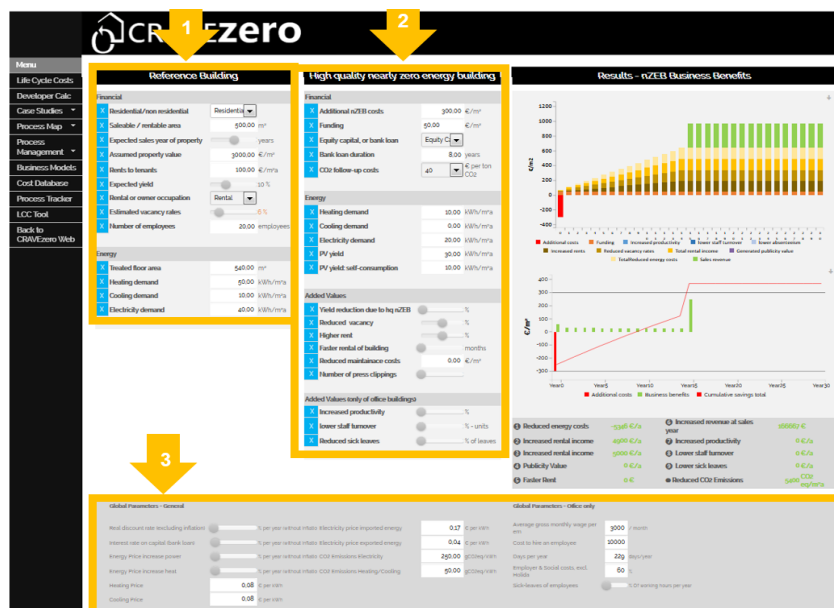


Figure 15: Overview of the dashboard

## Step 2 – Results

The results section shows the additional costs for the nZEB and the cost savings, structured according to the various added values. In addition, the second chart shows the payback time, which results from the entries.

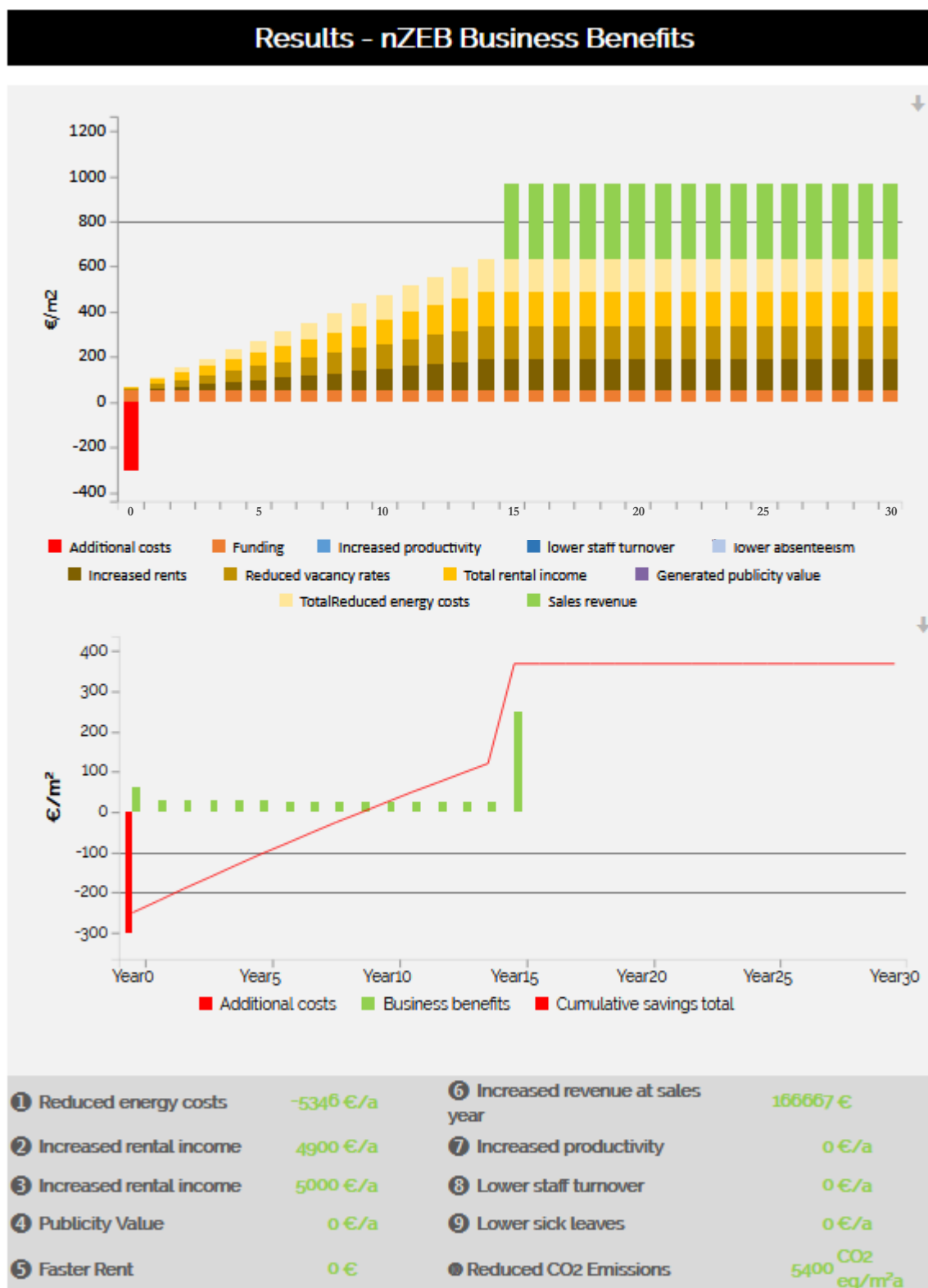


Figure 16: Results of the co-benefits calculation

Link: <http://www.cravezero.eu/pinboard/Developer/Developercalc.htm>

## 4. MODULE III: INTERACTIVE CASE STUDY DASHBOARD



### Step 1 – How to use the interactive dashboard



Figure 17: Pinboard selection of the interactive case study dashboard

The dashboard consists of three pages/ tabs.

The visualisations in the interactive dashboard represent a piece of information like for example the life cycle costs or relating CO<sub>2</sub> emissions of selected variants. Within the dashboard, users can add and remove data, change visualisation types, and apply filters. The idea of this interactive dashboard is to allow users of the pinboard to dig into the data, discover insights and look for optimal solutions that can also be applied for their nZEB developments. The web-report is highly interactive and highly customizable, and the visualisations update as the underlying data changes. Buttons at the bottom of a report can be used to navigate between pages. Also reports can be viewed full-screen, and users can save/print a screenshot of the report using the print option.

### Step 2 – Interaction with filters

Filters/sliders allow users of the dashboard to narrow the cost and energy-related data that is visualised on a page. Multiple filters, can be selected to narrow down the dataset. To remove a filter, users can deselect all filtered values. Example: All variations of the life cycle cost and performance optimisation are initially shown for the building. Selecting a special heating system or filtering a life cycle cost range in the visualisations shows only data for that heating system or life cycle cost range in the visualisations.





Figure 18: Interaction with filters

### Step 3 – Cross-highlighting related visualisations

The visualisations on a single report are "connected" to each other. If one or more values are selected in one visualisation, other visualisations will change based on that selection.

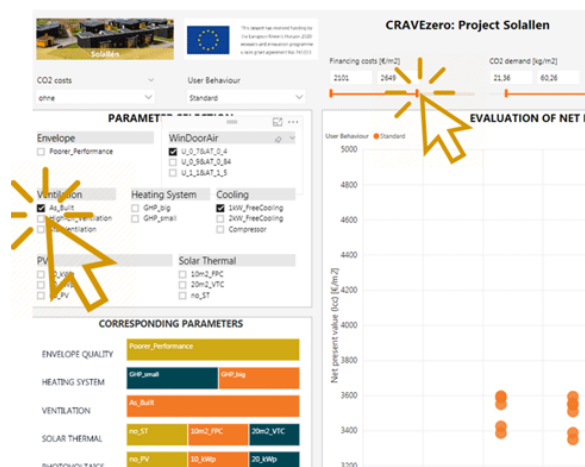


Figure 19: Cross-highlighting related visualisations

### Step 4 – Hover effects of visuals

If the cursor is placed on a variant, users can find out more about a selected variant. The cursor needs to be placed over any visual element in the dashboard in order to view detailed data breakdown.



Figure 20: Hover effects of visuals

### Step 5 – Export dashboard data

Data can be exported out of the visuals via the Export data option. The resulting .csv file will contain all the data presented in a visual and will respect any filters applied to the data.

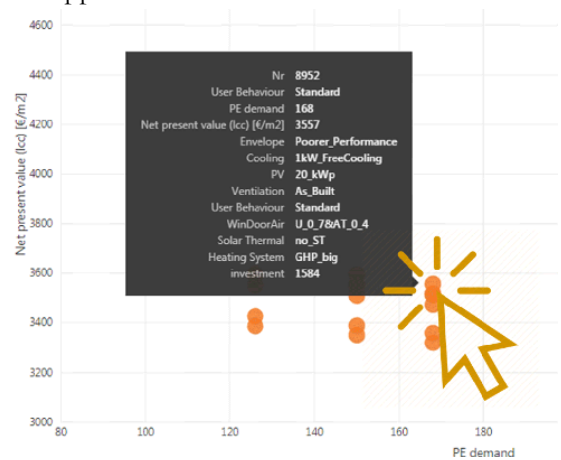


Figure 21: Export dashboard data

Link: <http://www.cravezero.eu/pinboard/Dashboard/Sollalen.html>



## 5. MODULE IV: CRAVEZERO PROCESS MAP



### Getting Started with the CRAVEzero Process Map

Overview of the complexity and the possibilities influencing the planning and construction process of nearly zero energy buildings

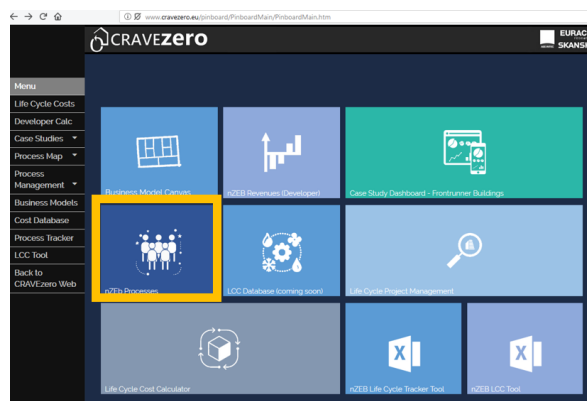


Figure 22: Pinboard selection of the CRAVEzero process map



Figure 23: User interface – front page of the Process Map

### Step 1 - The User Interface

The “interactive process map” gives an initial overview of the complexity and the possibilities of influencing the planning and construction process in order to develop a nZEB.

The "CRAVEzero 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. In the interactive process map, stakeholders are able to display

individual “nZEB specific action items” (To Do's) or alternatively to see which tasks other project participants have in order to achieve a nZEB. General information, such as the timeline in the process, and detailed information on selected action items can be accessed.

## Step 2 - Life Cycle Phases and Stakeholders

Pick phases and stakeholders that fit best your project Environment.

The process is divided into the following planning and construction process steps: Urban Planning; Planning; Building construction; Utilisation; End of Life. In addition, action items and bottlenecks can be displayed for the following stakeholders: Owner/User, Municipalities, Integrated planning team, Construction companies.

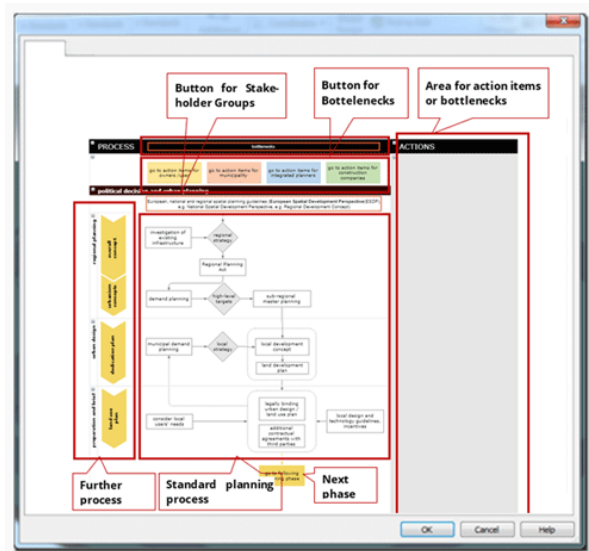


Figure 24: Life Cycle Phases and Stakeholders

## Step 3 - Process Structure

On the one hand all process phases have been designed to be as general as possible so that it is applicable to typical life cycle processes of buildings all over Europe. On the other hand the structure itself was developed as detailed as possible. The following descriptions refer to Figure 25.

1. First level of the standard planning process (Urban Planning, Planning, Building construction, Utilisation, End of Life).
2. Second level of detail into more specific process steps of the individual main points of the standard planning process.
3. Third level of detail of the planning process into individual main task packages within the framework of the main process steps.
4. Visualization of the workflow chart of the individual tasks in the standard planning process.
5. Buttons for forwarding to the following planning process step of the 1st outline level.

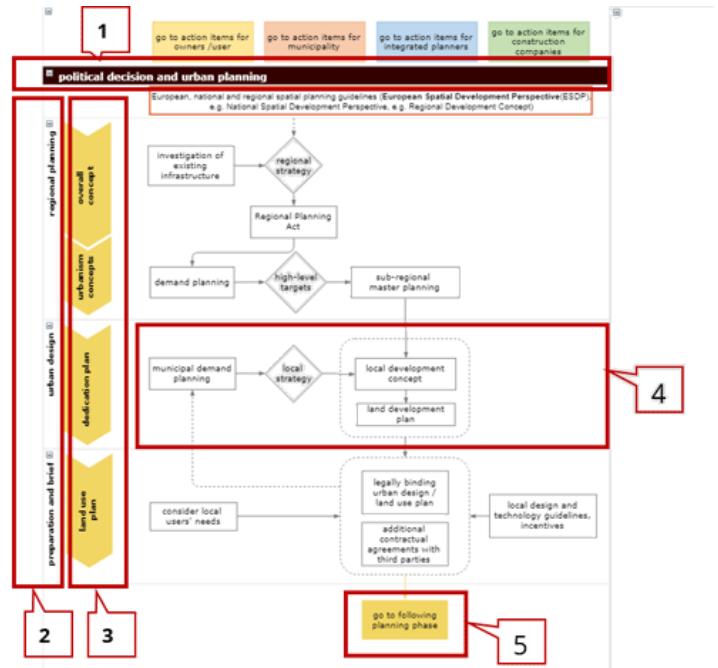


Figure 25: Process Structure

## Step 4 - Bottlenecks

Further information about possible bottlenecks (typical problems) in specific process steps can be accessed interactively

Once the red outlined button called “bottlenecks” in the top menu is selected, information about possible bottlenecks is highlighted on the right side and linked directly to the appropriate process step in orange. To get information about the bottlenecks the information can be interactively displayed or hidden by a cursor click. By moving the cursor over the individual bottlenecks, further information on the individual bottleneck is displayed.

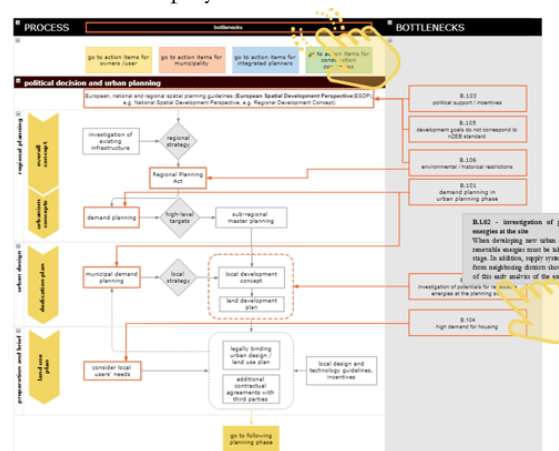


Figure 26: Bottlenecks

## Step 5 - Action Items

Check Possible Action Items Needed to Achieve nzeb Standard.

In order to display the action items for the different stakeholders, they can be selected in the top menu. This allows for displaying all possible action items for the selected stakeholder groups.



Figure 27: Action items

## Step 6 - Find out More About Specific Actions

If an action item is selected, detailed information about the action item is given in PDF format in a new pop-up window or downloaded as a PDF depending on the browser settings.

The detailed description of the action item contains information on the topics listed below:

- Co-benefits
- Conflict of Aim With other Actions
- Influences on other actions
- Importance/ Difficulty
- Standards and Regulations
- Main driver
- Involved stakeholders
- Methodology / technology / business model
- Specifications (quality/quantity goal)

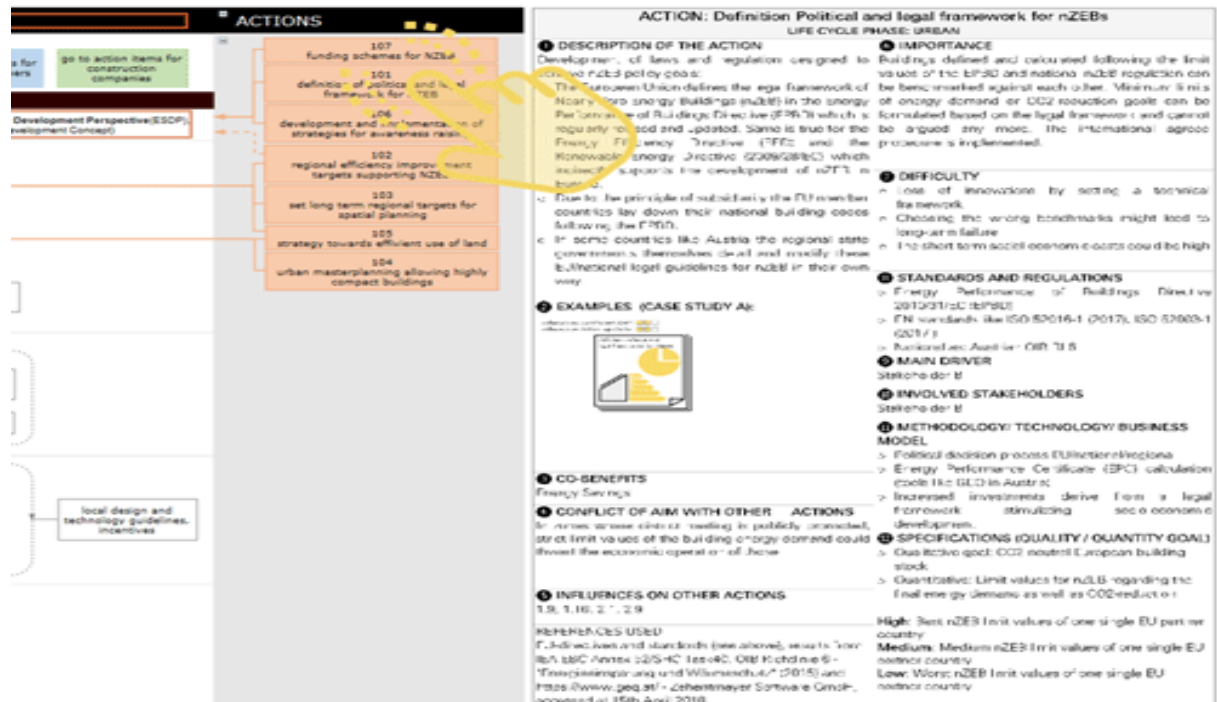


Figure 28: More information about specific actions

Link: <http://www.cravezero.eu/pinboard/PMap/Urban.html>

## 6. MODULE VI: CRAVEZERO LIFE CYCLE MANAGEMENT TOOL

### CRAVEzero Life Cycle Management Tool

#### Getting Started with the CRAVEzero Life Cycle Management Tool

A quick calculation method of life cycle costs of nearly zero energy buildings according to ISO 15686-5:2017

#### Step 1 – Getting Started



Figure 29 Pinboard selection of the CRAVEzero Life Cycle Management Tool

The six main functions:

1. Select "Process Management" at the side menu in the left to go to the life cycle management and choose a phase
2. Select a date to choose the start of the phase
3. Deselect actions which "should not" be included in the process
4. Deselect an action to get specific information about the action
5. Enter further information about the project
6. Click print to save your entries

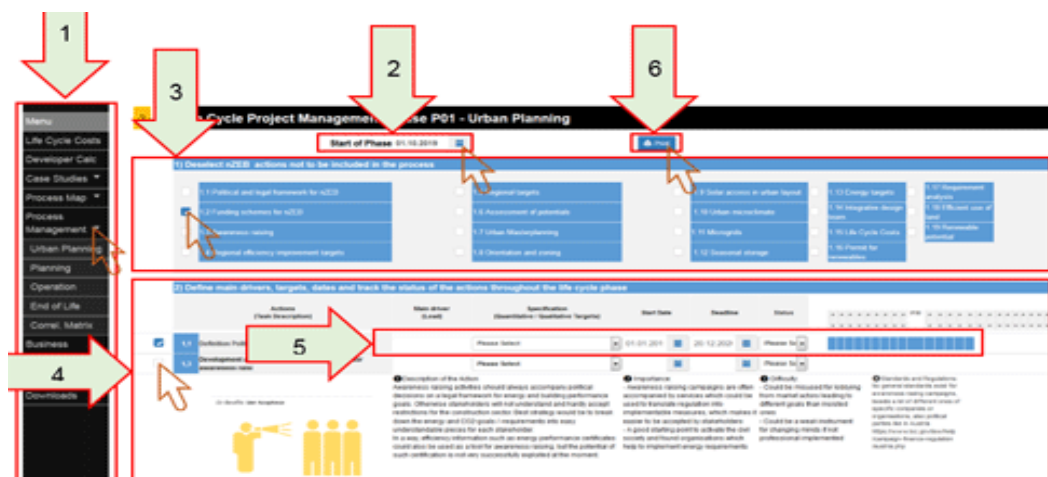


Figure 30: Main functions of the life cycle management tool

## Step 2 – Enter detailed information

More detailed information on the individual actions can be retrieved by clicking on the checkbox in the left of the action.

In addition, project-specific information can be entered here:

- Main driver: The main stakeholder responsible for the action
- Specification: High, medium and low targets can be selected depending on the goal you want to achieve
- Start Date: Enter the start date of the respective action
- Deadline: Enter the end date/ deadline of the respective action (subsequently, the timeline as “a bar” is displayed at the right side)
- Status: A selection between delayed, completed, pending and ongoing helps to track the status of the actions throughout the phase over time

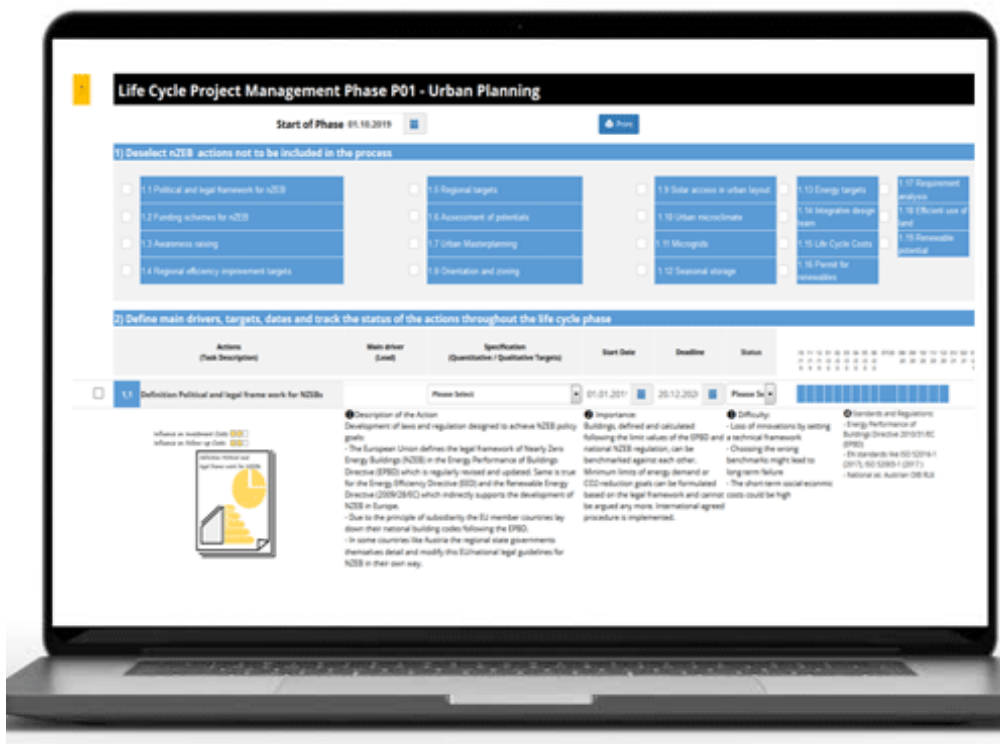


Figure 31: How to enter more detailed information

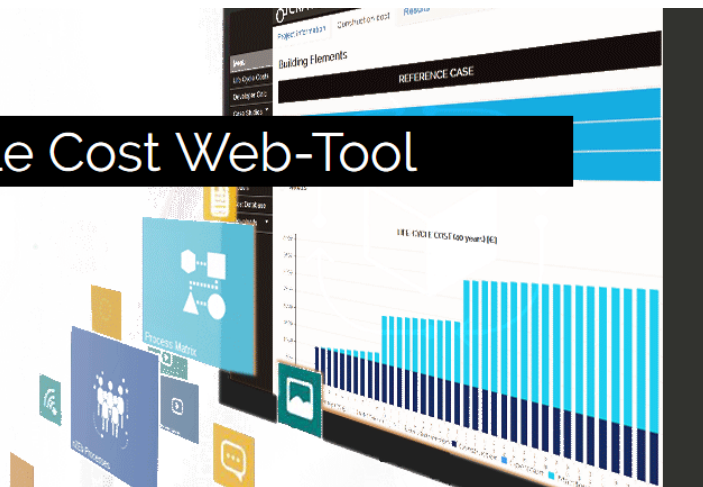
Link: <http://www.cravezero.eu/pinboard/LCTurban/LCTurban.htm>



## 7. PINBOARD MODULE VII: CRAVEZERO LIFE CYCLE COST WEB-TOOL

### CRAVEzero Life Cycle Cost Web-Tool

A simplified web version of the CRAVEzero LCC tool provides an easy-to-use tool to perform preliminary LCC calculation.



#### Getting Started with the CRAVEzero LCC Web Tool

A quick calculation method of life cycle costs of nearly zero energy buildings according to ISO 15686-5:2017

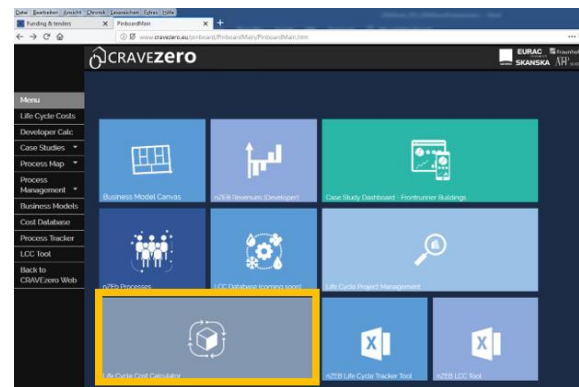


Figure 32: Pinboard selection of the CRAVEzero life cycle cost Web-tool

#### Step 1 – General Information / Energy costs

Insert data about the geometry, income, energy demand, design, economic boundary conditions and energy vectors' prices.

One variant of the reference case can be investigated.

Figure 33: Platform for filling in general information

Step 2 – Construction costs

In the second sheet, aggregated data about construction costs for building elements and building services can be inserted. Maintenance cost as a percentage of the construction cost and the lifespan of the building element must be selected.

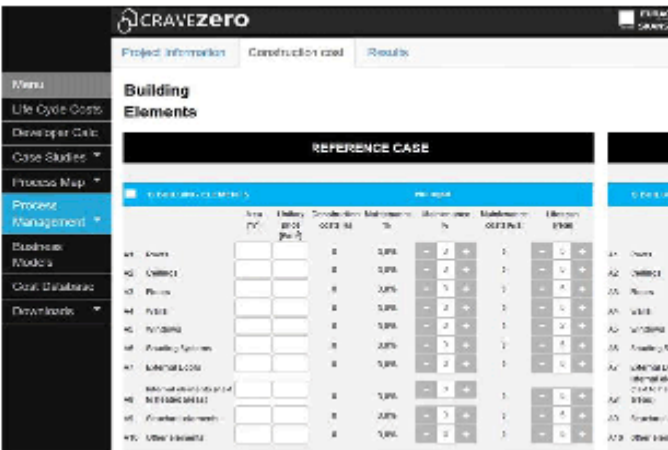


Figure 34: Aggregated data about construction cost and lifespan can be selected

Step 3 – Results

The last sheet displays the numerical breakdown of the LCC analysis, together with charts.

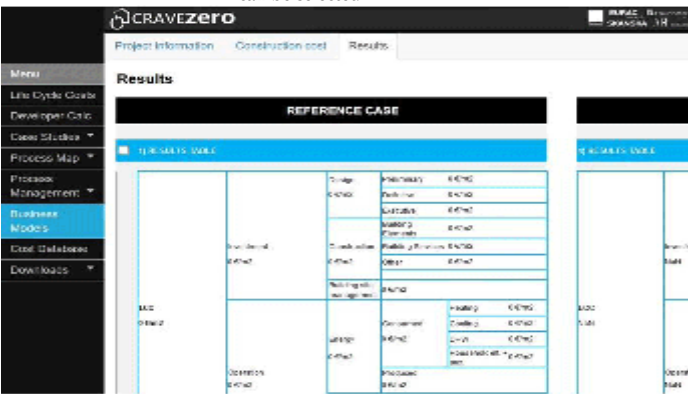


Figure 35: Results of the life cycle costs

Structure

The data collection within the tool is organized following as a base reference the LCC structure introduced by the Standard ISO 15686-5:2017 (Buildings and constructed assets -- Service life planning -- Part 5: Life-cycle costing). Furthermore, the source used to structure the construction costs is the European Code of Measurement, elaborated by the European Committee of the Construction Economists. Regarding the analysis of maintenance costs of HVAC systems, this is based on standard values from EN 15459:2018, which provides yearly maintenance costs for each element, including operation, repair, and service, as a percentage of the initial construction cost. Lifespan for system replacement is also provided by the standard. The ISO 15686-5:2017 groups the costs as indicated in Table 1: the LCC analysis includes the processes from point 2 to 5, and it deals with the activities connected with the design, construction and operation of the building. End-of-life costs (process 6 in the table) have not been implemented in the tool yet.

Table 1 Cost groups of the LCC Tool

Life-cycle cost	Life cycle processes	LCC tool
	1. Political decision and urban design phase	Non-construction costs
	2. Building design phase	Design costs
	3. Construction phase	Construction costs
	4. Operation phase	Energy costs
	5. Renovation phase	Maintenance costs
	6. Recycling, dismantling and reuse phase	Not implemented

Link: [http://www.cravezero.eu/pinboard/LCC/LCC\\_tool\\_web.htm](http://www.cravezero.eu/pinboard/LCC/LCC_tool_web.htm)

## 8. MODULE VIII: LIFE CYCLE TRACKER

### About

The “CRAVEzero-life-cycle-tracker” is a shared interdisciplinary tool for all stakeholders in the life cycle of nZEBs. It provides a shared framework for the organization and management of nZEB projects. It can be used for both as an editable process map and a management tool, providing necessary actions that need to be taken to reach the goal and best practice guidance from the CRAVEzero consortium. It reflects the actions in nZEB project management and provides strategic leadership. It incorporates nZEB design principles, promotes integrated working between project team members, and provides the flexibility to match project-specific challenges. “CRAVEzero-life-cycle-tracker” is an easy to customize electronic document that can be adapted to the specific needs of any practice, team or project. It organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. It gives

details of the tasks and outputs required at each stage, which may vary or overlap to suit specific project requirements. It is a downloadable spreadsheet, in Microsoft Excel format, containing customizable tables allowing easy creation of the project roles, design responsibility matrix and multidisciplinary schedules of services. It is part of the mindset of stakeholders involved in the construction industry and is woven into their processes.



Figure 36: Pinboard selection of the CRAVEzero Life cycle tracker

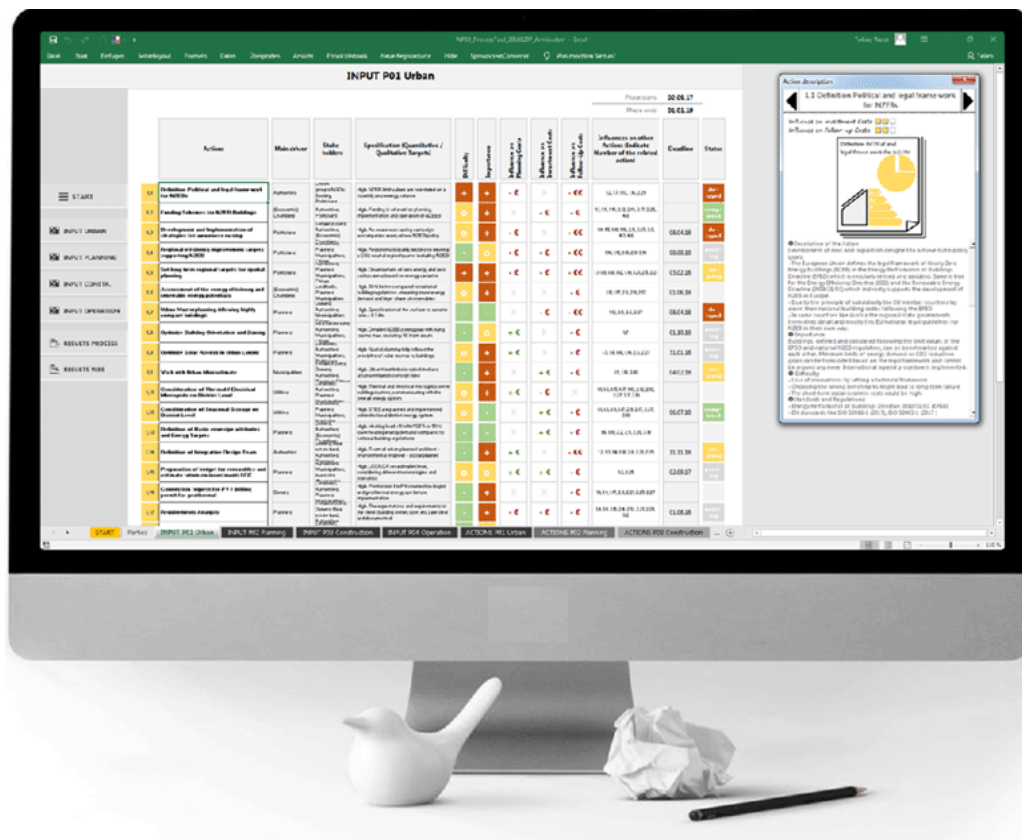


Figure 37: Dashboard of the life cycle tracker



## Step 1 – User Interface

The tool "CRAVEzero-life-cycle-tracker" consists of four phases from urban planning, via planning and 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. The actions are freely selectable (can be switched on and off). The defined process phases ensure the consistency of the entire CRAVEzero methodology.

The ability to turn specific actions on or off and vary the content of others provides a modular structure to create a targeted and tailor-made practice or project-specific version.

### The tool:

- Contains numerous key actions, which can be switched on and off
- Shows correlations between the individual actions in chronological order
- Gives an overview of the individual implementation phases and which actions should be taken and when

### Aims of the tool:

- To give an overview especially for the project management
- Create awareness of the interdependencies of different stakeholders
- Show definitions of individual actions to achieve nZEB

### Phases:

- Urban Planning
- Planning
- Operation
- Renovation



Figure 38: User interface of the life cycle tracker

## Step 2 – Worksheets

The workbook created for this purpose comprises several worksheets:

- |                            |                             |
|----------------------------|-----------------------------|
| (1) Start                  | (7) ACTION P01 Urban        |
| (2) Parties                | (8) ACTION P02 Planning     |
| (3) INPUT P01 Urban        | (9) ACTION P03 Construction |
| (4) INPUT P02 Planning     | (10) ACTION P04 Operation   |
| (5) INPUT P03 Construction | (11) Action view            |
| (6) INPUT P04 Operation    | (12) Timeline & Relations   |

The first two of these worksheets include the selection of actions and stakeholders, which serve as a basis for further actions. In worksheets 3 to 6, the selected actions are listed and ready for further processing. The actions are listed and explained again in sheets 7 to 10. These worksheets are only visible if a checkbox has been selected on “worksheet 1 – Start” if expert features are enabled via the checkbox. The worksheet “Action view” gives a repetition of the selected actions and where to assign them. At the last sheet – “Timeline & relations” - the dependencies are shown, which can be entered in the expert features, as well as the chronological order of the actions. Also, this sheet is only visible if the checkbox is selected on the first page.

### WORKSHEET 1 – Start

At the beginning of the management tool, a checkbox can be selected on the right side if expert features are desired. This activation allows more functions on the main worksheets 3 - 6. In addition to the level of difficulty and importance, the various cost influences and dependencies of the various selected actions can also be shown. In addition, selecting this checkbox makes worksheets 7 - 10 visible. These worksheets show the individual actions that can also be edited if expert features are enabled. Furthermore, the individual actions for the project can be selected in this sheet to create an individual nZEB process. On the side menu on the left, it is possible to navigate to the other worksheets. This side menu is also displayed on all following sheets (except sheets 7 - 10).

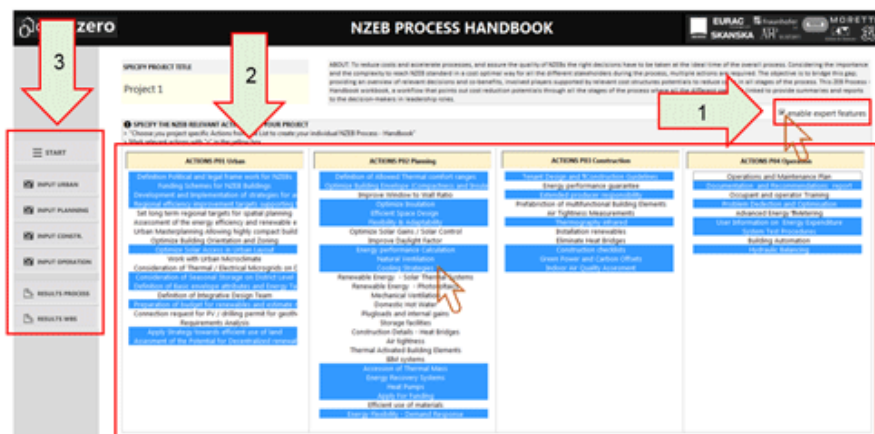


Figure 12: Screenshot: Life cycle tracker tool – Worksheet 1- start

1 > Set checkbox for expert view      2 > Selection of Actions      3 > Navigation to other worksheets

Figure 39: Worksheet 1 to select the individual actions for the project

## WORKSHEET 2 - Parties

“Worksheet 2 – Parties” shows the different stakeholders, which can be selected in the following worksheets. The stakeholders can individually be renamed by entering alternative names.

Function / default name	Alternative/specific name
Tenants/Users	
Owners	
Landlords	
Real estate fund	
Construction company	
Authorities	
Municipalities	
Investors	
(Economic) Chambers	
Citizen groups/NGOs	
Society	
Politicians	
Utilities	
Stakeholder C	
Stakeholder D	
Stakeholder E	
Stakeholder F	
Stakeholder G	
Stakeholder H	

Figure 40: Different stakeholders and alternative names

## WORKSHEET 3 - 6 (Input Part I)

In the “Input-Worksheets” for the selected life cycle phase, there is the side menu, which can be used to select the worksheets. In the column Actions (1) all actions that have previously been selected on “worksheet 1 – Start” are displayed. If more detailed information about the actions is required, a pop-up information field (2) appears by clicking the left mouse button on the action. By right-clicking with the mouse on the black arrow in the information field, it is possible to jump to the description of the next action.

Figure 14: Screenshot: Life cycle tracker tool – Action description

- 1 → Click on Actions
- 2 → Appearing of the action description
- 3 → Click to go to the next definition

Figure 41: How to get more information about the actions

## WORKSHEET 3 - 6 (Input Part II)

In the column with the heading “Main driver”, the main stakeholder responsible for the action can be assigned as presented in Figure 41. In the next column called “stakeholders”, stakeholders should be

selected who are associated with the action but are not primarily responsible for its implementation. In the tool, a preselection of typical stakeholders for the respective action is given, this can be changed. In the fourth column Specification (1), the qualitative requirements for the actions can be set by clicking with the left mouse button – and selecting high, medium, low goals. The column “Difficulty” (2) estimates how difficult the implementation is in relation to the individual requirements of the actions. In addition, the priority of the implementation can be specified in the column “Importance” (3). Also, for these two estimations, the input can be controlled by clicking the left mouse button on the input field.

Figure 15: Screenshot: Life cycle tracker tool – Definition of the difficulties and importance of each action

- 1 → Selection of targets
- 2 → Determining the difficulty of implementation
- 3 → Determining the importance of each action

Figure 42: How to choose the specification, difficulty and importance of different actions

## WORKSHEET 3 - 6 (Input Part III) Expert View

If the expert view has been activated on the first worksheet, additional entries can be made in addition to the functions already described in the basic view (more input fields appear on the right). In the columns “Influence on Planning Costs”, “Influence on Investment Costs” and “Influence on Follow-Up Costs”, expected cost changes can be entered. “+€” represents a cost increase in the respective planning step and “-€” indicates a cost-saving. This input can be changed with the right mouse click.

										Phase start: 01.01.20	Phase end: 01.01.20
	Actions	Main driver	Stakeholders	Specification (Quantitative / Qualitative Target)	Deliverability	Impact	Influences on other Actions (Indicate Number of the related action)	Influences on Planning Costs	Influences on Investment Costs	Deadline	Status
START	1.1 Evaluation of Advanced Thermal comfort ranges	Planners	Tenants/Owners, Owners, Utilities	High Co. (10% RDS)				+ €	- €	01.01.20	
INPUT URBAN	1.2 Improve Building Envelope (Components and Installation)	Authorities	Planners, Municipalities, Construction company	High performance in energy envelope building (at least energy: 0.10 kWh/m²/year; thermal insulation: 0.10 m²/K)				+ €	- €	01.01.20	
INPUT PLANNING	1.3 Improve Windows to Wall Ratio	Planners	Construction company	High Windows to wall ratio of 20-25%				+ €	- €	01.01.20	
INPUT CONSTR.	1.4 Optimise Insulation	Owners	Construction company	High insulation of the windows: 0.10 m²/K, walls: 0.10 m²/K, upper ceiling: 0.10 m²/K and ground ceiling: 0.10 m²/K				+ €	- €	01.01.20	
INPUT OPERATION	1.5 Efficient Space Design	Planners	Construction company	High floor area ratio of the space design considering energy envelope saving of the building				+ €	- €	01.01.20	
RESULTS PROCESS	1.6 Feasibility & Adaptability	Owners	Planners, Municipalities, Construction company	High: The building is 100% flexible and adaptable to other functions and surrounding				+ €	- €	01.01.20	
RESULTS WB	1.7 Optimise Solar Gains & Solar Control	Planners	Construction company	High: A building which does not need heating energy in a sunny winter day or cooling in a hot summer day				+ €	- €	01.01.20	
	1.8 Improve Daylight Factor	Authorities	Planners, Municipalities, Construction company	High: Daylight Factor of over 10% average of the office area				+ €	- €	01.01.20	
	1.9 Energy performance Calculation	Authorities	Planners, Municipalities, Construction company	High: The building's energy performance is based on a dynamic thermal building simulation and optimisation				+ €	- €	01.01.20	
	2.0 Natural Ventilation	Owners	Construction company	High: Natural ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.1 Cooling Strategies	Owners	Construction company	High: Operative indoor temperature according to EN 15251				+ €	- €	01.01.20	
	2.2 Renewable Energy - Solar Thermal	Owners	Construction company	High: Specific performance of a solar thermal system: 0.01 kWh/m²/year and 0.01 m²/K				+ €	- €	01.01.20	
	2.3 Renewable Energy - Photovoltaics	Owners	Construction company	High: The variation for the performance of the panels are given for 20 years, together with 10 panels for the thermal				+ €	- €	01.01.20	
	2.4 Mechanical Ventilation	Owners	Construction company	High: Mechanical ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.5 Renewable Hot Water	Owners	Construction company	High: First energy consumption for domestic hot water ranges below 100 kWh/100m²/year				+ €	- €	01.01.20	

Figure 43: How to enter expected cost changes

### WORKSHEET 3 - 6 (Input Part IV)

In the column “Influences on other Actions” (1), actions are to be selected which have a correlation to other actions and interact with each other. To do this, right-click on the corresponding action (1). This opens another window in which all actions selected in the Start worksheet appear (2). By holding the

Shift button, all actions that might have a correlation to the selected action can be selected. If the OK button is clicked, the window will close again.

										Phase start: 01.01.20	Phase end: 01.01.20
	Actions	Main driver	Stakeholders	Specification (Quantitative / Qualitative Target)	Deliverability	Impact	Influences on other Actions (Indicate Number of the related action)	Influences on Planning Costs	Influences on Investment Costs	Deadline	Status
START	1.1 Evaluation of Advanced Thermal comfort ranges	Planners	Tenants/Owners, Owners, Utilities	High Co. (10% RDS)				+ €	- €	01.01.20	
INPUT URBAN	1.2 Improve Building Envelope (Components and Installation)	Authorities	Planners, Municipalities, Construction company	High performance in energy envelope building (at least energy: 0.10 kWh/m²/year; thermal insulation: 0.10 m²/K)				+ €	- €	01.01.20	
INPUT PLANNING	1.3 Improve Windows to Wall Ratio	Planners	Construction company	High Windows to wall ratio of 20-25%				+ €	- €	01.01.20	
INPUT CONSTR.	1.4 Optimise Insulation	Owners	Construction company	High insulation of the windows: 0.10 m²/K, walls: 0.10 m²/K, upper ceiling: 0.10 m²/K and ground ceiling: 0.10 m²/K				+ €	- €	01.01.20	
INPUT OPERATION	1.5 Efficient Space Design	Planners	Construction company	High floor area ratio of the space design considering energy envelope saving of the building				+ €	- €	01.01.20	
RESULTS PROCESS	1.6 Feasibility & Adaptability	Owners	Planners, Municipalities, Construction company	High: The building is 100% flexible and adaptable to other functions and surrounding				+ €	- €	01.01.20	
RESULTS WB	1.7 Optimise Solar Gains & Solar Control	Planners	Construction company	High: A building which does not need heating energy in a sunny winter day or cooling in a hot summer day				+ €	- €	01.01.20	
	1.8 Improve Daylight Factor	Authorities	Planners, Municipalities, Construction company	High: Daylight Factor of over 10% average of the office area				+ €	- €	01.01.20	
	1.9 Energy performance Calculation	Authorities	Planners, Municipalities, Construction company	High: The building's energy performance is based on a dynamic thermal building simulation and optimisation				+ €	- €	01.01.20	
	2.0 Natural Ventilation	Owners	Construction company	High: Natural ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.1 Cooling Strategies	Owners	Construction company	High: Operative indoor temperature according to EN 15251				+ €	- €	01.01.20	
	2.2 Renewable Energy - Solar Thermal	Owners	Construction company	High: Specific performance of a solar thermal system: 0.01 kWh/m²/year and 0.01 m²/K				+ €	- €	01.01.20	
	2.3 Renewable Energy - Photovoltaics	Owners	Construction company	High: The variation for the performance of the panels are given for 20 years, together with 10 panels for the thermal				+ €	- €	01.01.20	
	2.4 Mechanical Ventilation	Owners	Construction company	High: Mechanical ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.5 Renewable Hot Water	Owners	Construction company	High: First energy consumption for domestic hot water ranges below 100 kWh/100m²/year				+ €	- €	01.01.20	

- 1 → Click on the corresponding column to open
- 2 → Select actions with correlation
- 3 → Click OK to save your selections

Figure 44: Correlations to other actions

### WORKSHEET 3 - 6 (Input Part V)

In the column “Deadline”, a date for each action can be defined in order to specify by when the action must be completed. Also in the upper right corner of the sheet, the beginning and end of the phase need to be entered. The column “Status” provides an overview of the status of the respective action. This setting can also be adjusted by clicking the right mouse button. Here the status can be changed to “pending”, “ongoing”, “completed” or “delayed”.

										Phase start: 01.01.20	Phase end: 01.01.20
	Actions	Main driver	Stakeholders	Specification (Quantitative / Qualitative Target)	Deliverability	Impact	Influences on Planning Costs	Influences on Investment Costs	Influences on other Actions (Indicate Number of the related action)	Deadline	Status
START	1.1 Evaluation of Advanced Thermal comfort ranges	Planners	Tenants/Owners, Owners, Utilities	High Co. (10% RDS)				+ €	- €	01.01.20	
INPUT URBAN	1.2 Improve Building Envelope (Components and Installation)	Authorities	Planners, Municipalities, Construction company	High performance in energy envelope building (at least energy: 0.10 kWh/m²/year; thermal insulation: 0.10 m²/K)				+ €	- €	01.01.20	
INPUT PLANNING	1.3 Improve Windows to Wall Ratio	Planners	Construction company	High Windows to wall ratio of 20-25%				+ €	- €	01.01.20	
INPUT CONSTR.	1.4 Optimise Insulation	Owners	Construction company	High insulation of the windows: 0.10 m²/K, walls: 0.10 m²/K, upper ceiling: 0.10 m²/K and ground ceiling: 0.10 m²/K				+ €	- €	01.01.20	
INPUT OPERATION	1.5 Efficient Space Design	Planners	Construction company	High floor area ratio of the space design considering energy envelope saving of the building				+ €	- €	01.01.20	
RESULTS PROCESS	1.6 Feasibility & Adaptability	Owners	Planners, Municipalities, Construction company	High: The building is 100% flexible and adaptable to other functions and surrounding				+ €	- €	01.01.20	
RESULTS WB	1.7 Optimise Solar Gains & Solar Control	Planners	Construction company	High: A building which does not need heating energy in a sunny winter day or cooling in a hot summer day				+ €	- €	01.01.20	
	1.8 Improve Daylight Factor	Authorities	Planners, Municipalities, Construction company	High: Daylight Factor of over 10% average of the office area				+ €	- €	01.01.20	
	1.9 Energy performance Calculation	Authorities	Planners, Municipalities, Construction company	High: The building's energy performance is based on a dynamic thermal building simulation and optimisation				+ €	- €	01.01.20	
	2.0 Natural Ventilation	Owners	Construction company	High: Natural ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.1 Cooling Strategies	Owners	Construction company	High: Operative indoor temperature according to EN 15251				+ €	- €	01.01.20	
	2.2 Renewable Energy - Solar Thermal	Owners	Construction company	High: Specific performance of a solar thermal system: 0.01 kWh/m²/year and 0.01 m²/K				+ €	- €	01.01.20	
	2.3 Renewable Energy - Photovoltaics	Owners	Construction company	High: The variation for the performance of the panels are given for 20 years, together with 10 panels for the thermal				+ €	- €	01.01.20	
	2.4 Mechanical Ventilation	Owners	Construction company	High: Mechanical ventilation system guarantees 60 l/s/m² and 100% fresh air				+ €	- €	01.01.20	
	2.5 Renewable Hot Water	Owners	Construction company	High: First energy consumption for domestic hot water ranges below 100 kWh/100m²/year				+ €	- €	01.01.20	

Figure 45: Define a date when the action has to be completed

## WORKSHEET 7 - 10 ACTIONS

Worksheets 7 to 10 are only displayed if the expert view was selected on “worksheet 1 – Start”. They show a detailed description of the actions. In this view, it is possible to revise these definitions by clicking on the respective text fields.



Figure 46: Detailed description of the actions

## WORKSHEET 11 - Action View

This worksheet shows the results of the entries previously made in worksheets 3 to 6 as a work-breakdown structure. The four phases are again split into three categories to allow a more precise classification.

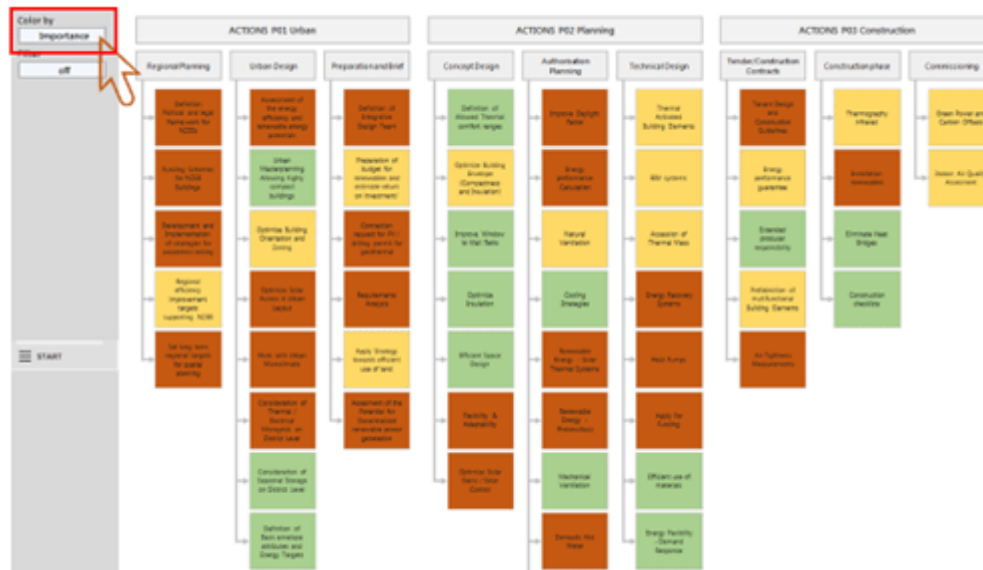


Figure 47: Results of the entries made in previous worksheets

## WORKSHEET 12 - Timeline & Relations

This worksheet is only visible if the “expert view” in “worksheet 1” has been selected. It graphically displays the individual timeline based on the entries in sheets 3 to 6 and shows the correlations between the actions again. A legend appears below the diagram to facilitate navigation.

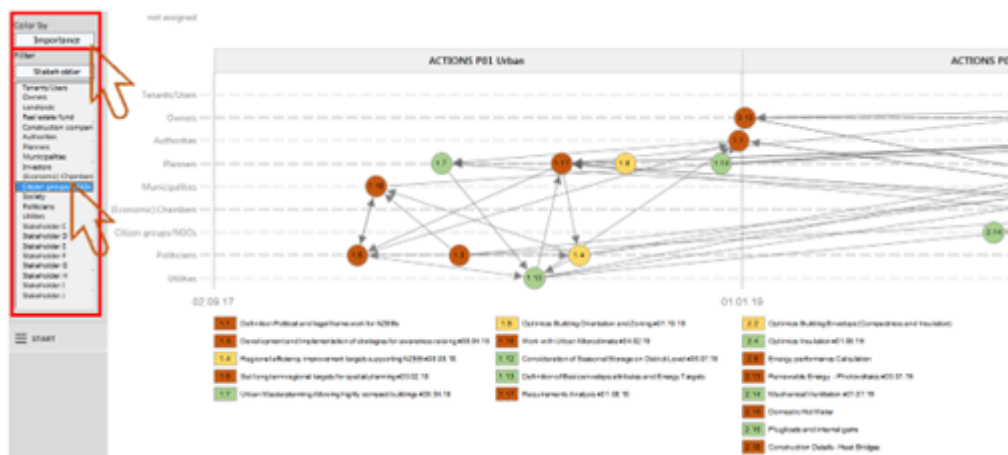


Figure 48: Individual timelines and correlations based on the entries in the worksheets 3 to 6

Link: <http://www.cravezero.eu/pinboard/Downloads/ProcessTracker.htm>



## 9. MODULE X: LIFE CYCLE COST TOOL

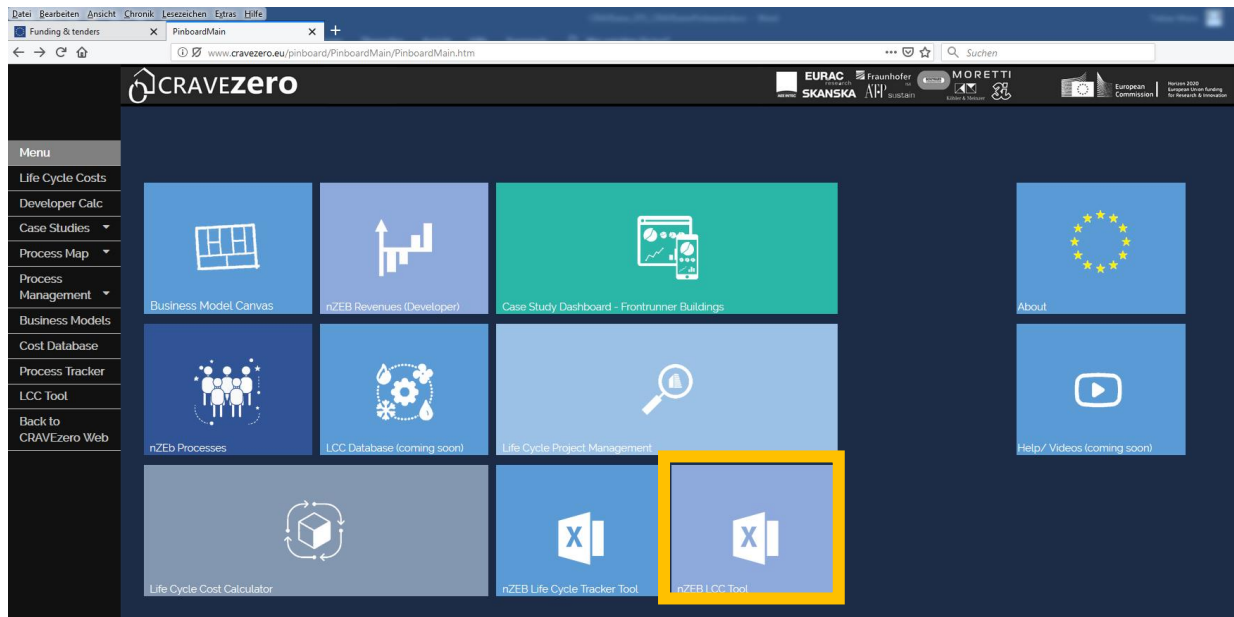


Figure 49: Pinboard selection for the life cycle cost tool

### Getting Started with the Life Cycle Cost Tool

This section provides a general overview of the LCC tool and its features, explaining the main sections and highlighting the input data.

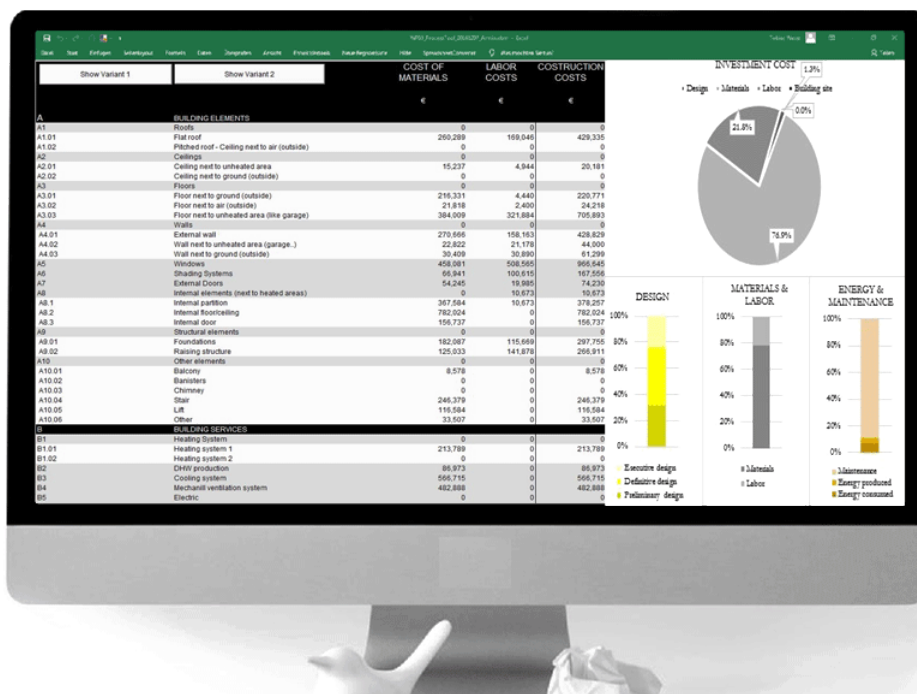


Figure 50: Overview of the LCC tool

Watch the online video tutorial of the life cycle cost tool. Federico Garzia from EURAC will guide through the main functions of the tool in 11 minutes. <https://www.youtube.com/watch?v=IQNuW5xEIJ0>

## General description of LCC tool sections

The LCC tool is composed by 6 sheets “Project information”, “WLC”, “Construction cost”, “Calc maintenance”, “Results” and “Charts”. The first 4 sheets are devoted to receive input values, the last 2 display the results of the calculation.

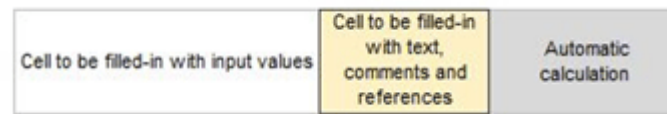


Figure 51: Overview of the result buttons of the calculation

### PROJECT INFORMATION - Part I

In this first input sheet, general data about the analysed building is collected together with those boundary conditions needed for the LCC calculation. In the first section, data about surfaces and volumes need to be provided. Following, data from the energy calculation is required. First, a reference area must be provided. The definition of “Treated floor area” comes from PHPP, the energy calculation tool used during the data collection campaign. If another tool is used for the energy calculation, the net floor area should be provided instead. The input parameters from “Average U-value opaque components” to “PV installed capacity” are not essential for the LCC calculation, since they are used to calculate indicators. A section, which provides a check on the building construction costs, was also integrated to support the data collection. In this way it is possible to verify the correctness of data inserted in the “Construction cost” sheet comparing the sum of those values with the total cost (design + construction) inserted manually (if already available from a separate calculation).

Figure 52: General data about the analysed building

### PROJECT INFORMATION - Part II

Economic boundary conditions are collected in this section (Figure 55). This permits the calculation of actualized energy and maintenance costs over the building life span. Essential for the calculation are interest rate, the fuel prices and their average annual price increase. Finally, data about energy consumption (kWh/m<sup>2</sup>) and production (kWh) must be provided, in order to determine operational cost.

Figure 53: Economic boundary conditions

### PROJECT INFORMATION - Part III (Variants)

Variants can be investigated. Two buttons, also present in the other sheets, permit to display up to 2 variants. In this way different input values can be compared.

Figure 54: Investigate different variants



## WHOLE LIFE COST (WLC) - Part I

In this sheet, non-construction cost and costs related to building design process are collected. This data, together with the construction cost collected in the next sheet “Construction cost” and the calculated O&M costs, build the WLC. In the first section, non-construction costs such as cost of land, enabling costs and planning fees can be provided. Two columns are available to split the costs and to maintain a better overview, if required by the specific cost structure.

- **Cost of lands:** costs of land (and the volume allowed to be built).
- **Price:** unitary price of land.
- **Enabling costs:** cost for site preparation works that might take place prior to work under the main construction contract. This could include: demolition, site clearance, tree protection, diversion and / or disconnection of existing site services, geotechnical and exploratory ground investigation, decoupling from existing buildings, decontamination, ground improvement and /or compaction, excavation of known below-ground obstructions, survey work, creation of access routes, perimeter fencing and security provisions, work to neighbouring buildings, discharging planning conditions that must be satisfied prior to construction commencing, historical architectural investigation fieldwork, access ramps, signage provisions, provision of statutory utilities to the site).
- **Planning fees:** taxes and fees to be paid for getting the permissions and fulfil the administrative issues
- **User support costs:** it includes all the cost for the support activities during the organization phase (management of the property, helpdesk and IT services, general administration issues).
- **Finance Costs:** costs related to the interest or costs of money (in case of bank loan).

Figure 55: Non-construction cost and costs related to building design process

## WHOLE LIFE COST (WLC) - Part II

In the second section of the WLC sheet, design costs should be provided, divided in preliminary, definitive and executive design. Standard cost typologies are displayed, nevertheless if required, other costs can be added starting from line 27. Building site management costs are also included in this sheet. These are costs for the general building site management, in terms of supervision of the activities, organization and cost for the general equipment (e.g. crane, scaffolding, etc.). Please, insert here the cost of the equipment when it deals with the general building site operation, while insert in the sheet “Construction cost”, in the cells related to “Other Costs” when it deals with a particular building element (e.g. use of a special crane for mounting a prefabricated element). In the same way as in the previous sheet, also here it is possible to display up to 2 variants to be analyzed.

Figure 56: Provided design costs

## CONSTRUCTION COST

In this section a detailed breakdown of construction costs is required (Figure 59). On the left side a brief description of the single layer and the corresponding area can be inserted (arrow n.1). Cost of the materials, labour costs and other costs can be provide. In the case of material costs, either aggregated costs or unitary price can be provided (arrow n.2). If a breakdown of material and labour costs is not available, the global cost (construction cost) must be inserted in the yellow section “Materials”.

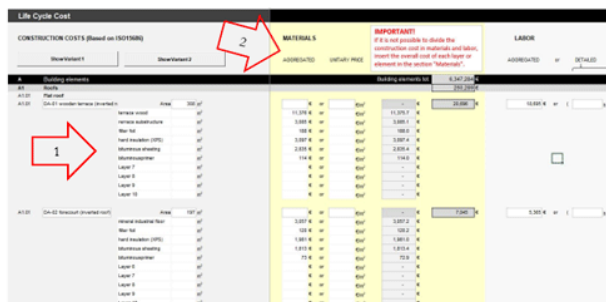


Figure 57: Detailed breakdown of construction costs

## RESULTS I

In this sheet the results of the LCC calculation are provided. The results have been divided summarizing building elements, building services, whole life costs, construction and operation.

Show Variant 1	Show Variant 2	COST OF MATERIALS	LABOR COSTS	CONSTRUCTION COSTS
		€	€	€
<b>BUILDING ELEMENTS</b>				
A1	Roofs	0	0	0
A1.01	Flat roof	260.289	169.046	429.335
A1.02	Pitched roof - Ceiling next to air (outside)	0	0	0
A2	Ceilings	0	0	0
A2.01	Ceiling next to unheated area	15.237	4.944	20.181
A2.02	Ceiling next to ground (outside)	0	0	0
A3	Floors	0	0	0
A3.01	Floor next to ground (outside)	216.331	4.446	220.777
A3.02	Floor next to air (outside)	21.818	2.400	24.218
A3.03	Floor next to unheated area (like garage)	384.009	321.884	705.893
A4	Walls	0	0	0
A4.01	External wall	270.566	158.163	428.729
A4.02	Wall next to unheated area (garage...)	22.822	21.176	44.000
A4.03	Wall next to ground (outside)	30.409	30.880	61.289
A5	Windows	458.081	508.565	966.645
A6	Shading Systems	66.941	190.915	257.856
<b>Treated floor area</b>				
134797 km²				
<b>Design</b>				
960 km²				
<b>Construction</b>				
73400 km²				
<b>Operation</b>				
50437 km²				
<b>Life Cycle Cost (LCC)</b>				
134797 km²				
<b>Cost Distribution</b>				
Design: 960 km², Construction: 73400 km², Operation: 50437 km²				
<b>Breakdown of Life Cycle Cost</b>				
Materials, Labor, Energy consumed, Energy produced, Energy consumed				
<b>Life-Cycle Cost (40 Years)</b>				
Bar chart showing costs in millions over 40 years				

Figure 58: Results of the LCC calculation

## RESULTS II

Finally, in the sheet “Charts” the numerical results can be displayed in graphical way.

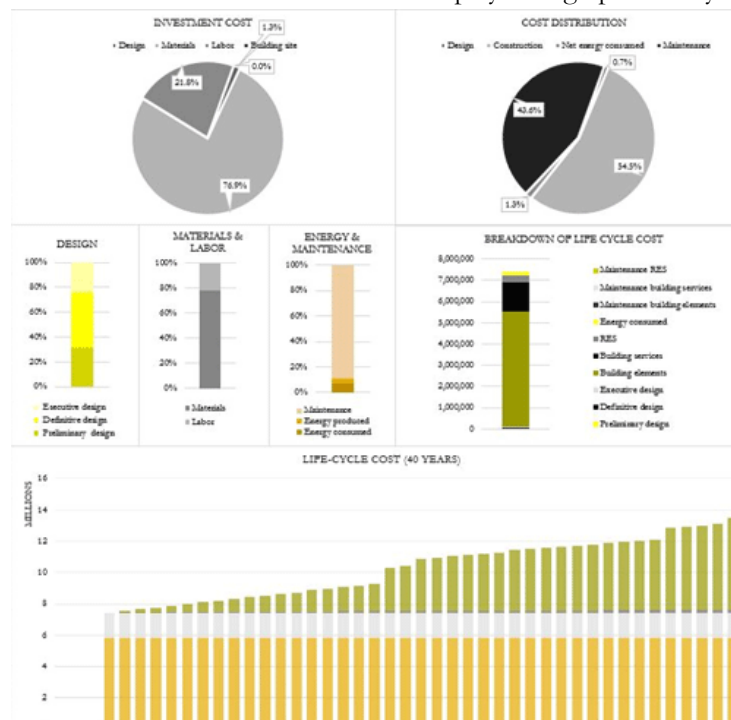


Figure 59: Numerical results in graphical way

Link: <http://www.cravezero.eu/pinboard/LCC/LCCInfo.htm>