Set of Solutions for Affordable Zero Energy Buildings

Preliminary results for inclusion in the AZEB methodology

April 2018

Affordable Zero Energy Buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

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Work package	5: Communication, Dissemination and Exploitation
Deliverable	Not applicable.
Project title	AZEB- Affordable Zero Energy Buildings
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Date of issue	April 2018
Status	Final
Security	Public Article

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1 |Introduction

This article summarizes all solutions collected through the European Project Affordable Zero Energy Buildings (AZEB) so far, until april 2018. These solutions are the building blocks for the methodology to be developed within the project. The set of solutions presented in this document is still rough and needs further development and ordering, but we wish to disseminate this list of first results as soon as possible to allow interested parties to take note already and possibly aid in the implementation and further development.

The AZEB project runs between May 2017 and October 2019 and will create, test and disseminate a general methodology for cost reduction for nearly zero energy buildings throughout Europe. The main target groups for using this methodology are 1. Decision makers such as home owners and housing corporations and investors and 2. Experts such as designers, project managers for construction and for maintenance and energy consultants. The methodology will give guidance for making cost optimal decisions, giving cost optimal advice and for cost optimally implementing decisions. This article summarizes input for this methodology.

2 |Cost drivers for NZEB per project phase

The table below summarizes the preliminary main identified cost drivers for nearly zero energy buildings, compared to traditional buildings. The set of solutions and the AZEB methodology aims to address these cost drivers with cost effective solutions.

Project Phase	**NZEB Cost Driver**
Initiative	Lack of clear and explicit indicators for targeted performances (on e.g. energy, comfort, health), especially from the user perspective: user needs and wishes - this makes it difficult to assess possible cost optimizations
	Lack of good AZEB references /- examples - makes it difficult to estimate reasonable lifecycle costs
	Contracting practices which do not entail an incentive for shared responsibility and risk throughout the supply chain, which creates space for much waste during the project lifecycle
	Lack of site information, geographic information, which is important for (cost-) optimizing NZEB designs.
	Benefits from lifecycle cost reductions through NZEB may affect actors in the project lifecycle differently: e.g. a developer may never reap the cost benefits of reduced energy needs, which the user will. This may stimulate short term cost

	reductions for one actor at the cost of longer term and potentially larger cost reductions for another actor.
Design	Lack of NZEB design expertise causes extra time due to training of staff and/or rework
	Not taking into account the whole lifecycle of the building and its elements. Lack of a long term "mindset". (Optimals at short term might be more expensive at long term). E.g. not taking into account the costs for the user, like costs for maintenance, replacements and operation of the building.
	Not using sound design principles for lifecycle cost-optimization (e.g. maximization winter solar exposure/minimizing summer solar exposure, eliminating thermal bridges, appropriate dimensioning of building services, passive before active measures) can lead to for example higher lifecycle costs, unnecessary overdimensioning of elements and/or malperformance in the use phase (e.g. health and comfort issues)
	Not using NZEB design tools (e.g. PHPP) for the good validation of the design against the chosen set of performance indicators causing a risk on performance (and/or - contract)
	Not detailing how the building will be commissioned, including measurement and verification procedures for its performance.
	Not using calculation and simulation tools where possible to reduce labour costs of doing these studies "by hand"
	No calculations on the influence of the way the building is used on the actual energy performance, leading to suboptimal design and risks for performance /-contract
	Not having / using the right tools to calculate the financial effects of NZEB design decisions from a life cycle costing perspective - this way longterm benefits might be sacrificed for short term benefits with a negative net result
Construction	Extra materials needed (e.g. thicker / more isolation)
	Higher performance needed per element (e.g. doors, windows)
	Extra labour for NZEB details (e.g. making the building airtight)
	Extra time needed for validation/verification tests of elements and complete building (e.g. blowerdoortests and testing & finetuning installations) and retesting if problems occur, e.g. air leakage due to bad quality window mounting or masonry work.
	Extra costs for monitoring equipment for use phase
	Lack of worker expertise (own workers and subcontractors) causing failure and rework and thus extra labour time
Use phase	User behaviour causing higher energy need and diminished performance on e.g. comfort or health
	Monitoring costs related to performance contracting and to influencing user behaviour
	Specialized maintenance of NZEB building services (e.g. heat pumps or ventilation systems, non-traditional and sometimes complex systems)
	Time-coincidence of peak demand for buildings
	Lack of energy performance clausules in the contracts, including guarantees and e.g. user instructions on maintenance, could mean higher maintenance or energy costs for the user due to installations performances being lower than expected or designed for.
	Lack of a properly detailed commissioning plan and measurement and verification plan for the installations; causing improper use, maintenance and/or measurements, which may lead to higher costs longterm.

End-of-life	Labour costs for careful demolishment for reuse and recycle of materials.

3 | Solutions for performance indicators on energy, health and comfort

The first type of solutions create the boundary conditions for controlled cost optimization efforts. There is still much unclarity in the market about how to define energy performance or on how to define and assess important user oriented performance indicators such as health and comfort. In nearly zero energy buildings, design choices, execution in the construction phase and user behaviour and maintenance in the use phase have a strong impact on the complete performance of the building. Correct execution of details is much more critical for performance than in traditional buildings. Therefore the performance targets need to be made clear and explicit to facilitate decision making for all stakeholders involved during the lifecycle of the project. A balanced set of indicators is also needed when applying any kind of performance contract in the project to control risks. In addition, when new insights during the project occur, a clear set of indicators can make sure decisions can be validated with the complete set of original purposes of the project, ensuring client satisfaction and continued performance of the building.

- using sound definitions, calculation methods and software for Life Cycle Analysis (LCA)
* costs may only be evaluated in relation to performance: the effect of cost reduction on environmental performance should be made explicit in the decision making process

- Using sound methods and tools for analysing and calculating lifecycle costs (LCC)
* this allows for calculation of true costs and comparison with other projects: benchmarking for cost-optimization

- Using sound indicators and measurement methods & tools for assessing the building's performance on energy, comfort and health
* costs may only be evaluated in relation to performance: The effect of a cost reduction on performance on e.g. energy, health and comfort should be made explicit in the decision making process

- Clear definition of language and concepts to be used in project
* avoid costs of mistakes due to misalignment of expectations

-Post Occupancy Evaluations: subjective methods and physical measurements
* identifying potential issues for user or contracting parties in time to mitigate - avoiding costs in use phase associated with energy use, environmental costs and diminished performance of building on e.g. comfort and health

4 | Solutions concerning technical or energy concepts

The second type of solutions, technical and energy concepts, will provide clear guidelines to design, build and maintain a cost effective NZEB. These solutions entail e.g. cost effective design principles (such as building orientation and shape to reduce loss of energy and gain maximum solar exposure in winter), cost effective building service concepts (such as combining several functionalities in one element) and the use of specific calculation and simulation tools for optimizing design. Below the preliminary collection of solutions to be integrated in the AZEB methodology.

-Design for use: Anticipate user behavior and comfort preferences and set design criteria in line with this, also take into account indoor air quality setpoints
* avoid overdimensioning or underdimensioning of building components
* avoid dissatisfaction of users hence lower (e-)value(-ations)
* construction costs can be limited to the user's demands instead of maximum comfort

-Design buildings with a long-time constant (low energy losses and high thermal mass)
* allow for "free" energy storage, low energy use and high comfort
* lower need of renewable energy services in scarce space situations

- First maximize passive measures then active measures
* avoid maintenance, disposal and replacement costs of installations
* lowers energy using costs since less energy is needed for building services

- Avoid time-coincidence of peak demand of buildings in district and with the grid peak load
* reduces size and cost of grid connections and energy storage

- Using criteria that help cost optimization when choosing technologies in early design solutions of passive and active measures, e.g. reduction of energy needs by acting on energy losses due to the envelope and ventilation reduces size/peak capacity and installation costs of active systems to optimal level
* increases value per m2, reduces capital costs per m2

- Adapt your building service solution to the climate zone
* correct choice of combination of air temperature, surface temperature, air velocity et cetera can achieve same or better comfort level with lower energy and power demand, implying strong cost reduction at very low cost

- Reducing for active (and especially expensive) equipment the ratio of peak heating / cooling requirement to average heating / cooling requirement
* reduced installation costs of peak capacity, allowing more efficient use of the active system (close to optimal load for large part of operating time), reduced replacement costs for active equipment

- Rational use of water via tested water distribution technologies
*reduce water usage costs

- Task lighting, choices of luminaires, light finishing colours etc
* reduce installed lighting power and hence reduce installation and maintenance costs

- Optimal layout for distribution piping
* reduces pressure losses and pumping peak power and thus installation costs and energy use

- Increase the amount of functionalities performed by a single component
* reduces total amount of and total costs for components and installation work

- analysis and design of micro-grid solutions for storing and distributing locally collected energy over several buildings in a specific area -
* exploiting cost reduction potential of these sources

- using energy grids and load-match indexes
*reduce coincidence of peak demand and thus reduce size and cost of grid connections and energy storage

- increase use of vegetation and cool surfaces
* reduces cost of cooling systems in buildings and available comfortable public spaces for users

- Sharing functions in common spaces
* better service levels with less m2's hence reducing cost per household or productive unit

- Maximization of winter solar exposure (&minimization of summer?)
* reduces energy needs and associated costs

- Reducing heat losses by increased compactness
* reducing energy needs and thus related costs (size of installation, energy use etc)

- Mutualizing walls
* reducing financial and environmental costs of materials

- Sharing renewable energy sources like district heating, centralized biomass boiler etc
* increased efficiency of energy systems means lower overall cost

- Take measures to reduce effects of a heat island, especially in cooling dominated areas. Main mitigation techniques are: green urban areas, cool pavements, cool roof and green roof. These solutions work by principles of: cooling through evaporative process, shading, high albedo (=solar reflection) and high far-infrared emissivity (=ability of surface to release heat)
* increase in cooling load & decrease in cooling potential of passive strategies causes higher costs due to higher energy demand for cooling (sizing installations and energy use)

- Choice of shape and orientation of building in sketch phase to influence heat losses and gains
* influences heating and cooling needs as well as thermal and visual (?) comfort, hence reduces need for sophisticated and expensive technical systems (building services)

- Use bioclimatic design: integrate climatic aspects in the design early on, focusing on passive measures and the performance of the building envelope, to achieve good energy performance and comfort at a low cost (instead of just addressing active measures at the phase of detailed design)
* reduced need for building services and installations, hence reducing the associated lifecycle costs

- Smart detailed design focusses on aligning functionalities of building elements with the user requirements and targeted performance of the building and pays specific attention to the interaction between the elements. Building physics is an important field of knowledge for this type of design. Examples of themes to be addressed are: thermal bridges and toxic emissions of materials in relation to ventilation capacity.
* Designing based on clear principles and on building physics enable cost effective choices to be made without jeopardizing the basic performance targets of the client. Attention for the interactions between elements and for their joint effect on performance avoids e.g. overdimensioning of elements or systems or malperformance of the end result, which can increase costs.

5 | Solutions concerning process optimization throughout the value chain

The third type of solutions focusses on eliminating wastes in all phases of the project. AZEB follows the philosophy of lean in this, identifying 8 types of waste: defects, overproduction, waiting, underutilization of talent, transportation, motion, inventory, extra-processing. The presupposition is of course that these types of waste create unnecessary costs. Within AZEB solutions are collected to reduce these types of waste for NZEB projects and for the NZEB value chain. These solutions have implications on the project scale, but also on the scale of companies and the complete value chain. Although many of these solutions are generic for all types of building projects, not just NZEB, we still integrate them in AZEB because the necessity to apply them will rise once the NZEB standard is enforced by law in Europe (2020). The challenge will then be to keep housing affordable, even with these high energy standards. AZEB presupposes this can only be done by increasing productivity and reducing waste throughout the supply chain.

- Choosing a stakeholder collaboration type for the project which matches the (cost optimization) goals of the project, and choosing a tendering and contracting method that stimulates and supports this collaboration type, for example integrated contracts like design-build-maintain and ESCO's.
* the right type of collaboration between client and different disciplines during all phases of the project will enable maximization of cost effectiveness
* the right contract stimulates lifecycle thinking and -costing and integrated design

- applying energy performance guarantee for a NZEB building (as a whole)
* this provides an incentive to the market to apply integrative processes in the value chain, which are needed to optimize costs
* this will force the contractor to a) keep the clients or user's needs central in the design and construction process, b) think through the complete lifecycle and to explore the interfaces between disciplines and different parts of the building, hence avoiding suboptimization and waste and stimulating synergy and efficiency.
* makes higher initial investments possible due to guarantee of lower LCC (eliminates a barrier) and this way makes a project more "affordable".

- Using semi-static and dynamic simulation tools early in design process
* optimize design for cost - research impact of design choices on cost and performance

- Using building energy simulation tools (BES) to optimize certain design parameters, based on specific contextual conditions such as the local climate. There are general BES tools, but for urban areas also mesoscale models and microscale models and even microclimate models. The use of BES tools is best combined with an LCA for the preferred scenario's to aid decision making on the balance of cost (financial and environmental)/performance/risk
* using simulation tools reduces study time and thus project costs

-Use energy calculation and optimization tools in the situation of complex buildings and or more buildings being built at once
* simulation tools reduce study time and associated project costs

- "Legolizing" and prefabrication: Use simplification, standards and prefabrication where possible
*easier quality control reduces costs of rework and malperformance

*reduction of waste (e.g. materials and time)
* increased productivity per worker hour

-Working culture, team and task definition
* improve integrative approach of project, avoid costs associated with non-integrative approach

- Influencing end-user behaviour by information, social interaction and education
* avoiding costs in use phase associated with energy use, environmental costs and diminished performance of building on e.g. comfort and health

- Applying lean principles throughout supply chain and in each projectphase
* reducing all types of waste and associated costs & maximizing customer value

- Applying value engineering studies at different stages of the project
* Optimizing costs in relation to performance, maximizing creativity across disciplines for best solutions

- Applying integrated design techniques, involving a multitude of disciplines, like the method of morphological design (can be part of Value Engineering also)
* avoids suboptimal design because all disciplines are involved from the start with their specific knowledge, experience and skills and their expertise from each project phase (initiative, design, construction, maintenance and use)
* boosts creativity over disciplines for cost optimal solutions, avoids risks occurring during project lifecycle

- Establishment of professional qualification requirements for subcontractors and service providers to share the risks (e.g. thermal bridges or air leakages by window mounting). Establishment of an open list (available to all on-site managers) of suppliers and subcontractors with demonstrated experience in their activities.
* reduces costs associated with failure (rework, lawsuits etc) and with delays in time

- training on-site working staff on proper execution of NZEB detailing, lean principles, best practices in waste management and using BIM
*increased productivity and stimulating continuous improvement

- implementing NZEB specific quality system for verification and validation during project lifecycle
* preventing costs associated with e.g. reduced performance and defects

- Explore possibilities local sourcing of materials and other inventory items
* reduce transport costs and environmental costs

6 | About AZEB and the participating partners

AZEB (Affordable Zero Energy Buildings) aims to achieve significant construction and lifecycle cost reductions of new NZEB's through integral process optimization in all construction phases. Optimizing construction processes to fully integrate available solutions in the areas of process, technology and contracting is seen as the largest potential in lifecycle cost reduction. The project will create a common methodology for cost effective NZEB. In the 30-month AZEB project 8 partners from Italy, Spain, Bulgaria, Germany, France and The Netherlands work together till end 2019.

The main steps of the AZEB project are:

- Evaluate available experience and solutions
- Create a common methodology for cost reduction
- Apply the methodology to demonstration projects
- Finalise the methodology including lessons learned
- Disseminate the results

The project will pave the way for the process and organizational innovation in construction, to enable significant cost reduction and solid market acceptance of NZEB's.

The AZEB Projectpartners are:

- DNA in de Bouw - The Netherlands (projectleader)
- OHL (Obrascon Huarte Lain) - Spain
- Tecnalia (Fundacion Tecnalia Research & Innovation) - Spain
- Visesa (Vivienda y Suelo de Euskadi) - Spain
- Passive House Institute - Germany
- Armines (Association Pour La Recherche Et Le Developpement Des Methodes Et Processus Industriels) - France
- Oberon Konzeptbau - Bulgaria
- Politecnico di Milano (eERG-PoliMI) - Italy

More information about the project and its results can be found at: www.azeb.eu.