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Deliverable 4.2
Informational material for experts

November 2019

Affordable Zero Energy Buildings

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Deliverable 4.2
Informational material for experts

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Other partners involved in this deliverable
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ARMINES, *France*
Oberon Konzeptbau, *Bulgaria*

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1 |Objectives

The methodology developed in the AZEB project serves as a guidance, like a “roadmap” for all involved in a planning and construction process – professionals, professional clients or individual home owners – and supports the often confusing journey of executing a building project from the first ideas until the phase of using and maintaining the completed building. The objective of this roadmap and the accompanying tools, methods and references, is to facilitate critical decisions during the whole process, which results in an immense improvement of the energy standard as well as an associated cost reduction. When applying the AZEB methodology, results are further optimized by the application of process-oriented tools and measures.

The information materials presented in this deliverable have been developed within the AZEB project specifically for construction experts, to support then when applying the AZEB methodology in actual projects. The materials help to improve the quality of nZEBs, the prevention of construction errors and the avoidance of performance gaps, and therefore help increase the cost effectiveness and users acceptance of nZEBs.

The AZEB roadmap not only provides a lot of support in chronological order of projects, but also offers this support in varying depth and intensity – from the first information about an important topic for the construction of an affordable nZEB to the detailed knowledge transfer up to the practical application of this field of knowledge and the tools developed for it. Digital or printed versions of first information documents facilitate to get an overview about the various topics, which are involved in a construction process and therefore have to be considered. They create awareness of existing knowledge and technologies which are possibly unknown in conventional construction, draw attention to difficulties that may arise and offer numerous proven solutions for highly energy efficient buildings. Additionally they raise interest on additional qualification and give information on how to get detailed knowledge.

The information materials presented in this report are related to different steps of the AZEB roadmap and will be uploaded on the e-learning platform of the AZEB website: www.azeb.eu/learn. All the information documents created in AZEB for professionals like e.g. architect, engineers or project managers are briefly described in this deliverable. Since some of the information materials (and the course materials and tools described therein) are used in more than one step of the methodology, an order according to the phases of the methodology does not make sense. Therefore the materials are listed here in the order of their first appearance in the AZEB methodology / roadmap, like explained in the respective chapters below.

The following table gives an overview of the information material described in this deliverable and their connection to the AZEB methodology.

Table 1: Overview of all deliverables in D4.2

AZEB MATERIALS		INITIATIVE PHASE						DESIGN PHASE/PLANNING PHASE		CONSTRUCTION PHASE/OPERATING PHASE					USE & MAINTENANCE PHASE		EXTEND YOUR IMPACT	
		Identify relevant contextual aspects	Set balanced requirements	Standardize costing practices	Plan validation & verification	Conceive & select alternatives	Define practices for procurement and guarantuues	Involve a multidisciplinary team	Design optimized buildings	Set up collaborative construction practices	Teach on-site team practical nZEB skills	Involve on-site team in time, quality and cost control	Commission the building services	Create a project dossier	Monitor and optimize performance	Guide user behaviour	Evaluate & apply lessons learned	Integrate the value chain
		Step1	Step2	Step3	Step4	Step5	Step6	Step7	Step8	Step9	Step10	Step11	Step12	Step13	Step14	Step15	Step16	Step17
2.1	AZEB-Guide for client requirement specifications and V&V plans		x		x							x	x					
2.2	Misbehaviour mini-guide		x						x							x		
2.3	AZEB TCO tool			x														
2.4	Cost element database			x														
2.5	Value integrated design methods and value chain integration					x	x		x	x								x
2.6	Renewable energy technologies for AZEBs					x												
2.7	Energy performance guarantee manual for professionals						x					x	x		x			
2.8	Energy performance example						x								x			
2.9	Factsheet Energy simulation								x									
2.10	Factsheet Life cycle assessment								x									
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2.12	Factsheets on tools developed in AZEB								x				x					
2.13	Information on Thermal bridges								x									
2.14	Commissioning - Factsheet for experts								x				x					
2.15	Factsheet on the energy balance tool PHPP								x									
2.16	Overview cost-effective design principles for AZEBs								x									
2.17	Critical practical construction skills for nZEBs										x							
2.18	Transforming the training material for cost optimization method										x							

Several information materials summarize factsheets, course material or tools which were developed in AZEB. More detailed information on these course materials or tools themselves therefore can be found in the respective steps of the AZEB Roadmap on www.azeb.eu/learn.

2 | Information material

2.1 | AZEB-Guide for client requirement specifications and V&V plans (DNA)

This guide is developed as a short e-book summarizing the most important aspects of creating balanced requirements for an AZEB project.

- It provides a basic format to use, explains the importance of good interviewing and stakeholder workshop skills to collect the requirements and shows how requirements can be updated throughout the project lifecycle.
- It suggests indicators to use for the main requirement categories: Environmental factors, social factors and economic (cost & benefit) factors.
- It explains the importance of a Validation and Verification (V&V) plan to track the progress of the project on cost and quality aspects and to guide commissioning activities. It suggests a basic format to use for this and suggests some AZEB specific V&V measures for the main requirements and indicators. Although there are general sources for learning requirements engineering and V&V practices, there are not yet directed specifically to nZEBs, and this guide tries to fill this gap.

This guide has been developed because good requirements engineering and solid V&V practices are the basis for an integrated nZEB development process, ensuring affordability and quality in each project phase while preventing failure costs along the way. The main influence on cost reduction and quality increase for an nZEB can be had in the initiative and design phase. Balanced requirements in combination with reliable V&V practices will guide each decision from the start of the project to find an optimum between environmental, social and economic aspects of the building and to be able to reliably ensure performance. Setting clear requirements and indicators and following a V&V plan throughout all project phases including commissioning, is not yet common practice in the building sector. This guide intends to show it is relatively simple to apply and greatly enhances project control and client satisfaction. For developing good AZEB's it is a must. The guide start being useful from step 2 (setting balanced requirements) and step 4 (Install a quality assurance system) onwards, right up to the use and maintenance phase of the project.

2.2 | Misbehaviour mini-guide (Visesa)

Users have shown to have a decisive impact on installations' performance. This is something The Spanish partner Visesa (Basque Country Public Housing Body) has learnt through the years. From direct experience with social housing users and now during the development of AZEB methodology they realized that, having this knowledge in advance, could have prevented latter inefficient performance of installations due to user's misbehaviour. This is the kind of knowledge that should be taken into account when they refer to contextual aspects of the project (Step 2: setting balanced requirements). In this case the relevant contextual aspect has to do with the especial characteristics of social housing users.

This mini-guide has been created as a tool to both aware the experts and train the users. User can behave incorrectly for several reasons, and this could be partially relieved by investing on user's training (Step 15: Guide user behaviour), but at the same time, it has been found necessary to raise awareness within designers, engineers and installers about the kind of use that the installations are going to have. Affordability is very much related to designing and installing robust installations, easy to use and with low maintenance costs (Step 8: Design optimized buildings).

This misbehaviour mini-guide, based on real experiences, aims to train designers and installers about eventual situations that may affect installations performance and could come up suddenly when tenants are social housing users.

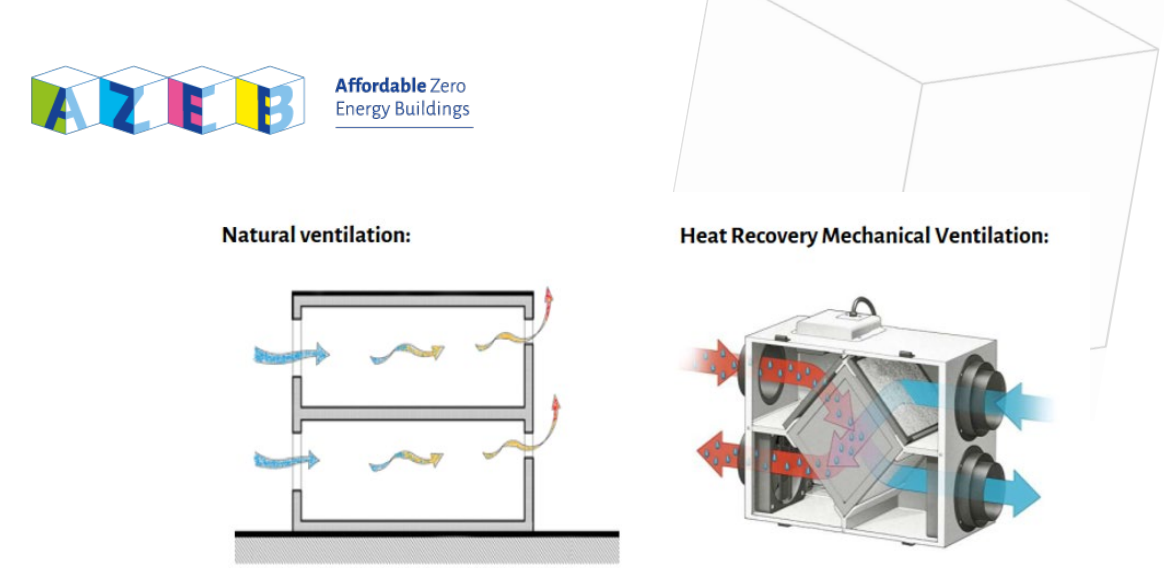


Figure 1: Explaining natural and mechanical ventilation in the misbehaviour guide

2.3 | Factsheet on AZEB TCO tool (DNA)

The TCO tool is an excel based decision making tool which integrates data of technical aspects of the building, associated lifecycle costs of building, social performance of the building and environmental performance of the building. By playing with the input based on various design, construction and maintenance options, an optimum can be found between costs, social and environmental performance of the building. The tool can be used by professionals and is also a great way to facilitate communication with clients to prepare for their decision making. AZEB TCO tool is the working title of the tool, but the name does not cover its full functionality yet. In the exploitation plan for AZEB we will discuss alternative names which may stimulate increased uptake (marketing issue).

There is a variety of tools on the market for the separate fields of performance for buildings: costs, social or environmental. Very few combine two or more aspects especially for integrated nZEB decision making. Also, they are usually not openly available. The AZEB methodology is intended to improve the decision making process during the project in such a way that affordable high quality nZEBs are the result. We facilitate project teams with a lot of information and tools to do this. What was missing was a practical tool to integrate this information towards decision making and a tool to facilitate communication with the client. We decided to create a decision making tool specifically fit for using while implementing the AZEB methodology, usable in each project phase, especially at crucial decision moments. Data for all advised areas of AZEB requirements and proposed AZEB indicators can easily be entered (also when separately using other dedicated tools, for example for lifecycle cost calculations and for energy performance calculations) and we can update and improve this tool in the exploitation phase of AZEB, fully within our own sphere of influence. The tool in itself is also a good method for verification and validation of the full AZEB program of requirements. During its development we decided to integrate the functionalities of the AQSI tool in it, so that no separate tool is needed for the social aspects anymore. Also, a link is created with a costs element database created within AZEB, as an example for implementing step 3: standardizing cost practices. The tool has been created based on D2.1 on indicators and methods for affordable nZEBs, on the main outcomes of PHPP and on the AQSI tool set up.
The factsheet of the tool located in step 3 of the AZEB roadmap (standardizing cost practices) and is available at AZEB project website (www.azeb.eu) and the tool itself is part of Deliverable 4.6 Decision making tool.

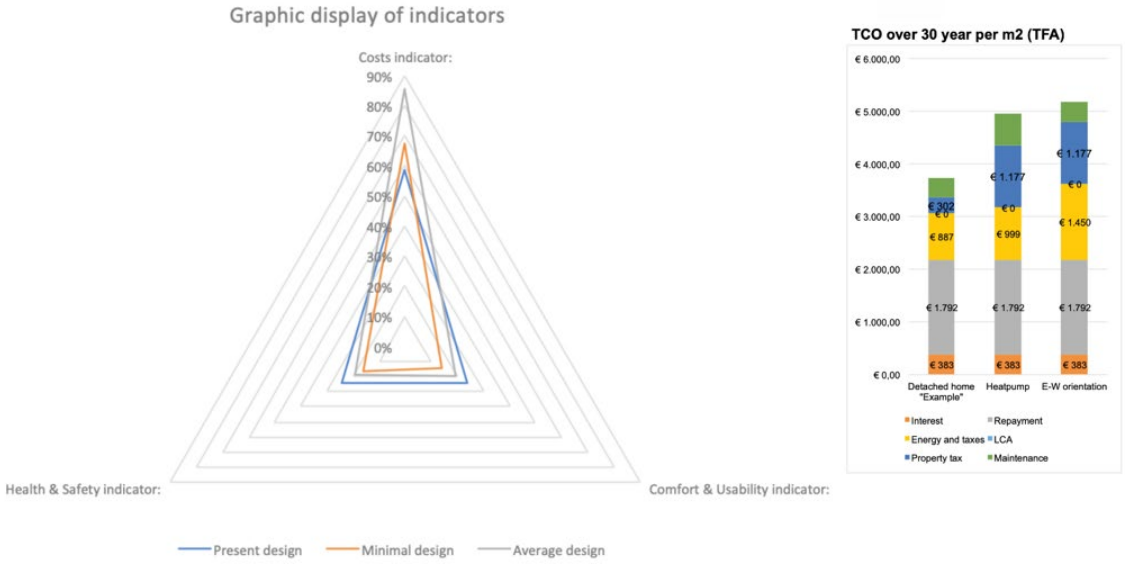


Figure 2: Screenshots from TCO tool

2.4 | Factsheet on cost element database (DNA)

The cost element database is an exemplary and customizable excel based tool to standardize the costing practices within and across projects. Building elements are clearly defined and coded, preferably based on international or national standards, so all building parties involved can use the same definitions underlying their cost calculations, which makes results fully comparable. Also, general cost changes can always be tracked back to the elements involved and vice versa. This improves reliable decision making. The cost element database can be linked to the AZEB TCO tool, or to BIM applications. The exemplary cost database used in AZEB uses standards which are often used in The Netherlands. However, projects can adapt the tool to suit their own preferred standards. Additional benefit of the tool is that for companies, or on a national basis, referential nZEB costs can be created for cost estimations in the early phases of the project. This can improve early decision making, for example in the initiative phase when selecting requirements and when selecting specific alternatives for the project.

Standardization of costing elements and costing practices is not common practice yet in the building sector. Within AZEB we have discovered this as one of the obstacles towards good decision making during nZEB projects, as described in earlier deliverables such as D2.1 on indicators and D1.2 on value chain integration. This database is an example of how to set up standardization of cost elements in order to facilitate standardization of costing practices and uniform costing information across involved building parties to base decisions on. The database, in combination with the TCO tool, aims to clarify what the added value is of standardizing costing practices and how this might be applied in actual projects. This factsheet therefore is also intended to be used in step 3 of the AZEB roadmap: standardizing cost practices.

2.5 | Factsheet Value integrated design methods and value chain integration (DNA)

This factsheet shows what integrated design methods and value integration are and why they are important to apply when creating affordable nZEBs. Relevant sources to learn more about these topics are referenced in the factsheet.

Integrated design methods are not yet common practice in the building sector, despite of the many other industries where it has been common practice for years. Building specialisms are scattered over numerous parties involved in a building project. Affordability and good quality of nZEBs can be created by achieving synergy between these specialisms. This is for example emphasized in the EU-project PROF/TRAC, listing the main work fields involved in nZEB development, which skills these work fields need to have specifically for creating nZEBs and what interdisciplinary skills are involved in this (www.proftrac.eu).

Existing methods for integrated design and for value chain integration can help the project teams to capture the potential synergy between these work fields by using clear facilitative processes. This factsheet can be used in the AZEB methodology especially in:

- Step 5, define tendering and contracting practices: To see how the client should select the contracted parties to ensure the use of these methods, and how the use of these methods can be stimulated through a specific type of contract (e.g. an integrated contract with performance guarantee)
- Step 6, involve a multidisciplinary team: Just having a multidisciplinary team is not enough to ensure success. The proper creative processes and decision making processes should be implemented to tap into the potential of integrating the variety of perspectives and knowledge. The factsheet shows examples of processes to use for this.
- Step 8, design optimized buildings: the factsheet guides the way to processes that create optimized buildings.
- Step 9, set up collaborative construction practices and step 11, involve the on-site team in time, quality and cost control: the factsheet shows processes and methods to facilitate these steps.
- Step 17, integrate the value chain: Lessons learned in one or more projects on opportunities to integrate the value chain can be institutionalized across the value chain by adapting collaboration practices and (inter-)company processes into new standards. The factsheet shows methods to facilitate this.

There are many general sources on integrated design methods and value chain integration methods, but they are usually not specifically linked to the ambition of developing affordable nZEBs. This factsheet shows the link in a summarized way and aspires to stimulate project teams to adopt these practices in their project and organisations. It is an important part of the AZEB roadmap and due to the many high quality general resources we suffice with a factsheet framing the topic to AZEB and giving clear references.

2.6 | Factsheets on renewable energy technologies for AZEBs (Tecnalia)

These factsheets about renewable energy systems were created to facilitate decision makers a quick overview of renewable energy technologies that can be applied in AZEB projects. While there is a lot of information around on renewables, a short, non-biased and independent overview for non-expert decision makers is considered helpful in initial stages of an AZEB project.
The factsheets have as an objective to present in a simplified form to project owners (building developers, project managers) the different options to include renewable energy technologies and systems into their AZEB projects, applicable both at building level and at district level. They give an overview of the specific technologies, describing their potential application and limitation, and providing some hints about the market and economic factors for each technology.
The material has been developed based on a literature review and in-house expertise for the different renewable energy technologies, condensing existing available information of a factsheet. This basic information should be used in the initiative phase when conceiving and selecting renewable energy technologies for the different building alternatives (step 5 of AZEB methodology).

Cost category	Average (€/W)
Hardware	
Module	0.675
Inverter	0.2
Other (structure, racking, wiring...)	0.48
Soft costs	
Installation	0.11
Operation and Maintenance	0.02
Subtotal hardware	1.355
Subtotal soft costs	0.13
Total	1.5

Figure 3: Economic information in the factsheet Photovoltaic Solar Energy

2.7 | Energy performance guarantee manual for professionals (DNA)

This manual is developed as an e-book, downloadable from the AZEB e-learning platform, showing step-by-step how to prepare, create and manage a performance guarantee for AZEB projects on a building level.

An important risk when developing an nZEB is a gap between the energy performance of the design (and related operational costs) and the actual energy performance (and related operational costs) of the realized building. Unfortunately many of those performance gaps have occurred within realized nZEB's throughout Europe. This prohibits investors and financial institutes to facilitate investment schemes based on lifecycle cost (instead of on the generally used investment costs). An nZEB however often has higher investment costs, but significantly lower operational costs. If these lifecycle costs could be the basis of the financing schemes the way is paved for providing loans to create nZEBs for generally excepted monthly costs, comparable to current buildings. When a contractor provides an energy performance guarantee, this risk of a performance gap is mitigated for the investor and such schemes can be created.
In addition to this motivation for applying a performance guarantee, it also facilitates clients to have control over costs and quality of the AZEB created for them. In addition, a performance guarantee on a building provided by the contractor or contracted consortium, stimulates the contractor to adopt an integrated approach to project management from the start, which enhances to opportunities for developing an affordable nZEB with good quality.
This manual can help professional clients to decide on a performance guarantee contract in step 6 of the AZEB methodology: define practices for procurement and guarantees. Professional contractors can use the manual in all steps within the AZEB methodology in which they are involved, once they have chosen to enter a tendering process based on performance guarantee and/or after the contracting process has begun.
The performance guarantee manual is part of the Grant Agreement for the AZEB project: task 1.5 /D1.6. Providing a performance guarantee is often daunting to the responsible party (usually a contractor or contracted consortium). The AZEB manual shows how following the AZEB steps creates the perfect basis for providing a performance guarantee on building level, without assuming unnecessary or excessive risks. We hope this manual will stimulate clients as well as contractors to adopt the energy performance guarantee approach and to use the AZEB steps when applying it.

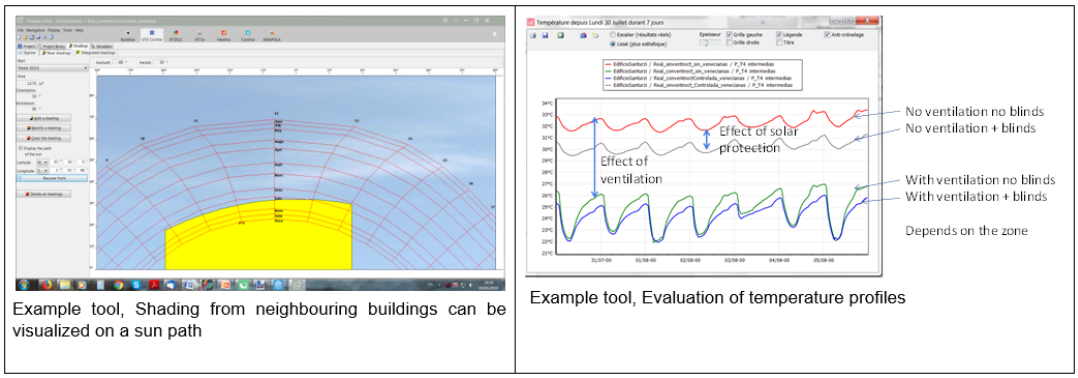
2.8 | Energy performance example (Visesa)

Energy consumption is one of the highest impacts of a building during its use and maintenance phase. Knowing this, it is extremely important to ensure the compliance between installation’s design and real operation performance. A useful measure to avoid this gap is to engage installers, operators and/or maintainers through an Energy Performance Guarantee that, as Public Body, can be added in the Contract Specifications Document before tendering the construction works (Step 6: Define practices for procurement and guarantees). By means of this, and combined with a proper Commissioning Protocol (Step 12: Commission the building services), part of the risk of a suboptimal performance of the installations is transferred from the user to the operator and/or maintenance company, paving the ground for a better use of the installations, lower maintenance costs and a longer life span of these. (Step 14: Monitor and optimize performance).
This fact sheet summarizes an example of energy performance guarantee clause for social housing developments that could eventually be included in the specifications documents of any public tender for construction works of future affordable social housing buildings.

2.9 | Factsheet Energy simulation (Armines)

Energy simulation can be used in the design phase to evaluate the energy use for heating, cooling, hot water, lighting, ventilation etc. as well as the thermal comfort level.
It is important to compare design alternatives and evaluate the project performance regarding energy and comfort.
It was decided within the AZEB project to include thermal comfort in the AZEB performance criteria and a simulation tool is then needed to address this subject.
The simulation tool and the related factsheet corresponds to step 8 of the methodology: Design optimized building.

The factsheet was created to explain the need and the benefits of this simulation and to give a first overview about the needed inputs and the output which can be expected by using the simulation.



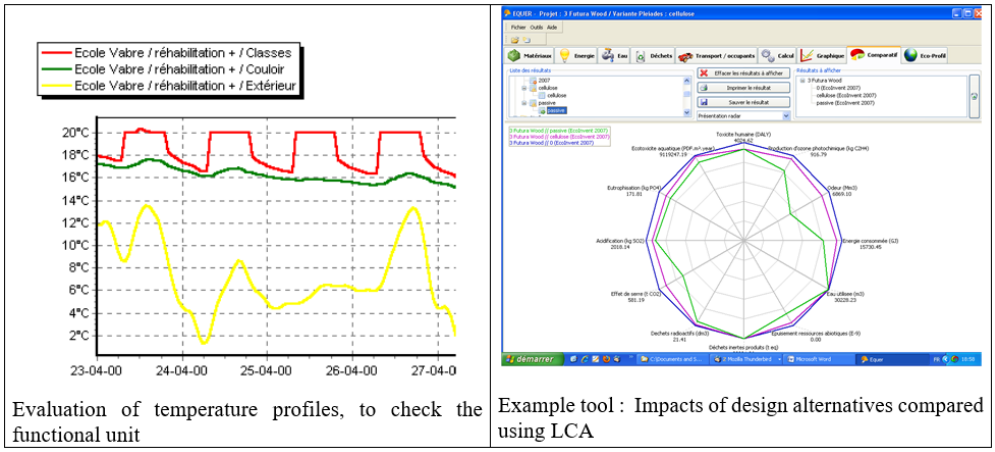
Example tool, Shading from neighbouring buildings can be visualized on a sun path

Example tool, Evaluation of temperature profiles

Figure 4: Output of the simulation tool described in the factsheet

2.10 | Factsheet Life cycle assessment (Armines)

Life cycle assessment can be used in the design phase to evaluate the environmental impacts of a building over its life cycle. It is needed if the requirements include such aspects, in order to compare design alternatives and evaluate the corresponding indicators (e.g. CO2 emissions).
It was decided within the AZEB project to include environmental indicators (at least primary energy and CO2) in the AZEB performance criteria, therefore an LCA tool is needed to address this subject. From the various LCA tools on the market one has been chosen and used in the case studies of the Bulgarian, the Spanish and the Italian project. The use of the tool in the AZEB case studies and the results has been described in detail in deliverable 3.3 of the AZEB project. This factsheet corresponds to step 8 of the methodology: Design optimized building. The target group is architects and consultants involved in building design.



Evaluation of temperature profiles, to check the functional unit

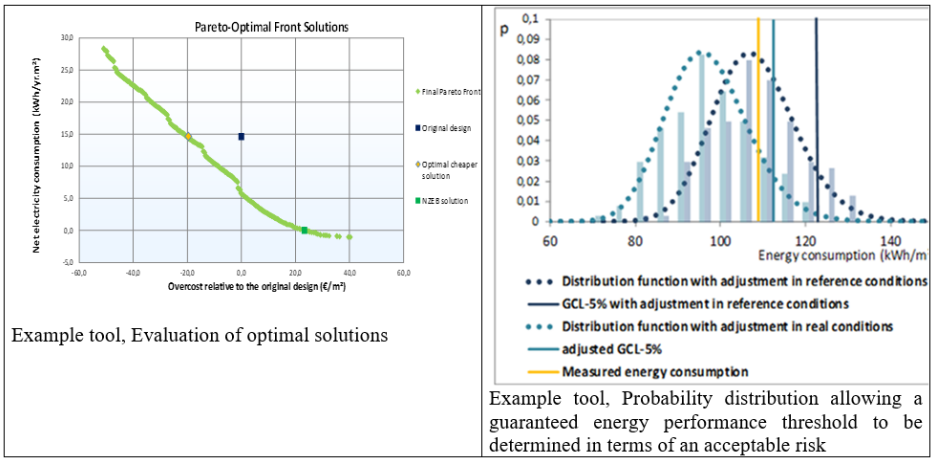
Example tool : Impacts of design alternatives compared using LCA

Figure 5: Output of the LCA tool described in the factsheet

2.11 | Factsheet Optimisation (Armines)

Optimisation allows identifying e.g. cheapest solutions for a given energy performance, solutions leading to the lowest CO2 emissions for a budget limit, possibly accounting for constraints (e.g. maximum number of overheating hours).
Trade-off between different aspects, e.g. energy, comfort and costs, is essential to achieve affordable zero energy buildings. Optimisation can help such decision making.

Developing such a tool, accounting also for uncertainties, and testing it on case studies has been proposed by ARMINES based upon previous experience. Optimisation is a core issue in the AZEB project.
The optimisation tool and the explanatory factsheet corresponds to step 8 of the AZEB methodology: Design optimized building.



Example tool, Evaluation of optimal solutions

Example tool, Probability distribution allowing a guaranteed energy performance threshold to be determined in terms of an acceptable risk

Figure 6: Output of the optimization tool described in the factsheet

2.12 | Factsheets on tools developed in AZEB (PHI, DNA)

Tools developed in AZEB are described in an individual factsheet to highlight their purposes, inputs and outputs among building professionals and project managers and also to inform about the application benefits. The tools also enable designers to better assess different components regarding their efficiency, based on verified performances values.
The following tools were developed in frame of AZEB project:

- TCO tool (DNA)
- Thermal Bridges Tool (PHI)
- Commissioning Tool (PHI)
- Cooling Systems Tool (PHI)
- Performance data generation tool for air-to-air heat pumps (PHI)
- Ventilation tool (PHI)
- Window tool: Tool on LCC windows (PHI)
- Hygiene Tool: Tool on f_{Rsi} (Climate-adjusted hygiene criterion) (PHI)

The factsheets on these tools are included in the methodology (D2.4) and thus uploaded on the e-learning platform (D4.4) of the AZEB website in different steps. Descriptions of these tools developed in AZEB are included in deliverable 4.6 and therefore not further explained here. The factsheets can be also found on the AZEB website (www.azeb.eu/methodology/).

DE0036a-München	Tilt & turn window		Combination	
	Example Timber-Alu double	Example Timber-Alu Passive	Example Timber-Alu double	Example Timber-Alu Passive
U_g [W/(m²K)]	1,12	0,55	1,12	0,55
U_f [W/(m²K)]	1,41	0,64	1,44	0,61
U_w [W/(m²K)]	1,35	0,63	1,51	0,64
U_{wi} [W/(m²K)]	1,86	0,65	1,94	0,66
Glass fraction	63%	72%	61%	66%
g	64%	60%	64%	60%
Shading factor	10%	10%		
Investment	1.724 €	1.856 €	3.161 €	3.751 €
Present v. Energy	417 €	- 65 €	903 €	- 135 €
LCC	2.141 €	1.791 €	4.064 €	3.616 €
LCC Saving		350 €		448 €
LCC Saving		16%		11%
CO_2 [kgCO2eq/a]	65	-10	140	-21
CO_2 Saving		75		161
CO_2 Saving		116%		115%

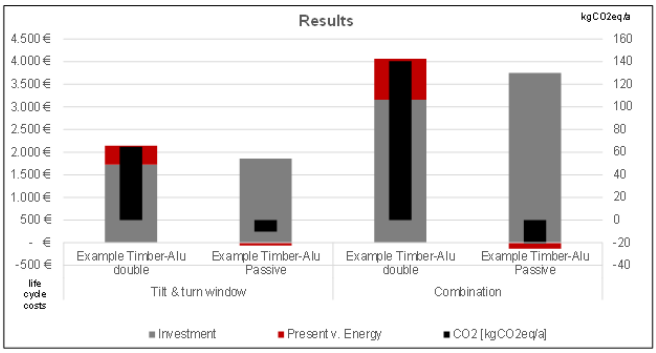


Figure 7: Screenshot of the LCC Window Tool described in the factsheet “Window Tool: Tool on LCC windows”

2.13 | Information on Thermal bridges (PHI)

Working with highly energy efficient planning and energy balancing it is very important to refer also the thermal bridge calculation to highly energy efficient constructions because the rate of efficiency has a great impact on the specific values of the respective thermal bridges. Dealing with nearly zero energy buildings the use of thermal bridge catalogues calculated for conventional buildings makes no sense. Another aspect is the increased heat loss caused by thermal bridges in the energy balance when improving the energy efficiency of buildings. Thermal bridges must therefore receive a more careful attention in nZEBs than in conventional buildings. Reducing thermal bridges has an immense impact on comfort, the health of the building structure and the energy efficiency and thus the cost effectiveness.
Conventional training on how to calculate thermal bridges is missing the connection to highly energy-efficient components. The training developed in AZEB therefore combines in-depth knowledge on thermal bridges with the high energy-efficiency of nZEBs.
This training material on thermal bridges ensures to improve the general knowledge regarding thermal bridges to a large extend and the skills and competencies to practically calculate thermal bridges and to use calculated thermal bridges in an energy balance of nZEBs. The training on the one hand helps to avoid planning and building construction errors and building damages. On the other hand it ensures that instead of rough assumptions the true amount of energy loss through thermal bridges is included in energy balances and therefore it helps – if used together with reliable energy balancing methods like the Passive House Planning Package - to avoid the performance gap between the calculated and the actual energy demand of buildings.
This factsheet was created to explain to professionals the necessity to pay more attention on thermal bridges by presenting most important contents of the training. The factsheet is located in step 8 of the methodology (Design optimized building) and is based on the training material developed in AZEB and on previous experiences with calculating thermal bridges and how to communicate this topic to building professionals.
The training material itself is set up as offline classroom training material with the option to be processed as online training out of AZEB depending on future capacities.

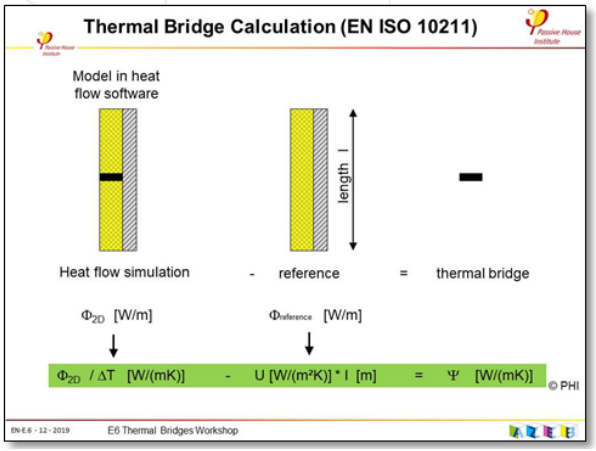


Figure 8: Example slide of the thermal bridge training in the factsheet

2.14 | Commissioning - Factsheet for experts (PHI)

The objective of this factsheet is to raise awareness of the need for timely planned and carefully executed commissioning of buildings. Particularly in larger buildings a systematic approach to commissioning is a key element for achieving the intended operation characteristics within a short period of time.
Since commissioning cannot be carried out successfully without careful planning, it is necessary to assign this topic already to the planning phase. Therefore this factsheet is assigned to the AZEB methodology in step 8 (Design optimised buildings) and a second time at the actual commissioning phase in step 12 (Commission the building services). The factsheet serves as an information for building professionals and project managers to make sure that this topic gets the needed awareness, explaining the risk of wasting a large part of the energy saving potential, if commissioning is not carefully planned and

carried out. The factsheet is designed to highlight the challenges in the commissioning process of new builds or deep retrofits. As such it is primarily focused on building services and controls, as well as on generalised performance monitoring. In the mentioned steps of the methodology also further information regarding in-depth training on this topic for professionals can be found as well as a short introducing information for building owners to also to create awareness of this topic among this target group.
The in-depth training on commissioning is also developed within AZEB by using some outcome of research activities for the 52nd meeting of the Research Group on Cost-effective Passive House proceedings, funded by the DBU (German Federal Foundation for the Environment) and the Hessian Ministry of Economics, Energy, Transport and Housing. The training itself is set up as classroom training with the option to be processed as online training depending on future capacities.

2.15 | Factsheet on the energy balance tool PHPP (PHI)

The Passive House Planning Package (PHPP) is a planning tool for energy efficient building design, for use by architects, building engineers and planning experts. Since its introduction in 1998 it has enabled the accurate and reliable design of tens of thousands of high performance buildings. Comparisons against dynamic simulation tools and various monitoring projects confirmed that projects designed with PHPP have shown no performance gap between the building models and the operational performance of the buildings.
PHPP offers a straightforward data entry system that requires moderate effort. It easily allows the comparison of the cost-efficiency of several efficiency measures and is applicable for highly energy efficient buildings and for less efficient new buildings or renovation projects.
In each European country there are other energy efficiency evaluation or calculation methods, such as the EnEV (Energie-Einspar- Verordnung, according to DIN 4108-6 + DIN 4701-10/12) in Germany. Besides there are regional energy efficiency assessment tools, like the efficiency calculation tool CasaClima Pro for the province of Südtirol in northern Italy, that have to be used to verify the energy efficiency of buildings. These tools work well regarding to their intended use and application, in order to fulfil the national or regional requirements. However in order to provide reliable outcomes for highest energy efficiency buildings and to be applicable in any European and global climate, their performance spectrum and applicability is limited. PHPP closes this gap and provides not only the applicability for highly energy-efficient buildings but also the needed comparability of energy balances in different European countries.
The Passive House Planning Package (PHPP) has been used in AZEB case studies and the factsheet on PHPP is located in step 8 of the methodology (Design optimized building).

2.16 | Overview cost-effective design principles for AZEBs (PHI)

This factsheet gives an overview about the aspects that have significant impact on the energy efficiency and on the cost-effectiveness of nZEBs. These aspects are the design principles of high energy efficient buildings and have to be considered for the planning of AZEBs. Therefore they should be known by any designers and engineers involved in the planning process of AZEBs. The knowledge transfer and development of skills and competences in this area is of great importance for the successful implementation of AZEBs.
The described design principles are suitable for all climates; some values and the principles regarding shading have to be adapted for the respective climate or hemisphere. In general, also due to climate change adequate attention must be paid to shading, cooling and internal heat sources.
The overview list is based on the extensive experience with highly energy-efficient buildings and the many years of research work on passive houses at PHI.
The factsheet is located in step 8 of the methodology (Design optimized building), where it also serves as a checklist for designers and engineers to create awareness of the need of sufficient knowledge and to encourage professionals involved in the planning process to improve their competencies.

2.17 | Critical practical construction skills for nZEBs (PHI)

This checklist gives an overview about the aspects that have to be known by construction workers to ensure the construction of AZEBs. It describes the needed knowledge and the needed skills and competencies to carry out a high energy-efficient building planning on site.
The checklist is based on the assumption that tradespeople already possess the relevant skills required for construction work due to their basic training. The content is therefore restricted to essential additional knowledge relating to the AZEBs. The overarching goal is to develop the competency of building a part of an AZEB as defined by the scope of the respective trade with a greater understanding not limited to the own part

- to purposefully interact with the architect/designer/site supervisor, and to identify issues where such interaction must be sought
- to identify critical parts of the building/building process both geometrically, practically and temporally and to gain an idea of which colleague tradespeople to contact for resolving any issue
- to ensure the competency to explain the benefits and implementation of AZEBs as well as the role of the own trade in the process to other people, particularly customers.

The checklist is based on the many years of experience with highly energy-efficient buildings at PHI and it is located in step 10 of the AZEB methodology / roadmap: Teach on-site team practical nZEB skills. It also intends to create awareness of the need of sufficient skills and to encourage professionals involved in the construction process to improve their competencies regarding the construction of high energy-efficient.

2.18 | Transforming the training material for cost optimization method (OKB)

One of the main AZEB methodology steps during the construction phase is "Teach on-site team practical nZEB skills" (step 10). The on-site team members need to make multiple choices per day, which have direct impact on the overall project outcome and success. In order to support the team to understand the importance of the quality of their work and allow them to make informed decisions, the Bulgarian partner OKB developed specialized training for them (however the training is applicable for any other experts form the construction industry).
The training materials builds upon the 5 theoretical principles for energy-efficient buildings and demonstrates how they find application in the construction process. It is rounded off with many examples, best-practices demonstration and practical tasks from design to construction completion. The training is suitable for both class room and on-site facilitation.
While other trainings for on-site workers either do not cover the knowledge of highly energy-efficient buildings or do not sufficiently address the learning needs of on-site workers, this training was developed on the basis of the building experience of two certified passive house projects in Bulgaria. Thus the training can demonstrate in a practical and very comprehensible way the benefit, the feasibility and the possible cost reduction of highly energy-efficient construction method.
Additional to the training material itself this factsheet was developed to raise awareness among building professionals and project managers for the need of trainings for on-site teams and to encourage on-site workers to improve their skills and knowledge on affordable nZEBs.

Figure 9: Examples of best practice solutions included in the training