Potential Barriers in the construction process of a NZEB and Energy+ Buildings

Deliverable 1.5
Potential Barriers in the construction of a NZEB and Energy+ Buildings

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Deliverable 1.5 corresponds to the task 1.4 of the document of works.

- **Task 1.4:** "Identification of potential barriers during the construction process (pre-construction, during-construction and post-construction)."

- **Deliverable 1.5:** "Potential Barriers in the construction process of NZEB and Energy+ buildings."

According to the Directive on Energy performance of Buildings (EPBD), all new public buildings will have to be Nearly Zero Energy (NZEB) by 2018, and also all new buildings by the end of 2020. In this context, the market has to switch from constructing standard buildings to constructing NZEBs. Then it must be understood that it is not just a desirable aim, but a mandatory goal to carry out.

In this deliverable, all the aspects that have been a constraint to NZEBs will be summarized, the existing potential technical and non-technical barriers and conditioning factors for construction of NZEBs or Energy+ buildings in an affordable way. Most of these barriers and factors are influenced and influence to some others, and most of them are linked to cost issues in one or another way. The non-technical barriers are divided in legal and economic barriers. Conditioning factors are divided in environmental, social, technical, functional and design aspects. All identified barriers are analysed in this deliverable and some suggestions for solutions are then already made, with specific emphasis on cost-effective construction.

In the next phase of AZEB (Work-package 2) these barriers and solutions will be elaborated upon for designing a general methodology and a corresponding educational program and dissemination strategy.
2 | Identification of potential technical and non-technical barriers in the design & construction process of NZEBs

2.1 | Barriers and Conditioning factors
In architecture, an architectural barrier is a physical conditioning factor that hinders or prevents universal access to buildings normally associated with access for people with disabilities.

When we talk about barriers for integrating green energy technologies in a project we define them as contrived elements preventing or impeding the installation of a measure in the building. The barriers are imposed and cannot be avoided with technical resources. In the present analysis on the feasibility of affordable NZEBs, a barrier not only refers to the obstacles to installing measures or solutions, but also that this installation can be carried out in a cost-effective manner.

The barriers in the construction process of NZEBs can be summarized into two: economic & financial barriers and legal barriers. The rest are architectural aspects that determine the integration mode of active technologies or passive elements in the existing building. Depending on the external conditions and characteristics of each building project (environmental, technical, functional and design aspects), it will be more appropriate to use one technology or another. These variable factors can even make infeasible or useless a particular technology.

We also have to take into account the social aspect, which has had much influence on the demand and promotion of NZEBs and Energy+ Buildings in the recent years. We will then say, therefore, that the barriers to introduce green technologies are economic and legal, and that the social, environmental, technical, functional and design aspects are conditioning factors that influence the choice of technologies to be implemented and the way they are performed.

2.2 | Non-technical Barriers and aspects in the construction process of NZEBs & Energy+ Buildings

2.2.1. Economic and financial barriers: Although NZEB projects save energy in the long term, the initial investment is a financial outlay which can make them unpopular. There are several reasons why construction costs tend to be higher in these buildings (this point will be analysed throughout the AZEB project), but from the top of head it is easy to think of higher
1.5 | Potential Barriers in the construction of a NZEB and Energy+ Buildings

costs due to a higher quality envelope, and overperformance of their facilities with specific energy-efficiency requirements. Short-term issues should be overcome and studies should be carried out to estimate long-term investment returns.

In public buildings, economic decisions must be taken by government agencies, so they cannot be adopted directly, and they take a different timetable than a private decision. In private buildings, it sometimes happens that the owner, who is the one who has to invest in measures of energy efficiency, will not finally be the one that receives its benefits. It is, for example, the typical case of rented houses, where homeowners must make the investment and renters take advantage of the benefits on their bills. In this sense, there is a difference between the countries where renting houses are the common choice for people and the countries where it is not.

Another economic aspect to consider is that energy costs are volatile. This fact becomes a barrier to achieve affordable NZEB projects as it introduces a point of uncertainty into their actual money savings. Otherwise, it sometimes happens that the energy bill is not accurate, and does not specify the actual cost of the energy itself. In case this cost is not so important compared with the total, this would discourage users to give positive consideration of energy efficiency measures.

A figure of financing when performing NZEB projects would be the ESCO’s. Energy Contracting - also labelled as ESCo or Energy Service Companies - is a “comprehensive energy service concept to execute energy efficiency projects in buildings or production facilities according to minimized project cycle cost. An Energy Service Company (ESCO) implements a customized energy service package (consisting of planning, building, operation & maintenance, optimization, fuel purchase, (co-)financing, user behaviour...). The ESCo provides guarantees for all inclusive cost and results and takes on commercial and technical implementation and operation risks over the whole project term of typically 10 to 15 years (after [Bleyl+Schinnerl 2008]). The Energy-Contracting concept shifts the focus away from selling units of final energy (like fuel oil, gas or electricity) towards the desired benefits and services derived from the use of the energy. When the energy is provided from renewable energy sources, usually solar photovoltaics, wind power or micro hydro, it is known as RESCO, Renewable Energy Service Company.

Despite the fact that NZEB projects are coherent with a very good return on investment, despite the fact it results in energy savings and improved CO2 emissions, and even if the public organization could provide financial funds to support NZEBs, it is highly necessary to analyse why the costs of NZEBs are higher and where the potential to reduce costs is.

2.2.2. Legal Barriers:
There is still an unclear definition of NZEB, and the lack of policy coherence is a real fact nowadays. The main difficulty comes with the transposition of the EPDB and other EU directives into national legislation. The different national and urban planning regulations, in some cases, lead to situations in which the most effective energy measure cannot be performed or is not cost-effective due to legal standards. The first step in designing and constructing a building would be to verify the current legal regulations that will apply.

A list of existing regulations applied to a building would be:
- Urban regulations:
Check if the design complies with local urban regulations, the conditions under which it can be performed and the type of permits requested.

- **Historical or protected building elements**: It is common the existence of particular regulations in historic neighbourhoods or in the vicinity of historic or protected buildings, and this fact can become a barrier to the design and construction of new NZEBs.

- **Local Energy legislation**: Check the real possibility of exploitation of Electricity. Verify with energy companies and existing regulations.

- **Technical standards and existing regulations**: The project must comply with current technical standards and this fact may affect the selection of materials, systems and facilities.

The verification of all these legal barriers will be a first step that will determine the real possibilities of a NZEB project, and establish the basis for the design and construction phase. From there, some will have to be discarded and consider other options.

**2.2.3. Social aspects:**

As stated in sections 2.2.1 and 2.2.2 (economic and legal barriers), the higher cost involving NZEB project is often one of the most important reasons for its social non-acceptance. But another social aspect is that, unfortunately, we can find a wide range of population with a significant lack of individual environmental awareness, probably linked with an educational poverty in this area of knowledge. Often, many people don't have a grasp of the idea of what Energy Efficiency is and what sustainability as a global concept really means. And, therefore, people don't have knowledge of what an NZEB project actually entails. The partial information received about all these concepts may lead to the widespread misconception that the success of these technologies or systems is not yet proven, or that these types of buildings are difficult to operate. The lack of awareness, lack of knowledge and collection of misconceptions could be responsible for the lack of social interest in such projects.

In addition to this, the organisational culture within the construction industry is conservative, and there is a resistance by constructors and developers to the changes needed to get reliable NZEBs at a large-scale. Examples of the changes needed could be:

- A different design strategy
- Integrating processes within the building supply chain, which means new kinds of collaboration across different organisations
- More discipline and rigour in executing the different building techniques (for example creating airtightness within the building facades). We will thoroughly go through this aspect in section 3.2 (Technical aspects).

As mentioned in the introduction, social acceptance won't be an aspect that prevents NZEBs from been promoted since, according to EPBD, all new buildings will have to be NZEB as of December 2020. But a social acceptance at all levels (developers, designers, end users...) will be necessary to achieve an integrated design process in the early stages, which is key to the control of the quality and costs of the NZEBs.
After studying the economic and legal barriers and the social aspects, the next step would be to analyse the environmental, technical, functional and design characteristics of the building. In this section we will focus on analysing the active and passive measures to improve energy efficiency and CO2 emissions of the building in NZEBs and Energy+ buildings.

The project itself will show us, when analysing it from a NZEB point of view, which are the best options for its design and construction.

Four aspects would be analysed: Environmental aspects, Technical aspects, Functional aspects and Design aspects.

3.1 | Environmental aspects
As an invariant, the environmental aspects of a building are one of the main aspects that will condition the implementation of green energy technologies.

3.1.1. Climate
Climate is a determining factor and one of the main aspects to analyse, since it will be the first factor to determine the complete choice of technologies and construction elements.

The climate determines the balance of the outside temperatures compared to indoor temperature, hygrothermic conditions and condensation related to humidity, construction solutions and ventilation. It will determine the return on assets of active and passive systems and potential sources of renewable energy. The conditions of wind and earthquake, will be considered in the installation and commissioning of the technologies as well as strength, fixing and anchoring conditions.

3.1.2. Building orientation
The orientation of each facade, sunlight-related depending on the different seasons (azimuth study, exposure to the sun of each façade), should be performed as a first step. Being a changing factor, it must cover the whole year.

Exposure to the sun of each façade affects the energy conditions, determines the insulation of the envelope and affects the level of comfort and use of the building. Each facade has a different behaviour and the efficiency of the solutions is completely determined by its personalized adaptability to each of the different orientations of the building.

3.1.3. On Site aspects
The physical characteristics of the site must also be studied, since they can be important determinants of the possibilities of design and therefore of the cost of construction. Examples:

- **The terrain** and its characteristics. If it’s natural terrain, or aquifers hygrometric conditions, the slope of the terrain, the surrounding vegetation.

- **Side walls.** Different contact with the outside in the case of one or several side walls, or in case of a detached house.
- **External constructions.** Outbuildings to overshadow the facades, building environment, urban or not, noise level and CO2 pollution.
- **Future urban planning.** Buildings to demolish or build are future factors that can change the initial conditions of the study of a technology.

### 3.2 Technical aspects
There are two types of technical aspects as barriers to consider:

One is the **lack of skills and expertise** across the construction sector, and also uncertainty about how technologies perform. This point must be highlighted, since improving the skills of all workers involved in the project can be a key-measure to reduce costs in NZEBS. Two professional levels must be trained in the NZEB project design and construction “know-how”:

- Professionals in touch with the design and decision-making of the project.
- Workers in real contact with the execution activities on-site.

Lack of experience in design and execution may lead to cost increases. Some of the possible failures can be:

- A wrong selection of strategies to include in the NZEB project to achieve the expected energy performance of the building.
- A wrong life-cycle cost analysis (partial or complete) may cause unexpected economic performance of the building.
- A non-integrated design process can turn into construction obstacles and interferences whose immediate consequences are delays (with the associated increase of costs)
- Works that have to be re-done; it implies demolition, waste management, and do the work again (direct costs), with the corresponding delays which also turns into added costs (indirect costs).
- The works don’t meet the specifications or have a sub-standard quality due defective on-site works.
- The operation and maintenance’s staff doesn’t have the necessary training to achieve an optimized performance of the facilities. The lack of knowledge or experience in control systems and in the new technologies implemented may generate unexpected costs in operation and maintenance.

The other is related to the **technical difficulties** themselves: why it can be complicated to introduce these technologies in the design and construction of new buildings, but especially in refurbishments.

The NZEB project will be analysed technically. Passive and active building elements must be defined:

- **Passive elements:** The envelope of the building will be described and analysed, defining all the constructive solutions to achieve the expected behaviour of insulation and tightness.
- **Active elements:** Renewable and non-renewable active systems will be detailed.

With this data collection, it is possible to finally carry out a study of the performance of all the selected measures working together as an integrated system, and to validate the selection of technologies and passive elements in the design of the building. The technical characteristics of each element must be taken into account, as they define the way in which it can be installed and how to perform the specific installation process. It must be ensured that the selected technologies are compatible with each other and with the geometrical
characteristics of the building. Also their interaction must be studied and predicted reliably.

The main construction elements and facilities involved in the choice are:

- **Structural frame:**
  Check that the projected structure is appropriate to support the weight of anchoring building elements and installations (for example building envelope, ducts and pipes, machines...).

- **Facade:**
  Check whether the design aesthetics fit the selected technologies (for example: façade solar panels chosen with projected quartering of facade).

- **Roof:**
  Check whether the necessary thickness has been considered to include all necessary insulation elements (sufficient physical space). Also check if the type (flat, inclined) and dimension of the roof surface provides space enough and facilitates the location of projected installations and machinery.
  Check whether in thickness considered are included all the necessary insulation elements (if there is sufficient physical space). Also check if roof geometry/type (flat, inclined) and its dimension provide space enough to locate the installations and machinery selected.

- **Facilities:**
  When designing the building (and in the construction phase, especially in fast track projects), you must take into account the space required to enter the selected facilities. (For example: projected utility shafts must allow pipes to pass through).

- **Isolation:**
  The best insulation is directly determined by the method of fixation, which will be marked by the architectural solution designed.

### 3.3 | Functional aspects

In decision making about the application of one technology or another, functional aspects of the building must be taken into account. These may affect the choice for one or another technology. Most of these functions are described in EN-16309: Sustainability of construction works – assessment of social performance of buildings – calculation methodology.

The functional aspects that most affect the implementation of a technology are:

#### 3.3.1 Hygienic conditions of the building

Temperature, ventilation, humidity and lighting needs inside the building. Each building must meet minimum requirements in this regard. The comfort of the user is linked to the appropriate parameters of these conditions. In case of public buildings, they are often stricter than in other types of buildings. These factors are directly related to the technologies to be implemented and can determine the choice of one or the other, and their characteristics:

- **Lighting** conditions in the building: for example, the electrical installation of LED lights will be conditioned by lighting requirements.
- **Temperature** scores the efficiency of air-conditioning and heating, and energy savings by installing passive elements.
- **Ventilation** conditions: mechanical ventilation systems (number of renovations/hour) and physical conditions (type of windows).
- **Humidity** score moisture levels to get.
- **Noise reduction**: from outside but also inside (resonance, echo’s)
- **Ability for the user to control the environment.** This is a psychological factor which influences the user's sense of comfort.
In the analysis of the hygienic conditions of the building, consideration should be given to the temperatures at the site, as well as the existence of adjacent buildings that may cause shadows (see 3.2.1 and 3.2.3).

3.3.2 Conditions of building use
The characteristics of the specific use of the building also mark the choice of a technology or passive measure. Teaching, hospital, administrative, etc. use of the building can decide the need for implementation of the measure. For example, some classrooms have a certain sound and lighting needs. Flexibility or adaptability of the building for different kinds of use is also important for continued use over a long period of time.

3.3.3 Safety conditions
How does a building cope with the load of extreme, incidental situations like extreme winds or snowfall, extreme temperatures, fire, explosion. And how safe is a building for burglars. What is the risk of defects in installations for the user (like doors of lifts).

3.3.4 Conditions for Maintenance of the building
Which maintenance is needed in the building, how often, how easy is it to perform, what are the costs and how much inconvenience does it cause.

3.3.5 Accessibility for people with a disability
How accessible is the building in terms of for example the entrance, facilities in the building and location of installations?

3.4 Design aspects
When combining active and passive measures in order to achieve a cost-effective NZEBs or Energy+ Buildings, their architectural design must be considered. The building forms part of the environment and determines it, generates an urban framework and contributes to the creation of a city model. Also, the interior design of a building is made in response to criteria of functionality that must be respected or improved.

Before deciding to implement a technology or passive measure in the design of a building, this design shall be analyzed at three levels:

- Urban (location)
- Enveloping (façade and roof of the building)
- Interior (distribution of building spaces)

Consideration should be given to the fact that the implementation of several particular measures in a project is compatible with the “project idea” (form, programmatic use) and if changes are needed to achieve the NZEB concept. The entire case must be analyzed to determine if the final design solution is consistent and of sufficient quality. For example a photovoltaic façade can (or cannot) meet with the aesthetic and design criteria of the project.

Particular construction requirements will be linked to building design and must also be taken into account. Sometimes, more time is required to execute carefully insulation works, to make required tests, et cetera. Example: Air Tightening required proofs, painstaking sealing application, and so on.
And, finally, we have to consider the possible requirements that will appear in the building exploitation phase (use and maintenance), that could be an imposition of the Client of the project.

The buildings make up the environment in which we live. The way we develop our life and work reflects the model of society towards which we move and which define us. **NZEB projects are part of that process of improving our environment and should not put aside the architectural aspects.** A comprehensive and multidisciplinary work, in which all the accumulated knowledge serve new targets for the reduction of emissions and the energy improvement of the buildings, improving this way people’s lives, a healthier life, and also collaborating in the care of our planet.

## 4 | Integration of active and passive measures in NZEBs’ construction process: potential conflicts.

The design process of a NZEB implies the selection of active and passive measures to achieve its sustainability and energy efficiency objectives. The main active measures are related to the **facilities and technologies** integrated in the building, and the main passive measures are related to its **envelope’s performance**.

The coordination among all these choices (facilities-technologies-envelope) and the architectural/structural project, will be a critical factor from the beginning of the project, in order to avoid conflicts in the construction phase and to achieve the expected performance of the building.

This coordination is especially important in case of refurbishments to create NZEBs, since new systems have to perfectly fit with existing elements. In these cases, building elements (existing structure, existing façade, et cetera) will be the determining factor for choosing between different possible active and passive measures. But we also have to consider these potential conflicts in case of new NZEBs, since sometimes the initial design is changed (owner proposal, builder proposal, problems caused by the supply of materials...) during the construction process, which may cause these potential conflicts.

The delays produced in the construction process and the additional costs due to these conflicts, can be seen as costs associated with the uncoordinated implementation of these energy efficiency measures. These costs due to avoidable failures may negatively influence public opinion on NZEBs.

### 4.1 | Facilities

#### 4.1.1. Heat recovery ventilation system

The architectural barriers will vary depending on the building structure and the ventilation system. However, it is possible to display a list of general barriers applied of any kind of building:

- Lack of space for the Heat recovery ventilation units. Taking also into account space to assure the accessibility for the Maintenance and cleaning of the equipment.
- Building structure does not bear the required load of the ventilation unit.
- Uncontrolled temperature and humidity level in the installation’s site.
- Uncontrolled exchange of heat, air and moisture.
- Lack of noise insulation in the installation’s room.
- Non-prevision of installation shafts or other spaces for ducts and pipes.
- Lack of space for the location of the fans and filters.

4.1.2. ICT – Information and Communication Technology
The architectural barriers will vary depending on the building structure and the four existing areas where the ICT works: building automation and control, IT network, telecommunication and security systems. However, it is possible to display a list of general barriers applied of any kind of building:
- Non-sufficient power in the building for connecting ICT Systems.
- Incompatibility with the current systems of lighting, ventilation, fire alarm, office network ...
- Lack of space for the location of equipment, wiring, pipes...
- Wiring difficulties.
- Redoing lighting and control systems.

4.1.3. PCM – Phase Change Materials
The architectural barriers will vary depending on the building structure and the thermal energy storage system. However, it is possible to display a list of general barriers applied of any kind of building:
- Idea of integration of PCM in the construction elements (walls, roof and floors) from the beginning of the project, because otherwise could imply the demolition and rebuilt again with PCM.
- Idea of integration of PCM in the structural element (beams) from the beginning of the project, because otherwise could imply the demolition and rebuilt again with PCM.
- Some kind of PCM are flammable and it is not possible their application in buildings because the fire and building codes do not allow them.
- Lack of space for the storage tank in application of PCM in thermal energy storage tanks.
- Difficult application on exterior walls, being exposed to solar gain reduces the capacity of the PCM.

4.1.4. Solar Thermal Panels
The architectural barriers will vary depending on the building structure and the heating system. However, it is possible to display a list of general barriers applied of any kind of building:
- Lack of space for the solar thermal panels in south façade or on the rooftop
- Dimensions of the solar thermal panels do not fit with the dimension of the panels in façade.
- Placement problems of the solar thermal panels in the façade because it does not enable the attachment to the envelope surface.
- Solar thermal panel do not support the wind load in façade or roof
- Surfaces not suitable for solar thermal panels because of shadings.
- Lack of space for the hot water storage tank.
- The roof/ façade structure does not bear the required load of the panels.
- Aesthetic problems.
- Architectural building protection and heritage conservation issues of the building façades and roof, which does not allow installing the panels.

4.1.5. PV Pannels
The architectural barriers will vary depending on the building structure and the electrical system. However, it is possible to display a list of general barriers applied of any kind of building:
- Lack of space for the solar PV panels in south façade or on the rooftop
- Dimensions of the PV panels do not fit with the dimension of the panels in façade.
- Placement problems of the solar PV panels in the façade because it does not enable the attachment to the envelope surface.
- Solar PV panel do not support the wind load in façade or roof.
- Surfaces not suitable for PV panels because of shadings.
- The roof/façade structure does not bear the required load of the panels.
- Aesthetic problems.
- Architectural building protection and heritage conservation issues of the building façades and roof, which does not allow installing the panels.

4.1.6. Lighting
The architectural barriers will vary depending on the existing building structure and the current electricity system. However, it is possible to display a list of general barriers applied of any kind of building:
- Incompatibility with the current systems of lighting.
- Lack of space for the location of equipment, wiring...
- Wiring difficulties.

4.1.7. Radiant Surfaces for heating and cooling
The architectural barriers will vary depending on the building structure and the heating system. However, it is possible to display a list of general barriers applied of any kind of building:
- Lack of space for the heating equipment. Taking also into account space to assure the accessibility for the Maintenance and cleaning of the equipment.
- The structure does not bear the required load of the heating system.
- Lack of space for placing the radiant surface on the floor because of the ground clearance reduction.
- Needed of additional ductwork
- Non-Existence of installation shafts or other spaces for ducts and pipes.

4.2 | Materials and systems

4.2.1. Envelope solutions (sate, ventilated façades...) 
The architectural barriers will vary depending on the building structure and the current envelope solutions. However, it is possible to display a list of general barriers applied of any kind of building:
- Inability to place exterior insulation.
- Inability to place interior insulation.
- Inability to inject insulation in the air chamber.
- Inability to place a ventilated façade because the structure does not bear the required load of the ventilated façade.
- Aesthetic problems.
- Architectural building protection and heritage conservation issues of the building façades and roof.
Study of barriers through survey analysis

Here, viewpoint of the different professional groups involved in the construction process of NZEBs is been analysed, based on the results of a wide survey performed.

5.1 | Participation

5.1.1. Questionnaires received
To elaborate on this analysis, an online survey has been distributed in different European countries to different professional groups, to assess the stakeholders and their network’s perception on barriers to NZEBs.

The questionnaire sent has turned out to be an agile tool, since it didn’t take a lot of time to be completed, and also permitted to explain longer the ideas of participants in blanks if necessary.

See AZEB Stakeholders Questionnaire on NZEB Barriers
https://docs.google.com/forms/d/14f6BzhsMV1teRl8g-udH2ubpnLqrzCxeDlihdY5ags/edit?ts=59770f34

5.1.2. Results by countries

More than one hundred people have participated in the completion of the questionnaires, most of them from the countries involved in the project as shown in the graphic:

![Figure 2](image)

Figure 2

Given that some differences were detected in the surveys (numerical and written survey’s part), these particularities will be explained in depth at a later time (see 5.2.3).

5.1.3. Results by professional groups

Below is the variety of groups involved in NZEB construction process participating in the survey:
5.2 Analysis

5.2.1 Main Barriers to NZEBs

In view of the general results of the survey, in which several European countries and professional collectives form the horizontal bars of the graphics shown below, the importance (from irrelevant to critical) of different barriers to NZEBs is:

Mostly critical—very high:
The answers indicate that the main problem is economic (larger investment, long-term return on investment, volatile energy costs, scarce public financial aid, etc.), but with the same importance as social (knowledge about NZEB, difficulty in operation, lack of environmental awareness, not seen as a proven technology, etc.). These two barriers are linked to each other: if a NZEB is not affordable to demand, it will consequently be seen negatively, it will be underestimated, and it will become unpopular. The legal aspects are very important as well (technical standards, urban regulations, local energy legislation, historical or protected elements, etc.).

The economic and legal aspects are very responsible for the social non-acceptance to NZEBs: economic and financial barriers can make them unaffordable, and legal barriers are a major obstacle throughout all of the construction process (before, during and after construction).
Mostly High-medium:
The rest of the aspects are not really barriers, since most of them can be solved with technical solutions described in this report, and with others that will appear in the coming years. And this has been the perception of most respondents (see graphics below).

Environmental barriers are referred to climate, building orientation, terrain, surrounding structures, etc.).
1.5 | Potential Barriers in the construction of a NZEB and Energy+ Buildings

Technical barriers are referred to passive and active elements in buildings, renewable energies, materials, etc...

![Graph](image)

Figure 8

Functional barriers are referred to lighting, temperature, humidity, noise, other hygienic constraints, etc...

![Graph](image)

Figure 9

Design, construction and exploitation barriers are referred to location, building envelope, interior design, programmatic use, construction requirements, maintenance use, etc...

![Graph](image)

Figure 10

Some main aspects of each group are analysed below:
**MAIN ECONOMIC BARRIERS:**

Elevated investment and long-term return on investment may be the origin of the problem. There is no easy access to case studies for investors.

![Figure 11](image1)

Lack or shortage of public financial aid is also a remarkable aspect in the questionnaires, but it doesn’t work in the same way for every country as we see:

![Figure 12](image2)

**MAIN LEGAL BARRIERS:**

The economic problem is the very important but the fact that the NZEBs may be unpopular can be due to other reasons, regardless of the money needed.

![Figure 13](image3)
Environmental awareness and the idea of getting more comfort may be the reason to change the promoter’s mind of preferring a NZEB to a conventional building. In this case, another concern may appear to deal with: legal barriers, which are such a problem that sometimes result in the worse propaganda for NZEBs.

### [Local energy legislation]

- **Critical**: 22%
- **Very High**: 15%
- **High**: 18%
- **Medium**: 15%
- **Low**: 21%
- **Irrelevant**: 9%

% Interviewees

![Figure 14](image)

### [Technical standards]

- **Critical**: 17%
- **Very High**: 21%
- **High**: 19%
- **Medium**: 22%
- **Low**: 36%
- **Irrelevant**: 3%

% Interviewees

![Figure 15](image)

### MAIN SOCIAL BARRIERS:

### [Knowledge abot NZEBs]

- **Critical**: 43%
- **Very High**: 39%
- **High**: 9%
- **Medium**: 5%
- **Low**: 3%
- **Irrelevant**: 1%

% Interviewees

![Figure 16](image)
OTHER TECHNICAL, DESIGN AND SOCIAL ASPECTS TO TAKE INTO ACCOUNT

The main barriers already appear in the decision making during early stage of the NZEB projects. Once the project has started, technical conditioning factors may appear, but most are avoidable, as we have seen, with prior planning, coordination and having the necessary technical resources.

The dissemination of NZEBs’ case studies with successful final performance (use and maintenance) is of great importance as it is a good opportunity to eliminate the negative idea or ignorance of promoters and users about NZEBs. This lack of knowledge is in fact one of the main negative conditioning factors to NZEBs from the social point of view.

The task of dissemination belongs to all but, in practice, the goal should be that the experts and authorities have an important role in this proposal.

[Lack of environmental awareness]

[Not seen as a proven technology]

[Renewable energies]
1.5 | Potential Barriers in the construction of a NZEB and Energy+ Buildings

Figure 20

[Passive elements]

- Critical: 7%
- Very high: 15%
- High: 21%
- Medium: 15%
- Low: 17%
- Irrelevant: 25%

Figure 21

[Difficulty in operation]

- Critical: 10%
- Very high: 21%
- High: 27%
- Medium: 24%
- Low: 19%
- Irrelevant: 9%

Figure 22

[Maintenance]

- Critical: 14%
- Very high: 21%
- High: 21%
- Medium: 16%
- Low: 10%
- Irrelevant: 10%

Figure 23

[Building orientation]

- Critical: 15%
- Very high: 14%
- High: 21%
- Medium: 20%
- Low: 18%
- Irrelevant: 11%
5.2.2. Perspective of the different collectives involved

At this point we will analyse the point of view of the professional groups involved in the construction processes, based on the results of the surveys received. It is interesting that the view of the barriers is different in the various groups questioned. For example, an architect or designer can see a great barrier in the orientation of the building (since it may condition the architectural design), but this barrier is almost imperceptible for other groups consulted. Here we have a classification of the professionals involved in the traditional construction process:

- **Pre-Construction**
  The pre-construction phase is essentially the design phase. The following professionals belong to this group:
  - Design Teams (Engineering and Consultants)
  - Associations promoting sustainable architecture
  - Researchers and technologists
  - Property owners, developers and investors
  - Property agents and valuers
  - Users
  - Public Administrations
  - Legislators
  - NGO

- **Construction**
  This phase comprises all the construction work up to the commissioning phase (usually included). The groups involved in it are:
  - Construction and demolition management (including managers and lead contractors)
  - Installers
  - Suppliers

- **Post-Construction**
  This phase comprises the stages of the building after construction, when the building can be seen as a place to live, an investment to be profitable, a social or environmental goal, etc.
  - Public Administrations
  - Public and private organizations that will occupy the buildings assessed (end users)
  - Investors
  - Asset and facility managers
  - Property owners, developers and investors
  - Energy providers
  - Facility Companies

As we can see, there are many groups involved, some of them included in two or three phases of the construction process. Please note that within AZEB we will promote an integrated method of working together in a multidisciplinary way, from start until end of the project. This means that more professionals described above may be involved in all phases instead of just the one they perform in now. This will be discussed in more detail in deliverable 1.2.

- In the general concepts, barriers rated more than 7/10, according to the survey:
  - **ECONOMIC AND FUNCTIONAL BARRIERS.** More than 3.5/5 (high/very high/critical) for contractors, architects, energy providers, promoters and providers.
1.5 | Potential Barriers in the construction of a NZEB and Energy+ Buildings

- **SOCIOCULTURAL BARRIERS.** More than 3.5/5 (high/very high/critical) for NGOs, contractors, architects, promoters, public administrations and providers.
- **LEGAL BARRIERS.** More than 3.5/5 (high/very high/critical) for Contractors, Architects and Energy providers.

In particular, barriers rated more than 3.5/5 (high/very high/critical), according to the survey:

- The most important barrier for most of groups is the lack of knowledge of what a NZEB is. Contractors, engineers, promoters, public administration, technologists, architects, providers, energy providers and researchers have valued the importance of this barrier more than 3.5/5 (high/very high/critical). For some of these groups, the same rating goes to the lack of awareness.
- At all stages (Pre-constr./Construction/Post-constr.), economic barriers are seen as one of the main barriers. Contractors, promoters, public administration, NGOs, technologists has valued more than 3.5/5 (high/very high/critical) high investment as a barrier.
- Contractors, suppliers and energy suppliers also award the 3.5/5 rating (high/very high/critical) to the barrier scarce of public help.
- For contractors, promoters and technologists, the long-term return on investment is considered as a major barrier.
- The fact that NZEB technologies are not considered sufficiently tested is also considered a major barrier for contractors, promoters and providers.

5.2.3. Perspective of the different countries

We have found that the main barriers to NZEBs are similar for most of countries, but in a more detailed analysis we can find differences between them and differences also with the importance that each country gives to each barrier. Let’s first take a look at the surveys on the main barriers, and then on the particular barriers where significant differences have been found:

**ECONOMIC BARRIERS**

Most countries agree on the evaluation of the problem: larger investment and scarce public financial aid, followed by long-term return in investment, are the main economic barriers.

![Figure 24: Relevance of the barrier (1 to 5)](image)

![Figure 25: Relevance of the barrier (1 to 5)](image)
LEGAL BARRIERS

Regarding legal barriers, here we can find significant differences between countries.

It must be noted that, according to the survey, local energy legislation can be a higher barrier in countries with mild climate than in The Netherlands. It is highlighted the existence of the huge on renewables energies problem (photovoltaic in particular) with their current local regulations in several countries.

SOCIAL BARRIERS

Social barriers are considered extremely important for most of the groups surveyed. The main social barriers are:

Figure 26: Relevance of the barrier (1 to 5)

Figure 27: Relevance of the barrier (1 to 5)

Figure 28: Relevance of the barrier (1 to 5)

Figure 29: Relevance of the barrier (1 to 5)
1.5 | Potential Barriers in the construction of a NZEB and Energy+ Buildings

**TECHNICAL BARRIERS**

The use of renewable energies is considered a barrier in most of countries for the legal aspects. The other point is the technical aspect: the integration of renewables in buildings can be a technical barrier. The same thing happens with the active elements.
5.2.4. Discussion of barriers at national level

The Netherlands

- **Main Barriers**

**Financial Barriers – TCO is not a factor**

One of the main barriers in The Netherlands for the uptake of new NZEB’s is the fact that cost of ownership is generally not part of the decision process concerning investment in buildings. Private home-owners or tenants often simply are unaware of the relationship between investing in their building and the potential monthly savings in for example energy and maintenance costs. Also they are unaware of the impact of well-build NZEB on comfort in their homes: Dutch home-owners and tenants have relatively low standards for comfort compared to people in some other countries, like Germany. They simply do not know better (yet).

In the professional market of investors and developers, the knowledge is usually present, but the financial incentives do not favour investing in the quality of the owned building. Tax benefits for example stimulate possession of a building, for example by making part of its value deductible from income or turnover, but the level of energy-efficiency is not relevant in these tax benefits (yet).

In addition to tax benefits, mortgage interest rates are very low, savings do not payoff and many investments are too big of a risk. For investors and developers it is therefore interesting to have more and more cash flow towards real-estate, looking for good returns. This, combined with the currently growing economy and more people searching for homes, inflates the price of existing buildings, especially in large cities. This makes it attractive to speculate with buildings, because prices keep on rising. And since the general home-owner or tenant is unaware of the relationship between the energetic quality of the building and the monthly costs,
and because Dutch people have relatively low comfort requirements for their homes, the investors and developers get away with very modest quality of the buildings in the areas of energy-use and comfort.

Planning Security

For commercial institutions, another obstacle for investing in energy-efficient buildings is the lack of a long-term policy. The national government is trying to change this now and set a more long-term perspective in its policies, but many incentives at lower levels are still short-term and feed the sense of insecurity of organizations.

In addition, most financial institutions are still reluctant to finance these new concepts because they have not yet shown the yields that have been promised. For example, there is a theoretical saving for going from energy labels C to label A of more than 75% of the energy costs. Unfortunately in practice only an average of 25% savings is being made. These disappointing and often costly experiences can hold institutions and other building owners back from investing. The main issue here seems the method of labeling, which has been point of discussion for the past few years but has not yet been changed.

Financial institutions have a surplus of existing, sometimes unprofitable buildings on their balance sheet. The past years a great increase in vacancies of office buildings and stores has arised. Demand for shops and offices is expected to continue to decrease due to for example flexible workplaces and internet shopping. This increases the risk of building devaluation and in this way threatens the stability of the financial sector in the Netherlands. Investing in new NZEB in this sector seems unrewarding for these institutions at this stage. This issue holds hostage the housing development market. To illustrate the influence of financial institutions: Dutch pension funds and insurers account for total +/- 227 billion (+/-13% of total invested capital) in domestic real estate and mortgages.

Cultural aspects and the crisis

The largest part of the manufacturing industry and construction-related companies in the Netherlands have a conservative company culture, preferably avoiding innovative construction methods. To put it black-and-white: the Dutch builder likes to do things as he has always done. After the financial crisis in 2008, a change seemed at hand, with more companies looking for opportunities to distinguish themselves from the other companies. An increased production of sustainable buildings has been observed, and those companies even survived the crisis relatively un-scathed. Unfortunately, now the economy is growing again, the increase of procurements and shortages in the labour market have seduced most companies to fall back to their old habits and methods again.

Another factor is that procurement policy is often still only driven by the selection on lowest price for the minimum requirements. As a more sustainable product often is more labor-intensive and therefore less profitable, the suppliers are not stimulated to take this path. Higher quality standards mean higher risks and are perceived as bad for profit models, especially since profit margins are already low for many construction companies (which is for a large part a result of a long period of procurement based on selection for lowest price).

In addition, the standards and calculation models do not match the real-life situation that users perceive. For example, the NEN 7120 model is no longer sufficient if one aspires a performance guarantee for an NZEB. Consequently, trust also cannot be strengthened between the market and the consumers through contracting based on accepted standards.
Long-term vision and policies

Policies based on long-term vision are needed to stimulate the market to uptake new developments like NZEB. This vision and a related policy has been lacking in The Netherlands until now. The new government coalition agreement of 10 October 2017 includes a number of improvements, which could create more opportunities for NZEB projects. However, more will have to be done to ensure that the cost of environmental impact will be allocated where they actually occur. Policy on a long-term environmental vision for 2050, for example, could provide more security for investors and other decision makers for the next 30 years, helping them make the step to long-term investments which will extensively boost NZEB projects. Creating clear and measurable performance evaluation standards will also help this process.

Education & Skill development

Many companies in the construction sector invest relatively little in education. This might have historically grown where in the past it was sufficient to have a good relationship as a contractor to acquire work. Building high quality NZEB’s requires new ways of thinking and working in which people need to be educated and trained.

In practice, some private and professional home-owners (like housing corporations) do try to make their homes more energy efficient and involve the construction companies to help them. The large risk because of the lack of education is that not having accurate knowledge leads to major mistakes. Resulting in loss of comfort, damage, moisture and other problems. These in turn can hamper the image of NZEB’s and thus negatively impact sales.

All this being said, there is a trend towards more competency-oriented procurement instead of only cost oriented. This might increase the perceived pressure to be skilled in the near future and stimulate people in the sector to educate themselves better.

• Suggestions for directions to find solutions to overcome the barriers

- National government

Based on the Paris agreement and agreements within the EU, a long-term policy should be developed to cover environmental costs where they occur. Financial stimulation (subsidy or tax benefit) should be given for performance-oriented building methods with use of measurable performance guarantees. The obstacle for this is to keep aboard the existing large companies that do want to slowly adapt, but not too fast. On the other hand, there are also many large companies that ask the Dutch government to implement a consistent policy on which they will then be able to adapt their policies and methods. For a clear direction, EU alignment is important, ensuring energy security.

- Financial Institutions

Need to increase interest rate differences between polluting buildings and buildings with low emissions. There are now a few banks that have favorable interest rates on their mortgages for low energy buildings.

Need to create a large scale action plan that transforms its own balance sheet value. In this plan for example commodities will be valued for circular buildings and a risk analysis will be included of the future value.

A new calculation model is needed for this, which among other factors incorporates the environmental tax legislation and the commodity factor.

- Real-estate Brokers

Brokers need to better inform buyers of the environmental effects policies and (future) legislation and offer them a related purchase-research-report. This can
include a “building passport” describing materials used, maintenance aspects and building-energy consumption. When selling the broker must demonstrate which energy-reduction/savings measure the building has. To be able to achieve this, the buying or selling broker must realize he cannot serve both masters (buyer and seller) and will have to make a choice, as is usual in the practice of law. The risk of wrong investment in a bad energy building (which will put a lot of financial burden on the buyer in the years after), will be lowered for buyers, because this practice will provide them with the correct information to base their decision on.

- Interest groups and associations in the building industry

Have to convert theoretical approaches to a performance-oriented approach. Education plays the key role here. Lifelong learning with compulsory educational objectives. Qualifications being linked to people and not to companies.

- Architects / Engineers

Convert theoretical approaches and supporting computational methods to a performance-oriented approach. The connection between education and the practical experience is essential to sharing the latest developments. Modern learning methods such as e-learning, video tutorials and serious gaming should make education more affordable and more attractive. Finally, this profession group will need to be made jointly responsible for the interests of the client. Different contracts and many new technical tools and measuring equipment are available for this.

- Relationship between existing barriers

- Transformation issues

A good balance is needed between employment, economic growth and the environment. The transition to a sustainable economy will create a lot of new opportunities and thus need not be a problem. However, it will be if we try to transform while keeping the existing structures as they are. We need to change our total societal and economic system in-depth. This will result in winners, but also many losers. We need to take this seriously and to make the transformation succeed, temporary arrangements will need to be made for the loosing parties so they are helped to also successfully make the transition to the new system. An example could be legislation requiring financial institutions to offer interest-free debt cancelation or even partially or completely cancelled funding.

- Coordination role as support for clients

Clients that have little knowledge of building techniques could have their interests protected by a third party like a building coordinator, through all building phases from initiative to design to actual construction. This person will have the task to start and finish a project in line with the envisioned performance. The correct translation of desired performance to technical requirements is of the utmost importance in this.

Procurement and contracting

In The Netherlands procurement methods and contracts have been redesigned to support the transition to better quality of building. In the traditional method of procurement and contracting, contractors compete on the price they offer for reaching the minimum standards. Without a very strict and intensive mode of control, this type of procurement and contracting is a sure way to inferior quality and therefore not future oriented. In new procurement practices the forming of consortia is stimulated (construction company, installer, architect), with the
partners accepting joint accountability for design, construct and often also maintenance and sometimes even financing of the new building. This way of working has many positive features, and also some limitations. One of those is that to be successful in this contract, both client/building owner and consortium need to significantly adapt their role and ways of working. This is often underestimated.

Old habits of cooperation are followed in the new contract and this can lead to serious failure. From the perspective of the client wanting a high quality building, it is very important for him to be educated in the roles needed. For clients not being building professionals it may be wise to have a coordinator directly assigned to the client to lead the entire construction process from design to realization. Basis for this leadership should be performance based contracting, so that the contractors/consortia have room to be creative and innovative in their solutions offered.

- **Some specific issues for the major construction companies:**

Major construction companies often hire subcontractors for their work. These subcontractors often lack knowledge and skills and do not perform high level. There is also a shortage on personnel. This has forced many big companies to increase their legal efforts in controlling through contracts and continuously put pressure on the prices paid. Many building processes are then started based on mistrust and a lot of bureaucracy. This is often invisible for the client. However, one of the effects is that generally building projects choose to take short time for preparation and then are faced with a large amount of time needed to manage problems in later phases.

- **Some specific issues for the small construction companies:**

Small businesses are less likely to be distrusted and are less bureaucratic. However, knowledge of new developments is a major problem, they need to input a great deal of effort to meet new rules and regulations. Money and education time are often scarce. These companies often do not want refuse a contract or job, even though the knowledge to perform the job is not present. These businesses might fare better if they were to specialize and develop themselves accurately within this specialization, making processes better manageable for all involved. These companies could make a transition the coming years into working in so-called “scrum teams” (multidisciplinary teams that use integrated design methods) with other specialized small businesses. These teams should be set to work on a clear assignment, describing required performance of the building, translated into verifiable technical measures. Companies that move toward specialization in proven energy efficient technologies are going to gain an advantage. There is still a huge shortage of these specialists. Certification for proven energy efficient technologies may also help.

**Spain**

- **Main barriers in Spain from the point of view of the groups involved**

- **Developers / Building Owners**

There is a clear barrier in the lack of knowledge, understanding or awareness by the final users (building owners or occupiers) of technical and economic performance of ZEBs. Regarding technical performance, there is a perceived risk that installations might not perform as expected at design stage. This risk is reasonably founded as there is a history of badly installed systems (such as solar thermal and heat pumps) that have generated a loss of confidence on certain energy technologies, which properly installed and maintained are very feasible. Economically, a life cycle perspective of cost assessment is rarely presented and decisions are taken paying more attention to upfront costs, without thoroughly analysing life cycle costs and additional potential benefits such as increased...
comfort or building value. Advanced ZEB solutions certainly need a life cycle cost analysis to understand and evaluate their benefits. Legal uncertainty about the use of renewable electricity solutions is also another key factor that prevents their installation, as for example current self-consumption regulation is highly restrictive and additional fees must be paid for self-consumed electricity.

- **Designers**

Building designers technical knowledge and qualification regarding energy efficient and zero energy buildings has greatly improved in Spain in the last decade, particularly regarding building envelope solutions. Interdisciplinary collaboration between architects and building engineers for better integration of renewable and energy efficient systems within the buildings is still not achieved in many projects. Follow up from design to installation, including commissioning of building and its energy systems is still a pending issue in many cases.

- **Builders and Contractors**

Although the situation has improved in the last decade, there is still a lack of expertise on building skills for ZEB, for example related to air tightness in buildings or attention to thermal bridging. This is also still the case for some energy systems, such as solar thermal, heat pumps or cogeneration.

- **Users**

There is a lack of understanding of building energy performance and management, and of behavioural issues that are generally increasingly important as we move towards zero energy buildings. Further education and awareness is needed.

- **Perspective**

Higher upfront costs for ZEBs could be overcome with more detailed information about whole life cycle costing and linking to financial schemes and innovative business models such as energy performance contracting. A stable regulatory framework for renewable energy electricity generation would also help to better estimate and reduce risks of initial investments.

Further training of building work force in ZEB technologies and systems is needed to further reduce costs and improve quality of installations, which would contribute to adding confidence and reduced perceived risks on real building performance. More detailed training and education to the users in needed in ZEBs. Building manuals should be complemented with live one-to-one or group training, and specific tools for visualizing and controlling energy use should be provided.

- **Germany**

- **Main barriers in Germany**

- **Lack of information**

Often, actors do not have sufficient information in order to independently identify cost-effective efficiency measures. This requires knowledge of existing savings potential, their own energy consumption and optimization possibilities. In order to eliminate information deficits, independent energy advice is preferred.
Interest in energy efficiency is diminishing

After significant increases in the energy consumption of natural gas and heating oil up until 2013, energy prices have fallen in recent years. The issue of energy saving has thus lost importance. Negative media reports on individual cases in which there have been problems with the insulation of buildings as well as reports of significantly lower energy savings than predicted have damaged the discourse regarding energy efficiency.

Expert deficit / demand for construction services

The economic climate in Germany is good. In the case of the relevant exporting companies, there is often even a shortage of skilled workers. This also leads to energy efficiency measures rising in price or being left out.

Application for funding

Applying for funding is often perceived as complicated and restrictive. Often, the complicated and limited funding application process is the reason why projects are postponed or not undertaken.

Complex legal requirements

The legal requirements for the building energy standard and the use of renewable energies are regulated in Germany in two different directives: the EnEV and EEG. The interaction between the two legal requirements is comprehensible only for experts and even the planned merger of the legal framework in the “CEG” will probably not simplify the requirements substantially.

Investor-user dilemma

In contrast to other EU member states, housing is often rented in Germany. About 57% of households rent. In rental housing so-called investor-user dilemma exists: While the owner invests in energy efficiency measures, the renter benefits from the lower energy costs. This is often cited as a reason for lack of interest in energy efficiency, but solutions for this also exist. However, current models which solve this issue are not yet sufficiently well-known.

The financing framework is tight

In Germany, construction is particularly concentrated in metropolitan areas. In these regions, building and construction costs are very high and the financing framework is tight. Additional and nonessential investments in energy saving measures are therefore often put aside.

Implementation of efficient heat pump systems

Electricity prices in Germany are around 27 cents / kWh higher in comparison to other European prices. A special electricity tariff for heat pumps is therefore often not worthwhile in energy-efficient buildings. Efficient heat pump systems thus achieve only low energy cost advantages compared to modern boilers.

Implementation of energy efficiency measures within the building

A highly heat-insulated building envelope and three-pane heat protection glazing are economically attractive measures in Germany. Ventilation systems with heat recovery, however, are often not yet as affordable as exhaust air systems (see [AkkP 42], [AkkP 50])

[EnEV 2013] Ordinance on energy-saving heat protection and energy-saving systems engineering for buildings (Energy Saving Ordinance - EnEV), 2013


France

Zero energy buildings require low energy consumption and local energy production, which is commonly achieved using photovoltaic (PV) systems. The main barrier regarding low consumption is the lack of knowledge in the building sector. There are many very small enterprises and e.g. installing heat recovery on ventilation air and reaching sufficient air tightness of building envelopes is difficult for them. The regulation imposes thresholds regarding energy needs and primary energy consumption including heating, cooling, hot water, lighting and ventilation. The air tightness threshold is not as strict compared with the passive house requirement.

Regarding local production, the barriers are more diverse. A call for tender is compulsory if the size of the project exceeds 100 kWP, which is the case for many large building integrated projects regarding e.g. the roof of a supermarket or a large tertiary building. A higher threshold, e.g. 1 MWp, would be preferred by the industry, or possibly 250 kWp, which corresponds to the low voltage grid. The management of a low voltage grid is complex and costs several thousand euros. It requires around six months duration. Since this new law, the annual market corresponding to professional PV roofs has decreased by 100 MWp (from 225 MWp in 2014 to 125 in 2016). This makes it very difficult to reach the energy transition objectives, planning to reach 10.2 GWp installed PV in 2018 and between 18.2 and 20.2 in 2023, the present situation being 7.2 GWp.

Because some fires occurred (in a very limited number of cases), the Agency for Quality in Construction decided to put roof integrated PV techniques in observation. The consequence is more expensive insurance for the professionals (they have to guarantee a roof during ten years after installation. These last years, the government has encouraged building integrated PV systems, e.g. imposing a maximum 2 cm gap between the PV modules and the rest of the roof. This induces thinner air layer between the modules and the other materials, reducing the ventilation and producing overheating, which reduces the efficiency of the modules.

Now the government encourages the use of batteries allowing self-consumption, which increases the cost of PV systems and increases pollution due to the batteries. The new energy regulation being prepared integrates a life cycle assessment (LCA) calculation. One of the thresholds imposes maximum CO₂ emissions per m² of floor area, accounting only for building products. As most PV modules are imported, foreign industry does not produce LCA data corresponding to the French method (which differs from the European EN 15804 standard). Therefore default values are considered, with a penalty of 20% on impacts (i.e. primary energy and CO₂ emissions obtained from a generic data base like ecoinvent are increased by 20%). This makes it very difficult to integrate PV in a project.

Another threshold corresponds to impacts over the whole building life cycle, but the avoided impacts of exported PV electricity (primary energy consumption) are divided by a factor 2.58: 1 kWh consumed electricity is equivalent to 2.58 primary energy, but 1 kWh exported electricity is only 1 kWh primary energy. This
regulation is still being discussed. The lobbying of traditional energy producers is very strong in this discussion.

Despite of these barriers, frontrunners show the feasibility of reaching zero energy balance, e.g. the headquarters of some energy consulting companies. Communities take part in the ‘plus energy territories’ project. Professional association in the field of renewable energies and energy transition promote such approaches.

*Bulgary*

The main barriers are purely economical, because the construction market is totally driven by the initial price. Consequently, the customers look for the cheapest price, completely ignoring factors like quality, sustainability and environmental friendliness. The reason for this is the lack of information, publicity about the benefits of eco-friendly houses and last but not least, the lack of support and incentives from the government to push in this direction. The lack of information and public examples for affordable zero-energy buildings leads to the common understanding and opinion that these houses are very expensive and that it is still OK to have a house with some kind of energy efficiency. And here comes the problem with the government support – as long as there are no strict regulations how energy efficiency should be measured and proved, anybody could sell a building with 10 cm insulation as energy efficient (if you compare it to a building with 5 cm insulation).

These barriers exist, because there is not enough willingness to change from all involved parties – the building sector, the customers and the government. Our government is more or less neglecting the building sector and the potential there for environmental improvements. The building companies do not see any advantages to invest in new capabilities, which will be required to build the energy efficient buildings, because they can sell their standard buildings and still generate profit. And the customers don’t have enough examples and alternative to see that there are also other factor that need to be considered when buying a home. On the other side, this also leads to lack of capabilities in the construction companies and they do not set their focus on promoting energy efficiency.

So far, there is no initiative to change this situation in the construction sector on a large scale. Distinct companies have tried to make examples for energy efficient buildings and promote their benefits. But since most players in the industry are happy with the status quo, there is not enough momentum for change. The only way to change this situation is through large-scale information initiatives and real government support through incentives. People should be able to read about the other factors in the building life-cycle like sustainability and eco-friendliness. The specialists should explain, that energy-efficient buildings will not provide miracles on short term, but will rather persist their high quality on the long run and provide better living climate at low cost. However the initial costs will never be equal to a building which has a very thin insulation layer and low-quality glazing. At this point the government could change the game by providing tax incentives for energy-efficient buildings such that the price gap between energy-efficient and standard buildings becomes smaller.

*Italy*

First, it should be pointed out that the Italian construction sector was heavily affected by the economic crisis, recording a significant reduction in investments in new and refurbishment interventions over the period 2007-2013. However, in the last quarter of 2014 and in the beginning of 2015, the market seems to show signs of recovery, particularly in the area of renovation of existing building assets. Hence nowadays in Italy the nZEB is still a niche market: there are between 650 and 850 units (93% for residential use) distributed mainly in the northern region (Lombardia, Trentino Alto Adige and Veneto), which can be considered as nZEB
buildings. In Lombardia, even though the nZEB obligation for new constructions and major renovations has been anticipated to 2016, only the 3% of the buildings “built” from 2016 are nZEB (ref. Energy Efficient Report 2017). The report does not specify the definition of built, so this might include buildings completed in e.g. 2017 but whose building permit has been issued in 2015, hence before the entering into force of the nZEB obligation.

The main barrier to nZEB uptake is represented by the perceived economic unsustainability. Often the investment analysis is performed by using oversimplified indicators, such as the payback time rather than more adequate ones (e.g. Internal rate of return or cost of conserved energy).

A second aspect is related to the limited knowledge about the correct alternatives to adopt, since there is not a unique solution when approaching a nZEB but the available choices must be carefully evaluated and combined in relation to different conditions (climatic, environmental, technical, social, etc).

“Small and Medium Enterprises (SMEs) working in the Architectural, Engineering and Construction (AEC) industry in Italy cannot sustain very high capital investments; they have difficulties to access loans, have low technological expertise and do not strive towards internationalisation or technological innovation. Often architects and building engineers do not have a comprehensive understanding of modern adaptations and improvements of passive techniques and available innovative technologies they could apply in their building designs in relation to climatic classification” (ref. Overview and future challenges of nearly zero energy buildings (nZEB) design in Southern Europe, 2017).

Furthermore, there is low awareness about the value of energy efficiency by the stakeholders and especially the end users. The marketing strategy is inappropriate because not directed to the user.

Specific training of the manufacturers and of designers to make it attractive to the end-user purchase. This condition is easier guaranteed if the end user is properly formed and thus able to handle the building in such a way that the actual performance is in line with the expected performance.

Inadequate management of territorial planning (data collected by different subjects e.g. tax deductions, energy performance certificates, thermal plant efficiencies, etc. should be made more easily accessible to local authorities to measure effectiveness of the policies).

Another important aspect is related to inadequate knowledge about the technologies available and their correct application:

“Night ventilation during summer is generally an effective cooling strategy in the Italian climates, while external temperature is relatively low. Residential buildings in rural and quiet urban areas can rely on natural ventilation, which could be ameliorated by openings and windows design. However, in part of the urban areas, due to noise and pollution, nocturnal natural ventilation in residential buildings might need to be substituted by mechanical ventilation, thus requiring a sizing of the ventilation system to achieve higher ACH that would be required for winter alone. The risk of overheating might be relevant throughout the country for newly built nZEB in case their energy concept would be simplistically borrowed from northern design experience and no night ventilation (or other connection to cool sources) is applied. Nevertheless large improvements in the ability of the building fabric to decouple interior from exterior conditions is highly needed. The health consequences of the combination of high temperature and low quality building envelopes are quite heavy.”

(ref. Overview and future challenges of nearly zero energy buildings (nZEB) design in Southern Europe, 2017).

The lack of regional plans (only few regions promote programs to encourage the diffusion of nZEB, according to PANZEB 17).
Incentives are available but some are addressed only to buildings renovations (e.g. tax deductions for private retrofit in residential sector). New NZEB buildings are supported by incentives only in the public sector (Conto Termico). During the design, architects and engineers need longer times which are not recognized nor awarded by the client. Poor knowledge and expertise by artisans and constructors to build innovative technologies.

Difficulties in integrated design process. Lack of a knowledge centre about nZEB (ENEA is nowadays planning a national centre “Osservatorio Nazionale NZEB”. In other countries e.g. Germany there has been a systematic monitoring of high performance buildings with a good methodology and coordination “ENOB”, which is lacking at the moment in Italy).

6 | Conclusions

At the end of this study, we have been able to detect the barriers to NZEBs, to point out the most important ones for most countries, to establish the relationship between these barriers, and to know the professional groups and institutions involved. With the individual vision of many people from different groups and countries, we finally have a broad vision of the problem in the recent years, and we can intuit where to find solutions for the future.

It must be understood that the scenario is changing, since the NZEBs will no longer be an option from 2020, but a legal requirement that every new building must comply (Directive on Energy performance of Buildings, DEPB). That’s why it is relevant and it is the aim of AZEB project, to find cost-effective solutions to turn NZEBs into more affordable buildings, and then reduce the existing gap between their cost and the cost of regular buildings.

After the exhaustive review of all the barriers and factors conditioning the NZEBs, and the analysis of the information gathered from the different countries (problems, actors, possible solutions), some points stand out:

- First, we must remember that in this deliverable the barriers have been analysed in terms of elements that prevent or impede the integration of green energy technologies in a building (in a cost-effective manner). Then, a barrier is not a fact that prevent the development and promotion of the NZEBs (remember that NZEBs are the only possibility for the construction of buildings in Europe in the coming years).

- The economic & financial and legal barriers have been the most important for the promotion of NZEBs in recent years, and refer directly to most of the cost increases associated with these buildings. As a result of these cost increases, the image of NZEBs has become negative for many target groups. This idea, together with the lack of awareness in a large part of the society, has negatively influenced the promotion of NZEBs. But, although social acceptance will no longer be a determining factor in the promotion of NZEBs, the existence of social acceptance at all levels (developers, designers, end users…) will be necessary to achieve a positive learning attitude and to achieve an integrated design process in the first stages, which is key to the quality and cost-control of NZEBs.

- Most of barriers to NZEBs are in relation with the economic aspects, and therefore with NZEBs prices. Price control involves a very complex analysis and exceeds the objective of AZEB project, which is Cost Control. But,
although there are other aspects to consider, cost control has a direct influence on the control of the final price of these buildings.

- The following scheme is a summary of all the information collected. It includes problems, actors and possible solutions. It is an attempt to point out and reinforce the idea that many barriers depend on others, and that if some are unlocked (for example, NZEBs been more affordable), the others can also be resolved automatically or with little effort.

As we said, the questionnaires reveal that the individual lack of knowledge and no interest have been considered the main problem for all in the last years. This could be a first step, becoming aware that if we want to improve our quality of life and make our planet a safer place, improving environmental awareness and getting information and new compromises must be also a personal goal. In this sense, AZEB project stands for a huge communication effort.

- In the current situation, more information is needed to become pro-NZEBs promoters and users. Also this information needs to be packaged in a way that is attractive for these target groups. But technical and attractive information is not enough for the target groups to become pro-NZEB; it is necessary that technical advantages go hand in hand with economic viability and social acceptance, including a sense of urgency due to environmental awareness.

- Some barriers and conditioning factors analysed in this document to be addressed in the next stages of AZEB project, in order to achieve and put into practice the methodology, are:

  - Initial Investment.
Technical aspects: active and passive elements (building envelope and green building technologies and services).

Improvement of the skills of all workers involved in the project as a key-measure to reduce costs in NZEBS. Two professional levels must be trained in the design and construction process: professionals in touch with the design and decision-making of the project, and workers in real contact with the execution activities on-site.

Integration of the new technologies with the architectural model: integrated design phase. Virtual pre-construction model.

Within the next phase of our project AZEB we will create a comprehensive methodology, based on current available knowledge and our case studies. This methodology will be the basis for developing attractive and informative learning material for the main stakeholders, which shall be distributed throughout Europe. With this we expect to add significantly to eliminating the economic and legal barriers and add positively to the awareness and skill of all involved.

In this way, little by little, NZEBS shall become more affordable, and every day they will need less financial help. NZEBs become AZEBs.