EXCESS

FleXible user-CEntric Energy poSitive houseS

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Abstract
In this report, the local regulatory and techno-socio-economic preconditions in the involved countries and how they boost a consumer centred clean energy transition are described giving solid legislative grounds to the project. In addition, the view of the stakeholders is investigated through interviews on the demo countries.

Keywords
Regulatory environment, Market environment, Incentives and barriers for PEBs

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EXECUTIVE SUMMARY

The objective of this deliverable is to present the regulatory and market incentives and barriers for implementing the EXCESS Positive Energy Buildings (PEBs) for each of the four EXCESS demo sites in Finland, Spain, Belgium and Austria. The approach is twofold: the deliverable first presents the views of a wide range of stakeholders, collected through interviews and workshops, and then summarizes the market and regulatory environments. Finally, the conclusions and recommendations based on the research are listed.

The work builds on the PEB definition and the exemplary cases collected in earlier phases of the project (see D1.1 and D1.2). The partners have analysed which factors enable and hinder implementation of PEBs in the demo countries.

Identification of general barriers and opportunities

First, the partners aimed to identify the challenges and obstacles for deploying PEBs by engaging with a wider range of PEB concept initiators, such as authorities, cities, energy market actors, technology providers or integrators. This exercise concentrated mainly on technical, regulatory or socio-economic aspects. For this purpose, Prospex Institute (PI) interviewed a selection of stakeholders identified in the mapping (T6.1) in each of the demos. A total of 18 interviews were carried out. In addition to the interviews, the first stakeholder workshops in each of the demos dedicated a session to the identification of barriers and opportunities with a specific focus on the respective demos. The results were compared with the outcomes of an internal workshop with EXCESS participants and the findings from the case studies (presented in D1.2).

Analysis of the demo sites

Next, the partners present the characteristics of the main market architectures and regulatory frameworks that can have a positive and limitative effect on the demonstration activities and associated use cases. This part of the report describes the state-of-the-art of the regulatory status and market incentives and barriers for local renewable energy business.

Conclusions on barriers and opportunities

The main technical barriers are related to the complexity of the PEB, and the lack of the highly necessary technology integrators, who would provide an integrated solution, from design, through construction to operation and maintenance. The opportunities are offered by the wide availability of technical solutions at high TRL. The integrated design also assures high performance during the use phase. The PEBs are also highly dependent on the local climate and other local conditions.

The fact that the regulations are developing to meet the climate goals through energy efficiency improvement and wider introduction of renewable energy is considered as both barrier and opportunity: the instability of the regulations gives challenges to the planning and life-cycle analyses, while the new regulations will most probably work for PEBs. The variation of regulations on different fields and governance levels makes it difficult to develop business models and PEB concepts that would be applicable for several countries or regions.

The main social barrier is the low awareness of the PEB concept and its benefits compared to the high initial cost. Municipalities could have an important role in promoting PEBs, e.g. through city planning

or examples of functioning PEBs, or financial support. Opportunities are created by the possibility to have better control over own energy provision and demand. Local energy communities were suggested as a good way to handle the balancing of the renewable supply and energy demand, and to create community spirit.

There were slightly contradictory views on the need of financial incentives. Some interviewees said that incentives are needed in order to roll-out PEBs, but as we could see from the case studies in EXCESS, some PEBs were realised without external financial support. Tax -based incentives could be beneficial.

Summary on the market and regulatory environments

While there are some evident similarities in the countries related to the market and regulatory environment, there also seem to be different points of emphasis.

Regarding the market, it is common for all demo countries that new construction is slowed down, and it is concentrated in cities and in multi-storey buildings. It seems that the renovation pace is lagging behind the energy efficiency targets in many countries. This calls also for more PEB solutions for renovation. Some RES solutions are however prevented by strict regulations related to historic buildings. This contradiction needs to be addressed in order to connect the points of PEB solutions and renovation. The status with the roll-out of smart metering is different in the demo countries.

Common for all countries is the immaturity of the regulations, which seems to build a significant barrier for the PEBs at the moment. However regulations are being formulated for the benefit of PEBs, as they are based on the aims of climate mitigation and CO_2 emission reduction, giving benefits for high energy performance of buildings and renewable installations. Also, the exchange of renewable energy between private consumers is getting easier. One current barrier is the fragmentation of energy regulations related to different fields (gas, heat, electricity) and different levels (national, regional, municipal). Overall, it was also seen problematic if the regulations are constantly changing. This creates a lot of uncertainties for the planning and life-cycle analyses conducted in the design phase.

Recommendations

A few recommendations can be collected from the interviews, internal and external workshops, and the analysis of the regulatory and market environments:

Technical

- Develop performance-based contracts to include also the maintenance of the PEB system.
- Set up solid and experienced (and interdisciplinary) project management team to handle the complexity of the project. This team also needs to be able to explain the benefits in an understandable way.
- Initiate long-term studies to show the energy savings compared to conventional systems and the technologies used.

Regulations

- A strong recommendation based on the analysis to develop an enabling, consistent (across various policy levels), stable and clear regulatory framework in order to support a wider roll-out of the PEBs.

Social

- Create awareness raising campaigns from municipalities or national governments on the benefits of PEBs. Municipalities are most often considered as a trustworthy and independent source of information. This campaign should cover a wide range of stakeholders: end-users, politicians, but also professionals in the relevant fields (building & energy).
- Develop common, easily understandable Key Performance Indicators for PEBs. First make an inquiry of the most common misunderstandings of the concept.
- Create tools and processes for peer-to-peer advice and information provision.

Financial

- Need to create enough funding and subsidies to support PEB solutions. Also, the funding and subsidies developed for energy efficiency improvements and RES are working for PEBs.
- The requirement to show the life-cycle effects should be made mandatory in the planning phase or in connection of the building permit, not just related to costs, but also to environmental aspects.
- Financing and incentive schemes at the national level play a major role in promoting PEBs (also social issue, improves social equality).
- Introducing a CO_2 or an environmental tax could help in the roll-out of PEBs (also social issue, improves social equality).

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1 Introduction

1.1 Purpose of the document

The objective of this deliverable is to present regulatory and market incentives and barriers for implementing the EXCESS PEBs in the demo locations (Finland, Spain, Belgium, Austria). The approach is twofold: the deliverable will first present the views of a wide range of stakeholders, collected through interviews and workshops, and then summarizes the analysis of the market and regulatory environments .

The location of T1.4 in relation to other activities in EXCESS project is presented in Figure 1 below.

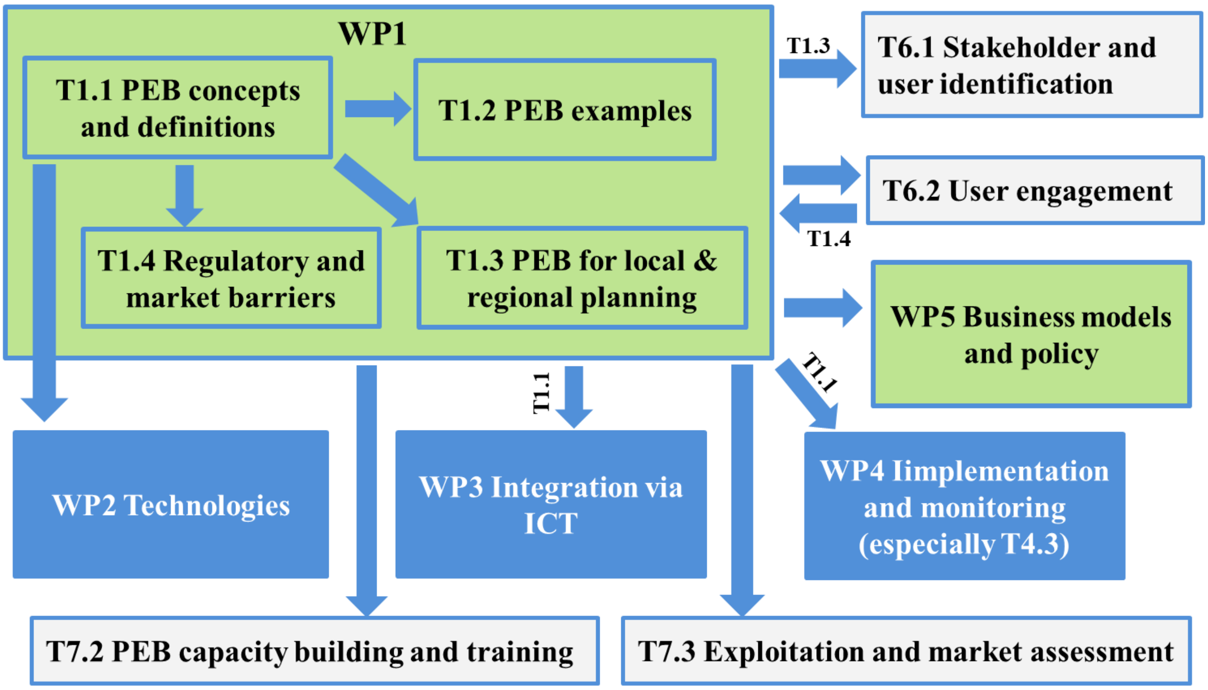

Figure 1. The connections of T1.4 in the EXCESS project, with main relations to other tasks.

Building on the definition of the Positive Energy Building (PEB, developed in T1.1) and taking reference to the exemplary cases identified during the stocktaking exercise (in T1.2), VTT and the demo leaders (CENER, VITO, AEE), supported by PI, analysed which factors enable and hinder the implementation of PEBs in the demo countries. This was realised in two steps:

1) Identification of general barriers and opportunities
   In this step, the partners aimed to identify the challenges and obstacles for deploying PEB by engaging with a wider range of PEB concept initiators, such as local and regional authorities, cities, energy market regulators, energy utility companies, aggregators, technology providers, technology integrators and building facility managers. This included technical, regulatory or socio-economic aspects. For this purpose, PI interviewed a selection of stakeholders identified in the mapping (T6.1) in each of the demos. In total, 18 interviews were carried out. In addition to the interviews the first stakeholder workshop (T6.2) in each of the demos dedicated a session to the identification of barriers and opportunities with a specific focus on the

respective pilot. The outcomes of the interviews were compared with the results from an internal workshop and with the findings from the case studies of T1.2.

2) Analysis of the demo locations

VTT, CENER, VITO and AEE, drew up a summary of the characteristics of the main market architectures and regulatory frameworks that can have either a positive or limitative effect on the demonstration activities and associated use cases, with a focus on buildings / communities and their participation / integration in flexibility / services markets.

VTT led the work and wrote the parts related to the Finnish demo, including the descriptions of market and regulatory environments. All task partners (VTT, CENER, VITO, PI, AEE) contributed to the formulation of the questionnaire, which was finalised by PI. PI conducted the 18 interviews with the stakeholders. VTT and AEE summarised the interview results based on PIs report from the interviews. The demo leaders (CENER, VITO, AEE) contributed with the descriptions of the demo sites and the analysis of the market and regulatory environment related to their demo sites. VTT finalised the report, formulating the conclusions and recommendations, with feedback from the rest of the team.

1.2 Scope of the document

This document presents a view on the general market and regulatory environment in the demo countries, to illustrate what kind of barriers or incentives these bring for wider roll-out of PEBs. The work is supported through interviews of a wide selection of stakeholders.

1.3 Structure of the document

After the introduction in chapter 1, the report first presents, in chapter 2, the general barriers and opportunities for a wider roll-out of PEBs, derived from stakeholder interviews and workshops. The methods used for collecting the inputs are briefly introduced in the beginning of chapter 2. The interviewees and workshop participants represented a wide variety of stakeholders. The analysis concentrated on technical, regulatory, social and financial aspects. A summary and comparison towards the results of the project internal workshop and the case studies of T1.2 are finally presented in chapter 2.4.

Next, in chapters 3 and 4, the analysis of market and regulatory environment in the demo locations is carried out, from the perspective of the demo buildings. Therefore, a short description of the demo building and aims in each country is provided first (in chapter 3.1).

Finally, in chapter 5, the report provides conclusions and recommendations based on the previous steps. This chapter concentrates on actions that could be the most effective in taking up the opportunities and removing the barriers for a wider roll out of PEBs. It also suggests some points of attention for further work in the EXCESS project.

2 General barriers and opportunities

2.1 Methods

Interviews

PI conducted 18 interviews with key local stakeholders from the four EXCESS demonstration sites (Finland, Spain, Belgium, Austria). The aim of the interviews was to identify challenges and obstacles for the deployment of PEBs in the local demonstration sites. Targeted stakeholders ranged from local authorities to cities and technology providers. A wide selection of stakeholders was finally reached, encompassing representatives of building owners (social and other), different levels of authorities (cities, regions), energy companies, energy service companies, construction and renovation companies, designers, architects, technology providers (e.g. PV, heat pump, façade, insulation materials), or, in some cases, parent organisations of these actors, each contributing to the overall image with their specific viewpoints. Six (or 30 %) of the interviewees were females[1].

The one-hour interviews were designed to tackle the main known barriers and challenges such as technical, regulatory, or socio-economic aspects and to identify new ones. In addition, the interviews were meant as an opportunity to uncover opportunities linked with the deployment of PEBs in these local communities. The interview questions are presented in the Attachment to this report. The main findings are presented on the following pages.

Workshops

A second important step for the identification of barriers and opportunities were the Co-Innovation workshops organised at the four demonstration sites (as part of T6.3), facilitated by PI and organised together with the local EXCESS actors. The first round of workshop was organised in 2020 and aimed at exploring the scope of activities being undertaken in the development of PEBs and map the needs, issues, challenges and opportunities. The workshops brought together a collection of 79 stakeholders to discuss these various points. The stakeholders included representatives from the EXCESS team and similar stakeholders as the interviews, but in addition e.g. a lawyer and IT professionals were involved. About 24 % of the 79 workshop participants were females[1].

One key session of these workshops was aimed at identifying and clustering challenges and opportunities for PEBs. Participants were asked to come up with challenges and opportunities and these were then grouped together per topic. A summary of the outcome of this session on challenges and opportunities is presented in the following section.

Internal workshop

The EXCESS project team consists of stakeholders that are active in the energy efficient building and renewable energy field, representing both research and commercial actors. Therefore, it is a good assumption that they would have a fairly relevant understanding of the barriers and opportunities for the PEBs. To collect their views, a workshop was organized in connection with the second General

[1] This analysis is based on the typical names for males and females, as we didn't ask of the gender in connection of the interviews or workshops.

meeting of the project in March 2020. The results of this workshop are compared with the findings of the interviews and co-innovation workshops presented above.

PEB case studies

In T1.2 of the EXCESS project, a set of examples of PEBs was collected in a stocktaking exercise.[2] Ten of the 58 examples were analysed in more detail, looking also for the potential barriers and opportunities recognised in the implementation of these existing cases of PEBs. The outcomes of these studies are compared with the results of the interviews and workshops for formulating the final conclusions.

2.2 Main barriers

A summary of the main barriers as investigated via the interviews and workshops is presented in Table 1 below. These aspects are described in more detail in chapters 2.2.1 to 2.2.4.

Table 1. Main barriers recognised in the interviews and workshops.

Field	Barriers
Technical	• Complexity of the PEB concept • Lack of integrators and interdisciplinary teams • Lack of actors providing services that cover the whole chain from planning to operation and maintenance • Constant emergence of new technologies and new ways of using them • Lack of tools for the coordinated control and optimization of the energy system • Pronounced need to consider the local conditions in the planning of PEB
Regulatory	• Immaturity of regulations • Fragmentation of energy regulation (different fields and governance levels) • Inability of the regulations to handle different ownership structures and energy choices • Tight restrictions in historic buildings in combination with renewable installations
Social	• Lack of public awareness • Multi-owner decision making (in some countries) • Affordability of PEBs
Financial	• Lack of existing examples of cost-benefit analyses of PEBs (life-cycle) • Typically high investment costs of PEBs • Wide range of design options > significant variation of the costs

2.2.1 Technical barriers

It was pointed out several times by the interview participants that **different approaches are required depending on the location,** whether the building is in the city or in the countryside and depends on the local conditions, related e.g. to climate or availability of solar irradiation (which can be affected by shading from surrounding buildings, terrain or vegetation).

[2] Jaeger, Andreas (ed.). 2020. Deliverable 1.2 of EXCESS project: Stocktaking of PEB Examples.

In general, the interviewees confirmed that the **necessary technologies are already available** but can be further optimized. The current "momentum", in which there is an increasing ecological awareness and also a certain pressure for more sustainability in the general public, should be used for a communication offensive or increased lobbying for the concept. According to the interviewees, there would **need to be some active players** on the market who offer the concepts professionally and promote them "aggressively". In the opinion of individual interviewees, this could also lead to the system establishing itself relatively quickly as the better solution on the market.

Experts suggest that the technological concepts should be offered as a **complete solution or a total solution** by a (coordinating) company, since otherwise the complexity would be too high for customers. "*The entire service must come from a single source*", as one of the interviewees expressed it. The idea is that one company offers **"all-inclusive" support**, from consulting and planning to complete implementation. However, the technical complexity also means that there are **few providers** in the market, which means that there are few experts available, which also means that **competition is very low**.

In this context, the interviewees also pointed out that the increased use of such concepts also requires **additional specialized knowledge among the professionals** (including architects) concerned. Since the technological concepts often require different professional groups, it is important to establish **interdisciplinary projects** or a really good interaction between those involved. It was also pointed out that there is a **lack of qualified workers** and that sector's own professionals have to be **constantly trained** in order to be always up to date with the latest technology.

The specific benefits of a system must be proven through **systematic analyses** over longer periods of time in order to help the concepts achieve a breakthrough. Emphasis should also be placed on **coordinated control and optimization** of the energy system. From the point of view of the interviewed stakeholders, **long-term studies** should in particular show the energy savings compared to conventional systems and the technologies used.

One interviewee also stated that in addition to good planning, business models should be linked to maintenance, and **performance-based contracts** should be used. Thus, in the long run, the efficiency of the maintenance of a building becomes an important element in this process.

Some additional barriers/challenges were also identified in the workshops, such as managing the interplay of energy production and demand, as well as grid interaction, architectural implementation of renewable technologies, and transferability.

2.2.2 Regulatory barriers

Higher costs of PEB's, lack of incentives and/or regulatory barriers restricting e.g. the possibilities to benefit from surplus energy were raised in the interviews. In one of the interviews, it was stated that there is a discrepancy between the need and will to promote sustainability and climate protection, and the need to provide housing that is affordable for the average consumer.

Regulatory barriers related to energy and energy markets were mentioned more frequently and in more detail compared to other regulatory domains. Challenges related to **fragmentation of energy regulation** (gas, heat, electricity) were mentioned implying that the issues may be different in various countries due to different national market structures and regulations. **Local energy communities** and challenges related to respective regulation and guidance (or lack of it) came up in two interviews

(Belgium, Spain). The fact that it is not possible or there are problems related to **benefiting or profiting from surplus energy** through selling it to other buildings, facilities or the grid was mentioned in several interviews (Belgium, Spain, Finland). In one of the interviews, the regulation that does not allow to make an energy balance between what you produce and what you consume (two-way controls not allowed) was also mentioned as a regulatory barrier.

The challenges were described in one of the interviews*: "For example, you cannot sell or give a share of your energy overproduction to your neighbour. That's why LECs (Local Energy Communities) are interesting, more optimal. Unfortunately, most pilot projects get stuck in that phase, while a far-reaching solution is needed."*

Regulations related to buildings and the built environment as barriers were mentioned only in the interviews of two countries highlighting the specific challenges caused by regulation and high protection of historic buildings and heritage sites (Spain) and lack of definitions (Austria). Linkage between the **ownership structure and energy choices** was brought up in one of the interviews, highlighting that there is not yet a legal basis in place, for example, to be able to include photovoltaics on an apartment building appropriately when there are several owners in the house.

In some of the interviews it was indicated that the **involvement of various levels** (e.g. regional and national in Belgium) and many departments in administration may cause challenges to the development of appropriate regulatory framework for PEBs and thus lead to barriers. It was also mentioned that sometimes there are uncertainties related to rapid changes in the regulatory framework.

In the workshops also some additional barriers/challenges were identified such as regulation on delivering and managing heat grid, urban integration of the area, (building) authority barriers, current use restrictions by building authorities and legal barriers related to neighbourhood identity.

2.2.3 Social barriers

Social barriers raised in the interviews included issues with perceptions related to comfort, user-friendliness, maintenance etc. and lack of information, attitude towards and affordability of PEBs.

Issues related to the **lack of information** came up in the interviews in all countries. It was mentioned that the **concept of PEB is not familiar** and there is not enough knowledge on what PEBs can offer. There is unclarity of what constitutes a PEB and how the field is developing, **even among experts**. It was highlighted that issues related to comfort, user-friendliness, maintenance and behaviour changes needed from residents of PEBs are not very well communicated or explained. Tenants of the building may lack knowledge about the system and how it works. It was also mentioned that the **needs for information and instructions** may **vary between various groups** of people. This may become a burden for e.g. housing organisations.

The demand for PEBs can remain low e.g. also because potential residents do not see anything special in living in a PEB compared to a conventional house. One of the countries noted that societal support for PEBs can be higher in cities than in more rural areas (e.g. acceptance of technological or innovative improvements when PEBs would be implemented in their neighbourhood).

Affordability of PEBs especially for several citizen groups came up as a societal barrier in some of the interviews. Other things that were mentioned are that private renting market is getting more and more expensive (Belgium) and that PEBs are not affordable to average income people (Austria).

In one of the interviews, it was also mentioned that PEB is a complex concept creating additional need to get the builders on board and motivated.

In the workshops also additional barriers/challenges were identified such as: engagement of residents, knowledge of users/residents and their profile e.g. for the development of information programs.

2.2.4 Financial barriers

Innovation was mentioned by the interviewees as one of the main drivers for improving the energy efficiency of buildings. But this innovation often results in a financial challenge for the construction companies or the owners with **additional costs for new solutions**.

At the current stage of development of technological concepts, there is a **wide range of design options** - both regarding the buildings, the technologies and the materials used, multifunctionality or type of exterior design, etc., so that the **costs vary significantly**. In addition, current implementations of **PEBs are mostly embedded in demonstration projects** and there is no standardization.

It is therefore clear that innovative solutions must be linked to business models that ensure acceptance on the broad market. Pure investment support is not seen as sustainable by interviewees. However, the interviews showed that it is important from the outset that governments become or remain active in this area. The framework conditions will be set at the national level and regional governments can support with important financial resources to drive the massive deployment of PEBs. Therefore, **financing and incentive schemes at the national level** play a major role in promoting energy efficient buildings (PEBs).

At present, the concepts are still characterized by an **increased effort in planning and higher initial costs**. In addition, many advantages or specific **benefits of the concept**, such as higher comfort, lower operating costs, potentially lower maintenance costs, lower maintenance susceptibility due to higher-quality materials or better recyclability, can only be shown or demonstrated **over a longer period of time** (ideally over the whole product life cycle).

A **holistic calculation** would therefore take into account not only the planning, manufacturing and construction costs, but also the lifetime costs. In most cases, however, such an analysis is not carried out in the run-up to an investment due to resource-technical considerations or also due to a low degree of specification / lack of information.

2.3 Main opportunities

A summary of the main opportunities is presented in Table 2 below. These aspects are described in more detail in chapters 2.3.1 to 2.3.4.

Table 2. Main opportunities recognised in the interviews and workshops.

Field	Opportunities
Technical	• Large selection of existing technical solutions on high TRL • Integrated planning • Few providers on the market > low competition • Emergence of smart energy management tools with user friendly applications
Regulatory	• Emerging regulatory framework for Local Energy Communities • Climate friendly regulation supports PEBs • Movement towards stricter energy efficiency targets on national level
Social	• High public awareness (in Finland) • PEBs could improve the residents' feeling of control • Local energy production and demand response to increase the community spirit • Local energy communities enable new ways of cooperation in the neighbourhood • Holistic sustainable design goals in PEBs increase the interest
Financial	• Life-cycle costs of PEBs are often lower than for conventional buildings • Financing and incentive schemes at the national level support the wide roll-out of PEBs

2.3.1 Technical opportunities

The interviewees expressed the opinion that **PEBs are planned in a much more integrated way** by developing energy concepts that take into account a variety of different aspects. This includes the building (architecture, ventilation system, windows, etc.), the energy production (renewable technologies) as well as the consideration of aspects that go beyond the building boundaries. Ideally, energy goals are included in the conception and design phase of real estate development from the very beginning of a project. In some cases, the implementation is accompanied scientifically, which also allows the different concepts to be made available to an interested community.

A noteworthy aspect of **integrated planning** is the potential to maximize the use of on-site renewable energy. This potential is further enhanced by clusters in neighbourhoods (energy communities). PEBs can provide a higher level of energy storage, for example in electric vehicles (bicycles, cars, etc.) but also in the intrinsic storage capacities of buildings or in electric community battery storage. In this way, fluctuating energy from solar power and windmills can be efficiently stored temporarily and used locally.

In this context, the interviewees also pointed out that a solid and **experienced project management team** is necessary to handle the complexity of the project. They must be able to explain the dimensions and the different "layers" of such a project and show that it is technically up to date and **transfer the benefits in an understandable way**.

This should motivate owners or investors to rethink the buildings in depth by implementing energy efficiency improvements in retrofitting and installing renewable energies on site, while balancing the targeted performance levels and the economic viability of the whole project.

In the workshops, some other advantages of PEB and the technologies used were identified, such as e.g.

- Increased Energy self-sufficiency
- Energy sharing between users
- Reduced energy demand and reduced CO_2 emissions
- Variety of possibilities for **intelligent systems** (connection with other applications, e.g. car sharing)
- **Smart steering/managing tools/applications used in households**

2.3.2 Regulatory opportunities

Regulatory opportunities were identified related to energy, city planning and buildings.

Local energy communities were raised as a regulatory opportunity for PEBs even though at the moment there are also barriers as the regulatory framework is under development (see chapter 2.2.2). As one of the interviewees said: *"Fine-tuning is needed, but many regulatory initiatives are in the pipelines and are well on their way to being implemented."*

In one of the interviews, regulatory interventions were suggested to be necessary in some cases since promoting and persuading have not been effective enough. In Vienna there are e.g. areas where photovoltaics or building with renewable materials has become a requirement. One of the interviews noted also market approach applied in the heating market stating that regulations could force local heating company to buy excess heat, which could keep it affordable. Concerning heat production, a planned tax reform in Finland introducing a slightly lower taxes for larger heat pumps was mentioned.

In some interviews (Belgium, Spain) references were made to the potential for finding solutions to national/regional/local level challenges related to e.g. public tenders and national grid operators through European level, e.g. in the form of guidelines for regulations and budget.

Regarding the regulations related to the built environments and buildings, the interviewees in Finland suggested **opportunities to encourage PEB's through city planning**, conditions for the transfer of plots of land and reduction of the cost of building permits or property tax if certain requirements are met. In Spain, the interviewees raised **opportunities through technical codes** for building constructions, rules to facilitate more flexible renovation (e.g. some areas in the old town are easier to renovate than others) or valuation of environmental improvements above the value of heritage in old towns. Also, abolishment of the building tax that is paid to the city council in case of new construction, as well as financial bonuses and tax/fiscal breaks were mentioned.

Enabling, consistent (across various policy levels), stable and clear regulatory framework was considered important. City Council/municipality was suggested in one of the interviews as an important actor that can help people to understand the new regulations and facilitate the implementation.

One of the workshops discussed climate change, mentioning that the government focuses more on heat and sustainable energy implying that addressing **climate change challenge may also create regulatory opportunities** for PEBs.

2.3.3 Social opportunities

Creating awareness/reputation and demand for PEBs as well as providing **information and support** in various ways was raised in all interviews.

It was mentioned in one of the interviews that there is no social resistance against PEBs and sustainable buildings have become self-evident to some consumers. There is much less scepticism than before regarding PEBs. Awareness creation was considered very important and **several ways** for this were suggested, e.g.

- creation of knowledge centre by government
- publication of best cases and practices (e.g. handbook or information in a visual and simple way)
- utilising articles and daily news
- being present at fairs and housing exhibitions
- building a central website and a strong brand
- bringing a network together of organisations that are in any kind of way involved in sustainable construction

Important issues in creation of awareness and demand were **costs**. PEBs can be considered as houses with extra costs. It was noted that costs, lifestyle, comfort, price and value of a house are important considerations. It would be important to explain the **advantages and benefits of PEBs** (e.g. long-term economic return on investment) and to **quantify the value-added** of PEBs to end-user. **Erroneous beliefs** such as well-insulated houses having more issues with humidity or mould were also mentioned as a topic that needs to be addressed. The timing and the target groups of awareness raising were discussed in one of the interviews stating that:

> *"Advising the consumer is not terribly effective, unless when it's a detached house and in the very beginning of a construction. When talking about multi-storey buildings, it should be also aimed at builders and real estate developers or the city."*

Need to create incentives for demand were raised but without concrete suggestions except in one of the interviews, where coupling the mortgage to energy efficiency criteria was suggested.

Information and support related to energy issues were raised as a social opportunity. Interviews included suggestions about actors like an 'energy reducer' or an 'energy ambassador' in the context of social housing, and a public or private Energy Manager that attends to the communities and generally creating a new energy culture through information and training on energy in buildings.

One of the interviewees raised communicating the Green Deal and **empowering citizens** as a social opportunity. **Local energy communities** were suggested as something that could enable new ways for cooperation in the neighbourhood.

Additional social opportunities were identified in the workshops, e.g. **learning lessons from initially not motivated residents**, giving residents responsibilities through participation, shaping energy communities via a demonstration project, PEBs as great learning opportunity and creation of 'Learning network' on PEBs, possibility to live differently enhancing mental and physical health, improving the identity of the area, provision of the model for sustainability, promoting pioneering work and role, read and settle individual consumption, get feedback on personal behaviour through an APP and provision of freedom, saving and independence for users.

2.3.4 Financial opportunities

It was mentioned in one of the interviews that everything is there to stimulate PEBs or at least energy neutral living conditions, when the regulatory barriers are removed and, in contrast to inefficient subsidies schemes, the financial aspect would be self-supporting.

This is accompanied by further inputs from the interviewees who also see financial incentives as only of limited suitability. They see the need to quickly introduce a CO_2 tax or an environmental tax, where the environmental consumption would be charged to those causing it.

Incentives in the form of tax benefits are also seen as an advantage. These advantages should also be extended in time and not only be reflected during the construction phase, but also during operation in the form of tax advantages.

Need to create enough funding and subsidies were raised but without concrete suggestions but PEBs could reach higher numbers, similarly to what has been done with electric cars. There is already funding available, but it should be increased significantly to make PEBs more viable.

2.4 Barriers and opportunities from EXCESS internal workshop

The EXCESS project team consists of stakeholders that are active in the energy efficient building and renewable energy field, representing both research and commercial actors. To collect their views, a workshop was organized in connection with the second General meeting of the project. This chapter presents the summary of those views, in order to facilitate a comparison towards the interview and workshop results related to the views of other stakeholders in the field, presented in chapter 2.6 below.

In the project internal workshop, the partners were divided into four groups, to discuss the barriers and opportunities in the demo countries. In these groups, three most serious barriers were to be chosen, as well as three best opportunities. These were then discussed in a bigger group, to see if there were similarities or differences in the demo countries.

As an outcome from the workshop, the following conclusions could be drawn: Climate could be a barrier (in Finland) or opportunity (in Spain) while immaturity of regulations seem to be a barrier in most demo countries. The lack of PEBs was also seen as a barrier (not enough good examples to present) and an opportunity (lots of room on the market for different solutions). One common group of barriers was related to cost or status of market development: the lack of integrators or the fact that often only the investment costs are considered when making the decisions. It was also seen that the definition and KPIs are needed in order to promote the PEBs: if the stakeholders don't know what a PEB is or how its performance is measured then it is hard to get PEBs widely on the market. Other barriers that were mentioned include multi-owner decision making related to apartment buildings in some of the demo countries and technical complexity of the PEB solution. In some countries the support of municipalities is seen as an important opportunity. Also, the movement towards stricter energy efficiency targets on national level is working for a larger introduction of PEBs. Public awareness was seen as an opportunity in some countries, and this could be used in other countries to improve the uptake of PEBs (improving the public awareness). In Finland, the good know-how of the market actors was seen as an opportunity.

2.5 Summary of the barriers and opportunities from case studies

In T1.2 of EXCESS project, a set of examples of PEBs was collected in a stocktaking exercise.[3] Ten case examples were analysed in more detail, looking also for the potential barriers and opportunities. In the following, a summary of these is presented.

- **High level of stakeholder collaboration was recognised as an opportunity:** To successfully develop PEBs, a range of specialised firms must be brought together, and the client's engagement is key to understand needs and expectations. This highlights the importance of stakeholder engagement and the close collaboration of specialist firms to design and realise a complex PEB.
- **A key challenge** recognised in the case studies is t**he connection of PEBs with local thermal and electrical grids**. Further information on current barriers related to this is needed, so that these can be **addressed at the relevant levels of governance**.
- **There is a lack of more fine-grained data on financial arrangements and affordability:** To fully exploit the examples from the stocktaking exercise, current locally applicable support schemes and regulations must be understood more deeply. Further the affordability of PEBs must be examined by calculating the costs for PEB developments compared to traditional construction or renovation.
- One important finding is that in many of the cases, the aim has not only been to achieve a status as PEB, but a **more holistic sustainable design goal**.
- With regard to building technologies, the cases both highlighted the need to innovate and push boundaries, but also showed that **market-ready technological solutions exist**.
- Although details on project financing were not always available in the case studies, preliminary findings suggest that **higher upfront costs can be a barrier** to the broader roll-out of PEBs and **government incentives do play a role** in helping projects to be realised. On the other hand, some cases showed that **PEBs can already be realised without significant external financial support**, with cost savings during operation representing a strong business case.
- It is found that the **client's vision** can play a key role in driving a project.
- Challenges can include **longer planning and design phases of PEB projects** and **lacking technical skills**.

[3] Jaeger, Andreas. 2020. Deliverable 1.2: Stocktaking of PEB Examples.

2.6 Conclusions and recommendations on barriers and opportunities

During the interviews as well as internal and external workshops, it turned out that some of the issues that are seen as barriers in some countries can be opportunities in other countries, or even both inside one country. Therefore, in this chapter, we summarise them, presenting also ideas on how to turn some of the barriers into opportunities based on learnings from other countries.

2.6.1 Technology related aspects

Regarding the technological barriers and opportunities, the interviews and workshops seem to be well aligned and support the findings from the case studies on existing PEBs. The common conclusion is that one of the important opportunities is provided by the large selection of existing technical solutions on high TRL. On the other hand, one of the most important barriers is also created by technology: PEB is a complex system, and the planning, construction and maintenance requires integrated design by a well-informed integrator, or even an interdisciplinary team in order to reach a well-functioning system. There is a lack of these integrators which creates an important barrier. The services of such integrator should cover the whole chain from consulting and planning to complete implementation. New technologies and new ways of using them are also emerging, which increases the need for constant training for the professionals in the field. There is still need for developing tools for the coordinated control and optimization of the energy system. The technical complexity of the PEB solution leads to several barriers, but also opportunities:

- There are only few providers on the market, which also means that competition is very low. This might be considered as a barrier (lack of examples, high prices) or an opportunity (lots of room on the market for forerunners).
- The integrated design also ensures the smooth operation of the whole system, as different interactions are taken into account already in the design phase.
- Additional specialized knowledge and interdisciplinary teams are required.
- Complexity leads to a lack of qualified workers.

Another point that became evident from all sources in this research is that the appropriate technical solutions for the PEB depend highly on the location and climate. The climate for instance can be either a barrier (in Finland, high seasonal variance of energy need and supply) or an opportunity (in Spain, good availability of solar energy).

The emergence of smart energy management tools combined with user friendly applications used in households provide a technical but also social opportunity, giving the possibility to better balance the renewable supply with the energy demand, but giving also the residents more control of their own energy use, and could be combined with increased awareness at its best.

Recommendations:

- Develop performance-based contracts to include also the maintenance of the complicated system.
- Create a solid and experienced project management team which is able to handle the complexity of the project and show the benefits in an understandable way.
- There is a need for longer-term studies to show the energy savings compared to conventional systems and the technologies used.

2.6.2 Regulatory aspects

One of the common conclusions from all sources of information (interviews, workshops and case studies) is that regulatory barriers seem to be mostly related to energy and energy markets, rather than to other fields. Most importantly these are related to the possibilities to balance the energy demand and supply, e.g. selling the excess energy to neighbouring buildings or the grid. Local Energy Communities were raised as a regulatory opportunity for PEBs even though at the moment there are also barriers as the regulatory framework is under development.

Regulatory barriers include:

- immaturity of regulations
- fragmentation of energy regulation (gas, heat, electricity & different levels: national, regional, municipal)
- inability of the regulations to handle different ownership structures and energy choices
- the very tight restrictions in historic buildings in combination with renewable installations

It was also pointed out that the regulatory changes made due to climate change will work for PEBs, as an example the movement towards stricter energy efficiency targets on national level. Some regulatory incentives already exist, and more are suggested by the interviewees. One opportunity suggested in relation to regulations is that there could be conditions for the transfer of plots of land and reduction of the costs of building permits or property tax if certain requirements are met. This could also be formulated in a way that it gives a financial opportunity for PEBs.

Recommendation:

- Enabling, consistent (across various policy levels), stable and clear regulatory framework is needed for wider roll-out of the PEBs.

2.6.3 Social aspects

A common finding from the interviews, workshops and case studies was that public awareness was seen as a barrier in many countries, while it was seen as an opportunity in some countries, and this could be used in other countries to improve the uptake of PEBs (improving the public awareness). Creating awareness/reputation and demand for PEBs was mentioned in all interviews, and several means to increase the awareness were suggested. Also the awareness of the market actors needs to be improved. The challenge is the different level of need for information and support.

To overcome the barrier caused by a lack of awareness, more information is needed on the concept of PEB, but also on the advantages and benefits of PEBs (e.g. long-term economic return on investment) and the quantification of the value-added of PEBs to end-user. Erroneous beliefs were also mentioned as a topic that needs to be addressed. For this, one suggested method is learning from initially not motivated residents.

As a social opportunity it was mentioned that PEBs could be used to improve the residents' feeling of control, and the local energy production and demand response could increase the community spirit. Local energy communities were suggested as something that could enable new ways of cooperation in the neighbourhood. Multi-owner decision making related to apartment buildings in some of the demo countries is seen as a social barrier. Support of municipalities is seen as a good potential and important for PEBs. One important finding from the case studies was that often the goal goes beyond achieving a status as PEB, e.g. more holistic sustainable design goals have been pursued. This probably presents yet another social opportunity for the wider roll-out of PEBs.

Recommendations:

- Awareness raising campaigns from municipalities or national governments on the benefits of PEBs are needed. Municipalities are most often considered as a trustworthy and independent source of information. This campaign should cover a wide range of stakeholders: end-users, politicians, but also professionals in the relevant fields (building & energy).
- Develop common, easily understandable Key Performance Indicators for PEBs. First make an inquiry of the most common misunderstandings of the concept.
- Create tools and processes for peer-to-peer advice and information provision (e.g. so called energy ambassador).

2.6.4 Financial aspects

From the interviews, workshops and case studies, it became evident that as PEB is still a relatively new concept, the cost-benefit can't yet be clearly shown from existing examples. Also, there are normally additional costs for new solutions, and the costs for PEBs have not yet stabilized to their final level. Current implementations of PEBs are mostly embedded in demonstration projects. In the case studies, some of the buildings used a significant amount of external financial support, while some didn't need any. Also, the wide range of design options result in significant variation of the costs. The lack of long-term cost data is a barrier, making it hard to prove the assumed positive life-cycle cost effects of PEB solution.

Incentives in the form of tax benefits are also seen as an advantage, but there were also views that incentives are not needed or not very efficient.

Costs, or cost-benefit analysis were also mentioned as one important issue in creating awareness and demand for PEBs. A holistic analysis would take into account not only the planning, manufacturing and construction costs, but also the lifetime costs. In most cases, however, such an analysis is not carried out in the run-up to an investment due to resource-technical considerations or also due to a low degree of specification / lack of information. This connects the barrier to the social and technical barriers related to awareness raising and lack of integrators.

The fact that there are not enough good examples of PEBs was seen as barrier and opportunity (lots of room in the market for different solutions).

Recommendations:

- Financing and incentive schemes at the national level play a major role in promoting energy efficient buildings (PEBs).
- Introducing a CO_2 tax or an environmental tax could help in wider roll-out of PEBs.
- Need to create enough funding and subsidies to support PEB solutions. The funding and subsidies developed for energy efficiency improvements and RES are also working for PEBs.

- The requirement to show the life-cycle effects should be made mandatory in the planning phase or in connection with the building permit, not just related to costs, but also to environmental aspects.

3 Analysis of the demo locations market architectures

This chapter presents the market architectures in the demo locations, concentrating on those aspects that are likely to prevent or encourage the introduction of PEBs and local renewable energy businesses. In each country the focus is on the structures that are relevant to the demo case in that country. Relevant markets related to the demo case are described for following stages in the life cycle: development and planning, construction, use, and renovation (Figure 2). Planning related to renovation stage is also relevant as the aim is that the PEB-concept can be applied after the demonstration also to conventional apartment buildings. One of the demonstrations is a renovation project (Austria).

Figure 2. The main life cycle phases in the market analyses.

3.1 Finland

3.1.1 Demo description

The Finnish demo case is a planned apartment building by Bassotalo (Figure 3) with about 180 apartments and a total (heated/cooled) floor area of 9,700 m^2.

Figure 3. Image of the Finnish demo building in Helsinki. [Source: SWECO Architects Oy]

The aim was to have the construction permit admitted and probated in January 2021 and carry out the construction work with a view that the first residents would move in during 2023. The aim is to develop a concept that integrates already proven technological solutions in order to be able to replicate the concept later and transform conventional apartment buildings into PEBs. The City of Helsinki has accepted Bassotalo for the Evolving multi-storey building -programme (Kehittyvä kerrostalo).

The demo case includes several technological and system-level innovations that contribute to the PEB-concept:

Geothermal heating system with beyond state-of-the-art efficiency

- deep boreholes (3x800 m)
- new type of collector
- high COP heat pumps

Solar panels or solar collectors

- electricity production
- heat production
- integration to balcony structures or facade

Utilisation of excess heat

- Exhaust ventilation
- Wastewater

Storage of excess energy (in the boreholes)

- Energy from solar collectors
- Heat from cooling of the buildings
- Excess heat from exhaust ventilation and wastewater

Use of smart energy control system

- Integrated control system
- Smart control of energy production and consumption
- User-friendly interface

3.1.2 Market architecture in relation to the demo

General drivers having impact on housing markets in Finland are increasing urbanisation, demographic development and changes in housing preferences and needs. The demand for small, well located apartments has increased both on owner-occupied and rental housing markets. In recent years, the vast majority – as much as 90% of new housing construction – has been concentrated in main city regions[4].

[4] The Finnish Property Market 2019. https://kti.fi/wp-content/uploads/The-Finnish-Property-Market-2019.pdf

Development and planning

The development and planning phase of the new construction and renovation includes opportunities to apply concepts developed in the PEB demo case.

The largest construction companies involved in commercial property development in Finland include YIT, Skanska, NCC, SRV, Hartela and Peab. Most of these companies also develop residential properties and typically buy and hold a significant number of plots. Construction companies have also been active in housing development projects, which they sell to investors, most often property funds. This activity, however, seems now to be slowing down due to increased uncertainty and an increasing supply of rental residential properties. There are also numerous, typically smaller local players, who mostly develop apartments for homebuyers.

Construction companies typically have a separate arm that specialises in commercial property development (including the residential sector). The redevelopment of existing properties is mostly handled by their owners or by specialized companies who buy properties in order to redevelop them[5].

According to Finland's long-term renovation strategy the availability and use of designing engineers, particularly in the case of residential renovation projects needs improvement[6].

Construction and renovation

As described earlier, there are currently several drivers having impact on the demand for residential properties including new multi-storey apartments in Finland.

According to the most recent outlook of the construction industry, the construction will remain at low levels for the next few years. The forecast for privately funded multi-storey apartments in 2021 is 7,000 units (compared to 10,000 in 2020, 19,800 in 2019 and 25,800 in 2018). The number of ARA funded multi-storey apartments is forecasted to be 10,000 in 2021. The value of the construction of residential buildings in 2018 was 7.3 billion Euros[7].

Some two thirds of new housing construction are concentrated in main city regions. In the Helsinki metropolitan area, some 14,500 new dwellings were started in 2017, and in 2018, the numbers were even higher[8]. The latest draft for housing and land-use programme sets goal for building at least 7000 new dwellings per year[9]. In Helsinki, 86% of the housing units are located in multi-storey buildings. New types of buildings are being tested in the City of Helsinki's Re-thinking Urban Housing programme. So far, about 30 projects have been involved in the programme - including the PEB demo case for the EXCESS -project.

There are some 62,000 multi-storey apartment buildings in Finland including some 1.4 million apartments. In 2019, about 8 billion Euros were used on renovation of residential buildings on the

[5] The Finnish Property Market 2019. https://kti.fi/wp-content/uploads/The-Finnish-Property-Market-2019.pdf
[6] Long-term renovation strategy 2020-2050, Finland. https://ec.europa.eu/energy/sites/ener/files/documents/fi_2020_ltrs_en.pdf
[7]https://www.rakennusteollisuus.fi/globalassets/suhdanteet-ja-tilastot/suhdannekatsaukset/2020/suhdanne_200528_en_final.pdf
[8] The Finnish Property Market 2019. https://kti.fi/wp-content/uploads/The-Finnish-Property-Market-2019.pdf
[9] https://www.hel.fi/static/kanslia/Julkaisut/Kotikaupunkina-Helsinki/2020/luonnos_AM-ohjelmaksi_2020.pdf

Finnish renovation market. According to the long-term renovation strategy 2020-2050, the age, location and future use of the building have an impact on renovation actions. In some cases, demolition and building a larger and more-energy efficient building on the plot is a feasible solution. Staged deep renovation - where the renovation is realised for one building part at a time - provides an opportunity to improve the energy-efficiency and to introduce low-carbon energy sources.[10] Demolition and new construction as well as deep renovations may offer possibilities for utilising the demonstrated PEB concept.

Use phase

Relevant markets in the use phase of PEBs are the energy markets (heating, cooling and electricity).

Heating, cooling and electricity

Average heating energy consumption levels of multi-storey apartment buildings are lower in newer buildings. The average heating energy consumption level (heating of premises, ventilation/air-conditioning, water, electricity for heating systems) of buildings completed prior to 1960 is 190 kWh/m^2, while the average consumption level of buildings completed after 2010 is only 85 kWh/m^2. A total of 15.4 TWh of delivered energy (fossil fuels, district heating, electricity) and energy generated with heat pumps is used for the heating of multi-storey apartment buildings (district heating amounts to a total of 89%) (Figure 4)[10].

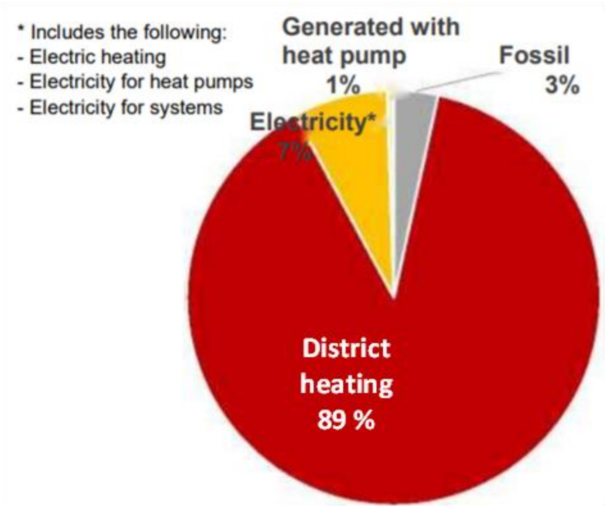

Figure 4. The shares of heating energy sources in Finnish blocks of flats in 2018 (15.4 TWh).[10]

The electricity markets have been open since the late 1990's. All electricity customers, such as households and housing companies, can buy their electricity from the electricity supplier of their choice. Households can buy their electricity directly also according to the price determined in the wholesale market or produce part of their own electricity with their own equipment[11].

The Finnish heating market is unregulated and competitive. Heating methods that are freely available for customers on the market include district heating, electric heating and various property-specific

[10] Long-term renovation strategy 2020-2050, Finland. https://ec.europa.eu/energy/sites/ener/files/documents/fi_2020_ltrs_en.pdf
[11] https://energia.fi/en/energy_sector_in_finland/energy_market/electricity_market

solutions based on heat pumps and renewable and fossil fuels. Cooling solutions include district cooling, heat pumps and electricity-based cooling equipment. Other key actors on the heating markets, in addition to customers, are district heating companies. Businesses that engage in the sale of electricity and participate in electricity network operations also play a significant role on the heating market. There are also many different service operators on the heating market, such as various equipment manufacturers and consultants offering their services to customers. The service business related to heating and cooling is a rapidly developing area where some of the energy companies are also active.[12]

An example demonstrating demand and supply of innovative solutions on the energy markets is an ongoing competition, the Helsinki Energy Challenge. A global one-million-Euro challenge competition – a sort of innovative public procurement process - seeks answers to the question: How can we decarbonise the heating of Helsinki, using as little biomass as possible?[13] It is possible that also concepts like PEBs may play a role in answering the question.

3.2 Spain

3.2.1 Demo description

The Spanish Demo (Figure 5) is a residential building which is planned to be built in 2021 (start of the construction phase is November 2021) within the first planned zero energy district in Spain (called "Solar City Nivalis") in the Dilar municipality (Granada) and a total (heated/cooled) floor area of 3,500 m^2.

The Spanish demo building is planned to be a three-storey building with 30 apartments (10 apartments per floor). In the top floor, 6 out of the 10 apartments will have an attic. The ground-floor will be a commercial space.

The aim is to develop a concept that integrates already proven technological solutions in order to be able to replicate the concept and transform conventional apartment buildings into PEBs.

This EXCESS PEB system concept for the Spanish Demo relies on maximizing the electricity production provided by PV panels integrated in the building's roof, minimizing the building thermal demand (space heating/cooling and DHW) with both, passive (highly efficient envelope) and active solutions (such as motorized blinds and heat recovery systems), and optimizing the sizing and operation of the thermal generation system.

The demo case includes several technological and system-level innovations that contribute to the PEB-concept:

- Geothermal heating/cooling and DHW system with high COP heat pumps
- Solar PV panels for electricity production and lithium batteries for storage
- High efficiency heat recovery in ventilation system
- Control of motorized blinds

[12] https://energia.fi/en/energy_sector_in_finland/energy_market/heating_markets
[13] https://energychallenge.hel.fi/

- Integrated controller for easing the integration and the management of the energy generated on site

Figure 5. The Spanish demo building in Dilar municipality (Granada). [Source: U·rb atelier]

3.2.2 Market architecture in relation to the demo

Development and planning

The development and planning phase of the new construction and renovation includes opportunities to apply concepts developed in the PEB demo case.

The largest construction companies involved in commercial property development in Spain include Acciona, Dragados (ACS), Ferrovial, OHL, FCC, Sacyr and Constructora San José. Most of these companies also develop residential properties and typically buy and hold a significant number of plots.

Construction companies have been active in housing development projects as well, which they sell to investors, most often property funds. This activity, however, seems now to be slowing down due to increased uncertainty and an increasing supply of rental residential properties. Construction companies typically have a separate arm that is specialised in commercial property development (including in the residential sector).

Redevelopment of existing properties is mostly handled by their owners, or by specialized companies who buy properties in order to redevelop them.

Construction and renovation

As described previously, there are currently several drivers having impact on the demand for residential properties including new multi-storey buildings in Spain.

According to the most recent outlook of the construction industry, the construction will remain at low levels for the next few years.

A high percentage (67.3 %) of people in Spain lives in multi-storey apartments building.[14] The percentage of multi-storey buildings in the Atlántico-Norte Area is smaller (59.1 %) than in the Continental (70%) or the Mediterranean Area (close to 70%).

A forecast for the construction of new buildings for 2021 is not available because of the uncertainty created by the COVID-19 issue.

The new housing construction is currently concentrated in the capital of the 52 provinces and mainly in main city regions (Madrid, Barcelona, Valencia, etc.).

The number of existing multi-storey buildings in Spain was 9,804,090 in 2011 with an increasing of 13.2% in the last 10 years. The multi-storey buildings constructed between 2002 and 2011 in Spain has been 1,538,425[15]. The construction permits[16] were 23,889 in 2019, 27,677 in 2018, 24,946 in 2017 and 22,105 in 2016.

Regarding renovation, the data of evolution on the number of buildings renovated allows affirming that the Renovation Sector has gone through a growth of 12.8% during years 2014, 2015 and 2016. The number of permits to renovate residential buildings was 22,413 in 2014 and 25,880 in 2016 (a growth of 15.5%)[17].

In 2020, about 300 million Euros will be used for the renovation of residential building in the Spanish renovation market within the PREE program (Royal Decree 737/2020). This program will pursue PAREER-CRECE and PAREER II programs carried out between October 2013 and December 2018 with a budget of 404 million Euros, where 80.000 dwellings were renovated in Spain.

The typologies of measures subsidized in this Program are:

- Energy efficiency improvement of thermal envelope
- Energy efficiency improvement in thermal/lighting facilities
- Replacement of fossil energy by solar thermal energy
- Replacement of fossil energy by geothermal energy

The energy consumption of existing buildings represents 30% of final energy use in Spain. Because of that, energy renovation is a priority measure to be taken as defined in the PNIEC (Energy and Climate National Integrated National Plan 2021-2030[18]).

According to the Spanish long-term renovation strategy defined in this plan, 1,200,000 dwellings will be energy-renovated by 2030.

In some cases, demolition and building of a larger and more-energy efficient building on the plot is a feasible solution. Deep renovation realised in stages provides an opportunity to improve the energy-

[14] Estudios IDAA 005: Estudio SPAHOUSEC II.2019
[15] Instituto Nacional de Estadística. 2011 (Nota de prensa. 12 de Diciembre de 2013)
[16] ttps://apps.fomento.gob.es/BoletinOnline/?nivel=2&orden=10000000
[17] Ministerio de Fomento. Serie Obras en Edificación (Visados Colegios de Aparejadores y Arquitectos Técnicos)
[18] https://www.idae.es/informacion-y-publicaciones/plan-nacional-integrado-de-energia-y-clima-pniec-2021-2030

efficiency and to use low-carbon energy sources. Demolition and new construction as well as deep renovations may offer possibilities for utilising demonstrated PEB concept.

Use

Relevant markets in the use phase for PEB(s) are the energy markets (heating, cooling and electricity).

The average heating energy consumption levels of multi-storey apartment buildings are much lower in newer buildings. This is mainly because there was not any regulation about insulation in buildings before 1979 and from 1979-2005 the regulation was less strict in energy efficiency terms than it is now.

The average consumption in a Spanish housing unit in a multi-storey building is 7,859 kWh/year (0.028 TJ)[19]. The 32.3% of this consumption is due to space heating, the 26.0% to DHW preparation and 27.4% to household appliances and 5.3% in artificial lighting.

Similarly to Finland, the electricity market is open in Spain since 1997[20]. Currently, all electricity customers, such as households and housing companies, can buy their electricity from the electricity supplier of their choice. Besides, households can currently buy their electricity directly according to the price determined in the wholesale market or produce parts of their own electricity with their own equipment.

The Spanish heating market is unregulated and competitive. Heating methods that are freely available for customers on the market include electric heating and solutions based on heat pumps or boilers provided by fossil fuels or renewable energy. On the other hand, cooling methods are mainly electricity-based heat pumps. In Spain, the development of district heating is only at a preliminary stage.

So, the heating and cooling market are provided by fossil fuels suppliers companies (mainly natural gas (Naturgy) and heating oil (such as Respol, Cepsa, etc.) and electricity companies (such as Iberdrola, Endesa, etc.). Therefore, the businesses that engage in the sale of electricity and take part in electricity network operations play a significant role on the heating market.

In Spain, there are very few operating district heating systems and there is no regulatory framework for this market.

Also, there are many kinds of service operators in the heating market, such as various equipment manufacturers and consultants offering their services to customers. The service business related to heating and cooling is a rapidly developing area where some of the energy companies are also active.

[19] Estudios IDAA 005: Estudio SPAHOUSEC II.2019
[20] Ley del Sector Eléctrico (Ley 54/1997)

3.3 Belgium

3.3.1 Demo description

The demo site in Hasselt (BE), completed in 2018 and built in three phases, consists of 68 apartments and 22 buildings for social housing. The demonstrator includes four apartment buildings with 20 dwellings. The dwellings are connected to a centralized heating system consisting of different thermal energy sources (geothermal heat pumps, gas-fired geothermal heat pumps and backup gas-fired boilers) and the thermal energy is distributed through a district heating network. Moreover, a wind turbine and a cogeneration unit (internal combustion engine) currently produce electricity to be consumed locally by the heat pumps.

Figure 6. The Belgian demo building in Hasselt. [Source: Cordium]

Within the framework of EXCESS, the buildings will be converted to Positive Energy Buildings by applying the following technologies:

- Additional ground-source heat pump
  - Increase the size of the BTES
  - Additional multi-source and modulating water/water heat pump
- Optimization of the existing heat generation system
  - Application of central thermal energy storage
  - Improved control functionality of the district heating system
  - Remove gas-fired boiler
- PVT panels
  - Renewable electricity production
  - Renewable heat production for the district heating system and recharging the BTES in summer
- Smart energy control system
  - Activation of thermal and electrical flexibility in the apartments (e.g. boiler and space heating)
  - Dynamic and lower supply temperature on the district heating system

3.3.2 Market architecture in relation to the demo

Over the last 10 years there is a significant increase in the number of building permits issued for apartment buildings compared to single family houses in Belgium, as can be derived from Figure 7. The number of building permits issued for renovation and new buildings is similar. According to the Flemish construction federation, the interest in apartments and apartment buildings will increase further because of two important drivers:

- Growing population
- Increasing number of single person households

As a result, apartment buildings are seen as an interesting investment and this reinforces the trend towards the growing number of apartments, even in smaller, more rural villages. Therefore, experts warn for a possible oversupply of apartments and a shortage on single family houses on the long term. This trend is only visible in Flanders, in Brussels the number of building permits for apartment buildings even decreased by 40% since 2010 and the situation remains stable in the Walloon area. Furthermore, recent changes in the taxation of real estate and measures on energy efficiency (EPB), which are divided regionally, also contribute to this effect.

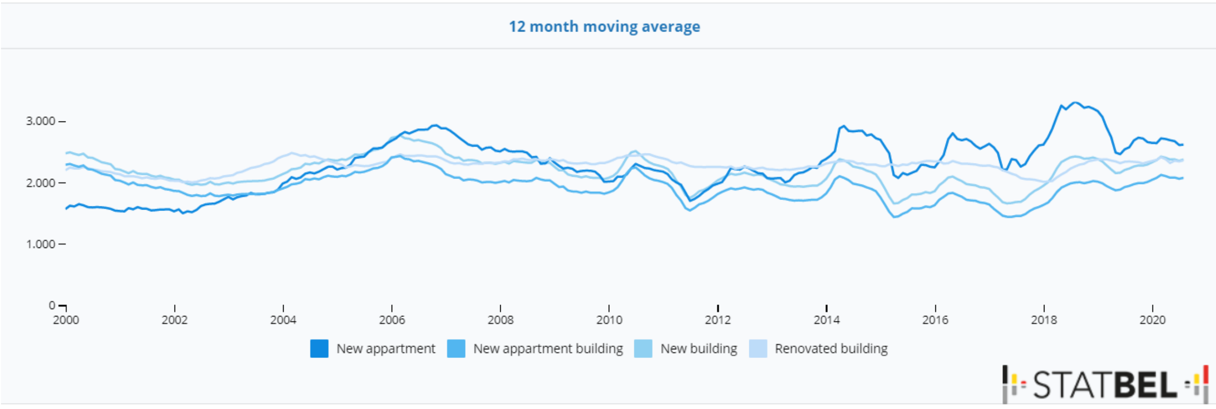

Figure 7. Number of building permits in Belgium over the last 20 years [21]

In the social housing sector in Flanders, there is also a growing need for affordable real estate. The number of people on the waiting list for a social dwelling increased dramatically over the last six years; from 120,000 in 2014 to 153,000 in 2019 (www.vmsw.be).

In order to increase the energy efficiency of existing and new-built social houses and to speed up the renovation process of older buildings, the Flemish Energy and Climate Plan 2021-2030 (www.omgeving.vlaanderen.be) defined different measures and targets, e.g.:

- As from 2021, new-built social houses should reach NZEB standards (E30). This also applies to the replacement of existing buildings.
- By 2050, all social houses should meet the EPC score of 100kWh/m², the standard is set to E60 for renovations which require a building permit.
- Changes in energy policy to increase renewable energy production at building level have been made. Since 2019, social housing companies can invest in PV panels on the roof of social

[21] https://statbel.fgov.be/en/themes/housing/building-permits#figures

houses. They recuperate the investment via the monthly rent and the tenants can benefit from the financial savings on the electricity invoice.

3.4 Austria

3.4.1 Demo description

The Austrian demonstrator project is part of a plan to reactivate a former industrial complex to act as a new and modern city quarter. In total 19 buildings exist on the area which were formerly used for feed production, as fodder silos, for packaging and logistics as well as for administration and maintenance. The final gross floor area of all buildings in the final development stage is 30,841 m².

Within the EXCESS Project, the focus is only on the refurbishment of the demonstrator building – a former feed silo. The declared goal for this building is to achieve positive energy building standard. To reach this goal, several energy efficiency measures must be integrated (highly efficient façade refurbishment with prefabricated façade elements including integrated building equipment). The building is a high-rise building with 10 floors and 40 m of height respectively (cf. Figure 8) It comprises around 1,161 m² of gross floor area and developed as a mixed usage building but mainly used as student hostel.

Figure 8: Demonstrator real building (left) and 3-D model (right)

A groundwater well is available on the property with an existing right for energy usage. Two groundwater heat pumps with a total capacity of 165 kW are already installed and support a currently existing gas burner (400 kW), which should be replaced in medium term by a completely renewable energy supply system. A small hydropower plant with a capacity of 140 kW_p will be installed in the eastward adjacent Mühlgang (bypass of the river Mur). Due to an existing water law, the hydroelectric power plant can be permanently operated with peak performance, except of maintenance work for one or two summer weeks.

Based on this energy concept for the heating and electricity supply, the number of groundwater heat pumps is further extended to replace the gas burner. Also, the on-site photovoltaic areas are increased. The second focus of the concept is to maximize the energy flexibility potential, which is available at the city quarter (thermal activation of the reinforced concrete with active façade elements, decentralized water storage, integration of flexibility potential on the side of tenants and users, provision of first electric cars and multifunctional integration of vehicle batteries into the electrical grid of the city quarter, stationary battery storage).

Table 3 summarizes the elements of energy supply system for the whole area.

Table 3: Elements of energy supply for the whole area

Electricity Supply
• Small hydropower plant with 140 kW_p and more than 8,300 operating hours per year • Electricity demands or surplus energy is balanced by the higher-level grid
Heat and Cold Supply
• 5 cascading groundwater heat pumps with a total heat output of 361 kW and a cooling capacity of 252 kW. • Controlled ventilation systems with heat recovery in buildings with passive house standard • Heat dissipation systems based on low-temperature systems (underfloor heating and wall heating via external component activation)
Energy flexibility elements, Storage and Smart Control
• Decentralized, storage tanks for efficient heat distribution and load matching potential for hot water preparation and space heating supply • 2,720 t thermally activated component mass as heat storage and heat delivery system • Intelligent business and tariff models for attracting tenants and energy consumers with regard to their gain of the flexibility potential of the city quarter • Integration of the e-mobility fleet as a flexibilization element, which concerns the charging times and capacities as well as the usage of the vehicle batteries in the energy concept of the city quarter • Installation of a battery storage with a capacity of 225 kWh. • Superordinate smart control algorithm • Interaction with the higher-level power grid to achieve flexibility potentials and to develop business models

3.4.1 Market architecture in relation to the demo

For a comprehensive building refurbishment in connection with prefabricated facades, large-volume buildings are more suitable from an economic point of view. Austrian multi-storey residential buildings differ significantly in terms of their architecture and thermal quality. A key aspect here is the construction period, which can basically be divided into five relevant epochs. Figure 9 shows the distribution of square meters of living space over these five eras. It can be clearly seen that most multi-story residential buildings were built in the periods "from 1981", "1961 to 1980" and "before ^ bn 1919".

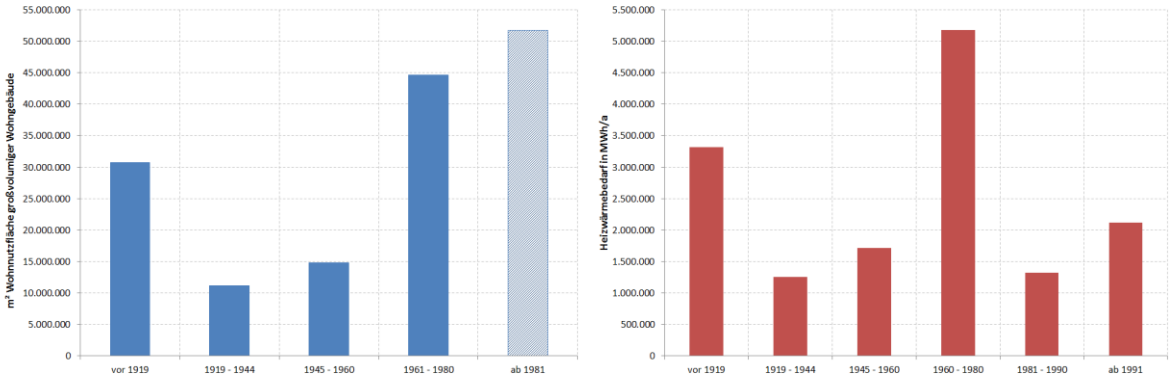

Figure 9 Comparison of the total square meters of living space in Austrian multi-storey residential buildings divided according to construction epochs (left); Total heat demand of multi-storey residential buildings in Austrian in MWh/a (right); (EPISCOPE, 2016) (TABULA, 2012) (KNOW-HOW-PLUS, 2012)

Based on an average specific heat demand of 140 kWh/m²a of the building epochs up to 1980 and a successively improved new building standard afterwards (TABULA, 2012); (KNOW-HOW-PLUS, 2012); (EPISCOPE, 2016), the total heat demand per epoch can be shown in Figure 9. It can be clearly seen that the epoch "1960 to 1980" has the highest absolute heating demand. Due to the lower age of the building epoch "from 1981", the need for a comprehensive thermal refurbishment for buildings in this category can be considered low. Due to the fact that the façade design is not very straightforward and the buildings are often historical monuments, buildings from the epoch "before 1919" are not well suited for thermal refurbishment using prefabricated curtain walls. Buildings from the period "1961 to 1980" have proven to be much more suitable in this respect (Figure 9).

Energy-related renovation is very often limited to individual measures such as the installation of thermal insulation composite systems, window replacement or a heating system conversion. Partial refurbishment steps are important, but only if a thermal-energetic overall refurbishment concept is available and the partial refurbishment step is in line with the overall refurbishment concept, as otherwise synergy effects of a combined and integrated implementation of construction and building services measures would be lost. In addition, this approach prevents the exploitation of further cost reduction potentials and the possibility of a considerable reduction of the (for the residents stressful) renovation time.

Organisational processes and technical system solution concepts are repeatedly redesigned by the planning and executing companies for similar refurbishment tasks. This is where there is considerable potential for optimisation and cost reduction. There is an excessive demand due to a multitude of possible variants, technologies and designs, whose different costs, consequences, interactions, etc. are connected with later challenges in operation. The implementation of high-quality thermal-energetic renovations requires that the generation, delivery and distribution systems also have to be adapted when the building envelope is renovated. Particularly in the case of the supply technologies solar thermal, photovoltaic, heat pump, etc., there is a high degree of technical complexity and uncertainty as to whether the systems will fit the energy-related building standard and whether the projected operating, maintenance and life cycle costs can actually be met.

The renovation cycles for buildings and their technical systems are generally very long, sometimes reaching well over 30 years. Current investment decisions therefore have a direct impact on the building stock and the energy policy goals in 2040. The basis for this is economic and reliable technical solutions that also take into account the diversity of the existing building stock. With the intelligent use of components that are available on the market but have not yet been widely introduced, it is already possible to build almost climate-neutral buildings today. Nevertheless, further efforts in research and development are necessary to improve the economic efficiency and implementation processes of innovative solutions, like it is done in the EXCESS project with the multifunctional façade element.

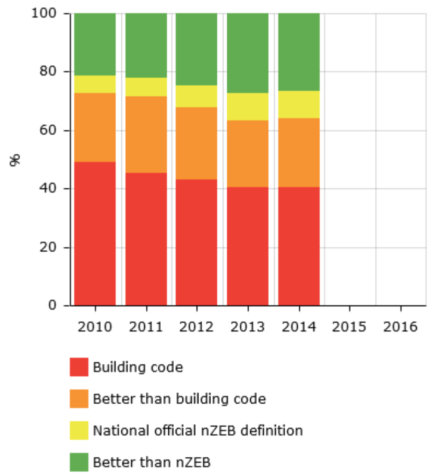

Figure 10: Distribution of new dwellings in 2014 according to the nZEB radar graph – Austria (EU IEE ZEBRA2020 Data Tool)

Starting from 2021, all new buildings must be nZEB. According to the EPBD, a "nearly zero-energy building" (nZEB) means a building that has a very high energy performance and the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. The project ZEBRA2020 carried out a picture of the new buildings in 2014. In Figure 10, the distribution of respectively new residential and non-residential buildings is displayed according to the performance target. The scale starts from red, which indicates the share of new buildings fulfilling where buildings with higher performance than nZEB definition are accounted.

3.5 Comparison of the market environment in the demo countries

The four demo projects in EXCESS are all in apartment buildings, two of them new constructions, one in a newly built existing building and one renovation project. All of the buildings include several energy efficiency measures, and different types of renewable sources are applied on the sites. The achievement of the PEB status is further improved by storage and control solutions, which improve the demand response and increase the self-consumption of the RES. The EXCESS demonstrations in new buildings can serve as examples of what is possible and give ideas also for renovation projects.

There are significant efforts to improve the energy efficiency of buildings in all demo countries - in accordance to the EU level targets - and this is visible in the energy performance requirements in the demo countries. It is noteworthy that many recent buildings have already reached the new, stricter energy efficiency targets (e.g. in Austria).

In all the demo countries, the share of apartment buildings is increasing, and the construction is concentrated in cities. In many countries there are subsidies available for renovation, as an effort to increase the renovation rate.

One of the main differences in the market situation in the demo countries is the big share of district heating in Finnish apartment buildings. This sets different kinds of challenges in developing PEB concepts and operating them in connection with DH networks. However, it is also the target for the DH companies to move towards CO_2 neutrality, and they are generally quite open to allow RES introduction to their networks. In other demo cases, the renewable heat production contributes to resilience of the sites.

In Finland, one relevant aspect to mention is the service business related to heating and cooling, which is a rapidly developing area where some of the energy companies are also active. This gives e.g. the district heating companies possibilities to extend their services to areas outside their existing infrastructure, without the need for further investments in DH networks.

4 Analysis of the demo locations regulatory framework

This chapter presents the regulatory framework at the demo locations, concentrating on those aspects that are likely to prevent or encourage the introduction of PEBs and local renewable energy businesses. In each country the focus in on the regulations that are relevant to the demo case in that country.

4.1 Finland

Possibly preventing or encouraging regulatory framework related to the demo case is discussed for the following stages in the life cycle: development and planning, construction, use and renovation. As the aim is that the concept is applicable to conventional apartment buildings after the demonstration, also planning related to renovations and renovation stage can be relevant.

Development and planning

The Land Use and Building Act and Decree provide legal framework for the development and planning phase of the building (and its surroundings). They include provisions on e.g. the following:

- Town planning
- Municipal building ordinances
- Plot division
- General requirements on building (e.g. energy-efficiency and renewable energy sources)
- Building permits and other supervision by authorities
- Action permits (e.g. for boreholes for geothermal heating and solar panels)

The reform of the Land Use and Building Act is underway with the target to complete it by the end of 2021[22].

[22] https://ym.fi/en/land-use-and-building-act

Further provisions and guidelines concerning buildings are issued in the National Building Code of Finland. The regulations in the Building Code have applied to new buildings only. In the case of renovation or alterations, the regulations have been applicable only when required depending e.g. on the type and extent of the measure or use of the building. As the Building Code is being revised, each of the new decrees will specify whether it is applicable to a new building or renovation or alteration of a building[23].

The Decree of the Ministry of Environment on Energy Performance of New Buildings (1010/2017) includes minimum requirements for energy efficiency. Compliance with these requirements must be demonstrated by calculations based on energy use, energy loss and the form of energy used[24].

At local level, energy efficiency norms can be more ambitious. The City Strategy of Helsinki states that: "The energy efficiency of buildings will be improved both in the construction of new and the renovation of old buildings. Helsinki's energy efficiency norms are more ambitious than the national minimum level. Helsinki strives to combine renewable energy sources with energy efficiency in an optimal way, both in individual buildings and in areas"[25].

In Helsinki, the City of Helsinki Building Order is applied in addition to regulations at national level. Other cities and municipalities may also have their own building orders. In Helsinki, a building permit application can be submitted by the builder once the necessary plans, reports and supplements are compiled and reviewed together with the permitting officer (in case of a major project). Building permit (or permits e.g. for major alterations to building technology) are decided at local level e.g. in Helsinki by the City of Helsinki Construction Committee or an officer at the Building Control Services[26].

Several parts of the national regulatory framework (more details in discussion regarding the use phase) also have an impact on the profitability of renewable energy investments thus affecting the energy-related choices in the development and planning phase.

Construction and Renovation

The initiator of a construction or renovation project is responsible for the execution and quality of the entire project as well as for the everyday supervision of the project in accordance with the building regulations and the permit granted for the project.

The main task of City of Helsinki's Building Control is to supervise that the responsible party fulfils its duties. In practice, this means that the Building Control approves the supervisors in charge, checks the qualifications of designers and runs inspections on the construction sites. Construction sites are inspected randomly and monitored to check the compliance of the projects with regulations and with the terms of permits. The building is approved for use in the final inspection[27].

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[23] https://ym.fi/en/the-national-building-code-of-finland
[24] https://ym.fi/en/the-national-building-code-of-finland (Energy efficiency of buildings)
[25]https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/HNH-2035/Carbon_neutral_Helsinki_Action_Plan_1503019_EN.pdf
[26] https://www.hel.fi/helsinki/en/housing/construction/info-builders/instructions-forms/
[27] https://www.hel.fi/helsinki/en/housing/construction/construction-stage/

Use phase

Energy use of the building and the tenants living in it as well as surplus production of energy from renewable resources related to PEB concept has several linkages to existing national legislation and ongoing national implementation of recent pieces of regulatory framework at EU level. According to Finland's Integrated Climate and Energy Plan, decentralised electricity and heat production based on renewable energy will be promoted - mainly on market terms and through economic incentives through the electricity markets and taxation. The interest of citizens, companies and the public sector in utilising renewable sources in the energy solutions of individual buildings will be encouraged through guidance with information and local reference sites. It is also expected that a planned Datahub will facilitate the development of services that are related to small-scale electricity production, the creation of energy communities etc[28].

Small-scale electricity production has already been promoted since 2015 through a legislative change related to taxation. Electricity production plants with a nominal output below 100 kVA and plants larger than that but with an annual production of at most 800,000 kWh were exempted from the obligation to pay electricity tax. These producers may use the electricity they have generated themselves at the site tax-free. If the electricity produced is distributed through the electricity network, the system operator distributing the electricity for consumption will collect the electricity tax on it.

There are however several pieces of legislation (e.g. related to electricity markets, VAT, energy taxation, housing companies, measuring instruments) that have created barriers for solar PV investments in residential apartment buildings. It is possible that some barriers will be removed as the national implementation of the EU level regulatory framework is taken forward.

Ongoing work by the working group on energy sector integration, led by the Ministry of Employment and Economy, aims at identifying potential and barriers (including regulatory) related to integration of various energy systems. This work as well as the regulatory developments at the EU level may have an impact on the regulatory framework for PEBs on the longer term.

4.2 Spain

Possibly preventing or encouraging regulatory framework related to the demo case is discussed for the following stages in the life cycle: development and planning construction, use and renovation.

As the aim is that the concept can be applied after the demonstration as well to conventional apartment buildings, planning related to renovations and renovation stage can be relevant.

Development and planning

The Land Use and Urban Regeneration Royal Decree[29] provides legal framework for development and planning phase of the building (and its surroundings).

[28] https://ec.europa.eu/energy/sites/ener/files/documents/fi_final_necp_main_en.pdf
[29] Real Decreto Legislativo 7/2015, de 30 de octubre, por el que se aprueba el texto refundido de la Ley de Suelo y Rehabilitación Urbana (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2015-11723)

The rules concerning the building are collected in the National Building Code of Spain. The last version of the Building Code was revised end of 2019[30]. Specifically, the document called HE ("Saving Energy") sets the minimum requirements related to energy efficiency in buildings. This document is divided into 6 Sections:

- Section 1 (HE-0): Maximum Energy Consumption
- Section 2 (HE-1): Conditions for Control of Energy Demand
- Section 3 (HE-2): Conditions for Thermal Facilities
- Section 4 (HE-3): Conditions for Artificial Lighting
- Section 5 (HE-4): Minimum Contribution of Renewable Energy for DHW demand
- Section 6 (HE-5): Minimum Generation of Electrical Generation

The regulations in the Building Code are mainly applied to new buildings and renovations. Every Section specifies if it is applicable in either a new building, for renovation or both.

At regional and local level energy efficiency norms can be more ambitious.

Also, several pieces of national regulatory framework (more details can be found in the discussion regarding the use phase) have an impact on the profitability of renewable energy investments thus affecting the energy-related choices in the development and planning phase.

Construction and renovation

The site manager of a construction or renovation project is responsible for the execution and quality of the entire project, as well as for the supervision of the project, in accordance with building regulations and the permit granted for the project.

On the other hand, the City where building is going to be constructed approves a supervisor in charge (municipal architect(s)). The municipal architect ensures that the requirements are fulfilled.

Construction sites are inspected randomly and monitored for the compliance of projects with regulations and with the terms of permits. The building is approved for use in the final inspection.

Additionally, in Spain, Regional Government (namely the Industry General Direction) is in charge of the supervision of fulfilment of regulations in some facilities.

Use phase

Energy use of the building and the tenants living in it, as well as surplus production of energy from renewable resources related to the PEB concept, has several linkages to existing national legislation.

The Spanish legislation currently facilitates and promotes the use of renewable energies by citizens, both individually and collectively. Specifically, the Royal Decree 244/2019[31], which regulates the administrative, technical and economic conditions for the self-consumption of electrical energy, introduces new schemes that are unprecedented in Spain, such as collective self-consumption, local self-consumption and simplified compensation for surpluses in self-consumption facilities.

[30] Real Decreto 732/2019, de 20 de Diciembre (https://www.codigotecnico.org/)

[31] Real Decreto 244/2019 por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2019-5089).

It is expected that these new schemes will facilitate the development of projects and initiatives for the installation of renewable energies in buildings, and as a result, PEB building developments.

On the other hand, small-scale renewable-based electricity production (< 50 MW) was already promoted in 1998[32],[33] through legislative change related to price of sale for producers based on renewable energy. Indeed, these producers could sell the electricity they have generated with a premium in the fee. However, it raised a problem for electricity production owners when the 2008 Economic Crisis in Spain occurred. The Spanish Government decided to remove the premium afterwards[34]. This introduced a great barrier to new investments in renewables source-based plants.

There are several regulations (e.g. related to electricity markets, VAT, energy taxation, and measuring instruments) that have created barriers for solar PV investments in residential apartment buildings.

Many barriers have been removed as the national implementation of EU level regulatory framework is taken forward. The regulatory developments at the EU level may have an impact on the regulatory framework for PEBs on the longer term.

4.3 Belgium

European directives such as those on energy efficiency, energy from renewable sources, energy performance of buildings and Ecodesign/Ecolabeling - some of these currently in recast versions or amended to newer directives - have been translated into national rules in the member states to accelerate the transition to a more sustainable energy use in buildings. This is further expanded by the "Clean energy for all Europeans package" and the EU Green Deal, including the European renovation wave.

In Flanders - one of the three regions of Belgium - this has led to the following specific legislative frameworks, related to the energy performance of buildings and indoor climate and the implementation of energy from renewable sources in buildings:

- energy performance of buildings
    - new or renovated buildings
        - residential buildings
            - EPB "Energy Performance of Buildings and Indoor Climate" (administratively coupled to the building planning permission) including "EPC construction" (into force since January 2006);
            - Ventilation preliminary design and performance report (for renovation only if it concerns a major energetic renovation) (into force since January 2016);
        - non-residential buildings ("EPU" school and offices: into force since January 2006; "EPN": most of the other non-residential functions: into force since January 2017)
            - EPB "Energy Performance of Buildings and Indoor Climate" (administratively coupled to the building planning permission) including "EPC construction";

[32] Real Decreto 2818/1998 Producción de energía eléctrica por instalaciones abastecidas por recursos o fuentes de energía renovables, residuos y cogeneración (https://www.boe.es/buscar/doc.php?id=BOE-A-1998-30041).
[33] Real Decreto 661/2007, de 25 de Mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial (https://www.boe.es/buscar/act.php?id=BOE-A-2007-10556)
[34] Real Decreto Ley 2/2013, de 1 de febrero, de medidas urgentes en el sistema eléctrico y en el sector financiero (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-1117).

- existing buildings
  - residential buildings (rent or sale): EPC "Energy Performance Certification Residential" (into force since November 2008 (sale); into force since January 2009 (rent))
  - small non-residential buildings (rent or sale): EPC-kNR (into force since January 2020)
  - common parts of apartment buildings: EPC-GD (into force since January 2022)
  - public buildings: "Energy Performance Certification of public buildings" (into force since January 2009)
  - large non-residential buildings: EPC-NR (in development)
- minimal requirements on technical installations for HVAC
- mandatory frequent maintenance and control of fossil fuel combustion boilers for heating (the nature and the frequency depend on the boiler specifications);
- mandatory frequent maintenance and control of heat pumps, cooling and air-conditioning devices (the nature and the frequency depend on the type of technology and the specifications);
- training and certification schemes for (candidate) professionals active in the execution of parts of the above-mentioned requirements and control mechanisms to minimize faults and fraud.

For the new or renovated buildings, the energy performance assessment is coupled with requirements concerning the energy performance level of the building unit, thermal insulation of the building envelope, indoor climate, net energy demand for space heating, share of energy from renewable sources. The specific requirements depend on the nature of the works, the building category (residential or non-residential) and the date of submission for appliance of the building planning permit.

Indication of the CO_2-emissions are only included for informative purposes. Similarly, the EPC for existing buildings is mandatory for specific building categories but merely informative.

The energy performance of buildings evaluation methods of the newly constructed or renovated residential buildings and of existing residential and small non-residential buildings already incorporate the concept of a positive energy building in the sense that the energy performance indicator becomes negative in the case the net primary energy use is lower than zero. In line with the PEB definition, the net primary energy use in this evaluation method represents the energy use on site minus the energy produced on-site and exported, expressed on the primary energy level and balanced of a 1 year period. Only in the case of this negative energy performance indicator value, the building is certified with an A+ label. It also pays some attention to the indoor environmental quality, although only indirectly through ventilation requirements and assuming standard indoor temperature in the calculations.

Also, for newly constructed or buildings undergoing major renovation (linked to building planning permission) the share of renewable energy is included in the performance indicator set and the specific annual renewable energy produced and/or used on-site is reported. The energy originating from heat pump, solar thermal system, PV on-site, biomass and/or external thermal energy delivery are considered as energy from renewable sources in the calculation of the share of renewable energy. For some of those, additional requirements apply for the actual ways of accounting them in the calculation.

Only on-site PV is considered. The PV collectors may also be collectively used and may also be positioned outside of the building as long as they are located on the same site or on an adjacent site of the same owner and connected to the electricity grid of the building.

For existing buildings some technologies delivering energy from renewable sources are taken into account as a reduction on the demand and are not reported.

These overlaps in the aspects of PEB that are currently already covered in the Flemish EPBD regulations are beneficial to the deployment of the PEB concept in Flanders, given the additional efforts and changes required to the existing legislative framework are minimal.

The aspects currently not covered in the Flemish EPBD regulations may pose barriers and at least require changes in the legislative framework. Differences to the PEB definition as established in the frame of the EXCESS project consist of

- External thermal energy delivered (not from on-site) is included in EPBD in Flanders potentially as energy from renewable sources while it is not included according to the PEB definition (only on-site).
- Other aspects related to the boundary conditions of the energy balance used to calculate the energy performance.
  - EV, plug loads, public lighting and elevators are not included in energy performance determination and evaluation methods. Furthermore, but only for residential buildings lighting is not included in energy performance evaluation methods in Flanders. Most of these choices are in line with the default (exemplary) choices published in the overarching EPBD standard EN 52000-1: 2017.
- Energy flexibility or impact on the grid is not assessed.
- Demand-response to increase self-consumption is not included.
- The effect of storage solutions is only limited accounted for (only specific thermal storage implementations).
- Visual and acoustic environment are not considered.
- Thermal comfort and indoor air quality aspects are only addressed indirectly (assumption of a standard indoor temperature, ventilation requirements and overheating risk assessment).
- Life cycle effects are not considered.

In succession of the Flemish Energy and Climate Plan 2013-2020, the Flemish government approved the Flemish Energy and Climate plan 2021-2030 in preparation for the integrated National Energy and Climate Plan that each EU member state was mandated to submit to the European Commission by the end of 2019.[35]

On May 29th 2020, the Flemish government approved the long-term strategy for renovation of buildings 2050[36]. This strategy is a further elaboration of the Flemish Climate strategy 2050 (mandated by the EC to be submitted no later than January 1st, 2020)[37]. This strategy aims at improving the average energy performance indicator value of residential buildings with 75% of the value of 100kWh$_{prim}$/year. There is no target set related to the contribution of energy from renewable sources. For non-residential buildings a renovation obligation after sale is envisioned but no specific information is yet available on the targets or the means to achieve these.

[35] Vlaams Energie- en Klimaatplan 2021-2030 - Departement Omgeving (vlaanderen.be)
[36] Vlaamse langetermijnrenovatiestrategie gebouwen 2050.pdf (energiesparen.be)
[37] Vlaamse Klimaatstrategie 2050 - Departement Omgeving (vlaanderen.be)

All of these aspects are aimed to contribute to the objectives of increasing energy efficiency and the share of the energy from renewable energy sources and of reducing greenhouse gas emissions.

Recently, the European Commission launched the Smart Readiness Indicator (SRI), a methodology to assess how "smart" the buildings are and to what extent they are ready to interact with their users and their connected energy grids. The European Commission has officially approved the implementation of the SRI within Europe as an additional scheme optional for member states to adopt in their regional regulations. It is not yet clear what the position of Flanders is in whether or not to adopt this instrument in the regional regulations. SRI will assess the smartness of the building on three aspects:

- Interaction with occupants,
- Interactions with energy grids,
- Efficiency of operation.

The SRI scheme shows clear overlaps with PEB definition as in PEB definition it is stated that:

- high self-consumption rate and high energy flexibility is aimed at (by technologies such as demand-response and storage solutions and user engagement),
- high indoor environmental quality is essential, maintaining comfort and well-being of occupants,
- integration of future technologies like electric vehicles is enabled

and it will incorporate general aspects related to smartness in the performance indicator set such as energy efficiency, RES integration, security of supply, ICT solutions performance, system interoperability, data security and privacy, etc.

Given this broad overlap, the adoption of the SRI scheme in Flanders would facilitate the deployment of the PEB concept in Flanders.

4.4 Austria

Energy policy objectives and challenges

Climate change is one of the greatest ecological, economic and social challenges of our generation. The goal of the Austrian Federal Government is to achieve Austria's climate neutrality by 2040 at the latest. An important interim goal is to reduce greenhouse gas emissions by 3 million tonnes of CO_2-eq by 2030[38]. All sectors contribute to the complete decarbonisation of the energy system, with the building sector playing a central role. After all, about 27% of Austria's final energy consumption is used for the provision of space heating, hot water and cooling in buildings.

In line with integrated contexts, the government's COVID-19 economic stimulus package anchored important investments in climate protection and a climate-friendly economy as supporting pillars. For the coming years 2021 and 2022, one billion Euros allocated for climate protection (for both years) is to supplement the previously budgeted priorities. The significant increase in funding to 750 million Euros in the areas of thermal renovation, boiler replacement and the decarbonization of local and

[38] #mission2030 (2018): The Austrian Climate and Energy Strategy (Vienna: BMNT, BMVIT)

district heating should provide a major boost. In order to achieve this, a thermal building renovation offensive is planned for the next few years in Austria[39].

In the building sector, economically and environmentally motivated initiatives were taken around ten years ago to stimulate comprehensive thermal refurbishment, with an average refurbishment rate - in the sense of comprehensive refurbishment in relation to the total stock of housing units - of 1.8%. Since then, refurbishments have been steadily declining, reaching a rate of only 0.5% in 2018[40]. An estimate of the need for refurbishment shows that almost 40% of the Austrian housing stock, i.e. about 1.9 million units, have an insufficient thermal standard. These figures impressively show the enormous potential of the building sector in terms of climate protection, economic recovery and regional value creation. However, looking at the concrete activities to tap this potential, the annual refurbishment rate of 0.5% in 2018 is clearly lagging behind (in terms of comprehensive refurbishment in relation to the total housing stock). This is because in order to achieve a complete thermal-energetic upgrading of the housing stock with combined construction and building services measures by 2040, the renovation rate must be increased to 2.6% in the short term and to 3.2% from 2025.[41]

Regulatory policy

The Austrian Institute of construction engineering carried out the “National Plan”. This contains minimum energy performance requirements for buildings by EPBD. In 2019, the new OIB Guideline 6 (OIB-RL 6) “Energy saving and heat protection” was published, where the definition of lowest energy buildings and the regulation of energy savings for both residential and non-residential buildings are contained. This guideline deals with heating and cooling demand and final energy demand related to space heating and DHW of new buildings or those, which are under a deep renovation process.

Energy performance and envelope features

The document “National Plan” includes minimum standards for four energy indicators: space heating demand, primary energy demand, CO_2 emissions and total energy efficiency factors. The provided requirements were tightened stepwise towards 2020 and defined from 2012 onwards. Furthermore, the guideline provides as a second, additional requirement on U-values for all buildings, which need an energy performance certificate (Table 5). The requirements are related to the Austrian reference climate.

Specific limits of energy demand are set. Thus, the building envelope should ensure minimum performance levels (calculated without the heat recovery of the mechanical ventilation system). The overall performance of the building is evaluated regarding the requirements shown in Table 4, and the contribution of energy from renewable sources is partly included in the energy balance.

[39] https://infothek.bmk.gv.at/zwei-klimaschutzmilliarden-fuer-oesterreich/

[40] IIBW (2020): Definition and measurement of the thermal-energetic renovation rate in Austria (Vienna: IIBW, Federal Environment Agency, on behalf of the associations FBI, GDI 2050, WKO, ZIB)

[41] IIBW (2020): Impact Assessment of measures for decarbonisation of the housing sector (Vienna: IIBW, on behalf of the Ministry of Sustainability).

Table 4: Requirements for residential and non-residential buildings, as well as for new and existing buildings

REQUIREMENTS FROM 2021	HEATING DEMAND	PE_{MAX} [KWH/(M²A)]
New residential buildings	$10*(1+3.0/l_c)$ [kWh/(m²a)]	41
New non-residential buildings	$10*(1+3.0/l_c)$ [kWh/(m³a)]	84
Existing residential buildings	$17*(1+2.9/l_c)$ [kWh/(m²a)]	44
Existing non-residential buildings	$17*(1+2.9/l_c)$ [kWh/(m³a)]	87

Table 5: Additional requirements on U-values.

U-VALUES [W/(M²K)]	
Wall	0.35
Roof	0.20
Floor	0.40
Window	1.4

Renewable energy sources

The OIB guideline 6 includes requirements for renewable energy share, for both new construction and major renovation of a building. Requirements are fulfilled in at least one of the following cases:

a) The non-renewable primary energy demand excluding household electricity demand or operating electricity demand fulfils, in case of a new building or in case of a major renovation, the corresponding requirement of the National Plan for the lowest energy building (nZEB) from 1.1.2021.
b) Use of renewable sources outside the system boundaries "building": 80% of the required heat demand for space heating and hot water must be covered by one the following renewable energy sources: biomass, heat pump, district heating from renewable energy, district heating from high-efficiency cogeneration and waste heat.
c) Use of renewable sources by generation on-site or nearby:
    - 20% of the final energy demand for DHW by solar thermal.
    - 20% of the final energy demand for household electricity by photovoltaics.
    - 20% of the final energy demand for space heating by heat recovery.

Equivalent to the three above mentioned options, the requirements for renewable energy share are fulfilled in case the reduction of the maximum permissible final energy demand or the maximum permissible total energy efficiency factor (fGEE) by at least 5% is reached by any combination of measures of solar thermal energy, photovoltaics, heat recovery or efficiency increase.

"Erneuerbare-Ausbau-Gesetz" (Renewable Expansion Act)

The Austrian government has set itself an ambitious goal in its government program: 100 percent of electricity is to be generated from renewable energies by 2030. This is an important step for the energy turnaround and on the way to climate neutrality. This requires a good legal framework: this will be created by the "Erneuerbare-Ausbau-Gesetz" (EAG, Renewable Expansion Act), which is currently under review and should be implemented in 2021. The EAG is the most important law in the energy sector for decades and creates new participation opportunities for citizens and companies. It will trigger up to 30 billion Euros in investments in Austria and at the same time save around 10 million tons of CO_2.

The plan is to increase electricity generation from renewable energy sources by 27 terawatt hours by 2030 11 terawatt hours of solar energy, 10 terawatt hours of wind power, 5 terawatt hours of hydroelectric power and 1 terawatt hour of biomass will be generated from all renewable energy sources (see Figure 11).

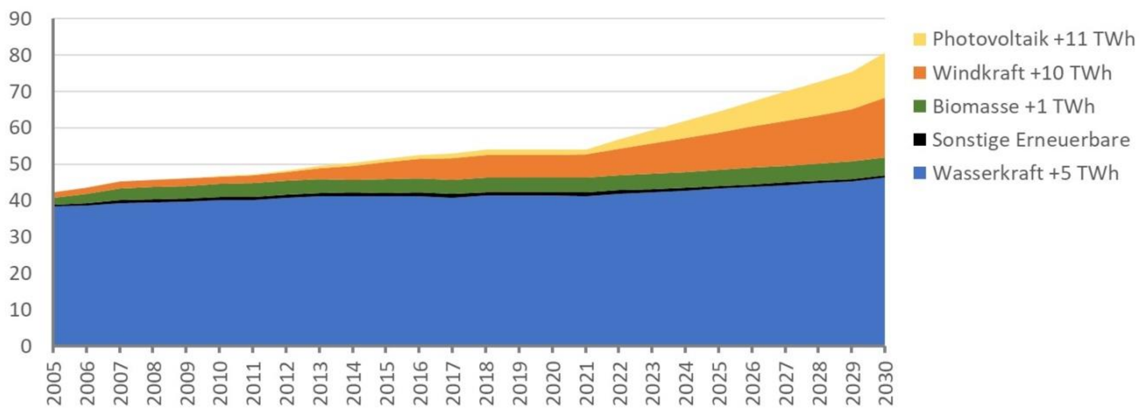

Figure 11: Renewable energy production 2005 - 2030, Federal Ministry Republic of Austria - Climate Action, Environment, Energy, Mobility, Innovation and Technology

Furthermore, the EAG provides the legal basis for Renewable energy communities and Citizens' energy communities, which enable people and companies to generate and consume electricity together. For intra-community exchanges, a reduced grid usage fee ("local tariff"), the exemption of various electricity taxes will be granted. Citizens' energy communities allow people from Bregenz to Vienna to buy photovoltaic systems together and use the electricity themselves.

4.5 Conclusions on the regulatory environment

As stated in D1.1[42], "EXCESS defines a positive energy building (PEB) as an energy efficient building that produces more energy than it uses via renewable sources, with a high self-consumption rate and high energy flexibility, over a time span of one year. A high-quality indoor environment is an essential

[42] Ala-Juusela, Mia (ed.). 2020. EXCESS Deliverable 1.1: PEB as enabler for consumer centred clean energy transition: shared definition and concept

element in the PEB, maintaining the comfort and well-being of the building occupants. The PEB is also able to integrate future technologies like electric vehicles with the motivation to maximize the onsite consumption and also share the surplus renewable energy."

In line with the EU-targets for climate change mitigation and CO_2 emission reductions, all four demo countries have set ambitious targets for energy performance of buildings as well as an increase of the share of renewable energy in the energy mix. Austria is even targeting for 100 % renewable electricity by 2030. These targets will work for the wider roll-out of PEBs. In most countries, the performance of buildings also includes aspects related to the indoor environment, which is included in the core definition of PEB in EXCESS.

In some countries (e.g. Austria) an important part of the COVID-19 economic stimulus funding is allocated to climate protection and a climate-friendly economy, including actions that are highly relevant for PEBs.

Especially the regulations and framework regarding the right to sell renewable energy is at various stages in the different countries, and developing constantly, making it difficult to estimate the costs and energy flows in the design phase.

5 Conclusions and recommendations

In this chapter, summaries of the barriers and opportunities, as well as the market and regulatory environments are presented first. Then, recommendations based on these are given, followed by some points of attention for subsequent work in the EXCESS project.

5.1 Summary of the barriers and opportunities

During the stakeholder interviews as well as internal and external workshops, it turned out that some of the issues that are seen as barriers in some countries can be opportunities in other countries or even such inside one country. Regarding the barriers and opportunities, the interviews, external and internal workshops seem to be well aligned, and support the findings from the case studies on existing PEBs.

Technology related aspects

A common conclusion is that one of the important opportunities for PEBs is provided by the large selection of existing technical solutions on high TRL. On the other hand, the technical complexity of the PEB solutions leads to several barriers (need of education of the professionals & interdisciplinary teams), but also opportunities (lots of room on the market). There is a lack of integrators, which creates an important barrier. The services of such integrators should cover the whole chain from consulting and planning to complete implementation. The integrated design will on the other hand improve the operation of the building and its systems, as it is planned with a holistic approach since the beginning.

Another point that became evident in this research is that the appropriate technical solutions for the PEB depend highly on the location and climate.

There is still a need for developing tools for the coordinated control and optimization of the energy system. The emergence of smart energy management tools combined with user friendly applications provide a technical but also social opportunity, giving the possibility to better balance the renewable supply with the energy demand, but giving also the residents more control on their own energy use, and could be combined with increased awareness at its best.

Regulatory aspects

One of the common conclusions from all sources of information is that regulatory barriers seem to be mostly related to energy and energy markets, rather than other fields. Most importantly these are related to the possibilities to balance the energy demand and supply, e.g. selling the excess energy to neighbouring buildings or grids. Local Energy Communities were raised as a regulatory opportunity for PEBs, even though at the moment there are also barriers as the regulatory framework is still under development. Regulatory barriers include the immaturity of regulations as well as the fragmentation of energy regulations regarding different fields and governance levels.

It was also pointed out that the regulatory changes made due to climate change will work for PEBs, as for example the movement towards stricter energy efficiency targets on national level. Some regulatory incentives already exist, and more were suggested by the interviewees.

Social aspects

A common finding from the interviews, workshops and case studies was that public awareness was seen as a barrier in many countries (lack of public awareness), while it was seen as an opportunity in some countries (good awareness). Several means to increase the awareness were suggested in the interviews. Also, the awareness of the market actors needs to be improved. The challenge is the different level of needs for information and support. More information is needed on the concept of PEB, but also on the advantages and benefits of PEBs (e.g. long-term economic return on investment) and the quantification of the value-added of PEB to end-user.

It was mentioned as an opportunity from social point of view that PEBs could be used to improve the residents' feeling of control, and the local energy production and demand response could add the community spirit. Local energy communities were suggested as enablers for new ways of cooperation in the neighbourhood. Support from municipalities is seen as a good potential and important for PEBs.

Often the goal in PEBs is broader than achieving a status as PEB, instead more holistic sustainable design goals have been pursued, probably presenting another social opportunity for the wider roll-out of PEBs.

Financial aspects

It became evident from the research that, as PEB is still a relatively new concept, the cost-benefit can't yet be clearly shown from existing examples. Current implementations of PEBs are mostly embedded in demonstration projects. Also, the wide range of design options result in significant variation of the costs. On the other hand, the lack of PEBs was seen also as opportunity (lots of room on the market for different solutions).

Incentives in the form of tax benefits are also seen as an advantage, but there were also views that incentives are not needed or not very efficient. In the case studies, some of the buildings used significant amounts of external financial support, while some didn't need any.

Costs or cost-benefit analysis were also mentioned as important issues in creating awareness and demand for PEBs. A holistic analysis would take into account not only the planning, manufacturing and construction costs, but also the lifetime costs. In most existing cases, the life-cycle analysis is not realised, due to the complexity and a lack of relevant information. This connects the barrier to the social and technical barriers related to awareness raising and lack of integrators.

5.2 Summary of the market and regulatory environment in the demo countries

In Figure 12 to Figure 15, an overview of the main points regarding the market and regulatory environment for the four demo countries is presented, country by country. In this chapter, the conclusions of the effect of these environments on the potential for a wider roll-out of PEBs are presented.

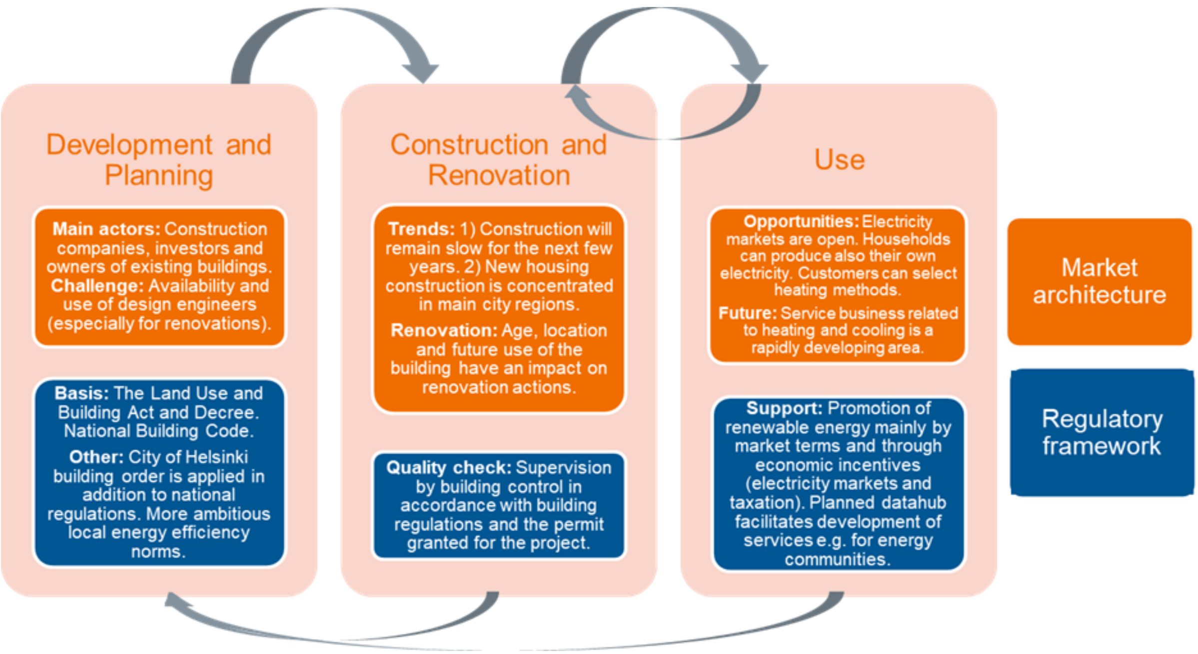

Figure 12. Presentation of the main points regarding the market and regulatory environment for the Finnish demo.

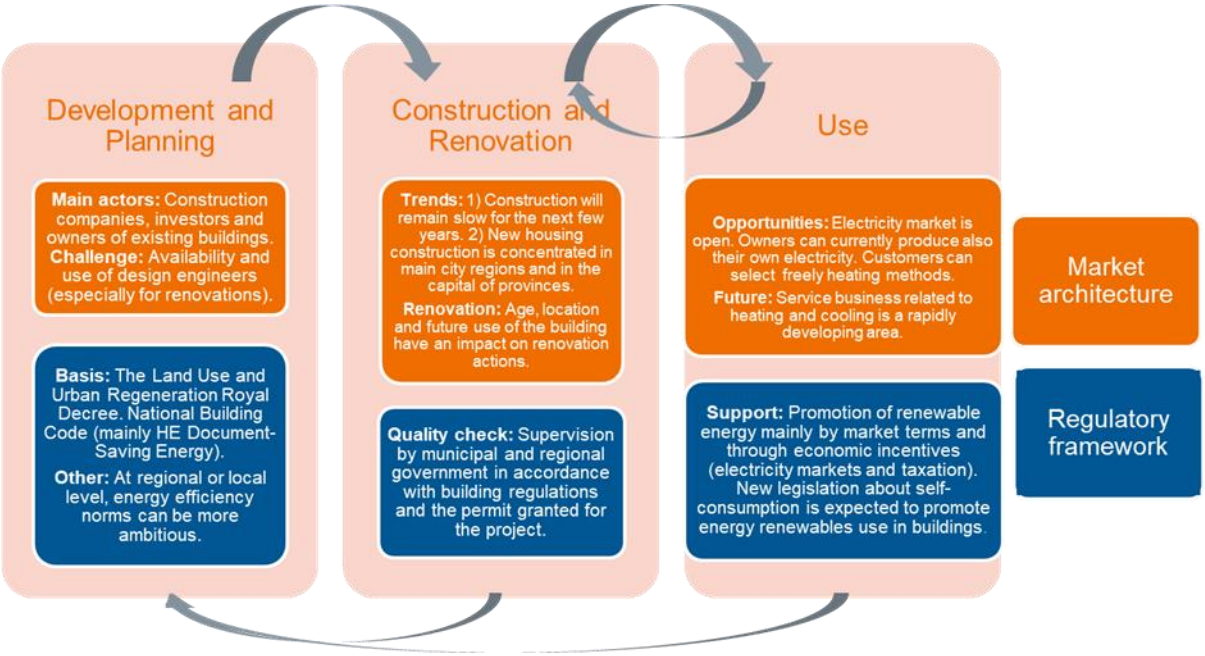

Figure 13. Presentation of the main points regarding the market and regulatory environment for the Spanish demo.

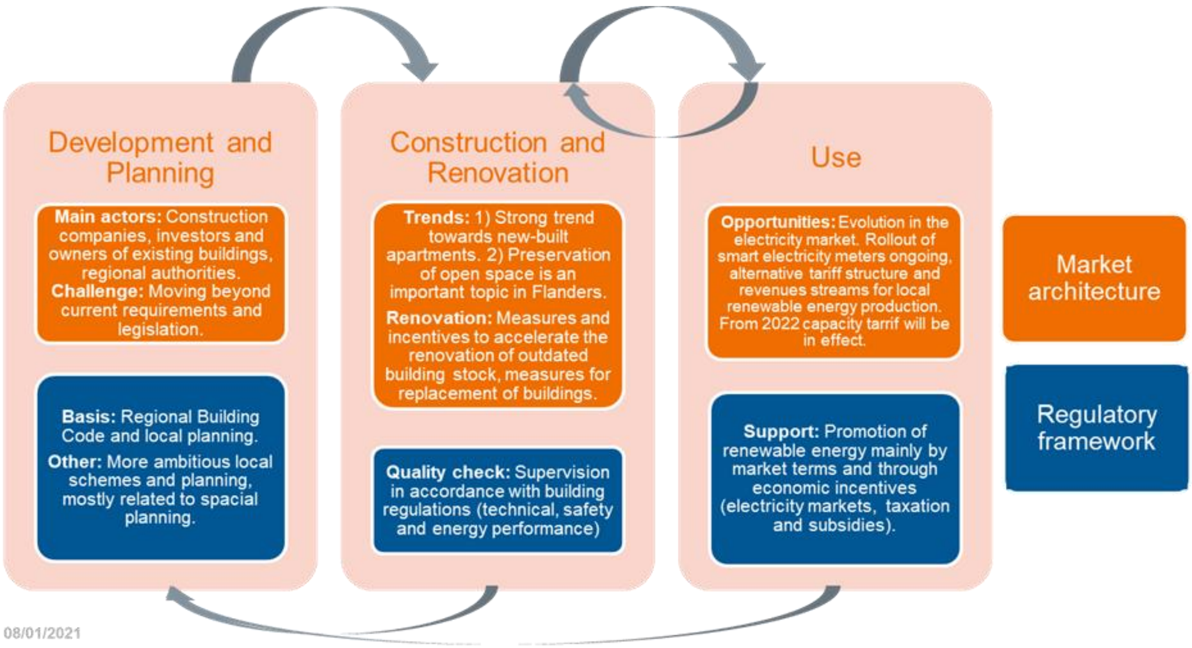

Figure 14. Presentation of the main points regarding the market and regulatory environment for the Belgian demo.

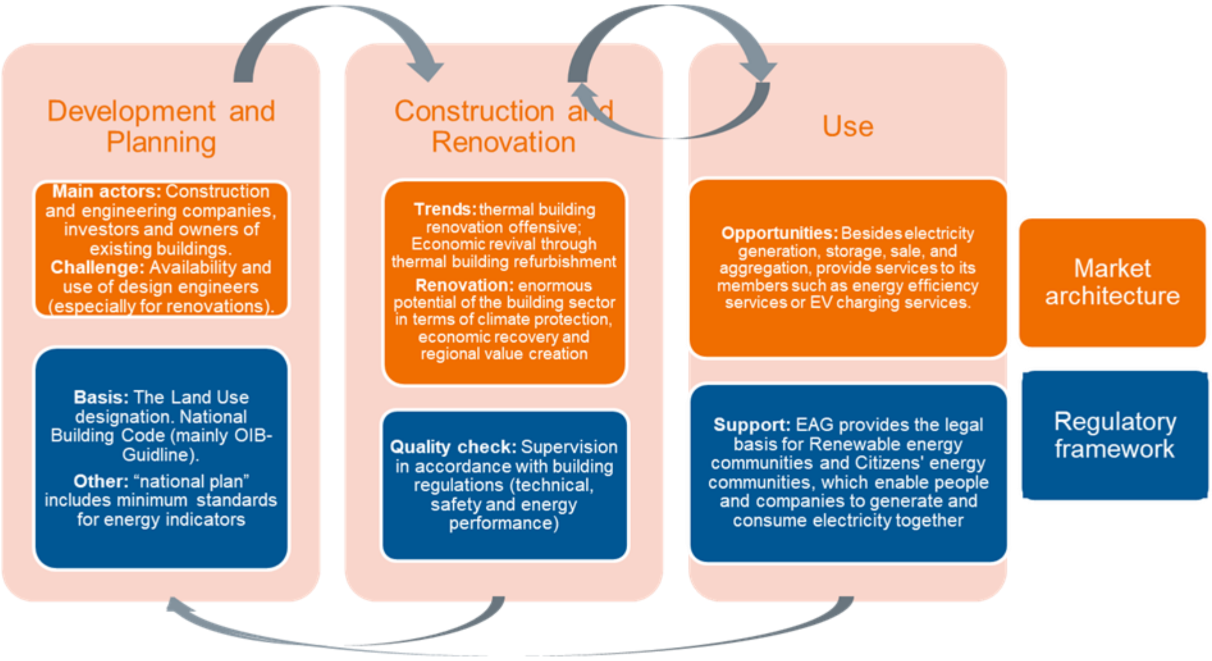

Figure 15: Presentation of the main points regarding the market and regulatory environment for the Austrian demo.

While there are some evident similarities in the countries, there also seem to be different points of emphasis in them.

Regarding the market, it is common for all demo countries that the new construction is less than usual, concentrated in cities and in multi-storey buildings. In many countries the COVID-19 pandemic even further slowed down the construction in 2020, and it is yet to be seen if it takes up the same pace as earlier. It seems that the renovation pace is lagging behind the energy efficiency targets in many countries. This calls also for more PEB solutions for renovation. Some RES solutions are however prevented by strict regulations related to historic buildings. This contradiction needs to be addressed in order to connect the points of PEB solutions and renovation. The status with the smart metering is different in the demo countries. While smart metering has been fully implemented in Finland since 2014, and a new round is starting to make them even more able to support flexibility and control of the energy system, in Belgium the first roll-out is currently ongoing.

Common for all countries is the immaturity of the regulations, which seems to build a significant barrier for the PEBs at the moment. But the good thing is that the regulations are being formulated for the benefit of PEBs, as they are based on the aims of climate mitigation and CO_2 emission reduction, giving benefits for high energy performance of buildings and renewable installations. The exchange of renewables between private consumers is also getting easier. It still remains to be seen, however, if the regulations on different fields and governance levels will be aligned even in the future. Namely, one current barrier is the fragmentation of energy regulation related to different fields (gas, heat, electricity) and different levels (national, regional, municipal). Overall, it was also seen problematic that the regulations are constantly changing. This creates a lot of uncertainties for the planning and life-cycle analyses conducted in the design phase.

Regarding the development of regulations, it is worth noticing that the EXCESS definition of PEBs is not totally in line with some national energy efficiency regulations, whereas it already contains similar elements as the SRI scheme. In these countries (e.g. Flanders area in Belgium), the use of the SRI scheme could be more relevant for the development of a local PEB concept.

5.3 Recommendations

A few recommendations can be collected from the interviews, internal and external workshops, and the analysis of the regulatory and market environments:

Technical

- Develop performance-based contracts to include also the maintenance of the (complicated) system in a PEB.
- Set up solid and experienced project management team to handle the complexity of the project. This team also needs to be able to explain the dimensions and the different "layers" of such a project and show the benefits in an understandable way.
- There is a need for long-term studies to show the energy savings compared to conventional systems and the technologies used.

Regulations

- A strong recommendation based on the analysis is to develop an enabling, consistent (across various policy levels), stable and clear regulatory framework in order to support a wider roll-out of the PEBs.

Social

- Awareness raising campaigns from municipalities or national government on the benefits of PEBs are needed. Municipalities are most often considered as a trustworthy and independent source of information. These campaigns should cover a wide range of stakeholders: end-users, politicians, but also professionals in the relevant fields (building & energy).
- Develop common, easily understandable Key Performance Indicators for PEBs. First make an inquiry of the most common misunderstandings of the concept.
- Create tools and processes for peer-to-peer advice and information provision (e.g. so called energy ambassador).

Financial

- Need to create enough funding and subsidies to support PEB solutions. Also the funding and subsidies developed for energy efficiency improvements and RES are working for PEBs.
- The requirement to show the life-cycle effects should be made mandatory in the planning phase or in connection of the building permit. Not just related to costs, but also to environmental aspects.

- Financing and incentive schemes at the national level play a major role in promoting PEBs. This is also a social aspect, as the incentives improve social equality, when the low-income households can also better afford the high investment costs of PEBs.
- Introducing a CO_2 tax or an environmental tax could help in the roll-out of PEBs. This is also a social aspect, as the taxes could improve social equality, when the low-income households are encouraged to acquire PEBs.

5.4 Further work for EXCESS team

The analysis in the task (T1.4) reported in this deliverable resulted in some points of attention that should be taken into account in the subsequent work in the EXCESS project:

Awareness raising & KPIs: For the remaining work in EXCESS, one of the important points is the need for awareness raising (in WP6 & WP7). It is recommended that in the future work, the EXCESS team looks for potential co-operation partners who are able to widely distribute the conclusions of this study and the learnings from the demos, and who are potentially able to reduce the barriers, as it is evident that this is a too big task for one project alone. The collection and distribution of the successful case examples (in T1.2) also seems to have been an efficient action inside EXCESS, dissipating the lack of information on existing PEBs, which was mentioned as one of the main barriers for a PEB roll-out. It also seems to be very important to develop well-informative KPIs (in WP4), and to communicate the findings of the demos as widely as possible, to different stakeholders in a language that is understandable for the relevant audience (in WP6 & WP7). The professionals in the field also need to be better informed about the PEB solutions, their benefits and challenges.

Business models & integrators: As PEB is a complex system, there is an evident need for integrators in the development and realisation of PEBs, in order to take into account the interactions of the different technologies and social innovations. The overall understanding of the function of the whole system is especially important in renovation, as the renovation activities need to be planned in such a way that the building remains functional during the different steps. The development of business models that will accommodate also the operation and maintenance of the system should be considered (in WP5). Without appropriate and timely maintenance, the system will probably not reach its potential performance level, and the results do not adequately prove the benefits of PEB. One emerging idea worth looking at is the service business related to heating and cooling.

Regulations: In WP5, the EXCESS team will develop recommendations for policy makers. In that work, the outcomes of this report need to be taken into account, especially the points related to the recommendation to avoid constant change of regulations, and the need to align the regulations for different fields and governance levels. The fragmentation of the regulations will affect the possibilities of the market actors to expand their activities to different countries or at least to different regions inside one country.

6 Attachment: Interview questions

Interviews to identify regulatory and market incentives and barriers for implementing EXCESS PEBs

Information on the EXCESS project

For Europe to reach its goal of becoming carbon neutral by 2050, transformation of the building sector is imperative as it uses more energy than any other sector. This is what EXCESS project addresses – a four-year long project, funded by the EU's Horizon 2020 programme. EXCESS will examine how to convert nearly-zero energy buildings (NZEBs) into positive energy buildings (PEBs). PEBs consume less energy than they produce over the course of one year, allowing the surplus energy to be either stored or used by neighbouring buildings.

EXCESS merges technical concepts for Positive Energy Buildings with new opportunities for the production of renewable energy and self-consumption. In addition to driving forward the development of building materials to enable PEBs in diverse climatic conditions, a key focus of EXCESS lies on facilitating the integration of building technologies. By facilitating technological integration, lifetime costs of PEBs can be effectively reduced, making them affordable to a larger share of society. The project's ambitions are reflected in the demonstration cases in Europe's four main climate zones:

- **Continental climate** | The main innovation in the Austrian demo case will be a multi-functional façade element with integrated photovoltaic solar panels and a geo-thermal heat pump, linked with an energy community smart control system and energy billing concept.
- **Coastal climate** | In the Belgian demo site, photovoltaic solar panels powering a ground source heat pump (GSHP) will be installed for a social housing complex. It will also integrate power-to-heat flexible thermal storage in district heating units, adding further resilience.
- **Nordic climate** | For the demonstration case in Finland a 800 m deep borehole with a system of pumps will use heat from different sources in the ground. During the transitional months, surplus heat produced by the building itself will also be used to charge the ground.
- **Mediterranean climate |** In the Spanish demonstration site, a positive energy building system will be achieved by maximising the electricity production from conventional photovoltaic solar panels. The produced energy will be consumed directly in the building and the surplus stored in a battery for daily use.

EXCESS will promote a user-centric approach, and will capitalise on new Information and communications technology opportunities, for optimising the interplay of local generation, storage, consumption at the building and district level.

As part of the work, the EXCESS team is looking to identify the challenges and obstacles for deploying PEBs by engaging with a wider range of PEB concept initiators such as local authorities, cities, energy market regulators, energy utility companies, aggregators, technology providers, technology integrators and building facility managers.

For more information about EXCESS: https://positive-energy-buildings.eu/

This project has received funding from the
European Union's Horizon 2020 Research and Innovation Programme
under Grant Agreement № 870157.

Information on the interviewee

Name of the interviewee:	
Organisation:	
Function:	
City/Region:	
Country:	
Relationship to demo:	

Interview Structure & Questions

This document provides a structure and list of questions as a basis for the live and telephone interviews.

The overall process of the interview is structured as follows (for details of each step, see below):

I. Introduction
II. Theme 1
III. Theme 2
IV. Theme 3
V. Conclusion and closure of the interview

I. Introduction

- Interviewer greets the interviewee and thanks interviewee for agreeing to the interview
- Short personal introductions by interviewer: own name, organisation.
- Short introduction on the aim of the interview with reference to the EXCESS project (what has been done there and why), how the interviews fit into the project (see first page)
- Reconfirm the name, organisation and position of the interviewee.
- Clarification of the use of the results and anonymity:
  - Anonymity: No statement or quote will be linked to one particular person
  - Project will release a summary report of the results obtained from the survey as part of *Deliverable D1.4: Identification of regulatory and market incentives and barriers*.
  - Do they give consent to recording the interview and exploiting the results (consent form)
  - Personal data: Their personal data will be securely stored following GDPR guidelines.
- Overview of the structure of the interview:
  - Introduction - general questions
  - Experience with PEB implementation
  - Reflection and outlook
  - Closure
- Information that any question on EXCESS the interviewee might have and that the interviewer cannot answer will be played back to the EXCESS project and responded to afterwards.

II. Theme 1: Introductory Questions

Interviewer: "The EXCESS project centres around Positive Energy Buildings (PEBs), which we defined as:"

(Interviewer provides interviewee with definition text of PEBs and gives time to read)

Q1. How long have you been directly / indirectly involved in with the development of Positive Energy Buildings (PEB)?

Number of years	

Q2. How important do you think are PEBs for the energy transition in Europe?

Using a scale of 1 – 5 with 1 being "Not / None" and 5 being "Very Much"

1	2	3	4	5	No answer	Don't know

Q3. How do you keep up to date about developments around PEBs?

(Follow-up if needed: What kind of information do you consult?)

III. Theme 2: Experience with implementing PEBs

Interviewer: "In this section we would like to hear about experiences with planning and implementing PEBs in the past. We are interested in hearing about both the successful and less successful implementation experiences."

Q4. In how many PEB projects were you involved in during the past 10 years?

Number of projects:

Q5. Please describe how you have perceived the implementation of those projects?

Q6. What were the main barriers to the implementation of the projects?

If the answers include the barriers listed below tick the "yes" box. If the interviewee does not mention the barriers below, please prompt and tick the "yes" or "no" box depending on the response.

Barriers	Yes	No
Regulatory		
Social		
Technical		
Economic		

Interviewer: "With the next four questions we would like to go through these four categories of barriers one after the other."

Q7. With regard to <u>regulatory barriers</u>, which ones have you encountered in the projects you have implemented or heard of?

Note to the interviewer: If little is mentioned by the interviewee you can prompt with restrictions such as rental laws, common property aspects, property laws, conflicting policies at various levels of government, relevant responsibilities distributed across various departments, barriers to feeding energy into the grid, etc.

Q8. With regard to <u>social barriers</u>, which ones have you encountered in the projects you have implemented or heard of?

Note to the interviewer: If little is mentioned by the interviewee you can prompt with users' interaction/engagement aspects, diverse tenants' concerns, etc.

Q9. With regard to <u>technical barriers</u>, which ones have you encountered in the projects you have implemented or heard of?

Note to the interviewer: If little is mentioned by the interviewee you can prompt with integration with city energy infrastructure, etc.

Q10. With regard to <u>financial barriers</u>, which ones have you encountered in the projects you have implemented or heard of?

Note to the interviewer: If little is mentioned by the interviewee you can prompt with financial investment mechanism such as energy efficiency schemes, etc.

Q11. Considering the barriers, you have mentioned in the previous questions, what would be incentives to overcome each of them?

Note the interviewer: Prompt the different aspects

<u>Regulatory incentives:</u>

<u>Social incentives:</u>

<u>Technical incentives:</u>

<u>Financial incentives:</u>

Q12. In your view, in how far do households and the private sector actors have sufficient economic incentives to develop / retrofit buildings into positive energy buildings (PEBs)?

Using a scale of 1 – 5 with 1 being "Not / None" and 5 being "Very Much"

1	2	3	4	5	No answer	Don't know

IV. Theme 3: Reflection & Outlook

In this section we would like to hear about your reflections and suggestions with regard to PEB projects and the possibilities to improve their planning and implementation.

Q13. Which impact do you think PEBs could have in your community?

Using a scale of 1 – 5 with 1 being "Not / None" and 5 being "Very high"

1	2	3	4	5	No answer	Don't know

Q14. How could the business case for PEBs be strengthened in future?

Q15. Do you feel that government / businesses / citizens are sufficiently aware of options that exist for PEB development?

Using a scale of 1 – 5 with 1 being "Not / None" and 5 being "Very Much"

	1	2	3	4	5	No answer	Don't know
Government							
Businesses							
Citizens							

Q16. How can decision-makers increase awareness?

Q17. What kind of support would you wish for with regard to the planning and implementation of PEBs?

Q.18. How relevant could demonstration projects such as in EXCESS be for your city/region?

Using a scale of 1 – 5 with 1 being "Not / None" and 5 being "Very Much"

1	2	3	4	5	No answer	Don't know

Q19. How could the relevance of demonstration projects for your city/region be increased?

V. Conclusion and closure of the interview

Interviewer: "We have reached the conclusion of the interview. I have a few more general questions for you before closing."

Q20. Are there any questions that we should have asked you but did not?

Q21. If yes, what is this question?

Q22. What is your answer to it?

Interviewer: "Thank you for your answers and for your time."

Attachment to the interviews: EXCESS Definition for PEB

EXCESS defines a positive energy building (PEB) as an energy efficient building that produces more energy than it uses via renewable sources, with high self-consumption rate and high energy flexibility, over a time span of one year.

A high quality indoor environment is an essential element in the PEB, maintaining the comfort and well being of the building occupants. The PEB is also able to integrate the future technologies like electric vehicles with the motivation to maximize the onsite consumption and also share the surplus renewable energy.

EXCESS considers mainly residential buildings, while looking at the role of the building in bigger context, especially through impact to the energy networks. In the assessment of the building, the energy needs for other than residential activities, e.g. commercial or public services are excluded, while the energy use for the shared spaces is included.

The local generation includes the energy produced at the building site, with technologies placed in/on the building or building site and technologies incorporated within the building elements.

The energy need components considered in EXCESS are heating, cooling and electricity. Heating includes both space and water heating. Electricity includes the lighting, plug loads, ventilation and the electricity needs for the shared spaces such as lighting in common zones and elevators.

EXCESS uses the definition of renewable energy from European RES directive, which defines it as energy from renewable non-fossil sources, e.g. wind, solar, hydro, geothermal or biomass.

High self-consumption rate contributes to minimising both the emissions and the negative impacts to the grid. The self-consumption rate can be increased e.g. by demand response and energy storage solutions.

Indoor environment consists of thermal, visual and acoustic environment and indoor air quality.

The life-cycle effects on costs and emissions should be considered in the planning and analysis of PEB.