EXCESS

FleXible user-CEntric Energy poSitive houseS

Deliverable 1.3: Report on making PEB concepts part of local authorities planning instruments

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Abstract

This report explores how local and regional planning instruments can promote the development of Positive Energy Buildings (PEBs) across Europe. To this end, a broad range of European local and regional authorities were interviewed regarding approaches to governing and planning the development of nearly and net zero energy buildings as well as PEBs. The analysis of the interviews provides insights on present local and regional authority strategies and planning approaches in relation to PEB development, identifies needs for – and barriers to – scaling and explores local as well as regional ambitions to adapt planning systems accordingly. This guidebook summarises the key findings of Task 1.3, aiming to empower sub-national governments to promote PEBs by integrating policies and measures urban planning frameworks at city as well as regional level.

Keywords

Positive energy building, urban planning, planning instrument, city strategy.

Revision	Date	Description	Author (Organisation)
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EXECUTIVE SUMMARY

This report documents how the development of Positive Energy Buildings (PEBs) can be promoted in the context of local and regional planning instruments. It reveals and recommends synergies with established urban and rural-urban actions to accelerate the large-scale roll-out of energy efficiency measures and on-site renewable energy generation in buildings.

Local and regional authorities across Europe were interviewed to learn about successful experiences pertaining to measures, actions and concepts for the planning of nearly and net zero energy buildings as well as PEBs, including technical, administrative, financial and governance aspects. Interviews also investigated the current needs and future ambitions of local and regional authorities in relation to PEBs.

The guidebook proposes measures and indicators that can be integrated into planning systems of local and regional authorities to promote effectively the development of PEBs (e.g. Sustainable Energy (and Climate) Action Plans (SEAPs/SECAPs), environmental strategies, urban plans, Smart Specialization Strategies, CityKeys - Smart City indicator set). In so doing, the guidebook represents an evidence-based knowledge resource for local and regional authorities that are keen to increase the energy efficiency of their built environments and increase the share of renewable energy generation at building and district-level.

A key conclusion that can be drawn from the interviews is that all levels of governance have an important role to play in the roll-out of PEBs and the coordination between the different levels of administration – as well as broad stakeholder engagement - is crucial. Further important factors that influence the planning process of NZEB and PEBs were found to be the cost, communication with investors about the importance of NZEB/PEB, feasible financial models, open discussion and the removal of legal barriers.

The ideas, learnings and insights gathered from the interviews were summarised into a guidebook. The main recommendations can be grouped as follows:

- Make room for PEBs in the overarching vision for sustainability.
- Good outcomes require the inclusion of a wide variety of stakeholders.
- Understand institutional arrangements and powers that influence PEB development.
- Embed PEB considerations into planning frameworks.
- Plan for positive energy at the individual building or building cluster level.
- Lead by example, learn by doing and share information .
- Strive for a sustainable built environment that leaves no one behind.
- Support and knowledge for financing.
- Policies and regulations as motivators rather than obstacles.

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1 Introduction

1.1 Purpose of the document

This report explores how Positive Energy Building (PEB) development can be promoted via local and regional planning instruments. It reveals and recommends synergies with established urban and rural-urban actions, as well as cities' future plans and needs, in order to accelerate the large-scale roll-out of highly energy efficient buildings that incorporate on-site renewable energy generation. This report summarises the results of the EXCESS project's *Task 1.3 Preparing PEB concepts to be part of local and regional authorities planning instruments*.

Work undertaken builds on the PEB concept and definition created in EXCESS Task 1.1 and presented in Deliverable 1.1. VTT led the planning of the survey for local and regional authorities, in collaboration with ICLEI, AAE, PI and CENER. Each partner performed 2-4 interviews around Europe, focusing on cities and regions. The city authorities of the four EXCESS demonstration sites for positive energy buildings were included in the interviews in Hasselt in Belgium, Granada in Spain, Helsinki in Finland and Graz in Austria. Interviewees were also invited to join the EXCESS Replication Group in WP6 as well as other stakeholder engagement activities. The interview results were analysed by VTT, CENER and ICLEI with the aim to create a guidebook, which includes a list of measures and indicators that could be transferred to policy and planning frameworks of local and regional authorities across Europe.

1.2 Scope of the document

It's estimated that the built environment accounts for approximately 40% of energy consumption and 36% of CO_2 emissions in the EU. Cities are facing huge challenges in reaching their ambitious climate and energy targets. The building sector is a key sector that needs to be decarbonised, which calls for the adoption of sustainable solutions at an unprecedented pace. This includes both accelerating deep renovation, the construction of highly energy efficient new buildings as well as stimulating local and regional energy production from fossil-free sources.

The guidebook, which is included in Chapter 5 and will be disseminated via the EXCESS website as a stand-alone product, includes a list of measures and indicators that could be integrated into local and regional authorities' policy and planning frameworks.[1] On the basis of interviews with local and regional authorities the team identified opportunities and challenges related to measures, actions and concepts for the planning of nearly and net zero energy buildings as well as PEBs. The analysis that underpins the guidebook's recommendations explores technical, administrative, financial and governance aspects. Furthermore, interviews also investigated current needs and the future ambitions of local and regional authorities regarding their building stock. Lastly, the analysis also explores the extent to which climatic characteristics and national policy environments may impact the scaling of PEBs in Europe.

1.3 Structure of the document and the roles of the partners

The report begins with an overview of common local and regional authority planning instruments in chapter 2. In this context selected instruments are introduced, including SEAPs/SECAPs,

[1] In particular, the guidebook draws its recommendations from the analysis of (the roles of) planning instruments, including SEAP/SECAPS, environmental strategies, urban plans, Smart Specialization Strategies, CityKeys - Smart City indicator set.

environmental strategies, urban plans (spatial and land-use plans in cities and regional land-use plans), Smart Specialization Strategy, and CityKeys Smart City indicator set. This brief overview that sets the stage for the subsequent chapters was provided by the EXCESS consortium member ICLEI, with AEA focusing on regional land use plans.

Following the background on European planning frameworks, Chapter 3 of the report outlines the VTT-led survey methodology design and implementation for local and regional authority interviews. The prepared survey questions are listed in Appendix 1. All the task partners (VTT, ICLEI, CEN, AEA, PI) participated in developing the survey questions and mapping the relevant interviewees.

The survey results are studied in Chapter 4, with the analysis being broken down into the subsections: 4.1 NZEBs and PEBs (summarised by VTT), 4.2 PEBs in policy and planning instruments (summarised by ICLEI), 4.3 Technical aspects (summarised by CENER), and 4.4. Governance and policy making (summarised by AEA).

The key findings from the survey are compressed into a brief guidebook called: “How to integrate PEB concepts into local and regional planning instruments” in Chapter 5. Here, the aim was to formulate the content in a concise, easy-to-grasp manner, so that these key findings could be shared more broadly (e.g. via the EXCESS website).

Lastly, Chapter 6 presents briefly the main conclusions of the work presented in this report.

2 Overview of the planning instruments of local and regional authorities

2.1 Summary of the planning instruments

Whilst European planning systems and territorial governance approaches have converged to some degree over the past decades social, economic, environmental and historical factors as well as the involvement of diverse communities of actors still continue to underpin their heterogeneity [1]. Every European Member State uses spatial planning policies to regulate the use of land and property, but the tools, methods and governance levels at which these are applied vary considerably. A report on territorial governance and spatial planning systems in Europe [2], which was commissioned by ESPON EGTC will form the backbone of this introductory chapter.

Overall, European Member States appear to have been continuing to decentralise planning remits to the local level. At the same time, however, significant levels of territorial collaboration to address systems-level, cross-boundary human development dimensions can be observed. [2]

Europe's diversity has given rise to a great range of planning systems, instruments and governance approaches, therefore the EXCESS team will only highlight a small number of approaches, to be described in this chapter and analysed in the context of 15 expert interviews at local and regional level (see Chapter 4.2). The instruments were chosen based on their relevance and applicability for how local and regional authorities could potentially affect the planning of PEBs. Instruments described in the following subchapters include: Sustainable Energy (and Climate) Action Plans (SEAPs/ SECAPs) and the Covenant of Mayors; environmental and energy strategies; urban plans (spatial and land-use plans), regional plans; Smart Specialization Strategies; and the use of smart city indicators (e.g. CityKeys).

2.2 SEAPs/SECAPs

The Covenant of Mayors (CoM) is an initiative launched by the European Commission 2008 to mobilise local authorities to plan and implement energy action plans in a bottom-up approach. The merger of CoM and the Mayors Adapt initiative resulted in the formation of the newly named Covenant of Mayor for Climate and Energy, which called upon local authorities to pledge to achieve a 40% greenhouse gas reduction target by 2030 and agree to developed integrative approaches to address climate change mitigation, adaptation as well as secure, sustainable and affordable energy. To this end, signatories to the CoM commit to emissions reduction targets as well as to developing baseline emissions inventories, articulating plans and submitting progress reports to the initiative. In light of the initiative's exponential growth, the Global Covenant of Mayors for Climate and Energy was formed in 2016 and now has regional Covenant offices across the world. [3]

Sustainable Energy Action Plans (SEAPS), which were the precursor to SECAPs, focused on the development and implementation of actions related to energy and climate change mitigation by 2020. SECAPs, which are to be submitted by signatories of the new Covenant of Mayors for Climate and Energy and have a time horizon of 2030, are more expansive as they now also include climate change adaptation measures. Whilst both the SEAP and SECAP are underpinned by a Baseline Emissions Inventory (BEI), the SECAP is further informed by a Climate Change Risk and Vulnerability Assessment (RVA). In light of the expanded scope of SECAPs, reporting and monitoring now also

includes indicators on risk and vulnerability, a scoreboard on climate change adaptation as well as a dedicated section on concrete adaptation actions.

2.3 Environmental and/or energy strategies

Strategies on environmental and energy issues tend to be developed at various levels of governance. At European level, noteworthy strategies relate to the urban environment, circular economy, energy efficiency / saving / security, renewable energy as well as waste and recycling, amongst others. [4] [5] Recent relevant directives and initiatives that have shaped or will influence national strategy-making include:

- The European Green Deal (2019) [6], of which the 2020 European Renovation Wave [7] is a part of, announced on October 14th 2020, the EU Commission is operationalizing the European Renovation Wave to at least double renovation rates in the next ten years. The initiative aims to significantly reduce greenhouse gas emissions attributed to Europe's building stock, create new jobs, aid the economic recovery and improve the reuse and recycling of materials. To this end, the Renovation Wave will focus in particular on decarbonising heating and cooling, tackling energy poverty and renovating public buildings.

- The New Energy Performance in Buildings Directive (2018) [8] and the Energy Efficiency Directive 2012/27/EU [9]: These Directives have been - and continue to be – effective in promoting policies to improve the energy efficiency and decarbonisation of the Union's building stock by creating a clear and long-term pathway to guide investment decisions in the sector and by enabling informed choices of consumers and businesses to make more informed choices. As a result of the introduction of energy performance rules in national building codes, it is estimated that buildings today already consume only half as much as energy as typical buildings from the 1980s.

- The Energy Performance of Buildings Directive (2018/844/E) [8] – Amendments to the EPBD have had particularly significant impact on policy development in Member States, with the updated Directive requiring countries to have developed robust long-term renovation strategies, to have raised ambition on minimum energy performance requirements, to have introduced energy performance certificates and to have introduced measures to promote smart technological solutions.

Whilst strategic functions are often associated with national level, with local authorities being said to be focusing more on regulatory aspects in Europe [2], strategy-making and connected stakeholder engagement activities as well as innovation are key elements of local governance. Depending on country-specific institutional arrangements, also regional / provincial governments and functional planning regions that span across administrative boundaries are often engaged in the development of environmental or energy strategies.

2.4 Building codes and standards

With regard to the built environment and the building level, local authorities are often found to be enforcing regulations and standards that have been formulated at European, national and sometimes

regional level. The aforementioned European Energy Performance in Buildings Directive [10], which was amended in 2018, is a key document shaping the new construction of buildings in Member States. The Directive, which Member States had to transpose into national law by March 10th 2020, includes a range of measures to make national standards more ambitious and sets out the requirement to introduce energy performance certificates for buildings. Key elements of the Directive include:

- The introduction of long-term building renovation strategies for the decarbonisation of buildings by 2050 across the Union.
- Measures to encourage the use of technologies for efficient buildings operation.
- The use of building automation and control (BAC) systems as an alternative to physical inspections as well as the introduction of "smartness indicators".
- Developing financing frameworks to strengthen the links between public funding for building renovation and energy performance certificates and reducing energy poverty by means of building renovation.
- Promoting the development of infrastructure for e-mobility.

The Directive effectively mandates that new construction is to conform to NZEB / passive house standards. The onus for translating the Directive into law lay at national levels, with some regions and provinces (depending on specific structures of governance) having been engaged in drafting building codes and local governments typically being only involved in later implementation and enforcement. Some cities have developed their own standards, yet their applicability tends to be limited to buildable land that is in their ownership.

2.5 Urban plans (spatial and land use plans) in cities

Spatial and land-use plans tend to be focused on the administrative territories of individual local governments, but could also span across functional planning regions. Spatial plans have a tendency to concentrate on the management of physical development (including aspects such as settlement structure, open space management, transport infrastructure, etc.), in line with overarching strategic goals and targets of local or regional governments that can be cross-cutting and difficult to translate. Frequent features of such plans include the definition of spatial typologies / building categories, guiding development along principal axes (i.e. transport), the identification of central spaces (which can be concentrated or polycentric) or the preservation / management of functions such as ecosystem services.

Land-use planning builds upon such spatial planning frameworks, by regulating the functional use of buildings and spaces in more detail. Such plans typically identify: green and brownfield land that can be developed; areas to accommodate transport infrastructure and utilities, spaces for public buildings, recreation, green spaces, agriculture, etc. At a more concentrated scale, local governments often draw up more concrete and legally binding land-use plans that specify in greater detail what kind of development may and may not take place. These more focused, usually neighbourhood-level / district plans specify requirements pertaining to aspects such as building heights and densities, building set-back lines, as well as building typologies. Depending on a city's remit, this scale of planning can also lend itself to setting (and later enforcing) minimum standards in relation to building performance.

2.6 Regional land use plans

As mentioned by the European Commission, Europe's urban areas are home to about two thirds of the EU's population, accounting for approximately 80 % of energy consumption and generating up to 85 % of European GDP [11]. They act as engines of the European economy and as catalysts for creativity and innovation in the Union. However, they are also the places where persistent problems, such as unemployment, segregation and poverty, reach their most pressing levels. As a result, urban policies are of importance that go beyond the urban boundaries themselves, and are therefore at the heart of policies being developed at the regional or national level.

The role of regions in urban planning and in defining sustainability objectives at local level depends on the degree of centralisation of the respective country. In this way, in highly centralised countries, such as in Poland or Croatia, regions play little role in urban planning or in setting specific energy targets, these being defined at national level and subsequently implemented by cities. Indeed, many of these cities set their own sustainable development goals, in addition to their own monitoring tools, as is the case with some of the cities that have been interviewed in the context of the task.

Contrastingly, in more decentralised countries such as in Spain[2] or Italy, regions play a very important role in urban planning, defining the basic guidelines for sustainability to be followed by new urban developments at local level. In addition, in these cases the regions usually have their own energy and smart specialisation plans, where energy and innovation objectives are defined at regional level, and measures are established for their implementation at local level, thus being the management reference for cities. Together with the definition of specific energy guidelines and objectives, most regions also play a very important role in terms of advising cities, with specific structures within the regional administration dedicated to technical assistance to municipal authorities, the approval of urban plans and the implementation monitoring of urban plans.

Also, in these decentralised counties, the regions have specific resources for the financing of specific urban rehabilitation energy projects at local level. In this regard, it should be noted that within the EU's cohesion policy for the period 2014-2020, a minimum of 50 % of the European Regional Development Funds (ERDF) was initially allocated to investments in urban areas, which is expected to be exceeded by the end of the period. Thus, close to EUR 10 billion from the ERDF will be allocated directly to integrated sustainable urban development strategies.

2.7 Smart Specialization Strategies

Smart Specialisation Strategies [12] are often developed at national and regional level, focusing predominantly on harnessing research and innovation as well as economic capacities in certain domains to increase competitiveness. Whilst some strategies do focus on exploiting synergies amongst actors in the field of energy and the environment, the impact on scaling up the development or refurbishment of buildings to NZEB/PEB standard is more indirect. The development of such strategies is, however, linked to accessing European Regional Development Funds as well as European Structural and Investment Funds. These funding channels are significant at a regional / provincial level and by extension of relevance for local authorities. In 2015, approximately 10.6% of 1299 strategies

[2] In Spain, the "CTE" (Código Técnico de la Edificación) regulates at national level the measures for energy saving. Each city (+20,000 inhabitants) in its own regulations can add other measures or improvements.

were found to focus on energy production and distribution and only 2.9% of strategies were related to construction. [13]

2.8 The use of smart city indicators (e.g. CityKeys)

Monitoring plays a key role in meeting ambitious decarbonisation goals of cities in relation to their building stock. Moreover, at national levels as well as at the European level it is important that these are standardized and data is accessible and reliable to inform evidence-based policy making. In this context, smart city indicators, such as CityKeys, CELSIUS, CiTyFied as well as ISO, ITU and DIN need to be adopted more commonly at local level.

Projects, such as CityKeys [14], which provide indicators for project-level projects as well as city-wide monitoring frameworks, exemplify the broad range of indicators that should ideally be considered. It should be noted that these indicators relate to projects more broadly and are not limited to buildings only. The below list has therefore been limited to a small selection of possible smart city indicators:

- **Project-level indicators:** health (encouraging a healthy lifestyle); safety (data privacy); access (to public transport, amenities, bicycle routes, etc.); education (environmental awareness); diversity and inclusion (vulnerable groups, etc.); quality of housing (diversity, connection to cultural heritage, sense of place, accessibility, etc.); energy and climate (lifecycle energy use, final energy consumption, local RE generation, CO_2 savings); materials, water and land (recycled / renewable material use, water consumption and re-use, compactness, etc.); climate resilience; replicability & scalability and impacts on the ecosystem, employment, equity, etc. [15]

3 Survey methodology

Expert surveys by interviewing local and regional authorities were conducted across Europe in the spring and summer of 2020 to gather qualitative and quantitative information for the analysis and recommendations development (*Figure 1*). The survey included questions about experiences regarding Nearly and Net Zero Energy Buildings and plans for the PEBs as well as questions to shed light upon how policy and planning instruments encourage their development. In addition, the questionnaire covered technical and governance aspects (please refer to Appendix 1 for the full set of questions).

Figure 1: Map of countries involved in the survey. Figure modified from https://www.google.com/maps

In total, representatives from 9 cities, 5 regions, and one national level contact were interviewed. In many cases, more than one person in each city and region was interviewed to get a more comprehensive understanding of the overall situation via different viewpoints (technical, administrative, financial and policy aspects) of local / regional conditions. Interviewees from the cities and regions were chosen from a large European pool of contacts that the Task 1.3 partners had compiled in preparation for the task, with support from T6.1 outcomes (stakeholder and user identification).

The selection of cities and regions was carried out to achieve a broad coverage across Europe, whilst also ensuring that different sizes of cities in urban and rural-urban areas were included. The final selection ranged from smaller cities such as Porvoo (50 361 inhabitants [16]) in Finland and Hasselt (76 000 inhabitants [17]) in Belgium, to large cities like Vienna with 1.9 million inhabitants [18] and Zagreb with 688 000 inhabitants [19]. Similarly, the team sought to collect expert inputs from a diverse

variety of regions, ultimately settling on the Province of Limburg in Belgium, Greater London in the UK, the Provincial Government of Granada in Spain, Opole Province in Poland and North West Croatia. Further, an interview from the Ministry of Environment in Finland was also included in the survey to validate and put into perspective local expert views from Helsinki and Porvoo. All cities and/or regions where EXCESS demonstration projects are being realised were included in the interviews: Graz in Austria, Hasselt and the Province of Limburg in Belgium, Helsinki in Finland, and the Province of Granada in Spain. All the interviewed cities and regions are shown in *Figure 2*.

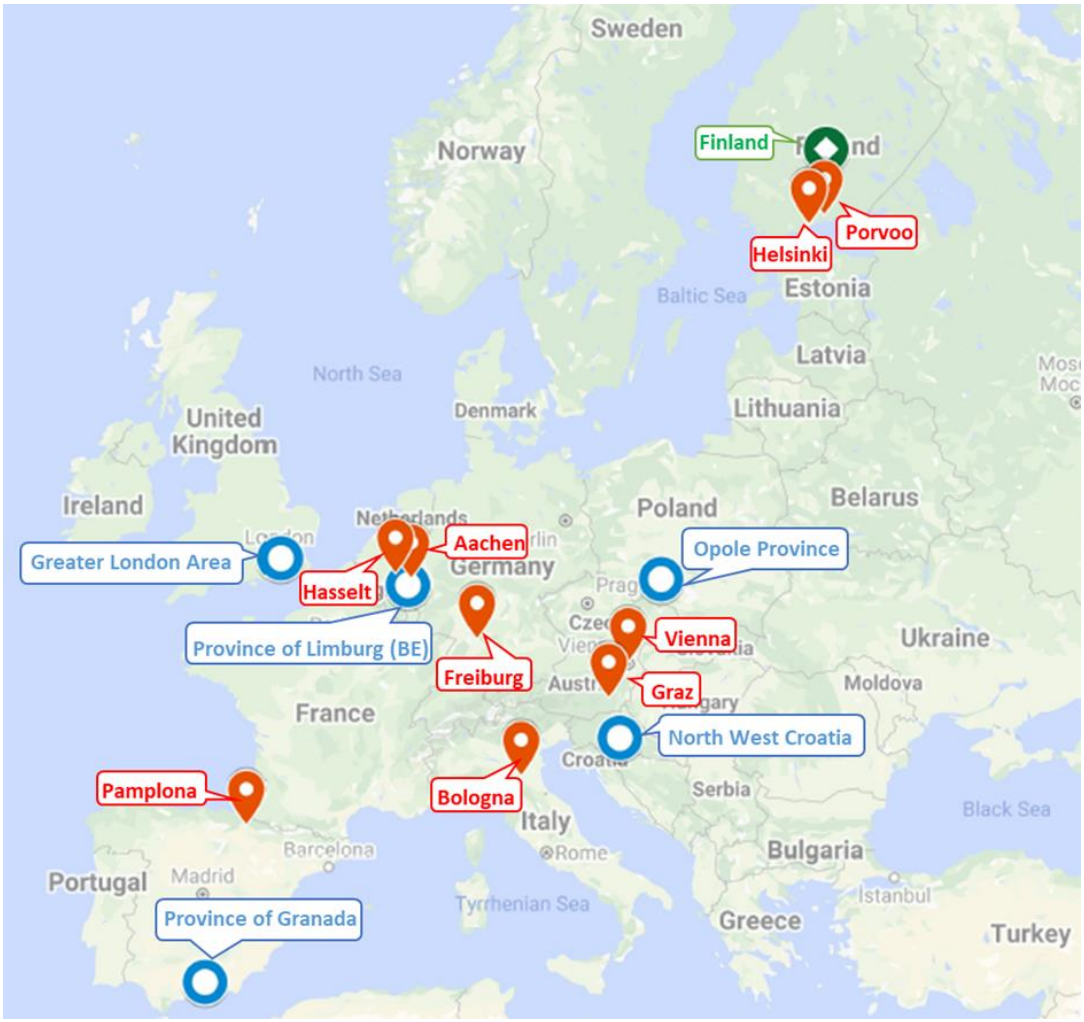


Figure 2: Map of regions and cities involved in authorities' interviews. Figure modified from https://www.google.com/maps

The timing of this survey was challenging, as the interviews were scheduled for April and May 2020, when Europe was simultaneously fighting with the Covid-19 outbreak. Some cities and regions declined interview invitations due to the challenges related to Covid-19 lock downs and other related obstacles, especially in the most affected countries, such as in Italy.

The core team of Task 1.3 processed the survey responses, with each of the group member focusing on the survey questions in their expertise area. Even though the questions were the same in each interview, many of the responses were broad and the focus of the interviews varied a bit depending on the expertise of the interviewee. Based on the semi-structured survey responses, the survey results were summarised and classified into five thematic areas in the section 4 following. Further, the summary of the responses creates the basis for formulating the guidelines in section 5.

4 Summary of local and regional authorities interviews

This section summarises the survey responses from the authorities interviewed from cities and regions. The responses are classified in five subsections. First, the experiences related to energy efficient and sustainable buildings are collected in section 4.1. The role of NZEB and PEB in the policy and planning instruments is studied in section 4.2. Technology related issues, including both energy efficiency measures and RES integration are grouped in section 4.3. Learnings about assessing of PEBs and the required KPIs and data acquisition are collected into section 4.4. Governance and policy related topics are summarised in section 4.5.

4.1 Experiences from Nearly and Net Zero Energy Buildings and expectations towards PEBs

This section introduces interviewees' practical experiences on nearly and net zero energy buildings, as well as their expectations and reflections on positive energy buildings. Some of the interviewees had also either been involved or knew of positive energy building demonstrations realised in their city or region. Some comments were given about the current NZEB building regulation both with positive remarks for reducing the energy demand of buildings, but also criticising that it is not sufficient in the long run to meet European Green Deal goals for decarbonization of the EU by 2050. The EXCESS definition for PEBs [20] was accepted by interviewees in general. Many interviewees raised the importance of the affordability of housing at the very outset of their interviews. Also, the various stakeholders involved in the development of PEBs were recognized.

4.1.1 Experiences from Nearly and Net zero energy buildings

Generally, all respondents described nearly zero energy buildings (NZEB) as highly energy efficient buildings, which require only a small amount of energy during operations. The NZEB concept is known by all the interviewees and they were well aware of the existence of NZEB policies in Europe, even though there are some variations of interpretation in the context of national and subnational NZEB regulations in different countries. The majority of the interviewees are or have been involved in the development of NZEB or PEBs (Figure 3) at some level, many of them in several projects' strategic planning.

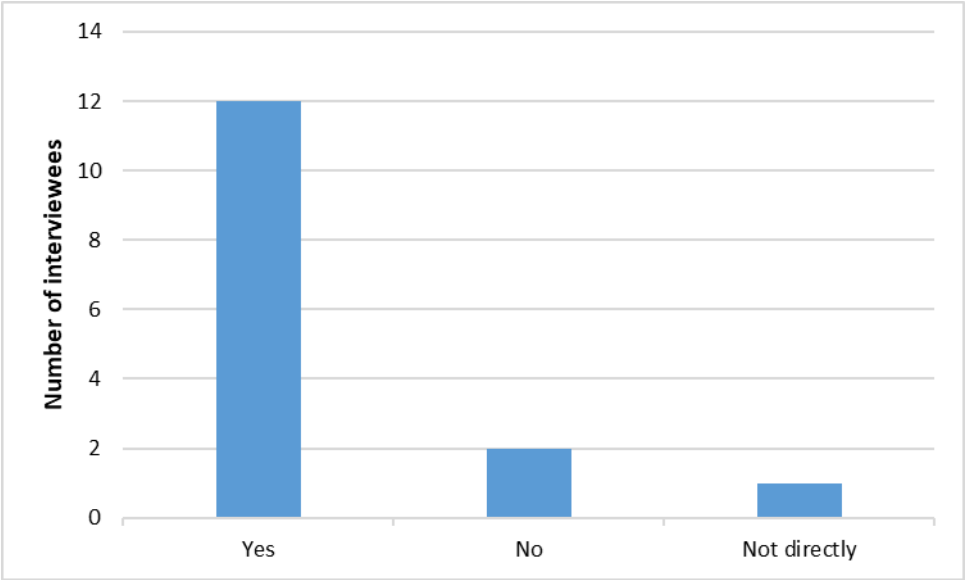


Figure 3: Number of interviewees involved in the development of nearly-zero energy buildings or positive energy buildings.

Many interesting ongoing building-related projects and programs in different cities were introduced that aim to mitigate climate change and to meet the carbon emissions reduction targets. Most of these are at large scale or at municipality level and not at the individual or private building level. Among others, interviewees provided details about the following projects and programs:

- In Finland, there was a national program called "An energy-smart built environment [21], targeting for reducing carbon emissions from built environment.
- Porvoo (Finland) has many projects related to carbon neutrality, being a central point of urban planning, leading also to new job positions in order to support such actions, such as the Sustainable Development Expert. A big change started about 10 years ago with the Skaftkärr project, which was aiming at carbon neutral residential area. This project has strongly affected the urban planning process by bringing the energy and emission aspects to the center of urban planning. The whole process has been changed thoroughly.
- The NZEB kindergarten development in the City of Sveta Nedelja in Zagreb County[3] (Croatia) is named as a good practice case study from Eastern Europe.
- In Granada Province (Spain), several pilot projects have served as inspirational demonstration examples, such as the main offices of the Sustainable Construction Cluster. Many new pilot scale projects are ongoing, supporting new amendments for future challenges and to improve the overall energy performance of the buildings and energy systems.
- In Aachen (Germany), the municipality is working to raise building performance levels in the area to passive house standard by 2025, which is better than the low energy standard. The city will target to initiate energy efficiency renovations in buildings, which have poor energy efficiency, when those buildings are put on the real estate market, targeting to reduce the energy consumption to 60-70 kWh/m^{2}y.

[3] https://www.interreg-central.eu/Content.Node/eCentral.html

- In Freiburg (Germany), the activities of the Environmental Protection Agency relate to reflecting on the lessons learnt from development projects and adapting strategies accordingly. An example of this is the energy positive City Hall in Stühlinger, where a scientific institution is carrying out monitoring, with findings used to develop further guidance for improving the energy efficiency of government owned buildings.
- In Vienna (Austria), the department of energy planning of the city accompanies development projects that include residential, non-residential and educational buildings. From the insights gained, the department can identify key aspects that still need start-up financing in order to make the leap to implementation, and also, the lessons learned are reflected in the further development of the energy standards and minimum legal requirements.
- The City of Graz (Austria) is engaged in various projects focusing on energy efficient building and building integrated RE generation. The city oversees the ´House of the Future´ program in Reininghaus Süd, which seeks to develop a plus-energy building.
- In the UK, the carbon neutral policy focused on dwellings (10 units at least) and later in 2020 the focus will shift to the non-residential buildings. The urban plans underpin the authority's high expectations to fulfil the carbon neutral target stablished in 2016 in residential buildings.
- In Opole Province (Poland), there was a plan to build a NZEB project, however the project was not completed because the investor did not receive the funding he was hoping to get.

Many experts stated that their cities have been working towards green and/or sustainable buildings for many years. In Freiburg, for example, green buildings, deep renovation and promoting renewable energy generation have a long tradition, being embedded in local government plans and strategies, mandated by regulations and incentivized by grants. The city has made contractual agreements with the housing association and developers to construct and renovate buildings to a high energy efficiency standard.

4.1.2 Comments regarding the current NZEB regulation

Whilst one of the interviewees commented that current NZEB regulations help reduce energy consumption well below the average of the buildings in the territory, some interviewees spoke less favorably of the current national NZEB policies. A key point of criticism voiced was that regulations seemed to result in buildings that may perform well on paper but are in truth still close to the earlier business-as-usual levels with regard to energy consumption.

Another commentator stated that the NZEB standard is not sufficient in the long run to meet European Green Deal goals for decarbonization of the EU by 2050. The Energy Efficiency Agency of North-West Croatia REGEA has decided to upgrade the Croatian NZEB standard, especially regarding the share of RES, and formulated Green Deal Construction Guidelines (Green Deal Smjernice Gradnje), which they advocate to counties and cities as well as private investors to assure that buildings are actually designed and renovated accordingly. These guidelines are stated to be very close to the PEB standard or definition and they are based on the principles of sustainability.

4.1.3 Practical experiences with PEBs

Responses show Positive Energy Buildings are not the focus in cities. A few PEB demonstration sites have been constructed or are under construction in order to learn and to check the performance in real life. Introduced examples of PEB projects include:

- A PEB kindergarten being planned in Aachen, Germany.
- In Freiburg, Germany, there are numerous examples of PEBs, such as the New City Hall "Rathaus im Stühlinger", smaller residential buildings such as the "Heliotrop®" house, the "Plusenergiehaus®" and the worldwide first commercial-residential PEB "Sonnenschiff". At the neighbourhood level, noteworthy positive energy projects include the "Solarsiedlung am Schlierberg" and NZEB development district-level projects such as the Opfingen, Rieselfeld and Vauban.
- In Vienna, Austria, there are some examples of PEB and NZEB, such as:
    - Technische Universität Wien and HSVB Kundmanngasse [22] (an office building that was renovated to passive house standard and equipped with a host of PEB technologies).
    - The MGG22 residential project (highly innovative, powered fully by renewable energy, harnessing thermally activated building structure elements, featuring environmentally friendly cooling. The MGG22 project stands out for its affordability and high levels of comfort it provides to residents.
    - Passivhaus Eberlgasse [23] is an energy focussed renovation of a residential building built from 1888 achieving passive house standard and integrating renewable energy generation technologies (ground water heat pump and photovoltaics).
    - Aspern IQ [24] is an office building constructed for positive energy performance that features an innovative façade design and building energy management system.
    - GreenHouse [25] is a student accommodation building that was developed to produce more energy than it requires, but reportedly has a tendency to overheat in summer.
- A PEB upper secondary school in Haikko district in Porvoo, Finland, serving also as an educational site for new experts to this field and raising awareness for the subject.

Many of the interviewees reported that their cities and regions are already utilizing the gained experience and are making further sustainability improvements as a result. In order to increase the knowledge about PEBs, public communication, dissemination and public engagement is needed to communicate the PEB concept, definition and benefits. Also, it would be important to share facts about realized pilots and tests, and how projects performed financially. Examples and learnings from pilots enable to roll out new development. Some interviewees also highlight the future perspective by focusing on sharing the lessons learned and challenges with today's students among others from the fields of architecture and urban planning.

4.1.4 Reactions to the PEB concept and its definition

PEB is a novel concept that is not yet reflected in city policies and local political strategy documents. Some of the respondents were aware of the PEB concept at a general level. At present, cities do not mandate or aggressively promote PEB development, with many interviewees questioning whether PEBs would be needed at all. Some stated that there is no need for PEBs if the energy supplied through the grid is from renewable sources. The reactions among the interviewees on whether there is any need for PEBs was ranging from general interest to discarding the idea of PEBs entirely as unnecessary.

Some interviewees stated that instead of focusing on PEBs, the focus should be put on renovating instead of building.

The EXCESS definition for PEBs was accepted by interviewees in general. Respondents described PEBs generally as buildings with the ambition for a net-positive energy balance over the course of a year, with some highlighting the role of renewable energy production. There was some variation with regard to whether all energy types (heating, cooling, electricity) and different groups of electricity demands (equipment, lighting, plugs) should be included or not. The need to focus at first on energy efficiency was highlighted, instead of focusing only on RES production. One of the urban planners wondered, how big a building or a building estate should be in order to match to the PEB targets and achieve a PEB in a financially sensible way.

Some of the interviewees seemed to think that PEBs would operate autonomously from energy networks. There were some comments that it would be nearly impossible to make buildings across the city fully autonomous from energy networks by (re-)designing them to cover all their energy demand themselves. They expected that it would require massive PV arrays, installing geothermal technologies, energy storage, etc. which would not be economically sensible, as the grid offers opportunities to exploit synergies between buildings (e.g. an office building that produces excess energy over the weekend is used by neighboring residential buildings for cooking, lighting, etc.).

Many interviewees emphasized the need to integrate the PEB concept into a broader definition of sustainable and high-quality building development. Moreover, it was stated that PEBs should be viewed as a part of a wider group of ecological objectives. It was noted that PEBs could be defined to include the broader concept of user-friendly buildings, which is a much more complex problem that requires a harmonious design solution that responds to local environmental, socio-cultural, urban-architectural conditions and regulations. Further, it was noted that good indoor air quality should also be considered.

Another viewpoint relates to how PEB can be implemented in society. Some interviewees stated that in suburbs, social sustainability should be fixed first, and only after it, environmental sustainability or energy issues can be addressed. However, it was noted that if energy efficient solutions can be found, there is a high demand in suburbs if the costs for living can be lowered, and especially if these would be marketed at the district level.

With regard to energy generation an interviewee commented that the option of producing electricity outside the boundaries of the building (but close to it) should not be discarded. Exploiting such potentials could contribute to lowering the impact in cities, in the sense that a common energy strategy approach between private and public space must be evaluated to move towards the ambitious objective. For example, in the promotion of energy communities it would be beneficial if developers analysed whether a close by outdoor public parking (out of the boundaries) could be covered by PV panels that could supply energy to the building. One example of this kind of development was introduced by the City of Helsinki, which targets to increase the utilisation of ground source heat pumps significantly from 1% of total heat generation to 15% by 2035, as guided by the Carbon-neutral Helsinki 2035 action plan[4]. To make this happen, the pace of building new ground source heat pump systems should be accelerated around 10 times above current levels; or alternatively, the scale of the solutions should be larger. Currently, ground source heat pumps mostly feature in detached buildings or in plots, but recently focus has shifted to larger ground source heat

[4] Carbon-neutral Helsinki 2035 action plan. City of Helsinki, website, accessed 5.8.2020 https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/julkaisu-08-20.pdf.

pump solutions, moving from building level towards bigger applications: in blocks, districts, the whole city and in the context of regional land use planning. At the larger scale, the wells could be placed also outside of plots, in green areas, parks etc. This would ease also the maintenance and the drilling of new wells when the old ones have drained, if the wells do not exist directly under buildings or other structures.

4.1.5 Affordability and financing of PEBs

Many interviewees raised the importance of the affordability of housing at the very outset of their interviews. In the context of some of the interviews the social awareness and prioritization of sustainable development was recognized, but was seen to be colliding with the requirement for affordable housing and ensuring quality of life. In this context, it was highlighted that sustainability performance needed to find a balance with the use and services of buildings as well as their energy efficiency and cost. On the other hand, one of the interviewees stated that it would be important to let go of the idea that sustainability is automatically expensive.

Interviewees broadly felt that the PEB concept would be easier to implement in the context of public buildings. A number of cities and regional representatives provided details with regard to the on-the-ground reality of financing building development. Costs were identified as the key limiting factor for the scope and ambition of projects.

Overall, PEB projects were not considered as affordable by the interviewees and it was broadly felt that PEBs would need considerable additional subsidies to make projects economical. With some interview partners appearing to define PEBs as being able to operate fully autonomously, without any energy grid connection, PEBs were associated with large investment into technological solutions that would ultimately make their development uneconomical.

One expert highlighted the central role of the building ownership, because the life cycle costs are associated with long ownership, while real estate developers tend to have a limited willingness to invest in long term technologies. Another city representative stated that while they are working towards developing NZEBs and PEBs, there is no direct collaboration with the private investors, and the private sector was generally dissuaded by the many prescriptive regulations associated with ambitious energy performance of buildings (which, amongst others, increases cost significantly). Further, it was emphasized that proper communication with investors (both public and private sector) about the necessity for NZEB/PEB development had to be ensured. Dialogue would enable the development of quality financial models that are suitable for such buildings, and encourage the removal of legal and other barriers for wider the realization of PEB.

It was estimated that PEB concept would be easier to implement in the context of public buildings. A representative from Hasselt, Belgium, explained: "*we don't only try to raise awareness, but also try to be a lead example to make 'green investments' in city-owned buildings. We make deals with companies who can take such work on, for which the city then pays the additional costs*." Acknowledging that considerable challenges would be faced regarding the implementation at the level of private residential buildings, joint public-private partnerships were identified as a possible avenue to scaling up PEBs more broadly.

Some respondents felt that the PEB concept could adversely affect the present state of the art in heating networks and pose challenges for their continued operation. With many PEBs and NZEB connected to district network, the economic feasibility of the district heating and cooling might be difficult to maintain. Centralised grid-integrated CHP (Combined Heat and Power generation) might fit well together, even when greater numbers of PEBs and NZEBs would be developed, as buildings

would be meeting their own demand with the onsite supply from renewable sources in summer, but would still require energy imports for heating and electricity during winter (especially in the heating dominated climates).

Financial support schemes to lower the cost associated with PEB development are seen as very important at all governance levels. Interviewees suggest that such schemes already exist in a lot of countries (e.g. in Austria, Finland, Germany, Poland etc.), but many would need to be ramped up even further. Existing programs include ones offered by the German KFW Bank and BAFA, the Austrian climate and energy fund and the 'Wohnfonds Wien' (for building renovation, to upgrade buildings to be more energy efficient) as well as tax credits in Finland. In Poland, programs of the National Fund for Environmental Protection and Water Management as well as the Thermomodernization and Repair Fund are highlighted. An interviewee from the Province of Limburg stresses that the financial and economic added value must be clear and cautions that higher upfront cost is a particular barrier for households with lower incomes, even if PEBs are attractive in the medium- to long-term.

Financial instruments that could be introduced to encourage PEB development include spot pricing of electricity, new energy trading systems, special low-interest loans, measures to encourage households, municipal owned buildings and the private sector to install solar panels, as well as CO_2 taxes and higher energy prices. It is further noted that co-benefits should be taken into account more strongly in the context of devising financial instruments.

4.1.6 Stakeholders involved in developing PEBs

The interview responses suggest that planning for PEBs should involve a range of different stakeholders from the very beginning. In pilot projects, it has been underlined that also the energy producers or energy specialists should be involved right from the outset, in order to avoid solutions that unnecessarily prevent renewable (e.g. solar energy) utilization. On the other hand, it is essential to explore different options in the design / planning stage and try to find the best of these.

The key actors involved in the planning of PEBs are: city representatives including the urban planning department, architects and energy planners, with the collaboration with engineers and designers of energy companies, developers, consultants, land owners, water companies, environmental protection agencies as well as building owners and users, which may include nurseries, educational establishments, youths, the elderly and others. Researchers were also listed as relevant actors, providing for instance calculations and trying to solve relevant research questions. Also, teaching students at universities about how to shape environmental architecture including zero-energy building is mentioned.

At local and regional levels, the coordination between different stakeholders is crucial. The decisions are taken at different levels regarding building and energy system planning, as illustrated in *Figure 4*. One interviewee noted that "the mutual competition among governmental and policy levels must really stop".

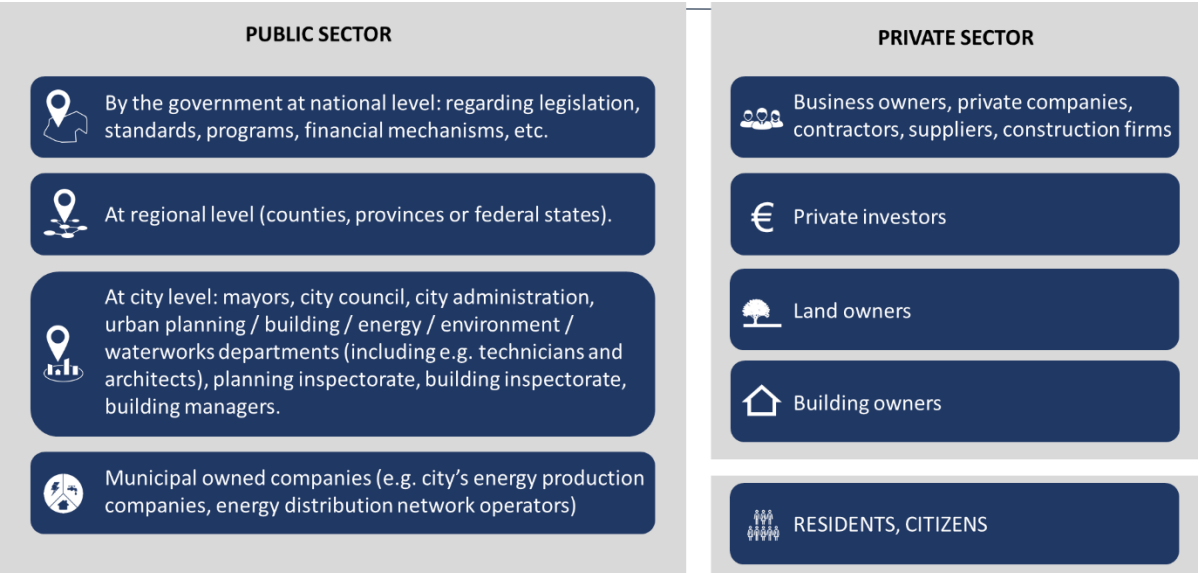


Figure 4: Diagram of principal stakeholders engaged in the decision-making process for PEBs.

Local circumstances and practises also vary, depending on whether the related operations (e.g. energy, water) are private companies or municipally owned ones, for instance. Also, land ownership was seen to have a great impact. Some interviewees also raised the question, how energy supply companies will react to PEBs, with varying comments ranging from passive energy supply companies with no interest regarding PEBs, to energy companies who have significant interest to include small-scale RE generation in their project pipeline.

Another factor influencing stakeholder composition is whether the project is a new construction or the refurbishment of an old building. For example, in Freiburg, multiple departments of the city government as well as associated institutions are involved in providing citizen's advice, facilitating access to grants and providing step-by-step guidance on energy efficient renovation strategies.

Cities and regions have different means to collaborate and exchange information. In Helsinki, for instance, every time a new urban planning project is launched, a meeting with a wide participation of stakeholders is organised, including an urban planner, district manager/director, technical planning specialists (streets, parks, water etc). In the starting meeting, the representative of a project gets all the comments related to the project, following a one-stop-shop principle. Also, different experts and actors are included in the project on a case-by-case basis. In addition, exceptions to the current detailed plan are dealt within this group. For example, if special needs pertaining to the application of PEB solutions arise that the detailed plan does not allow. However, these kinds of exceptions should have been brought up already in the development or updating of the detailed plan earlier.

Apart from a small number of exceptions, which will be mentioned hereafter, interview responses overall did not identify a great need to change the composition of stakeholders already involved. Rather, many interviewees saw the most pressing need in closer collaboration, the development of skills, capacity building regarding technical solutions and integrated, multidisciplinary approaches as well as awareness raising and the engagement of citizens and the private sector.

With regard to interviewees that identified further stakeholders, the Province of Limburg and City of Hasselt (which is located in Limburg) identified additional stakeholders such as the Flemish Energy Agency, the inter-municipal utility companies (Fluvius), the Flemish Government and other provinces. Interestingly, the interviewees from the Province of Limburg advocate for a more bottom-up

approach, whilst the representative from the City of Hasselt, which is located in Limburg, emphasized the importance of European level ambition to drive national action. The local government representative from the City of Graz highlighted that more complex PEB development would require the involvement of appropriate moderators or mediators to bring about consensus solutions and greater administration and documentation-needs would require more human resources. Lastly, the interviewee from Bologna in Italy emphasized the importance of engaging occupants / users of buildings (including amongst neighboring buildings) to a greater degree.

The collaborations are also extended beyond the local or national levels. Some regions and cities are currently collaborating with other cities in the world, such as the cooperation initiative between the City of Vienna and the City of Vancouver on "most livable cities" in which a "Vienna House" will be built in Vancouver and a "Vancouver House" will be built in Vienna. Another collaboration mean for cities are different national or regional networks and platforms, such as national Smart City networking platform in Austria, where cities share their experiences and current challenges. Other collaborations at European level include European projects related to energy rehabilitation of buildings (FP7, H2020 & Climate-KIC).

4.2 NZEB and PEB in the policy and planning instruments

Based on the interviews' responses collected, this chapter explores planning frameworks that influence NZEB and PEB development at various levels of governance. The chapter is divided into three sections, looking at (1) what policies and instruments exist at various levels of government; (2) what revisions to policy and planning instruments might be necessary to encourage PEBs and (3) whether cities and regions are planning to adapt their policy and planning instruments.

4.2.1 Existing policy and planning instruments used for Nearly Zero Energy Building and Positive Energy Building development at city and regional level

The subchapter examines a range of existing planning instruments of relevance to NZEB and PEB development. It is found that most of the cities interviewed have developed Sustainable Energy (and Climate) Action Plans and are signatories to the Covenant of Mayors. Further, interview responses suggest that energy and climate strategies tend to refer to the building sector more often than environmental strategies. Whilst regional planning is of relevance to NZEB and PEB development in a number of contexts, the degree of their impact is not easy to gauge. Urban plans, in particular at neighborhood or district-level, appear to be very important instruments to encourage or mandate NZEB / PEB development. Lastly, the interviews reveal that smart city indicators are not frequently used and it is unclear whether Smart Specialisation Strategies have significant impact on NZEB / PEB development. The policy and planning instruments used by the interviewees are listed in Table 1.

Table 1. Policy and planning instruments used by the interviewees

City	SEAP/ SECAP	Covenant of Mayors	Environmental and energy strategies	Urban plans (spatial and land use plans)	Regional plans	Smart Specialization Strategies	CityKeys - Smart City indicator set	Others what?
Helsinki, Finland	x	x	x	x	x			x (N1)
Porvoo, Finland			x	x	x	x	x	x (N2)
Opole Province, Poland	x	x	x	x	x	x		
North West Croatia, Croatia	x	x	x					
Granada Province, Spain	x	x	x	x	x	x		
Hasselt, Belgium	x	x	x	x	x			
Limburg Province, Belgium		x		x				
Aachen, Germany	x	x	x	x	x	x	x	
Greater London Area, UK	x	x	x	x	x	x	x	
Pamplona, Spain	x	x	x	x	x			
Freiburg, Germany	x	x	x	x	x	x		
Vienna, Austria	x	x	x	x		x	x	
Bologna, Italy	x	x	x	x	x			
Graz, Austria	x	x	x	x	x	x		

(N1): In Helsinki, they are using tools to assess impacts, e.g. eco-efficiency indicator tool KEKO [26]
(N2): In Porvoo, they have developed a Climate Program, which contributes to the city strategy [27].

Sustainable Energy (and Climate) Action Plans SE(C)APs and Covenant of Mayors

All interviewees but one at city-level confirmed that Sustainable Energy Action Plans (SEAPs) or Sustainable Energy and Climate Action Plans (SECAPs) have been developed. These plans outline goals, targets and actions for sectors including energy, mobility as well as climate change adaptation and mitigation (e.g. Pamplona, Spain). The City of Hasselt in Belgium complements its more technical SECAP by implementing additional projects that are more acceptable for - and easier to promote to – the public. Similarly, in the context of the City of Helsinki (which launched the Carbon-neutral Helsinki 2035 action plan) it is emphasized that analyses and calculations alone are not enough, but that targets must be tied to concrete measures to reduce emissions.

The Finnish City of Porvoo has not introduced a SEAP or SECAP, but the city's climate program is very similar, as it aims towards carbon neutrality by 2030 and includes over 50 actions to achieve this (incl. on energy efficient buildings and renewable energy generation). Whilst regions interviewed have not set up such plans, cities in these territories have developed SEAPs or SECAPs. In the Province of Granada, Spain, up to 86 such plans have been developed by cities.

Apart from the City of Porvoo, all cities in which interviews were conducted are signatories to the Covenant of Mayors (CoM). Illustrating the levels of CoM engagement it is noted that the City of Hasselt makes use of the reporting tools and is part of the 'Future Proofed Cities' group. In the City of Freiburg, key CoM action areas related to energy saving, energy efficiency and renewable energy generation are highlighted. All the regional representatives interviewed know cities in their jurisdiction that are CoM members.

Environmental and energy strategies

Strategies on environmental and energy issues that impact NZEB and PEB development could be identified in all cities as well as in two of the three regions. Many strategies appear to be focused on energy and climate mitigation, with broader environmental targets and related actions featuring less prominently. Selected foci of city-level strategies include energy efficient buildings (Porvoo), the integration of renewable energies (Pamplona), the intelligent use of locally available, viable energy resources and the greening of building facades and roofs (Vienna). Whilst the focus of the interview is on strategies for NZEBs and PEBs, two interviewees note that sustainable transport is a significant priority in the context of environmental strategy-making (Pamplona and Porvoo). Environmental strategies of relevance to PEBs and NZEBs at regional level include national acts that must be implemented by a region (North West Croatia) as well as the Local Agenda 21 or regionally coordinated city networks (Granada Province).

Urban plans (spatial and land use plans)

Urban planning documents play a role in the development of energy-efficient buildings / building-integrated renewable energy generation in all of the cities about which interviews were conducted. Responses suggest that, whilst overarching development plans contain goals and broader action areas that are relevant to NZEBs and PEBs, more detailed plans at district or neighborhood level can include very specific building performance requirements. Some interviewees stated that urban plans can encourage development to go beyond regulations and can set binding requirements in relation to urban design, building typologies, transport infrastructure, ecology / green space, etc. Planning starts with setting the targets for the plan: the aims and the purpose of the plan. Many strategic urban development plans can be found to place considerable emphasis on energy-related goals and the sustainability of the built environment. For example, in the Spanish region of Andalusia, regulations stipulate that urban planning must include an energy analysis. Also, the City of Limburg is developing ‘zonal heat maps’, which could be an important foundation for individual projects to identify what space or zone could be used for what specific purpose.

Yet, it was noted that there should be freedom to define targets broadly, and not stipulating single technical solutions too strictly. The level of detail increases in each step of the process and the detailed local plan tends to have the biggest effect on the building level. The urban plan seeks to create possibilities and incentives for good solutions, but the choices are finally made by the builder/building owner. There are some possibilities to affect this in the lot release terms, for instance by giving discounts on the lot price if energy efficient or renewable solutions are used. In one project in Porvoo, Finland, the inhabitants got a discount if they agreed to give energy data to support research. Many of these actions require technical projects or designs, as well as financial expertise.

The case of the City of Freiburg demonstrates how NZEB and PEB requirements can be embedded into development plans: the “Perspektivplan Freiburg 2030”, which articulates the overall vision for urban development, forms the basis for the articulation of the city-wide land-use plan as well as complimentary frameworks and concepts. These in turn are then used to develop more concrete development plans and, in the case of new development sites on land that is owned by the local government, buyers of building lots are required to sign contracts to guarantee that minimum energy performance standards and other sustainability requirements are met.

As another example, Helsinki searches the best possible places to affect and guide the urban area development through testing different choices both in the urban planning and through the terms for the plot assignments. They can also set stipulations to the terms of the plot assignment (this can be also a benefit for the construction company, if they can offer solutions that support city's targets).

Regional plans

The impact of regional planning on city-level NZEB and PEB development is more mixed and generally appears less significant than the strategies and plans of individual cities. Interviewees representing regional actors mention intentions to establish cooperation plans for larger cities as well as counties, but it remains to be seen how prominently the building sector will feature in these. Granada Province has developed a set of strategies, such as the Energy Strategy for Granada Province or the Urban Plan for mobility that also encompass buildings, but it is noted that these do not always reach the local level. Yet, regions are working to increase small scale RES, as for example in Granada Province, where the local urban environment and building use is studied and later the possibility to integrate renewables is analyzed.

Smart Specialization Strategies and CityKeys - Smart City indicator set

Strategies that seek to establish and encourage economic or technological specialization have been developed in most cities, but in many cases, it is unclear how much impact these have on the NZEB or PEB development. The Smart City Framework Pan of the City of Vienna includes a range of goals and targets that form the basis for more concrete programs and initiatives related to energy efficiency and RE generation in the built environment. Further smart specialisation strategies of note include the Polish National Smart Specialisation Strategy (which includes the focus on sustainable energy) as well as two specialisation clusters in Freiburg, namely the Green City Freiburg cluster (sustainability) and innoEFF cluster (climate and energy efficiency). Regional engagement in smart specialization is comparatively limited, with only Granada Province and the State of Baden-Württemberg appearing to be coordinating such efforts (according to the interviewees' answers).

Only a few interviewees from city and regional level were able to confirm that smart city indicators are being used. Vienna's aforementioned Smart City Framework Plan is underpinned by 153 indicators that use 47 data sources, Aachen uses an energy management system that complies with the European Energy Award and London is introducing an energy monitoring requirement for newly constructed buildings in 2020. In relation to indicators the interviewee from Helsinki stresses the importance of evaluating social sustainability and prioritizing this over energy efficiency and the representative from Graz notes that smart city indicators are being developed.

4.2.2 Revising policy and planning instruments to encourage PEBs

City and regional level stakeholders largely indicate (in Table 2) that policy and planning instruments would need to be adapted to encourage the broader development of PEBs, (57.1% of interviewees). 28.6% of interviews qualified their response by stating that these would have to be partly changed, whilst 14.3% stated that no changes were needed.

At a policy level, a number of interviewees state that considerable shifts would be needed, but there would likely be insufficient will to do so.

One interviewee highlights a greater need to mainstream ecological building design than PEB development at the moment. It is also mentioned by several interviewees that PEB development is not a priority of elected officials and many decision-makers in public administration.

Table 2. Overview of Interviewee answers regarding whether policy and planning instruments require changes.

City	No	Partly	Yes
Aachen, DE	0	0	1
Freiburg, DE	0	0	1
Granada Province, ES	0	0	1
Greater London, UK	0	0	1
Hasselt, BE	0	0	1
Limburg, BE	0	0	1
MoE, FI	0	1	0
North West Croatia, HR	0	0	1
Opole, PL	0	1	0
Pamplona, ES	0	1	0
Porvoo, FI	1	0	0
Vienna, AT	0	0	1
Bologna, IT	0	1	0
Graz, AT	1	0	0

With regard to planning and regulatory instruments, several interviewees would see a need for changes at various levels of governance to allow for a shift towards PEBs. Policies that aim to protect historical buildings and districts, for instance, can be an obstacle to realizing PEBs, with roofs and facades being protected and PV installations being forbidden. Lastly, grid integration and feeding PEB energy surpluses into the grid was identified as an area where regulatory change would be needed.

The planning process

Just over half of the interviewees believe that current planning processes do not need to be adapted further to promote PEBs. It should be noted, however, that there were differences in how individuals interpreted the word “planning”, with some referring to procedural planning steps whilst others also saw planning to include the conception and design of individual PEBs.

Speaking more generally, some interviewees stated that national policy needed to be more ambitious, whilst others noted that a clear commitment from politicians to back a PEB standard would be required, even in national legislation. On the other hand, it was cautioned that in addition to focusing on PEB development and local renewables, also the changing climates need to be taken into account, to assure that PEBs are able to perform as intended in the future.

At the regional level, interviewees called for the better integration of urban and energy planning (North West Croatia), for changes on the planning process to influence building design from the outset (Granada Province) as well as for integrated approaches to ensure that PEBs are not only efficient and using sustainable energy, but are also comfortable and affordable. Further, the interviewee from

the Province of Opole added that priority should be placed on combatting urban sprawl and (at a building-level) passive energy gains should be prioritized in planning and design, before focusing on PEB technologies. Moving to the city level, the interviewee from the City of Freiburg remarked that the city council would have to revise current strategy documents and embed new targets into planning documents as well as plans for new urban development sites to promote PEBs.

The City of Porvoo highlighted that the starting point is that it should always be possible to make a Positive Energy Building within the framework of the urban plan. The potential challenges will be assessed, and solutions are looked for, ref. taxation of energy from the lot next door. The microclimate is very carefully considered in the local detailed plan, e.g. regarding the orientation of the buildings.

One interviewee stated that before implementing PEBs at the city level, there are broader questions: where is the building situated, in which kind of environment? Is PEB needed in this environment? How will it contribute to the environment? Is there a use for the energy that is exported from the PEB? What other types of energy sources (e.g. from waste) are available? The survey found that both Freiburg and Porvoo rely on 100% renewable energy, hence PEBs are less relevant there. It was observed that many cities promote and prioritize the energy efficiency of the building and renewable energy integration. However, there are relatively few cases or locations where PEB are given priority, as shown in Table 3.

Table 3: Do you give any priority for PEBs?

City	YES/NO	Notes
Helsinki, Finland	Yes	Plots are assigned in competitions to constructors, energy class is one of the key factors in the bidding competition
Porvoo, Finland	Yes	E.g. the discounts on the lot price, see above in 4.2.1
Opole Province, Poland	Yes	Each of the factors is important. However, addressing human needs should be the key priority.
North West Croatia, Croatia	Yes	We do more and more. REGEA has been involved, for example, through Interreg Central Europe eCentral project (as lead partner) where the partners developed an EPC tool (Energy Performance Calculator). EPC intention is to be helpful and handy for public officials in order to help them in assessing possibilities and potentials of turning existing public buildings through discount energy retrofitting into nZEB standard.
Granada Province, Spain	No	
Hasselt, Belgium	No	
Limburg Province, Belgium	No	
Aachen, Germany		In municipal buildings, there is priority, but in the private sector, the feelings are that these types of buildings do not have much priority.
Greater London Area, UK		We encourage developers to ensure their buildings consume as little energy as possible and to go beyond our minimum standards. We don't have policy specifically on positive energy buildings.

Pamplona, Spain	No	There is not a priority at the moment. It is market regulated, in the sense that if in a public tender one proposal is PEB, and it shows it is a better option than a nZEB from an economical point of view, then that would be the winning proposal.
Freiburg, Germany	No	PEBs are not a key policy priority in the City of Freiburg. Whilst building-integrated renewable generation is encouraged through generous grants, the biggest priority is to focus on increasing the share of renewable energy distributed by the electricity grid and ensuring high energy efficiency in the context of district and neighbourhood level schemes.
Vienna, Austria	Yes and No	The building code calls for NZEBs to be built (but these can be connected to gas and district heating, which undermines their nearly-zero performance). In projects in which the city's department of energy planning is involved in, great efforts are made to ensure highest levels of energy efficiency and local renewable energy generation. At the political level NZEBs / PEBs prioritisation is not fully mainstreamed, due to differing agendas of political parties and conflicts of interest.
Bologna, Italy	Yes	
Graz, Austria	No	Refurbishment is more the solution, with lot of potential for energy savings. The financing of PEBs is a big challenge. People want normal housing that they can afford.

Building standards, codes and permits

Normally, regulations at national level set the minimum standards on energy efficiency performance and energy generation for buildings, which are guided by the European Energy Performance of Buildings Directive (EPBD). According to some interviewees, the EPBD places a strong emphasis on passive house approaches (meaning buildings that require very little energy). These national regulations can be complemented with additional requirements at regional and local level such as the case of Aachen (Germany), where public buildings owned by the municipality must achieve the passive house standard or the case of the City of Vienna where more ambitious sustainable development targets for investors or real estate developers have been set in strategic development areas. Interviewees also identified specific regulations for certain parts of the buildings, such as in the case of Poland with the thermal insulation of buildings or the self-consumption in Spain.

In relation to building standards and codes, interviewees' responses varied considerably, with some seeing the need for significant changes, whilst others see little or no need. In Pamplona restrictions pertaining to renewable energy integration would need to be reassessed and whilst an interviewee from the Province of Limburg suggests that new construction should not only just-about reach minimum requirements, but buildings should also be designed to accommodate further improvement in the future. Lastly, the need for quality control and auditing as well as the clear definition of standards (and closing loopholes) upon which approvals are based is highlighted. In some contexts, loopholes and exemptions in the building code need to be addressed. For example, it was stated that the Austrian ÖNORM standard for building technologies is outdated and - particularly in relation to minimum heating capacity requirement - needs to be loosened significantly to increase the cost competitiveness of heating from renewable energy sources.

Interviewees identify the need to change regional and national building standards as a key requirement to promote PEB development. In North West Croatia, the Regional Energy Agency is pushing for substituting the NZEB with GDSG standard (Green Deal Smjernice Gradnje/ Green Deal Construction Guidelines), for instance, to introduce the PEB concept and promote its adoption at county, city and private sector level. In Austria, a new standard (Klimaaktiv) is under development to certify the sustainability of city quarters.

Some interviewees described how their building permit process is designed to support the designer. In Porvoo, for instance, building lots for development are released in autumn, but the building process is only allowed to start in the spring. This gives plenty of time for the builder to consider different alternatives. The building supervisor gives advice in an early phase, before any decisions on the buildings structure etc. are made. This is part of the Porvoo city's proactive quality assurance process, which has received excellent feedback from clients. Among others, they report to have got information that they did not even know that they should have during the planning process. The choices made in the building design phase will be seen in the life-cycle costs. A weakness observed in the Finnish building code, on the other hand, is that the integration of sustainable building technologies can be prevented in certain circumstances.[5]

According to the survey it is also observed that more new knowledge is needed to change present regulations so as to allow more flexibility in terms of energy efficiency, renewables and other measures at the building level.

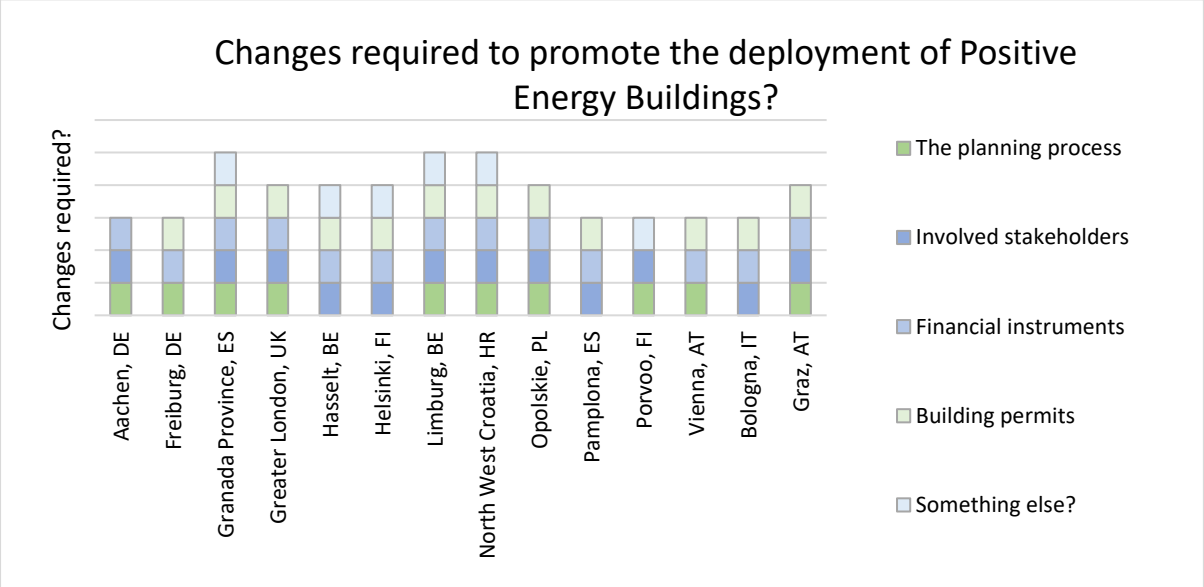


Figure 5. Ideas raised in the interviews for potential improvements to policy and planning instruments

4.2.3 Plans to adapt planning instruments that will impact PEB development

A number of cities and regions covered in the interview are adapting some of their instruments, and participating or following current research and pilot projects, which will impact upon building energy efficiency and building-integrated renewable energy generation. Examples of these activities include:

[5] e.g. air-to-air heat pump installations to existing buildings aren't happening in some cases, because pipes are not allowed to be installed externally and installing them inside the building structure is often too expensive, if not done at the same time with a deep renovation of HVAC systems.

- In the United Kingdom, the government is consulting on new national building regulation which will also affect London's policy. Primary energy may become the principal metric for new buildings, but government has not confirmed its decisions or the timing of this yet.

- The City of Freiburg is currently conducting a review on whether energy efficiency standards for buildings should be adapted (made even more stringent), but the interviewee suggests that the chances of this happening are slim.

- The City of Vienna is continuously expanding spatially defined energy / climate protection zones called "Energieraumpläne"[28] in which newly constructed buildings may not derive energy from fossil fuels.

- In Finland, the Land Use and Building Act is currently being changed. It has been discussed that the assessment of climate effects would be mandatory. The main aim is to mitigate climate change.

- The Provincial Council of Granada, through the Provincial Energy Agency, is involved in the POCYTIF project of the Horizon2020 programme on positive energy districts. It is expected that the results of this project can be applied in the City of Granada and in the rest of the municipalities of the province. Generally, the Spanish regulation (CTE), which regulates the basic requirements of energy saving, has been updated in September 2020 and is addressed to the design a more efficient and sustainable buildings.
- The representative from the City of Graz does not see a need for new planning tools. Instead, needs such as funding, courageous politicians, and social / behavioral change are emphasized. Further, it is noted that PEBs are not yet sufficiently understood (definition, technical requirements and cost), hence it is too early for governments to take action.

4.3 Technologies for Positive Energy Buildings

4.3.1 Building technologies

Interviewees broadly felt that PEBs and NZEBs should be planned in a much more integrated manner by developing energy concepts that consider aspects such as building technologies, airtightness, windows, renewable energy generation, etc. as well as energy flows out of and into the buildings. Indeed, in relation the conception and design phase of real estate development, it was suggested that energy targets should be included in the process from the start of a project, because altering plans at a later stage is much more challenging.

There were also reservations regarding the challenge to find synergies between different load profiles of PEBs. In this context, the importance of energy grids was highlighted, as these provide flexibility in terms of sharing the load profiles of different buildings, which might not be possible with PEBs if they are autonomous.

Answers from the interviewees suggest a broad consensus that in order to move to a PEB standard, the building shell has to be improved to lower energy demand as a priority. Further, it was noted that energy systems have to be highly efficient and thus lower the energy production requirements from Renewable Energy Sources (RES) to achieve the PEB standard. Seeming outliers from this general view

were the interviewees from the cities of Helsinki, Bologna and Graz, who did not mention the building shell as a high priority. This divergence might be due to the fact that strict requirements for new buildings are already in place, with only small reductions of energy demand possible if further tightened.

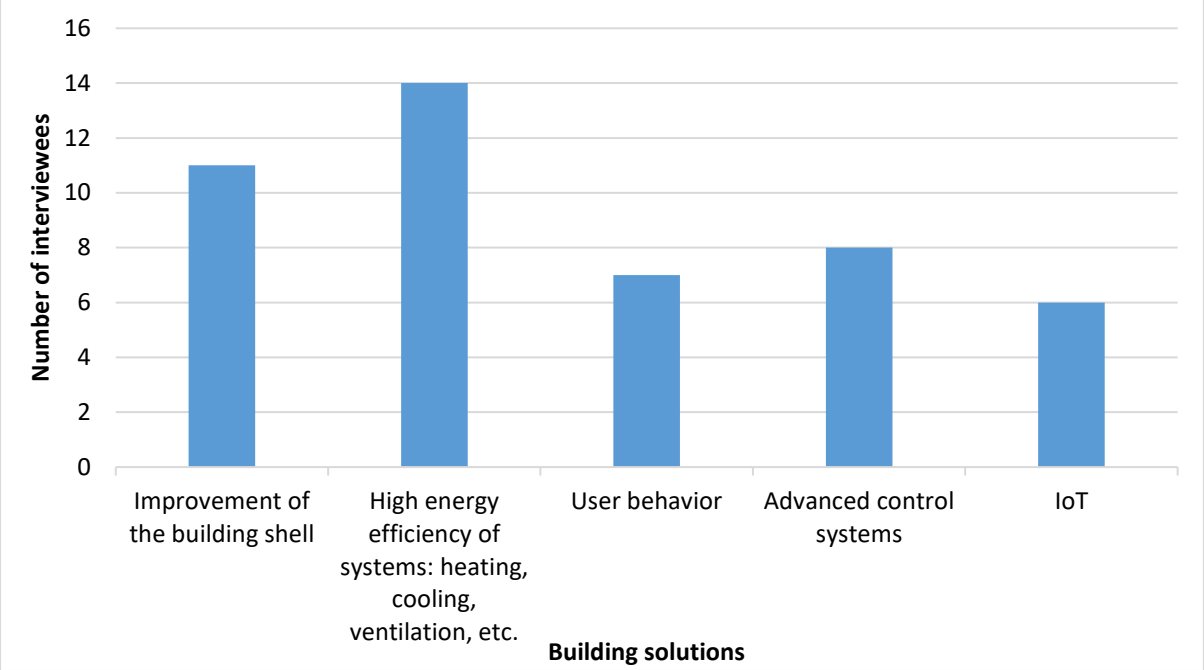


Figure 6. Which positive energy building solutions have the most potential for broad implementation in your geographic and climatic conditions?

According to interviewees, user behavior is generally seen to have significant impact on final energy demand of the buildings, therefore information campaigns play an important role. Concentrating on user behavior opens up possibilities to have a big influence without big technical changes in the building shell or systems. A user behaviour study conducted by the City of Aachen indicated that measures to influence behaviour (through learning lessons) decreased energy consumption by 8%. The inclusion of central laundry rooms in the houses was mentioned as a practical example of how to encourage energy efficient user behaviour. User satisfaction is also seen to play an important role, hence buildings should not only be energy positive, but user comfort is an important consideration, also.

Another example worth mentioning is the Sustainable Lifestyles Accelerator [29] experiment in Porvoo. In this exercise the inhabitants developed a road map for themselves with the help of an easy-to-use tool. The tool provided several understandable and easily applied methods from which the family could choose the best for them. The most popular and effective methods were related to mobility and food, but also methods related to building energy demand were often included, e.g. shorter showering times and lowering room temperatures. Representatives from the City of Porvoo noted that "*The key word is the concretizing, the methods were described in a very concrete way*." The first results indicate that the inhabitants did not consider the actions too difficult to implement and keep up.

Regarding the advanced control systems (ACS), interviewees reported high interest and, whilst there was no universal consensus, related interventions were viewed as critical to reduce the energy

demand. In a number of interviews, it was noted that the introduction of technologies such as ACS had to be progressive.

Finally, it is interesting to note that the Internet of Things (IoT) seems to be deemed as not so important, with only a half of the interviewees identifying related solutions as important for realising PEBs. Those who identified IoT as one of the technologies with high potential also considered the previous four solutions as important.

Interviewees listed the following aspects as having the biggest effects on realizing NZEBs and PEBs:

1. The recognition of local conditions in particular regarding the possibility of obtaining energy directly from the surroundings of the planned facility.
2. Integrated design.
3. Functional and spatial design.
4. Design to minimize energy needs by passive means: choice of location, orientation, insulation, natural light, shading/insolation, ventilation, etc., focusing at first on passive heat recovery and recuperation; and accumulation of thermal energy, based on functional, construction and material solutions.
5. Evaluation of possible RES, and active solutions for the accumulation of thermal energy, based on technical devices.
6. Design of renewable energy installations and use and maintenance plan.

In relation to the technical performance of PEBs and NZEBs, it was noted that, as 2/3 to 3/4 of energy demand in buildings is typically associated with the conditioning of interiors (heating, cooling, ventilation and warm water), it is important that one does not place too much focus on electricity self-supply in the context of NZEBs.

It seems that many new buildings, which conform with NZEB standards (and for which energy efficiency ratings have been calculated in energy performance certificates), perform well only on paper. In reality, many such buildings in Austria are equipped with vastly overproportioned energy solutions, drawing significant amounts of energy from the combustion of gas / via district heating and require great amounts of electricity for cooling. NZEBs need to be planned in a much more integrated manner by developing energy concepts that consider aspects such as building technologies, airtightness, windows, renewable energy generation, etc. as well as energy flows out of and into the buildings. Such an integrated approach is conducive to buildings that have a minimal need for energy to be brought in from external sources during operation.

The opinions about the importance of cooling varied. While one interviewee stated that cooling is of low importance, another interviewee raised the need to increase the focus on cooling due to overheating in summer. In some locations, low carbon cooling is becoming increasingly important, with high performance and financial viability being key considerations. An interviewee noted that local cooling systems (e.g. with heat pumps) seem to be a better option, which is why they have been working for a long time to create plus energy buildings and, so to speak, help to generate, use and consume the energy on site.

4.3.2 RES in PEBs

The PEB definition developed in EXCESS mentions that a PEB is a building that produces more energy than it consumes, and it refers to the Renewable Energies Directive [30] to find the renewable energy sources that can be used to achieve the PEB standard. Therefore, in order to find the potential of

the RES for small scale installations, the interviewees were asked about different RES and the applicability and appropriateness of these in their local context. The interviews confirmed that different approaches are needed depending on the location, whether the building is in the city or on the countryside.

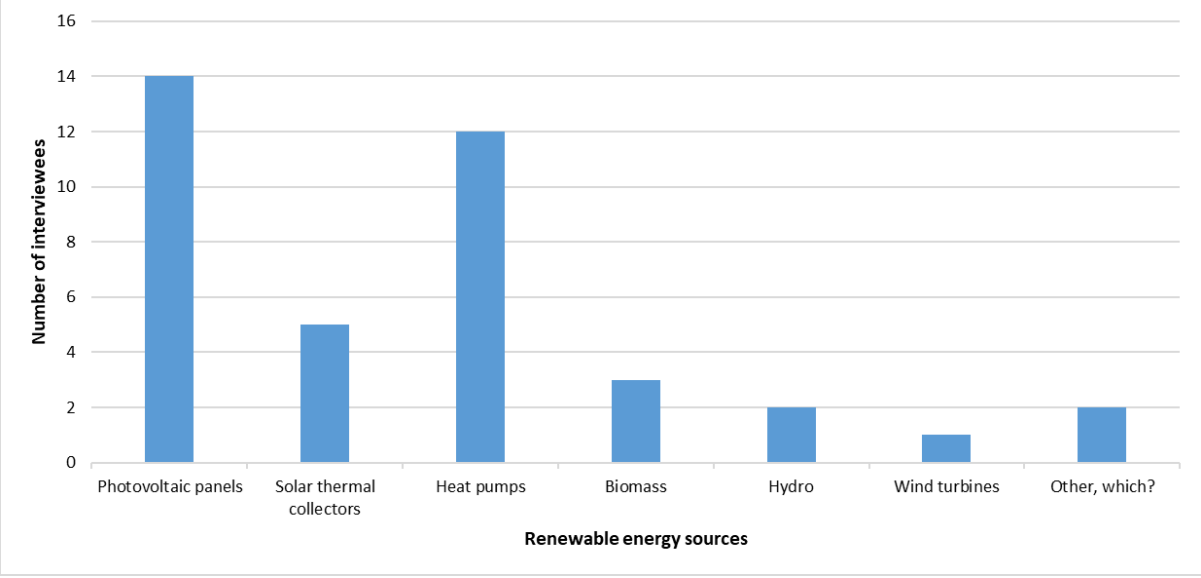


Figure 7. The interviewees' response to the question: "Which renewable energies have the best potential for small-scale installations in the region/city (from the legislation viewpoint)?"

There is clear evidence that the most suitable technologies are perceived to be PV panels and heat pumps, which coincides with the common solutions implemented in the different pilots in EXCESS. Therefore, EXCESS demos are well aligned with the objectives from the different authorities that are working on or with planning instruments to empower the PEB concept.

There are two more technologies that could be important in the PEB deployment. One of these is the solar thermal collector, which in conjunction with the aforementioned PV panels highlights the importance of solar resources that can be harvested by buildings. Besides, these technologies can be combined in PVT panels, which generate electricity and thermal energy at the same time, and it is a technology which will be installed in two of the demos in EXCESS. Another interesting technology is biopower, with plants having a low CO_2 impact, if the location has good biomass availability.

Some interviewees also saw some potential in technologies such as hydropower, wind turbines and excess(/waste) energy resources. Regarding these technologies, it should be noted that wind turbines were considered to be a city-level rather than building integrated solution, therefore not fitting very well the PEB definition's emphasis on on-site RES. In relation to waste resources it was noted that such technology had potential in the context of a district heating grid, hence it is a solution that tends to be considered at district or neighborhood level and not by building planners. Finally, for hydropower the availability of water resources in the surroundings limits the widespread adoption of this technology, especially at building level. One interviewee also noted that there might be some local limitations for the use of hydropower due to potential ecosystems impacts, which need to be carefully assessed before installation.

Some interviewees commented on the topic at a more general level, with one noting that the answer depends on the location of the object and local conditions. Many interviewees also commented that when talking about energy demand and balancing, the focus needs to be scaled up from the level of

individual buildings: "[an] *open discussion is needed about the energy system (in general)",* as one interviewee formulated it.

> *"In all cases, it is important to make a holistic assessment and time related scenarios. What suits one area/building is not useful for others, and maybe a certain order of the actions would be the most cost and carbon efficient." City of Porvoo, FI*

The need for the holistic assessment was brought up also by another interviewee, from a different perspective:

> *"Multifunctionality is an important factor or condition, for example when it comes to energy regions or landscapes. We believe that the energy must be produced as close as possible to where the demand is located; therefore, we need as many multifunctional applications as possible. For example: solar panels capture sunlight, but also shadow if they are placed in a certain way, which could then be used to provide cooling. That should be the guiding principle, even though it is not easy to translate that to very specific regulations."* - Limburg Province, BE

The discussion with Porvoo representatives raised the question of what challenges a large roll-out of PEBs would pose for the energy system, which is largely based on renewable CHP at present. With a high share of NZEBs or PEBs, it is no longer economically feasible to build up or maintain district heating and cooling infrastructure. These district networks are, however, seen as a very good way to balance the heating and cooling needs inside the city (e.g. by using waste heat). Further, if the heat is not needed, it is unclear how electricity would be produced during winter, which is currently provided via highly energy efficient CHP. New solutions would therefore have to be developed for this new situation where energy production is distributed at building level. With a small amount of PEBs, this could still be relatively easy now, as the CHP would provide the heating and electricity during winter, and the houses could cope with their own systems during the summer.

In some interviews, the interest of people towards onsite renewable energy generation were discussed - with opinions on popular sentiment diverging. One interviewee told of a case where a family was moving to a new town and contacted a city representative, asking where to find an apartment that is heated with a ground source heat pump. She reflected that perhaps the energy source in the own home starts to have a bigger effect in choosing one's home in the future, and it of course does affect the costs of the living. In contrast, another interviewee stated that people do not want to live in positive energy buildings, because the costs are unfeasible and PEBs are too complex, so instead of PEBs, the carbon neutral way of living should be found through other life style changes (such as eating less meat).

4.4 Assessing of PEBs: indicators, data collection and monitoring

4.4.1 Criteria for assessing PEBs

Primary energy use and the efficiency of the building were considered key criteria for assessing PEBs. However, some discussions were noted to be ongoing whether or not it is enough to focus on the energy efficiency of buildings. Adopting life cycle analyses was raised as a good alternative, although this option is difficult to implement in private buildings. Further approaches mentioned included the ecological footprint as well as the carbon handprint or footprint classification.

An interesting finding in the survey is that energy performance measurement criteria can be based on the emissions caused by the building rather than the energy consumption. For example, in the UK,

the primary metric towards energy performance in new buildings is CO_2 emissions instead of the energy consumption. London's carbon neutral policy has been in place for all major new residential buildings since 2016 and a carbon neutral policy for major non-residential buildings will be introduced in 2020. Through this policy, the carbon neutral targets for new buildings contribute directly to the London's carbon neutrality target by 2050.

In one interview, city representatives were wondering if construction phase related carbon emissions could be included as well by taking into account the costs of the carbon emissions (calculated through carbon ton price) in total construction costs (they noted that they had heard of such experiments in the Netherlands). This kind of new classification for building projects could be developed through some real-life pilot projects through plot assignment competitions and monitored to gauge whether such an approach might be sufficient and guide development well enough.

4.4.1 Data collection about energy efficiency and RES in buildings

In some countries, the data collection and the energy targets are more centralized at national level, such as in Poland or Croatia[6] whilst in other countries data are collected mainly by regions and municipalities, which use their own tools and indicators to manage and monitor it, such as the case of Spain, Austria or Germany. In these cases, municipalities even have their own energy targets.

The data refers mainly to the energy consumption (thermal and electrical) and energy efficiency of the buildings, the production of green energy, and also, the greenhouse gas emissions (in Poland as part of the national targets for sectors not included in the EU Emissions Trading System – ESD sectors). In some cases, the information also includes the share of renewable energy powering district heating networks and the amounts of electrical and thermal energy produced by the city's energy plants.

The granularity of data collected depends in some cases on the type of buildings, such as in the case of Vienna, where data collection and evaluation is a particular priority in relation to educational buildings, or in Finland where specific information on the heating systems is required for single-family houses. At local level, data collection appears to focus mainly on municipal buildings, whilst collection at regional level or national level normally includes all types of buildings, not only the municipal ones.

The level of information collected also differs depending on whether the building is a new or existing one. Further, some data is collected to identify some specific issues such as fuel poverty, such as in the UK. There are different sources of data and some of them are provided by the energy suppliers.

In some cases, the information is collected during the building permitting process, such as in Finland, whilst in other cases different tools are used to monitor electricity use and energy consumption once the building is built, such as in Belgium. At regional level, other tools, such as the "dynamic energy atlas", also in Belgium, are used for regional planning.

4.4.2 Indicators used in the data collection

Most of the information collected relates to the efficiency in the energy consumption, the electricity fed into the grid, and the shares of different energy generation sources/systems including renewables and the greenhouse gas emissions. Other information, such as the year of construction, the occupation or the surface are collected to obtain indicators that link energy consumption with these variables. For example, one of the most useful indicators used in the City of Pamplona is the ratio

[6] North West Croatia: a national ISGE system for public buildings; and EMIS Energy Management Information System) for buildings. [31]

between the energy production from RES per citizen (kWh/pax), whilst the indicator that is used the most in Aachen and Bologna is kWh/m^2·y, which means the ratio of energy consumed by a building per area in one year. Other indicators used in the City of Vienna are the final energy consumption in kWh / person or the energy consumption for room conditioning (space heating, air conditioning and hot water per capita) in kWh/capita. As mentioned previously, several indicators depend on the energy use, use of the building, etc. These indicators are frequently updated and analyzed, such as in the case of Poland which conducts a review every three years.

To make information understandable, energy certificates or labels with letters or codes are commonly used, which give an idea of the energy performance of the buildings. If the builders, such as in Finland, choose to build to higher specifications than building requirements dictate, this higher performance is clearly shown by the specification of the building's energy class (or via a letter score in energy certificates provided in countries such as Spain).

4.4.3 Assessing the PEB status for an individual building

According to the answers collected from the interviewees, it is clear that the best option for assessing PEB performance is widely believed to be energy metering, hence the deployment of energy meters and monitoring of the energy data is critical to confirm that a building behaves as a PEB. In North West Croatia there is an initial audit regarding energy aspects.

For data analysis, there is no clear agreement on the time period of data collection, in the sense that one of the interviewees mentions that one year is adequate while another mentions biannual data collection. Other interviewees do not refer to a specific period of time and one mentions to do the control of the energy consumption during the lifespan of the building.

There is broad consensus that energy metering and controlling are key to enable the optimization of energy consumption. Aligned with this point it is furthermore noted that such monitoring allows users and building managers to learn how a building consumes energy and how, after a learning period, its energy consumption can be reduced. Management and control systems are also viewed as an important tool to manage energy efficiently and to know and respond in real-time to situations of surplus energy generation. Control system user interfaces can also help individual house owners to see the impacts of energy consumption on financial aspects (payback of the installations etc.).

Regarding what to measure, energy consumption is mentioned most frequently, with the most detailed approach defined in Hasselt, which mentions *"electricity consumption/production by business and heating production/consumption by individuals and households*". In addition, costs are also considered as important criteria, especially the very high costs for the end-users to invest in PEBs in the beginning, unless the long-term benefits (e.g. reduced costs in energy bills) are clear.

In Vienna**,** in development projects in which the city's department of energy planning is involved in, energy calculations are examined and the modelled performance is compared with real performance, by checking data from the main electricity meter. In case of significant divergences between calculated and real performance individual components are examined in more detail. In a PEB project called MGG22[7] (in Vienna), monitoring looks at energy demand, energy generation and energy imported from a wind park outside Vienna (which when the grid has an overcapacity does not switch off, but allows the PEB to store the produced surplus).

[7] The MGG22 residential project is highly innovative, powered fully by renewable energy, harnessing thermally activated building structure elements, featuring environmentally friendly cooling.

On a more critical note, one of the interviewees stated that past monitoring projects were often carried out by academic partners who tended to go overboard with regard to installing sensors and data collection frequency, which resulted in huge datasets that could not be evaluated easily. Building on this experience, the current approach is "less is more" and only core indicators such as input / output are examined routinely.

It was also stated that when talking about monitoring, it is not only about operations, but focus should also be placed on controlling the monitoring: How to set up the process and ensure what actually works. This has not yet been established, and that means that monitoring and evaluation systems have to be set up via data platforms- which will of course also have to be financed.

4.5 Governance and policy making

4.5.1 Financial support for EE and RES in buildings

A variety of financial support schemes for energy efficiency and renewable energy systems were outlined by the interviewees. Grants and incentivization schemes are regularly being developed to address specific challenges in the built environment, such as in Poland or Pamplona to promote the installation of PV panels in residential buildings, in Freiburg that provides funding for the energy renovation of residential buildings via the support program "Förderprogramm Klimafreundliches Wohnen" or the City of Vienna with different programs addressing thermal and electrical energy storage, solar thermal applications, heat pumps, etc. In Bologna, building owners are entitled to a fiscal deduction of all expenses for energy renovation.

In addition to the subsidies, some countries such as Croatia have developed financial models at national level to boost the energy rehabilitation of buildings. At local level a good example of small financial incentives is being implemented Hasselt (in Belgium) with its 'now or never deals' program, where businesses can purchase a full package of helpful tools that should be paid back only when it's clear that they can recuperate profit from this investment within the next two years. Tools the private sector can utilize include an energy audit via an energy coaching program. Further, 'green investments' are made in Hasselt's city-owned buildings and companies who can work on such projects are given additional investments. Another innovative tool to promote energy efficiency is the 'purchases in group' for green energy investments initiative (e.g. for heat pumps, solar panels, green roofs, insulation, etc.) coordinated by the Province of Limburg (Belgium).

Other measures are more oriented towards disincentivising energy consumption, such as in the case of the Greater London Area, where developers must make an offset payment if they cannot achieve the zero-carbon target on site. Also, a higher carbon offset price has been introduced, which will incentivize developers to go beyond the minimum on-site carbon standards. One interviewee from Graz stated that instead of new PEBs, the focus of the regulation should be put on taxation of carbon, gas and oil, and in buildings to the renovation of the existing building stock. In one interview, the effectiveness of incentivising versus mandating change in the built environment was reflected upon: *"the Flemish and Belgian governmental need to move away from non-binding measures. Those are often linked to certain incentives such as grants, but usually don't work well together. Therefore, we think it would be good to rethink that pattern and make more sustainability-related elements or programmes mandatory, yet affordable too."* The interviewee continued, "*The commitment should be put on paper as well; we see that 'freedom of choice' in this regard works more restricting than it is empowering improvement."* In relation to stakeholder behaviour it should be noted that dissemination and education actions were viewed as very important by a number of interviewees.

4.5.2 Relevant policies and programs supporting urban development

Interviewees see climate mitigation and carbon neutrality in land use as key drivers that encourage the development of the governmental legislation on energy rehabilitation of buildings at national levels. This requires collaboration across different administrative levels (multilevel governance). However, sometimes there is a gap in the development of the appropriate programs to fulfill the ambitious objectives. Further, it should be noted that in some countries, most of this legislation is developed and administered not at national level, but at regional level, such as in the case of the City of Vienna (as a federal state), where the real impacts of the actions can be measured. This varies across countries depending on individual governance structures and institutional remits, however, with countries such as Finland setting such regulations are at national level, for example.

At local level there are also some initiatives, like the Finnish Hinku municipalities network (Hinku= Hiilineutraali kunta, Towards Carbon Neutral Municipalities network) or the local plans for Greater London Area, but some cities have noted their limited efficacy in affecting decisions to invest in renewable installations in buildings.

A number of interviewees also identified laws that discourage interest in investing into renewables in many cities and regions. In Limburg, for instance, it is not legally possible, as an individual, to sell surplus energy into the grid, which misses a huge potential for making renewable energy solutions attractive. Obstacles linked to legislation are also mentioned by Hasselt (Belgium) and Porvoo (Finland).

Innovation is also mentioned as a driver for improving the energy efficiency of buildings, but the additional cost of new solutions could be a challenge for the construction companies or the owners. It is clear, therefore, that innovative solutions must be linked to business models that ensure market uptake. Cities are piloting innovative solutions, with the help of regional and national funds and supported by academic institutions.

Energy label requirements and funding availability are mentioned as key elements that influence energy efficient building renovation. Thus, linked with the aforementioned financial support program (in section 4.5.1), impacts expected by cities and regions are an increasing number of photovoltaic installations, a greater share of renewables in gross final energy consumption and an improvement of the energy efficiency in buildings.

Also, it is noted that in Finland, the integration of sustainable building technologies can in certain circumstances be prevented by regulations, which are being updated too slowly, thus hindering the best building solutions from being realized.[8]

4.5.3 Who has most power for the roll-out of PEBs?

From the survey answers we can conclude that all levels of governance have an important role to play in catalysing the realization of PEBs. As mentioned in the previous sections, the national level is important to define the general framework and minimum standards, but the implementation of the programs and the contact with the stakeholders are mainly at regional and local level. At local level, it is possible to evaluate the specific local solutions best suitable for each area. The local level is also important for the implementation of specific measures such as information campaigns or innovative development projects, reinforcing the engagement of all stakeholders.

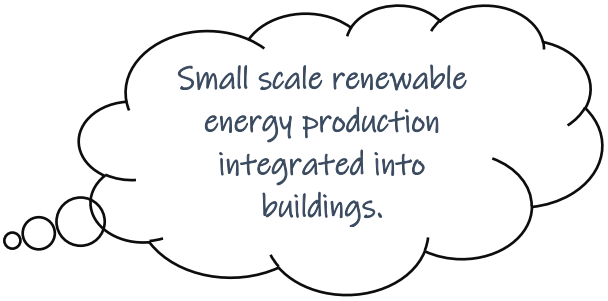
[8] e.g. in one case the best place for the solar installation would have been on the common parking lot owned by several building companies, but the current regulations did not allow that, or would have meant that the transfer fees and taxes needed to be paid for this local energy.

Interviews reflect that as the general framework is set at national level, it is important that the government is active on this. An interviewee stated that national governments could already facilitate plenty of procedures or implementations of pilot projects and technologies, only by slightly changing the legal frameworks. Then, "*the market will follow*". Another important remark from the interviews is that, in addition to legislating, the national and regional governments have the main financial resources to support the massive deployment of PEBs. Therefore, national-level financing and incentivization schemes play a big role in encouraging energy efficient (even positive energy) buildings. Local governments are more limited in this respect. Other entities mentioned are the universities providing courses on environmental architecture. Also, citizens were mentioned as having power on developing PEBs.

According to an interview, in the end, the most binding force is the building law, because it states what the building authorities have to do. It is noted that these kinds of strategic goals need to be pursued at EU-level, developing them into EU requirements, then spreading them into the specifications in national building plans and regional planning laws. Many interviewees shared an opinion that the binding requirements will have the greatest power.

5 Guidebook: how to integrate PEB concept in local and regional planning instruments

This guidebook details concrete steps to foster PEB development to increase renewable energy generation, improve energy efficiency and decarbonise building stock in local and regional authorities' policy and planning documents in Europe. Based on the survey, a list of measures, actions and concepts were collected that could be transferred to local and regional authorities' policy and planning frameworks.



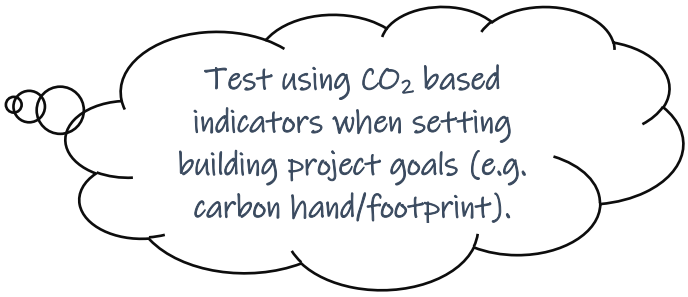
Cities and regions typically have ambitious targets for sustainable urban development, targeting carbon neutrality through affordable solutions. Positive Energy Buildings represent one solution in their toolbox, yet PEBs are not viewed as a priority goal in cities and regions.

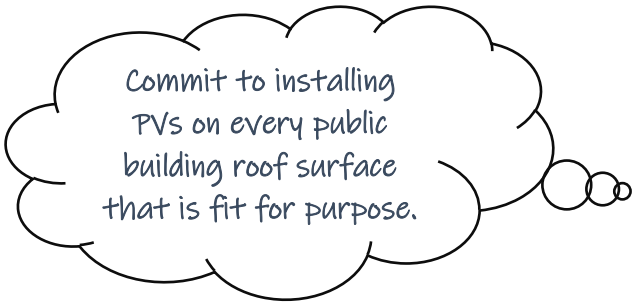
Positive Energy Buildings seek to minimise energy demand and maximise the on-site produced RE. These same basic principles guide low-carbon, smart city development in general. However, from the city's and region's perspective, energy management and decarbonisation efforts often focus on the district-level or entire urban systems, rather than on individual buildings. Against this backdrop, the EXCESS team has developed guidelines that center on how cities and regions can best benefit from the various PEB solutions when these are integrated in the built environments at scale.

5.1 Make room for PEBs in the overarching vision for sustainability

Visions for sustainability usually focus on broader concepts and often there is no specific interest in PEBs or the building level. When urban and regional energy and climate visions are wisely formulated, they can serve to enable and make PEBs attractive. Following learnings and recommendations can be outlined based on the survey:

- ✓ Set **long term local and/or regional targets** for spatial planning, energy efficiency improvements, RES utilization and reducing of greenhouse gas emissions.
- ✓ **Keep goals as simple as possible.**
- ✓ Choose the **essential guiding indicator(s)** and give **sufficient flexibility regarding the detailed design and technology choices** to the stakeholders in new building or renovation projects**.**
- ✓ Regulate the crucial elements, but **try to avoid complex and overlapping regulation**. Check both on mandatory regulations as well as complementing voluntary and/or incentive schemes. This will require mapping and analyzing regulatory frameworks as well as other relevant schemes at all levels of governance.





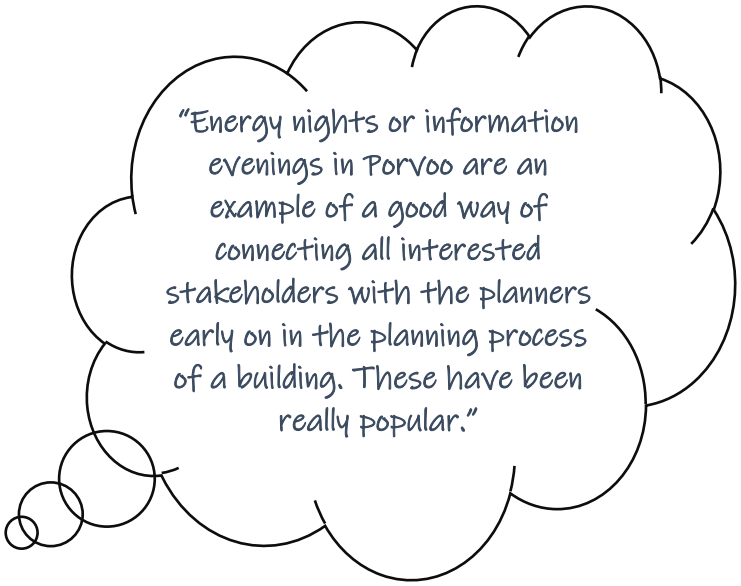
✓ Transform high level targets for carbon neutrality **into practical steps and initiatives.**

✓ Make a strategic decision to install **PVs on all city owned buildings** where it is an economically justifiable choice.

5.2 Good outcomes require the inclusion of a wide variety of stakeholders

It was pointed out in several interviews that the successful realization of NZEB or PEB projects requires the participation of many different stakeholders from early phases of the project in order to manage complexity, respond to needs and address requirements from different perspectives. The inclusion of a wide variety of stakeholders is also mentioned as a crucial element for developing strategies or regulations that support the implementation of PEBs. Also, end users need to be encouraged or rewarded for a correct energy use. It is important to raise the awareness of all stakeholders and to educate them on all energy efficiency and local RES integration.

- ✓ Ensure **commitment of the people** through an open process and **broad stakeholder engagement** when developing city's or region's strategy.
- ✓ **Municipalities can support building designers from the beginning** through other means than mandating or encouraging PEBs in urban plans: provide **practical guidance**, initiate discussions, organize energy nights, bring stakeholders together, offer one-stop-shop models for project owners and construction firms, launch awareness raising campaigns and disseminate knowledge.

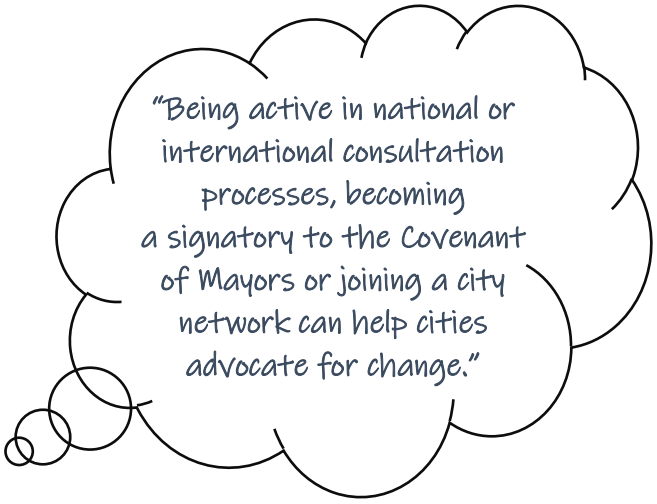


5.3 Understand institutional arrangements and powers that influence PEB developments

Interviews have highlighted that the leverage points for the effective roll-out of PEBs differ, depending on the governance structure of a particular country. Whilst in some contexts urban planning authorities provide concrete frameworks for spatial interventions, the regional authorities in other

countries appear to have greater power to affect sustainability transitions in the built environment. In light of this diversity of institutional arrangements there is no "one size fits all approach", but the activities need to be localized:

- ✓ **Clarify the roles** of different governance levels and **build bridges** for co-operation.
- ✓ **Work in the existing structures to advocate for change** at national or even European level (join a city network that advocates on your behalf, take part in EU consultation processes, etc.)
- ✓ **Understand who are the decision makers** for revisions to building standards / codes, **what kind of vested interests they may have** to retain the status quo and how local and regional political stakeholders might be able to lobby for amendments.



5.4 Embed PEB considerations into planning frameworks

According to the survey, PEBs can be considered in urban planning frameworks as follows:

- ✓ **Translate the commitments** and leadership for urban sustainability transition in medium to long-term **urban development planning documents**. Include **specific goals for the built environment**, because 40% of energy consumption and 36% of CO_2 emissions can be attributed to buildings in Europe.
- ✓ **Break goals down into milestones** to underpin the levels of ambition of planning documents, programs and initiatives to be implemented on the ground.
- ✓ Link the plans to **robust monitoring frameworks**. In this context, many cities benefit from becoming signatories to the EU Covenant of Mayors for Climate & Energy.

Sector-specific plans help authorities to manage the development by increasing specificity. However, it is crucial that plans are not developed in silos but in an integrated manner:

- ✓ **Explore possibilities for integrated planning**, such as grid-to-building interactions, the impact of electric vehicles, and climate adaptation and mitigation synergies or conflicts (i.e. greening roofs to reduce heat island effects vs. the greater roll-out of solar panels).
- ✓ Optimize **building orientation and zoning**.
- ✓ Optimize **solar access** in urban layout.
- ✓ Aim for comfortable urban microclimate.

Concrete development plans at neighbourhood / district level:

- ✓ Neighbourhood and district plans allow for the greatest incorporation of PEB development at local level, so be sure to include **the sustainable development principles at their core** in **these plans from the beginning.**
- ✓ **Provide information and authority on optimal solutions, e.g. for building orientation or RES integration in the spatial plan or** the lot release terms.
- ✓ Particularly when new districts are being developed **on government-owned land**, cities should mandate **very detailed minimum sustainability requirements.**
- ✓ As is the case with all plan-making, it is critical that **stakeholders are engaged throughout the process,** to gauge the technical and financial feasibility, social and environmental impacts as well as to create awareness and a sense of ownership.
- ✓ Start discussing and collaborating with local stakeholders **early on in the process**, including energy system operators, energy producers, grid operators, load balancing aggregators, etc.
- ✓ Before implementing anything on a wider scale, **define the basics clearly,** including the **definitions and technical requirements** for a plus-energy building and the **cost** of these requirements.

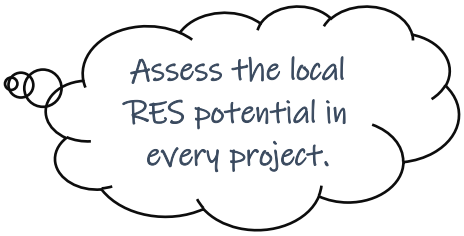
At regions: check the elements for a big picture: small scale RES generation from PEBs and energy flexibility can play a role in energy systems.

- ✓ Set regional energy objectives and minimum standards.
- ✓ Identify and enable financial support, e.g. through European regional development funds.

5.5 Plan for positive energy at the individual building or building cluster level

Survey findings included also various notes for the design of individual buildings or building clusters:

- ✓ Design the building with **maximised use of the on-site RES potential** and **energy efficient building design** practices.
- ✓ Adopt **a lifecycle approach** already **at the conception and initial planning stage** to reduce delays and avoid higher costs associated with corrections made later on in the process.

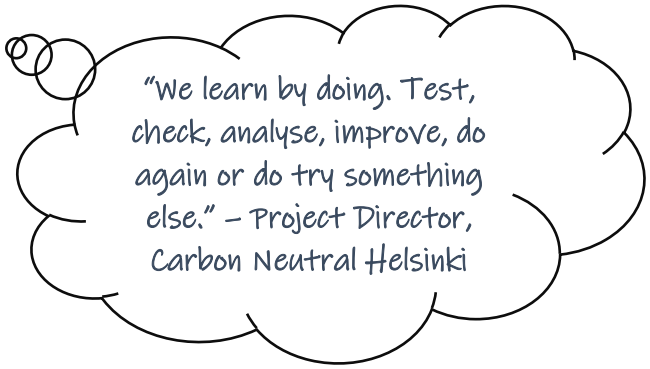


- ✓ Bring on board an **experienced project management team** to handle complex and possibly large-scale PEBs, consisting of experts at local or regional authority level as well as private sector specialist firms to stay on budget and time.
- ✓ Engage homeowners, real estate and pension funds to **catalyze the deep refurbishment** of their buildings towards PEB performance levels - implementing energy efficiency improvements and retrofitting on-site RES generation, whilst balancing targeted performance levels and the bankability of the whole project.

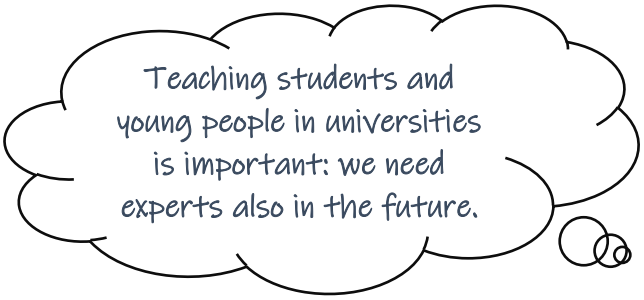
5.6 Lead by example, learn by doing and share information

Providing easily and clearly accessible information, data and processes for project developers and planners is recognized as an important success factor in the survey. Pilots, especially driven by public actors, would be a good way to promote PEBs. Building is a big investment and, therefore, it is important to have independent information. Local and regional governments are generally perceived as a good, trustworthy source of information.

- ✓ Initiate and co-operate in developing new local **PEB pilots.**
- ✓ **Share examples and learnings** from previous cases.
- ✓ Transform or develop new **buildings owned by the local or regional authority** to a PEB standard, as a high-impact way to raise awareness, demonstrate leadership and move towards the decarbonisation of the public sector.



- ✓ Implement a **performance-based procurement or contracting approach** (in the context of government owned buildings).

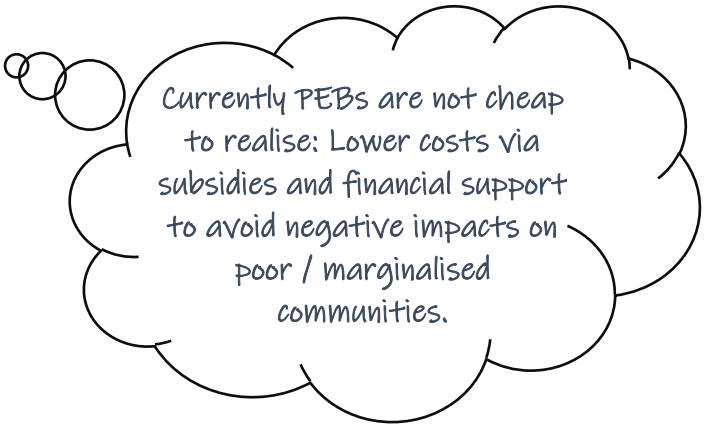


✓ **Share the hard facts about savings** (often for building occupants) **and other benefits.** Building owners tend to be conservative, so it is essential to address the risks in the construction sector. There is a need for data-driven knowledge to convince people for investing in new solutions that are bankable, such as PV.

5.7 Strive for a sustainable built environment that leaves no one behind

Throughout the survey, the need for "just sustainability transitions", which incorporate social issues, was highlighted repeatedly.

- ✓ Ensure that the financial support supports pathways towards sustainability that are fair, especially in suburbs and low-income areas.
- ✓ Social sustainability challenges often need to be addressed as a priority, before resources can be allocated for climate neutrality.



5.8 Support and knowledge for financing

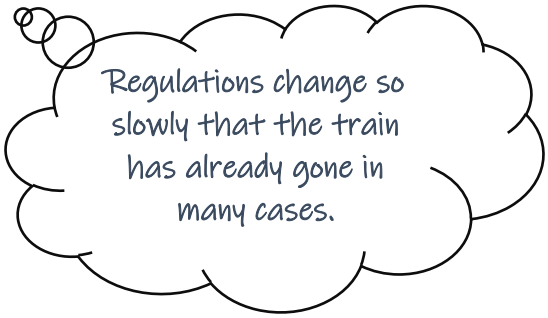
Some cities are already offering financial incentives for low carbon built environment transition.

- ✓ Financial incentives are needed for the roll-out of PEBs such as 'now or never deals' where businesses can get funding and only have to start reimbursing it when it is clear that they can recuperate profit from this investment within the first two years.

5.9 Policies and regulations as motivators rather than obstacles

Survey findings suggest that policies and regulations should be developed to support the transition towards low carbon urban environments, instead of hindering climate neutral activities. The EU and national level are very important in the context of financing and developing building codes and standards. Therefore, it is important that local and regional governments have opportunities to advocate their positions to ensure that national guidelines and requirements are implementable on the ground. Here, city and regional networks, as well as EU- and national consultation processes and engagement in international projects can be very useful.

- ✓ **Check that national, regional and municipal level policies comply with PEB targets** to increase renewable energy generation, reduce consumption and decarbonise building stock.
- ✓ Take into account also **other than building related regulations**. One specific policy barrier example is the taxation of the energy flows in Finland.



- ✓ **New legislation coming up** for Energy communities can impact the role of PEBs.
- ✓ **Clear regulations** are needed **to clarify the opportunities** that become available with the energy remnants/overproduction.

6 Conclusions

"We can reduce emissions by taking actions that reduce emissions. First the required analyses and calculations at the rough level, but then, the most important thing is to start acting. Some things need to be studied further if we don't have enough information, but still, we shouldn't wait for the perfect solution. We learn by doing, and develop while realising things. Single pilots are sometimes left as they are ready, but instead they should be utilised in learning and doing it again in following projects.

We need to accept that everything does not always succeed, but it is better to try and fail quickly, and then learn and try again something else. Pilots are a tool for taking steps towards strategic targets that are really clearly set. Pilots are also needed to solve a current problem or issue at hand, to get them interesting enough to get started. This is sometimes challenging in the project lead world."

- Project Director of Carbon Neutral Helsinki, City of Helsinki, Finland.

This deliverable summarises the main findings from interviewing municipal and regional representatives, experts and urban planners about how Positive Energy Buildings could be taken into account in urban and regional planning instruments. The above is a representative quote from one of the interviewees. The interviews provided an eye opening glimpse into the practical work of 15 cities and regions across Europe. The discussions with various experts revealed their expectations, beliefs and perceived challenges regarding positive energy buildings, and even more importantly, shed light on practical work at local and regional level undertaken to develop a sustainable, low carbon, energy efficient built environment in conjunction with local renewable energy production.

This work provided an exclusive opportunity to see and discuss what is going on in current research, European policy implementation, on-the-ground efforts to develop sustainable built environments and what happens in reality when these different fronts collide. First of all, the interviewees noted one after another remarkable activities to catalyse energy efficient buildings and increasing local renewable energy production. Furthermore, the future ambition and carbon neutrality targets for cities and regions were set high. Interviewees highlighted a great diversity of practical examples and lessons learnt in relation to energy efficient buildings in general, yet only a few were in a position to share experiences on positive energy buildings so far. Many experts indicated that the PEB concept should be considered and applied at a scale that goes beyond individual buildings, focusing rather on integrating the PEB approach in conjunction with broader sustainability targets: affordable housing, integrated energy systems, social sustainability, and increasing the share of local renewable energy production at the district and city-level.

As for the indicators, primary energy use and the efficiency of the building were considered a key criteria for assessing PEBs. Life cycle analyses were also suggested as one potential approach. Other relevant indicators included the ecological footprint as well as the carbon handprint or footprint classification. An interesting finding in the survey is that energy performance measurement criteria can be based on the CO_2 emissions caused by the building rather than the energy consumption.

A key conclusion that can be drawn from the interviews is that all levels of governance have an important role to play in the roll-out of PEBs and the coordination between the different levels of administration – as well as broad stakeholder engagement - is crucial. Further important factors that influence the planning process of NZEB and PEBs were found to be the cost, communication with

investors about the importance of NZEB/PEB, feasible financial models, open discussion and the removal of legal barriers.

Engaging in more detailed discussions with the interviewees revealed key opportunities and barriers to scaling-up PEB development at local and regional level and also shed light on reservations regarding the current political, social and economic feasibility of prioritising PEBs. These valuable learnings and insights were analysed, structured and translated into accessible and implementable recommendations in the guidebook section of this report.

The main recommendations can be grouped as follows:

- Make room for PEBs in the overarching vision for sustainability.
- Good outcomes require the inclusion of a wide variety of stakeholders.
- Understand institutional arrangements and powers that influence PEB development.
- Plan for positive energy at the individual building or building cluster level.
- Lead by example, learn by doing and share information .
- Strive for a sustainable built environment that leaves no one behind.
- Support and knowledge for financing.
- Policies and regulations as motivators rather than obstacles.

This report will support the development of the demo cases (in WP4) and related business models (WP5), and contribute to the knowledge of the state-of-the-art of PEBs, which will be communicated to different stakeholders through the capacity building and training activities (in WP7).

7 List of references

[1] D. , Stead and G. Cotella, "Differential Europe: Domestic actors and their role in shaping spatial planning systems," *The Planning Review*, vol. DISP3, no. 186, 2011, doi: 10.1080/02513625.2011.10557140.

[2] V. ; Nadin *et al.*, *COMPASS-Comparative Analysis of Territorial Governance and Spatial Planning Systems in Europe*. APA, 2018.

[3] "About the Covenant of Mayors." https://eumayors.eu/about/covenant-initiative/origins-and-development.html (accessed Oct. 20, 2020).

[4] "Environment | European Commission, EU environmental policies and legislation." https://ec.europa.eu/info/policies/environment_en (accessed Oct. 20, 2020).

[5] "Energy policy: general principles | Fact Sheets on the European Union | European Parliament." https://www.europarl.europa.eu/factsheets/en/sheet/68/energy-policy-general-principles (accessed Oct. 20, 2020).

[6] "A European Green Deal | European Commission." https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (accessed Oct. 20, 2020).

[7] "Preparing the future Renovation Wave initiative – Have your say | European Commission." https://ec.europa.eu/info/news/preparing-future-renovation-wave-initiative-have-your-say-2020-jun-12_en (accessed Oct. 20, 2020).

[8] "New Energy Performance in Buildings Directive comes into force on 9 July 2018 | European Commission." https://ec.europa.eu/info/news/new-energy-performance-buildings-directive-comes-force-9-july-2018-2018-jun-19_en (accessed Oct. 20, 2020).

[9] "Energy efficiency directive | Energy." https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en (accessed Oct. 20, 2020).

[10] "Energy performance of buildings directive | Energy." https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en (accessed Oct. 20, 2020).

[11] "Urban development - Regional Policy - European Commission." https://ec.europa.eu/regional_policy/en/policy/themes/urban-development/ (accessed Oct. 20, 2020).

[12] "Smart Specialisation | EU Science Hub." https://ec.europa.eu/jrc/en/research-topic/smart-specialisation (accessed Oct. 20, 2020).

[13] J. Sörvik and A. Kleibrink, "Mapping Innovation Priorities and Specialisation Patterns in Europe," Sevilla, Spain, Jan. 2015. Accessed: Oct. 20, 2020. [Online]. Available: http://www.jrc.ec.europa.eu/.

[14] "CITYKeys - project webpage," 2015. http://www.citykeys-project.eu/ (accessed Oct. 20, 2020).

[15] Bosch Peter, Jongeneel Sophie, Rovers Vera, Neumann Hans-Martin, Miimu Airaksinen, and Huovila Aapo Huovila, "CITYkeys indicators for smart city projects and smart cities," 2017. Accessed: Oct. 20, 2020. [Online].

[16] "Porvoo – Wikipedia." https://fi.wikipedia.org/wiki/Porvoo (accessed Oct. 20, 2020).

[17] "Hasselt in a nutshell | Visit Hasselt." https://www.visithasselt.be/en/hasselt-in-nutshell (accessed Oct. 20, 2020).

[18] "Vienna in Figures - Urban Area, Population, Education, Economy, Transport, Public Administration." .

[19] "Zagreb – Wikipedia." https://fi.wikipedia.org/wiki/Zagreb (accessed Oct. 20, 2020).

[20] M. Ala-Juusela *et al.*, "EXCESS D1.1 PEB as enabler for consumer centred clean energy transition: shared definition and concept," Espoo, Finland, 2020. Accessed: Oct. 20, 2020. [Online]. Available: https://positive-energy-buildings.eu/.

[21] SITRA, "ERA 17 for an Energy-smart built environment 2017." https://media.sitra.fi/2010/11/03104905/ERA17_brochure.pdf (accessed Oct. 20, 2020).

[22] "Das neue Büro im Passivhaus-Mantel mit Gold-Plakette." https://www.energie-bau.at/bauen-sanieren/3356-das-neue-buero-im-passivhaus-mantel-mit-gold-plakette (accessed Oct. 20, 2020).

[23] "Sanierung Gründerzeitgebäude Eberlgasse auf Passivhausstandard - Haus der Zukunft." https://nachhaltigwirtschaften.at/de/hdz/projekte/sanierung-gruenderzeitgebaeude-eberlgasse-auf-passivhausstandard.php (accessed Oct. 20, 2020).

[24] "aspern IQ - energy-innovation-austria." https://www.energy-innovation-austria.at/article/aspern-iq/ (accessed Oct. 20, 2020).

[25] "GreenHouse Studierenden Wohnheim: Innovative Gebäude." https://www.innovativegebaeude.at/wiennoe/news/artikel/detail/greenhouse-studierenden-wohnheim/ (accessed Oct. 20, 2020).

[26] "Eco-tools for urban development - KEKO A." https://www.syke.fi/en-US/Research__Development/Research_and_development_projects/Projects/Ecotools_for_urban_development__KEKO_A (accessed Oct. 20, 2020).

[27] "Climate Programme of the City of Porvoo for 2019 - 2030," 2019. Accessed: Oct. 22, 2020. [Online].

[28] "§ 2b BO für Wien (Bauordnung für Wien), Energieraumpläne - JUSLINE Österreich." https://www.jusline.at/gesetz/bo_fuer_wien/paragraf/2b (accessed Oct. 20, 2020).

[29] "Finland – The Sustainable Lifestyles Accelerator." http://suslife.info/category/finland/ (accessed Oct. 22, 2020).

[30] "Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources ." https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L2001 (accessed Oct. 20, 2020).

[31] "Energy Management Information System-EMIS." Accessed: Oct. 20, 2020. [Online]. Available: www.isge.hr.

Appendix 1. Survey for local and regional authorities:

How to consider Positive Energy Buildings in the planning and policy instruments?

Information on 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. EXCESS is 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 a time span 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 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 demo, a positive energy building system will be achieved by maximising the electricity production from photovoltaic panels. The produced energy will be consumed 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 for measures and indicators that could be transferred to local and regional authorities' policy and planning documents in order to support the rollout of PEBs. This will help the cities to achieve their climate and energy targets, by stimulating local and regional energy production coming from fossil-free sources.

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

Contact person in Finland: Mari Hukkalainen, mari.hukkalainen(a)vtt.fi

Background information

Country:
City/Region:
Number of inhabitants in the city/region:
Person(s) interviewed: - Name, Role in organization, Focus area (technical/administrative/financial/governance) -

Nearly-zero Energy Building (NZEB) and Positive Energy Building (PEB)

1. What is your understanding of nearly-zero energy building (NZEB) and positive energy building (PEB): what makes a building NZEB or PEB?
   Note to the interviewer: First freely discuss, also focusing on the differences between both concepts, then have a look at our definition with the interviewee, ask if the interviewee agrees or not.

2. Do you have any information on how much there are nearly-zero energy buildings and positive energy buildings in your city/region?

3. Have you already been involved in the development of nearly-zero energy buildings or positive energy buildings, or considering them in the urban plans or in city's/region's strategy planning? Y/N

4. Follow-up: If yes, what kind of project/development? What kind of impacts did it have on your work?

5. How do you take nearly-zero energy buildings or positive energy buildings into account in your work?

6. Could you describe the planning process for the development of nearly-zero energy buildings and positive energy buildings in your city/region?
   Who are the actors involved in the process?

   What are the steps in the planning process that have biggest effects on realising NZEB/PEB?

   Do you give any priority to positive energy buildings?

Nearly Zero Energy Buildings (NZEB) and Positive Energy Buildings (PEB) in the policy and planning instruments

7. What policy and planning instruments are used **related to nearly-zero energy buildings and positive energy buildings** in your city/region? *(Note: go through the list below and discuss about the details on all of those that are used and maybe also reasons for not using the others.)*

Sustainable Energy Action Plan (SEAP) / Sustainable Energy and Climate Action Plan (SECAPS)	Yes/No, any details?
Commitment to the Covenant of Mayors (every two years the city has to evaluate the success of the SEAPs)	Yes/No, any details?
Environmental and energy strategies	*Yes/No, Please specify*
Urban plans (spatial and land use plans)	*Please specify*
Regional plans	*Please specify*
Smart Specialization Strategies https://ec.europa.eu/jrc/en/research-topic/smart-specialisation	*Please specify*
CityKeys - Smart City indicator set	*Have you established a system to monitor the deployment of positive energy buildings?*
Others, which?	*Please specify*

8. Would aspects related to Positive Energy Buildings affect your policy and planning instruments? Y/N

9. Follow-up: If yes, how? If not, why?

10. Do you think any changes are required in order to promote the deployment of Positive Energy Buildings?

Any changes required to:	
The planning process	*If changes are needed, which?*
Involved stakeholders	*Are new kind of actors in the planning process needed? Or changes in the roles of existing stakeholders?*
Financial instruments	*If changes are needed, which?*
Building permits	*If changes are needed, which?*
Something else?	

11. Are there any future plans to adapt the planning instruments you are using, for what concerns positive energy buildings aspects?

Technical aspects for Positive Energy Buildings

12. Which positive energy building solutions have the most potential for broad implementation in your geographic and climatic conditions?
    - Improvement of the building shell (insulation, windows, etc.)
    - High energy efficiency of systems: heating, cooling, ventilation, etc.
    - User behavior
    - Advanced control systems
    - IoT

13. Which renewable energies have the best potential for small-scale installations in the region/city (from the legislation viewpoint)?
    - photovoltaic panels (solar electricity)
    - solar thermal collectors (for heat production)
    - heat pumps (air-to-air/geothermal/water-to-air)
    - biomass
    - hydro
    - wind turbines
    - other, which?

14. How would you monitor the achievement of the PEB status for an individual building?
    Prompt: Through an energy simulation or controlling the energy consumption, a checklist of installed equipment, etc.

Governance and policy making

15. What data does your government collect to measure energy efficiency and renewable energy generation in buildings?

16. And following previous question: From the collected data, what kind of indicators are used?

17. Please describe how the energy efficiency of - and energy generation by - buildings is incentivized or mandated in your city/region/country (regulations, minimum standards, grants).

18. Please also describe the impact of relevant policies and programs at other levels of government (local/regional/national) that encourage such developments.

19. Do you co-operate with some other authorities on Positive Energy Buildings?

20. Which authorities are most powerful for the large roll-out of Positive Energy Buildings in your opinion?

What's next?

21. Would you be interested in learning more about tools, methods and good practice approaches for the development of Positive Energy Buildings at one of our future EXCESS Replication Group meetings or other stakeholder meetings?

Attachment in the survey: EXCESS Definition for PEB (from D1.1)

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.**