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Sustainable
plus energy
neighbourhoods

# WP6- Innovation Management, Exploitation, Market Uptake and Business Models

## D6.3 – MARKET ANALYSIS OF EACH OF THE FOUR DEMONSTRATION CASES

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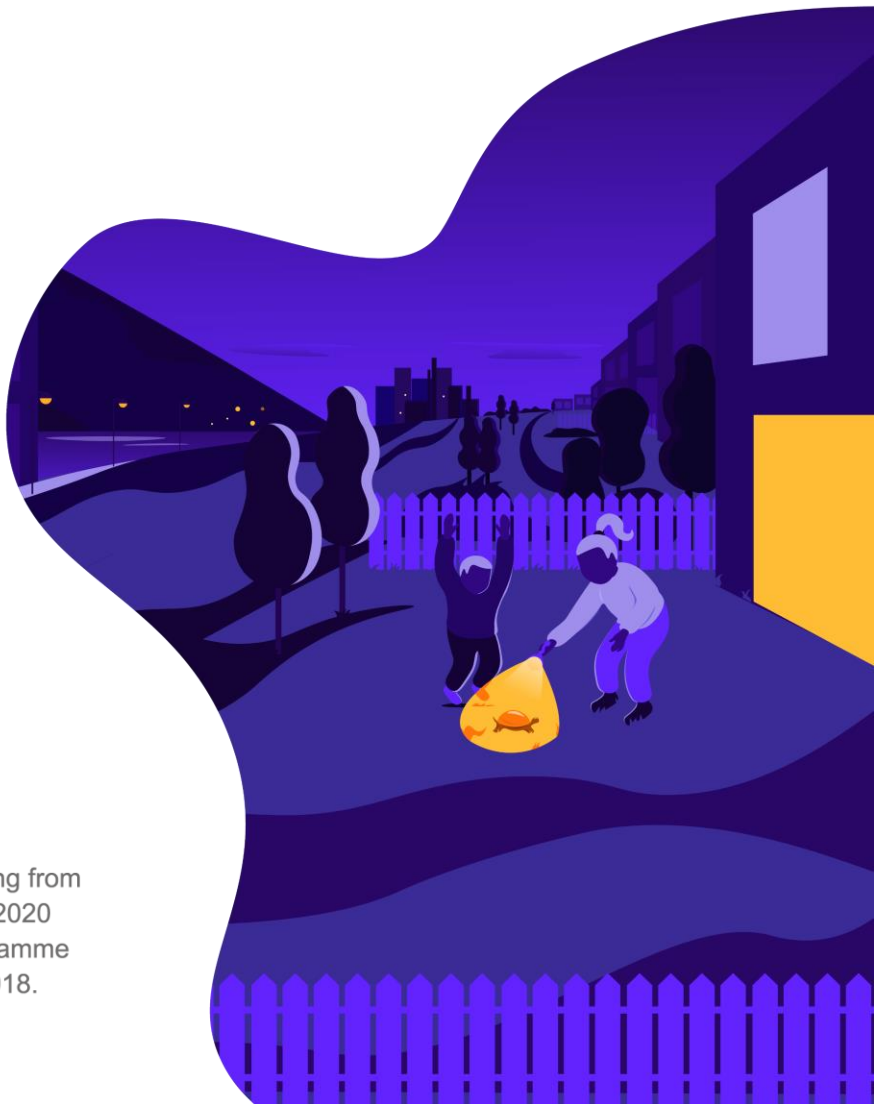

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# 3. Executive Summary

One of the goals of syn.ikia is to facilitate a 10% market uptake of plus energy houses by 2030. The neighbourhood scale innovations of the syn.ikia project have the potential to increase the share of plus energy houses. In this report, we focus on the SPEN concept which foregrounds four dimensions - maximizing energy efficiency, unlocking energy flexibility, and maximizing renewable energy, without undermining comfort and well-being for the inhabitants. In this report, we also pay particular attention to social housing, as three of the four demonstration cases are focused on providing social housing.

There is a significant opportunity in addition to delivering solutions for Sustainable Plus Energy Neighbourhood (SPENs), to also deliver innovations to the wider EU market. Market uptake is an essential outcome of the syn.ikia project. The focus is the market for multi-storey apartment buildings with SPEN ambitions and with an extra eye on the importance of social housing. The markets investigated are the built environment value chain from initiative to use, as well as the residential energy market value chain from energy production to consumption. The markets have been investigated through an analysis of the demo contexts combined with an analysis of political, economic, social, technological, legal, and environmental framework conditions to the spread of the SPEN concept.

The aims of the report are:

- to describe the key characteristics of the four markets related to each demonstration project in Austria, Netherlands, Norway, and Spain.
- to analyze the drivers and barriers to a wider uptake of the SPEN concept

Social and affordable housing frequently adopts the district approach since it can be found benefits from a wider spatial scale. Amongst the many advantages that SPENs and similar concepts can provide, some of them include economies of scale and cost-effectiveness for building owners, district regeneration, unlocking investment opportunities and many services and technologies that may not be available on an individual building scale.

There are identified several drivers and barriers to the development of SPENs throughout the report. When it comes to housing, willingness to pay is still higher for other qualities than the environmental. The SPEN concept do not seem to be attractive enough yet. This can change when more projects are developed if the experience is good, and it is well communicated.

*Rising awareness of climate change and the higher energy prices is favourable to the developments of SPENs. This can make it easier for politicians and others to introduce changes to the benefit of the climate.*

Knowledge about SPENs is still low in all groups of society. It is necessary to inform about the advantages to a larger scale, not only about benefits to the environment, but also that the energy bill can be lower. The public facilitation and ownership of best practice projects are important to ensure competence building in the supply chain, and to demonstrate how these innovative concepts work. So far, the SPEN concept is less known and less widespread than Positive Energy Districts (PEDs) which is a partly overlapping concept.

Reduction of energy poverty has become more imminent over the last year, and SPEN can be one solution for this. However, tenants are less incentivized to make improvements in their homes as they may not earn back their investments. Likewise, landlords may not have the possibility to raise the rent to earn back investments they have made. As investments costs are generally higher for SPENs than regular developments, financial support is necessary in an initial phase.

Policies and regulation are important to enable the socio-economic transition to the carbon neutral society. More locally produced energy can also contribute to increased energy security, but the transition from centralized systems to more distributed energy production is conditioned by the ability to do structural changes in long established structures.

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# 4. Roles and Responsibilities

Table 1: Roles and responsibilities

| Name | Role | Responsibility |
|---|---|---|
| NTNU | Project coordinator<br>Partner in consortium<br>Reviewer | Provide input in the planning of the task and the aim and structure of the content of this deliverable.<br>Contribute to the Norwegian country sections |
| DTU | Partner in consortium | |
| BPIE | Partner in consortium | Contribute to information on policy/political issues and the chapter on drivers and barriers |
| SINTEF | Task leader<br>Partner in consortium | Task leader for T6.3 Market Uptake. Contributor to Norwegian country chapter. Responsible for content creation and report as a whole |
| Housing Europe | Partner in consortium | Contribute to information on housing policy and social housing |
| IREC | Partner in consortium | |
| AREA | Partner in consortium & Demo lead | Contribute to the Dutch country sections and information about the demo |
| INCASÒL | Partner in consortium & Demo lead | Contribute to the Spanish country sections and information about the demo |
| TNO | Partner in consortium<br>Reviewer | Contribution to the Dutch country sections<br>Quality assurance of the deliverable |
| ENFOR | Partner in consortium | |
| ABUD | Partner in consortium | Contribution to the Austrian country sections |
| SIR | Partner in consortium & Demo lead | Contribution to the Austrian country sections and information about the demo |
| ARCA NOVA | Partner in consortium & Demo lead | Contribution to the Norwegian country sections and information about the demo |

Acknowledgements: SINTEF would like to acknowledge the contribution from 15 experts that provided input to the report. See the full list of experts in appendix B.

# 5. Introduction

### Introduction and aims of the deliverable

Market uptake is an essential outcome of the syn.ikia project. There is a significant opportunity in addition to delivering solutions for Sustainable Plus Energy Neighbourhoods (SPENs), to also deliver innovations to the wider EU market. SPEN is part of a wider transition to a carbon neutral society. To achieve this transition substantial socio-economic and socio-technical change is needed. In this report, features and characteristics of the four demo contexts are analysed for the purpose of better understanding of what barriers and drivers to market uptake that are relevant to the syn.ikia concept. By reading this report, you will have an overview and understanding of what is affecting the further development of SPENs and hence also be better equipped to influence its development.

The project identified the following target markets for syn.ikia solutions: prosumers or future plus energy houses, investors in energy efficiency and distributed generation, building developers, municipalities and communities, grid operators and utilities, and building owners. These target markets are part of the analysis of business models and will be summarized in a separate report "Evaluation of existing business models as well as identification and design of novel business models" due in June 2023. In this report, the market for multi-storey apartment buildings in the context of a sustainable plus energy neighbourhood is the focus. This implies, in addition to housing policies, also in particular energy policy, as these policy areas are intertwined in the SPEN concept. The SPEN concept focuses on multi-storey apartment buildings in urban contexts in which the syn.ikia project aims to significantly increase the overall energy efficiency, enhance energy flexibility, and integrate technologies for energy generation from renewables (photovoltaics, geothermal heat etc.) in a cost-effective manner. Interconnected with the energy aspects of neighbourhoods, the SPEN concept also pays equal attention to social aspects, aiming at supporting environmental-friendly, healthy, resilient, and sustainable living environments, promoting healthy lifestyles and consumption behaviour, and contributing to the development of an equitable, inclusive, and trusted society. The SPEN notion is a progression of nZEB/Plus Energy Buildings, where significant gains can potentially be made at the neighbourhood level.

The four syn.ikia demo projects in the Netherlands, Spain, Austria and Norway will demonstrate the functionality of the SPEN concept for the rest of Europe. The SPEN concept embodies several strategies, processes, technologies, systems, and tools that will be showcased in the design, construction, and operation of SPENs in each of the four climatic zones in Europe. Even if there are commonalities among the demo areas, and all are affected by policies developed by the EU, there are also differences. Some of the most important differences consist of climate zones, other national and institutional conditions, traditions and customs, policies, and practices to mention but a few.

### Aims and scope of the report

This report highlights key market characteristics of the four demo contexts of Austria, Netherlands, Norway, and Spain. It has the SPEN concept as its starting point, and does not assess the market situation for each individual associated innovation that has been identified in the syn.ikia project.

The focus is on the market for multi-storey apartment buildings with SPEN ambitions. That is, what market factors influence the adoption of SPENs? What market-regulatory incentives, and socio-economic aspects will improve the market attractiveness of SPENs. This report therefore presents a study of the four demonstration cases and combines this with a macro-analysis of political, economic, social, technological, legal, and environmental conditions (PESTLE-analysis) to the spread of the SPEN concept. For each of the demo contexts, aspects of the market that affect wider uptake of the SPEN concept are highlighted and discussed.

The report is structured as such: after an explanation of research method, the relevant markets for the development of SPENs are explored. This is followed by a chapter elaborating in more detail the demonstration case contexts, and a chapter presenting a macro analysis where Political/policy, Economy, Social, Technology, Legal and Environmental issues in the four demonstrations countries are further explained. Finally, the drivers and barriers to the further development of SPENs are extracted and discussed and the last chapter is the conclusion.

# 6. Objectives, method and analytical framework

Although there are several conditions in the various countries that are comparable, country specific situations will differ and affect the developments ahead. In order to undertake a thorough analysis of the markets for each of the four demonstration projects in syn.ikia, we have conducted country-specific interviews and built upon the competence in the syn.ikia consortium. This knowledge has been supplemented by findings in the literature. Due to differences on both macro (country) level and case study level (the four demonstration cases), the market analysis is based on a layered approach of demo innovation market analysis (explained in 6.1) complemented with a demo macro context analysis using PESTLE (explained in 6.2)

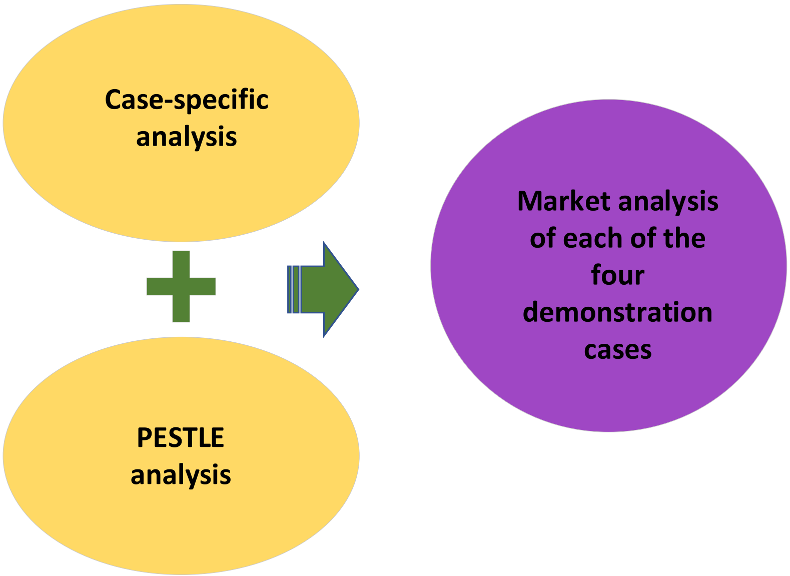


Figure 1: Research approach in the report

A PESTLE analysis is applied to capture the macro-level environment. This method has been supplemented by a gathering of market-relevant information using the demo projects as starting points.

## 6.1 The market analysis at the demo level

In the syn.ikia project, the four demo contexts act as innovation hubs, testing and implementing solutions as the project develops. The specific situations in each of the four demo contexts are decisive for the development ahead, as are contextual elements such as EU regulation, and other developments affecting supply and demand. Some factors are macro-oriented spanning from political matters to the legal framework relevant for SPENs. Others are more micro-oriented, depending upon the solutions that SPENs provide, how the competition is set on the supply-side, and what is characterizing the demand side.

The analysis of the demo contexts is built on Aaker and McLoughlin (2010) and includes the following aspects:

1. Target market
2. Market size
3. Market trends
4. Competition
5. Barriers and drivers to entry

Based on these aspects the following open-ended questions were developed:

a. Who are the customers? Who has bought or rented (or buy/rent) a flat at the demonstration case?
b. What are the main qualities of the concept/innovation (how do you market it/why should someone buy/rent from you?)
c. How do you consider the total market for this concept (in the respective demo-countries)? In total and for yourself. (Include both new developments and renovation projects)
d. What trends are affecting the market / do you expect to affect the market today and forward?
e. Who are developing the same or similar concepts in the national context?
f. Who are your main competitors?
g. Who are your strategic partners (if any)? Who do you think would make a good partner in the future?
h. What prevents potential competitors from entering the market?
i. What incentives are there to enter the market?

This case specific information is complemented by the PESTLE analysis. It is important to be aware that the notion of a "market" is not necessarily the same in all the four demonstration contexts. Three of the four demo cases are social housing, and the "market" here has a different dynamic, actors, competitors, and customers. We will return to this point in 6.3.

## 6.2 The PESTLE analysis

The PESTLE analysis is a strategic planning tool to evaluate the impact of political, economic, socio-cultural, technical, legal and environmental factors might have on a project (Perera, 2017; Ho, 2014)). Furthermore, it can be used as a strategic framework to the understanding of external influences, in this context on the development and spread of SPENs.

The model gives a comprehensive outlook and good support in the evaluation process of the dynamic and competitive business environment (Perera, 2017). In this respect, it is a way of exploring the market for SPENS in a framework that makes it comparable across the four demo countries. However, there are some challenges in the model as well. One limitation mentioned by Ho (2014) is lack of perceiving the systemic nature of the external environment, which needs to be compensated to achieve the expected analytical value. Another limitation is that the analysis is static and need to be repeated, if the market is in rapid change (Perera, 2017).

The main questions that our informants were asked, were:

Table 2: Questions that the informants were asked

| | |
|---|---|
| **Politics/policy** | How will the current political climate impact the development of SPENS? |
| **Economical** | How are interest rates, exchange rates, taxes and prices/costs affecting the development of SPENs? |

| | |
|---|---|
| Social | What lifestyle, norms, customs and values or demographics could affect SPENs? (Including relevant businesses, partners and customers) |
| Technology | Could new technology innovations disrupt or enhance the development of SPENs? |
| Legal | Could any new laws or regulations impact the development of SPENs? |
| Environment | Could climate change or other environmental issues affect SPENs? |

The elements of the PESTLE analysis have been used for example to describe barriers related to the spread of innovations in the construction process.

To supplement the PESTLE analysis and as a remedy for some of its limitations, complementary analysis has been done, using the demo projects and - contexts as starting points. What aspects of the market is essential to consider if SPENs are to become mainstream? This will be more thoroughly explored in the report "Measures and strategies to achieve market uptake of 10 % plus energy neighbourhoods within 2030" due in June 2024, but this report will identify barriers and drivers to be aware of.

## 6.3 What markets are investigated in this report?

The SPEN concept can be broken down into a multitude of markets. In this report, however, we focus on the concept level. Nevertheless, also at the concept level it is evidently so that the built environment value chain and the residential energy value chain are combined. This is illustrated in figure 2.

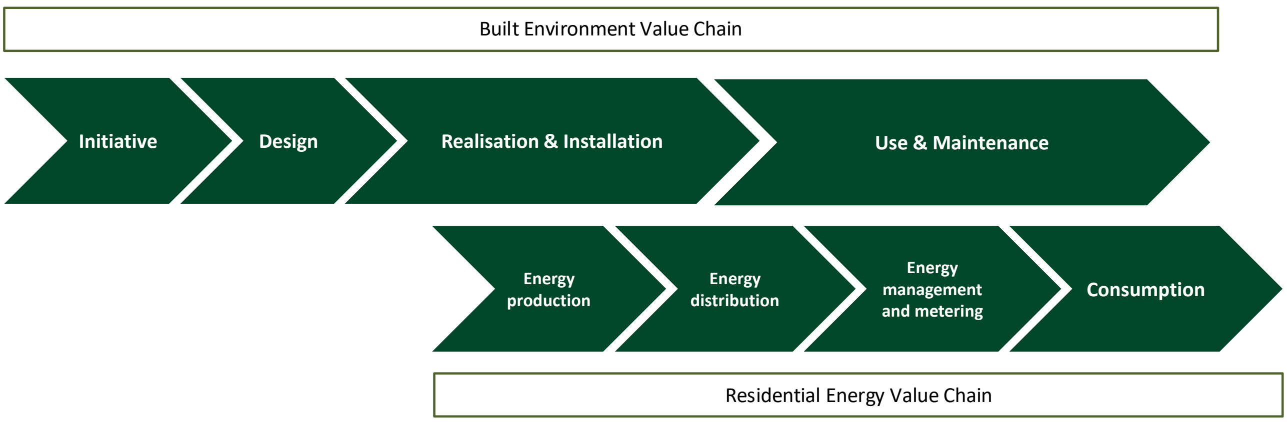


Figure 2: Combined value chains for plus energy neighbourhoods, adopted from the Grant Agreement of syn.ikia

To implement the syn.ikia concept and realizing SPENs, we must target these two combined value chains; the value chain of the built environment from initiative until use of the buildings, as well as the energy value chain in residential areas, from production to consumption. The built environment and the residential energy markets share some common drivers and barriers but are also distinguished in ways such as governance level and actors involved. These markets are further elaborated upon in chapter 7.

### 6.3.1 Social and affordable housing in Europe

A key difference in the markets is housing policy, which varies considerably per country. Three of the four demo projects are social housings, and the customers are tenants. The fourth demo project is a commercial flat complex which differentiate itself from other commercial projects by the very high sustainability aims.

Social housing in the EU means ensuring adequate and affordable housing for all citizens yet guaranteeing open competition among market players (European Parliament, 2013). Innovation is encouraged in this market. The provision of social housing involves a range of different actors/stakeholders such as local authorities, public companies, non-profit or limited-profit associations and companies, cooperatives, and in some cases even private for-profit developers and investors (ibid.)

According to the State of Housing in the EU 2019, the Public, Cooperative & Social Housing providers account for an approximate number of 25 million homes (11% of the total EU building stock). They construct 200,000 new homes yearly (€40 billion investment per year) (Housing Europe, 2019) and renovate over 200,000 dwellings each year.

In 2020, the Observatory of Housing Europe developed a survey of social housing providers in 16 countries in the European Union (Observatory of Housing Europe, 2020)[1]. The survey shows that the housing stock for social housing is old, as figure 3 displays.

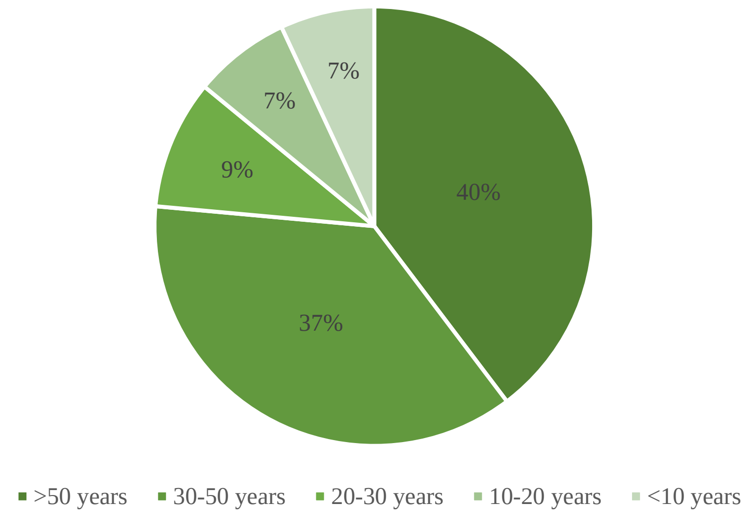


Figure 3: Composition of the age of the social housing building stock, in percentage (Observatory of Housing Europe, 2020)

According to the survey, more than 3/4 of the social and affordable housing stock in Europe is at least more than 30 years old, 40% is more than 50 years old. From the whole stock, a small percentage (7%) can be considered recent – less than 10 years old.

Social and affordable housing is a segment that traditionally caters for low-income families, people with special housing needs and more generally speaking people who cannot find decent and affordable accommodation on the private rental market or through access to homeownership (Housing Europe, 2018).

The present stock of social housing in different European countries varies considerably. In the Netherlands and Austria, it represents more than 20% of the total housing stock, while in Denmark, Sweden, United Kingdom, Czech Republic, France and Finland it represents between 15% and 20% of the total housing stock. In all other countries, such as Norway[2], the figure does not reach 10%.

### 6.3.2 What relevance has social and affordable housing to the development of SPENs?

SPENs can be one of many measures to ease or alleviate the lives of people with less means. Social housing is becoming a major area of interest for energy researchers because of the benefits renewable energy produced on-site can have to the tenants (McCabe et. al., 2018). In an article exploring state-of-the-art on application of

[1] The 16 countries interviewed include Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Slovenia, Spain, Sweden, UK

[2] In Norway the total housing stock is 2 637 521, of which 108 128 (2021) are social housings (4%) (www.ssb.no)

renewable energy to social housing (2018 ibid.) it was found that many of the important motivational, success and hindering factors relates to the unique relationship between tenant and housing, that social housing arrangements produce. The importance of tenant acceptance and education is highlighted because it incorporates broader socio-technical issues in the research (Sovacool, 2014). When implementing renewable energy in social housing projects, this poses opportunities for energy intervention, but it also comes with unique barriers and complications as it is generally not a bottom-up approach. The importance of understanding and succeeding in engaging residents appropriately, managing to keep the engagement over time is an unanimously result.

The district approach has been placed at the core of the Renovation Wave strategy[3] to avoid focusing on individual dwellings and tackle all aspects involved in renovation work besides energy efficiency, such as the local economy, social services, or public space. Social and affordable housing frequently adopts the district approach since it can be found benefits from a wider spatial scale. It is because district renovation projects have proven effective and successful, especially SPEN, that the Affordable Housing Initiative[4] comprised in the Renovation Wave will pilot 100 lighthouse renovation districts in a smart neighbourhood approach.

### 6.5 Methods and collection of data

We have conducted 15 interviews in total. Among the informants are the demo owners. The other informants are selected based on input from the demo owners, and the partners knowledge of the market and relevant actors. A partner from each country has been responsible for conducting and analysing the interviews from their country. The compilation and the comparative analysis have been done by SINTEF.

We had a common interview guide with open-ended questions for all the interviews.

In Austria, the information was collected in two ways. One source of information was available results from research projects (PEQBacker, Zukunftsquartier, klimaaktiv). Another source was interviews with different stakeholders (GBV, project developers, architects). In the Netherlands, experts in the Dutch housing market were interviewed. The interview insights were synthesized and presented back to the interviewees to iterate the accuracy of the findings. Additionally, it was drawn from the scientific literature to further elaborate on the input offered by the interviewees. In Norway, interviews were recorded, transcribed and color-coded according to the main topics. In Spain, the information was collected from interviews with in-house capacities as well as a supplementing survey sent to selected stakeholders. The survey resulted in 30 answers.

The informants are familiar with the content of the report and have been given the opportunity to provide input to an earlier draft of this report.

An overview of the informants can be found in appendix B.

## 7. The market context for the four SPEN demos

There are many aspects, beyond climate zone, that distinguish the four demo contexts from each other. In this chapter some key features and figures of the housing and energy markets in the demo contexts are highlighted.

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[3] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en#a-renovation-wave-for-europe

[4] https://single-market-economy.ec.europa.eu/sectors/proximity-and-social-economy/social-economy-eu/affordable-housing-initiative_en

## 7.1 Comparative statistics of the housing market and energy market for households

### 7.1.1 The current housing market context

Since SPENs are better suited for densely built areas and multi-dwelling buildings, we have looked at the distribution of level of urbanization and housing type per income group in the demo contexts. Income and ownership status influence the willingness to invest in SPEN related technologies and solutions, and age, income, ownership status and housing type is related to the type of households, so in the following section we have also compiled statistics on this. In cities it is most common to live in flats. Those with lower incomes live in flats rather than houses. Families with children with two breadwinners tend to live in detached houses or terraced houses, while single and single breadwinners live in flats.

In Spain there are more inhabitants with low income (below 60% of median equivalized income) than in the other pilot countries. These amount to 21%, and almost half of these live in cities. In the Netherlands, more than half of the population is living in the cities. In Austria, the largest share of the population is living in rural areas (38%), while in Norway, the largest share of the population is living in towns and suburbs (41%). Irrespective of the income group, in Norway it is most common to live in a detached house, in the Netherlands the most common typology consists of semi-detached houses while in Spain it is most common to live in flats. In Austria it is most common to live in a detached house for the high-income group and in a flat for the low-income group.

Figure 4 shows the distribution of dwelling types in cities, towns and suburbs and rural areas in the four demo context and the EU.

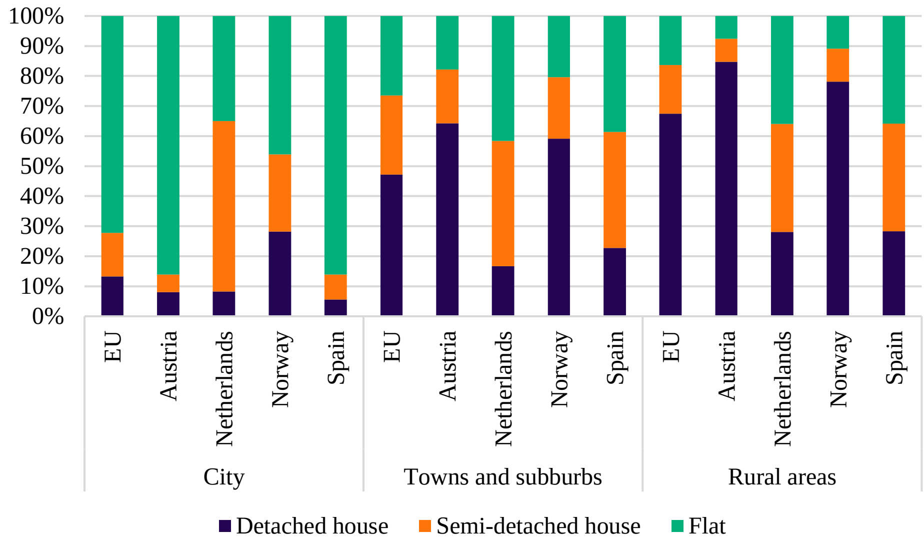


Figure 4: The distribution of dwelling types in cities, towns and suburbs and rural areas in Austria, the Netherlands, Norway, Spain, and the EU in year 2020.

Ownership is the most common tenure status in the high-income group, while renting is the most common for the low-income group. This is not surprising, but there are some exceptions. In Spain, it seems that one can become loan-free faster, even for the low-income group. Ownership without outstanding loans is the most common tenure status for single adults in Spain, both for those over and under 65 years of age. In Norway, this applies to single people older than 65. Among the high-income group ownership with a mortgage or loan is most common even for singles below 65 in Spain and Norway, and for singles above 65 it is only for the Netherlands that tenancy is most common. In Austria, social housing seems to be more common for the elderly in the low-income group. If the household consist of two adults without children, the most common tenure status is ownership with no remaining loans, even for the low-income group, except for the Netherlands. In Spain and Norway, it is most common to own your house, but still have a loan if you have two children, while in the Netherlands this tenure status is most common if two adults live together with three or more children in the low-income group.

Figure 5 shows the distribution of people in the demo contexts owning or renting their home, in relation to the housing price in the respective countries.

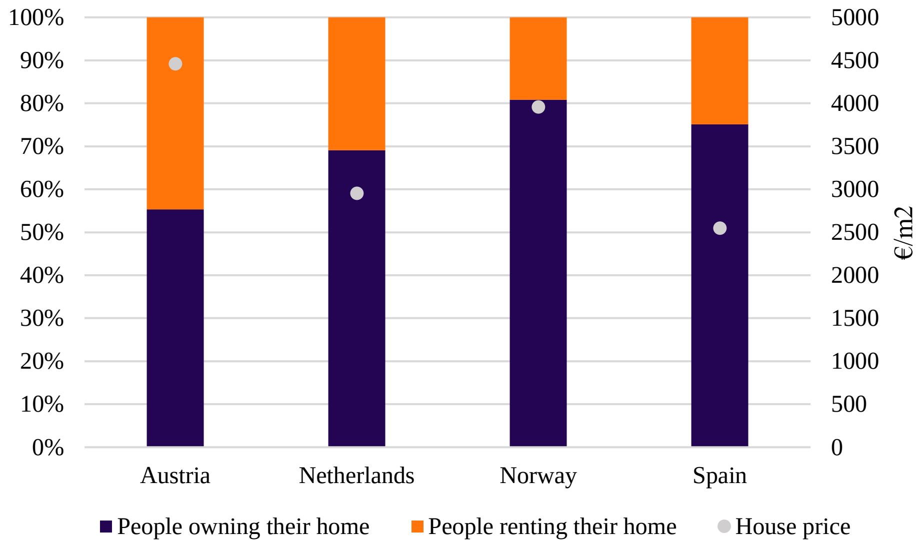


Figure 5: The distribution of tenure status and housing prices in Austria, the Netherlands, Norway, and Spain in 2020

80.8 % of the population in Norway is owning their home, followed by Spain with 75.1%, the EU with 70%, the Netherlands with 69.1% and Austria with 55.3%[5]. Relatively more people are renting their home in Austria, compared to the other pilot contexts and the EU, comes from the fact that housing prices are the highest of these countries. After the Netherlands, the house prices rise second most in Austria[6]. The housing development rate in Austria (10.85 per 1000 citizen) is almost the double than in Norway, followed by the Netherlands and Spain (Linhart, et al., 2021).

Demographic development can inform about housing demand going forward, but also about economic prospects. When looking at population projections, all countries are expected to have an ageing population. Figure 6 displays the distribution of age groups in year 2020 compared to the projections for 2050.

[5] https://ec.europa.eu/eurostat/cache/digpub/european_economy/bloc-2c.html?lang=en
[6] https://ec.europa.eu/eurostat/cache/digpub/european_economy/bloc-2c.html?lang=en

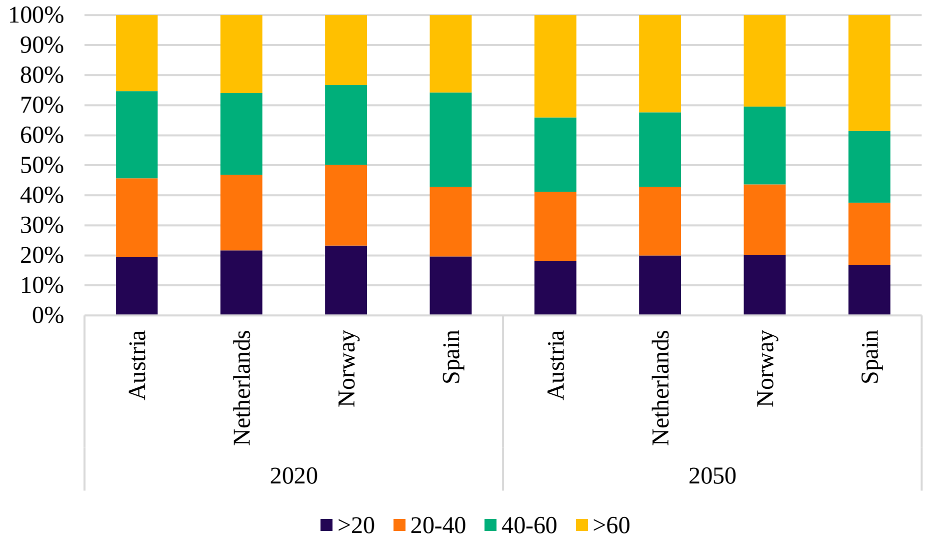


Figure 6: The age distribution in 2020 and the expected age distribution in 2050 in Austria, the Netherlands, Norway, and Spain.

An interesting observation is that Spain is expected to have a “silver tsunami”, with a particularly high proportion of elderly population (aged 60 and over) in 2050[7].

Energy efficiency and renovation rate may say something about the need to act, which can be a driver for investment in SPEN solutions and technologies. Around 35% of the buildings in Europe are over 50 years old and almost 75% of the building stock is regarded as energy inefficient (Zhang et al., 2021). The major 14 countries within the EU have an average annual renovation rate of 1.1%, with the range varying from 0.08% (in Spain) to 2.4% (in Norway). The current renovation rate is thus far below the expected rate of 3% to achieve carbon neutrality in building sectors by 2050[8].

### 7.1.3 The current energy market for households

Besides energy efficiency and renovation rate, the share of renewables can also say something about the need for emission-free solutions in the demo contexts. Figure 7 shows the share of renewables in household's energy consumption, and in the countries' production of electricity as well as heating and cooling[9].

[7] https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&uri=CELEX:52020DC0662
[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#Share_of_renewable_energy_more_than_doubled_between_2004_and_2020

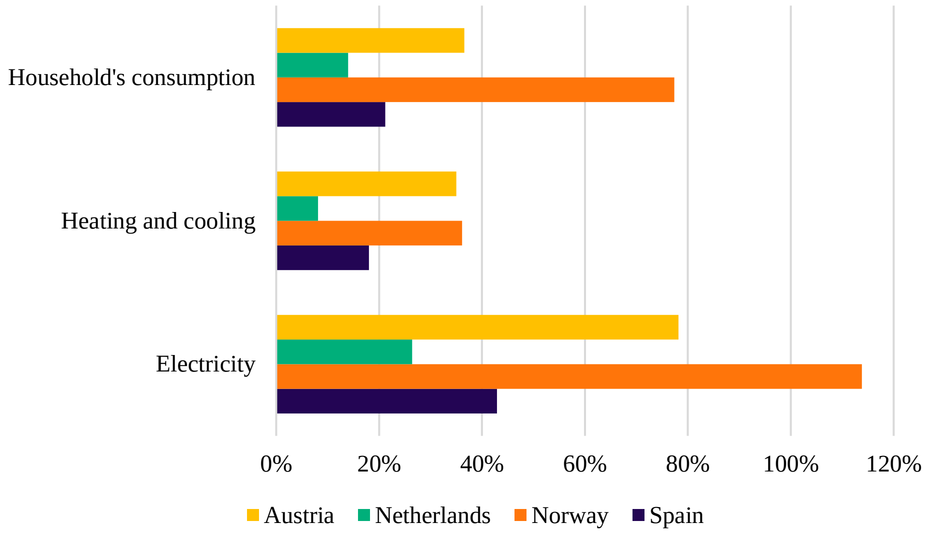


Figure 7: Renewable share of household's energy consumption, and the generation of heating, cooling and electricity in Austria, the Netherlands, Norway, and Spain in 2020.

There has been an increasing renewable share in all countries since 2018. Due to international commitments and plans, this trend is expected to continue. The Netherlands has the lowest renewable share, while Norway has the highest. This applies both to household energy consumption and electricity and heating/cooling generation. The reason why Norway's share of renewables in the production of electricity exceeds 100% is that the share of renewables is very high (mainly hydropower), and that Norway produces on average more than they consume, and exports renewable energy to Europe[10]. The greenhouse gas emissions have on average decreased in all the four countries since 2005. The Netherlands has the highest level of emissions per capita, of 8 tons $CO_2$ per capita in 2020. The peak level was close to 12 tons $CO_2$ per capita in 1996. Spain has the lowest emission level, followed by Austria and Norway. The share of electric vehicles in Norway is the highest in the world with a market share (new car sales) in 2022 of 86%, while in the Netherlands, Austria (AustriaTech, 2022) and Spain it is 30, 20 and 8% respectively[11]. Figure 8 shows the energy consumption in households, broken down by fuel type.

[10] Source https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#Share_of_renewable_energy_more_than_doubled_between_2004_and_2020

[11] https://www.iea.org/data-and-statistics/data-product/global-ev-outlook-2022#

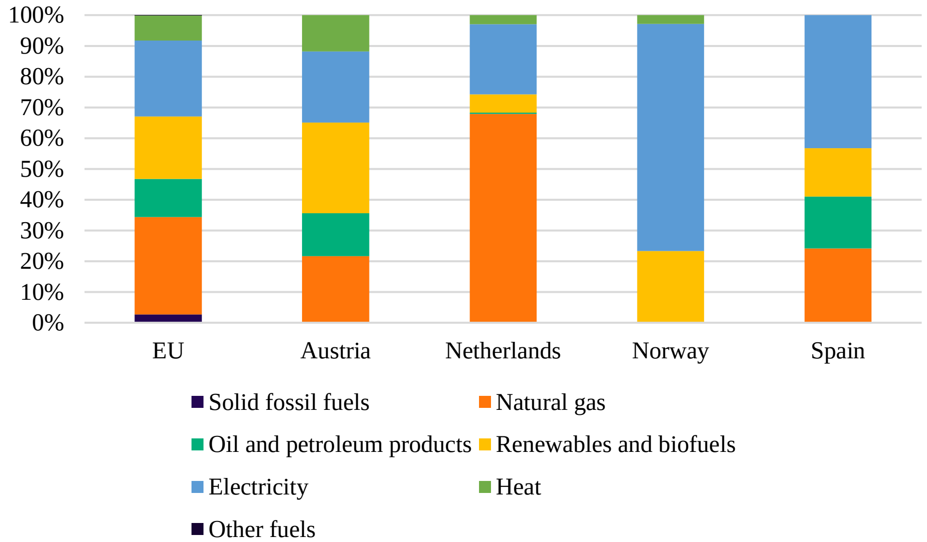


Figure 8: The distribution of household's fuel consumption, by type of fuel, in Austria, the Netherlands, Norway, Spain and the EU in 2020.

Norway has by far the highest electricity consumption, while the Netherlands has by far the highest natural gas consumption, which contribute to a high fossil share and high climate gas emissions[12]. Norway has traditionally had an energy surplus, low electricity prices and a higher electricity consumption than strictly necessary, which has made Norwegians very dependent on electricity, also for heating.

Periods of drought and the war in Ukraine has led to a very high rise in energy prices. Figure 9 shows the development in energy prices that the household sector faces when taxes and levies are included[13].

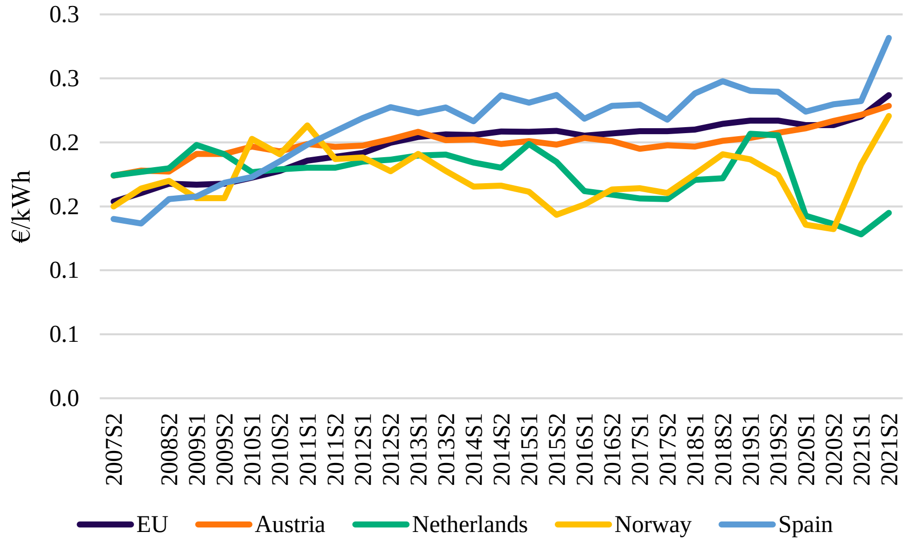


Figure 9: Household's electricity prices in Austria, the Netherlands, Norway, Spain and the EU in 2007-2021.

Energy prices for households have increased significantly from 2020 in all four countries.

[12] https://ec.europa.eu/eurostat/databrowser/product/page/nrg_ind_fecf

[13] https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_204/default/table?lang=en

### 7.1.3 Summary of sub-chapter 7.1

In Spain, it is most common to live in a flat, regardless of income group. It is also more common in Spain to have owner status without outstanding loans. At the same time, Spain has more poor people than the other pilot countries. Norway has the highest share of people owning their home, and it is most common to live in a detached house. Austria has the highest rental share, the highest housing prices, and the highest housing development rate, while the Netherlands has the highest rise in housing prices. The Netherlands also has the highest share of fossil fuels and the highest emissions of the four demo countries. All four countries suffer from a high electricity price, low energy efficiency and low renovation rates. Spain has the lowest renovation rate and the highest electricity prices for households. Norway has the highest renovation rate of the four countries and has experienced the highest growth in electricity prices of the four countries the recent years.

## 7.2 SPEN and SPEN related developments

What developments are presently built or underway, that are like SPENs? This overview is complementing the overview of PED projects in the four demo countries in the syn.ikia report "Policy mapping and analysis of plus-energy buildings and neighbourhoods".

## Austria

Currently, the Federal Ministry on Climate Protection, Environment, Energy, Mobility, Innovation, and Technology is running a project to support the development of Plus-Energy District (PED) concepts in five Austrian cities, together with housing developers. Cities are connected via a smart city initiative which aims to create an avenue for information sharing between cities and stakeholders and strengthen their bond to accelerate municipal processes. With the help of a centralized coordination office located in Salzburg, relevant stakeholders can connect, develop, and discuss solutions to multiple local problems. Thus, the network creates a direct channel between municipalities and market participants, and forum where barriers and potential solutions can be analyzed[14]. This will help to compare results, derive recommendations, and analyze which frameworks or instruments enhance the planning, implementation, and operation of PEDs. Five of the most prominent projects in the initiative are located throughout the country, in Innsbruck, Salzburg, Klagenfurt, Graz, and Vienna, with floor areas ranging from 5 259 to 62 263 m2. Figure below showcases these projects.


Figure 10: Five of the most prominent PED initiatives in Austria

SIR created and visualized a calculation to map the potential of SPENs, where they assessed data on residential population, as well as technological advancement and the municipality's openness to sustainable solutions. The map can be found in section 8.1.3. Based on this they identified areas, that have more

[14] https://nachhaltigwirtschaften.at/en/topics/smart-cities/smart-cities-network-austria.php

potential for a SPEN development to succeed. These areas are mostly the bigger cities and the rural areas near these cities. This calculation could be a big help for the federal government in steering grants and programs to areas where the likelihood of success is higher.

## The Netherlands

**What developments are presently built or underway, that are similar to SPENs?**

SPENs and related concepts are still in an early phase of development in the Netherlands. It is still more focus on becoming independent of natural gas, instead of developing positive energy buildings and districts. However, there are some relevant developments across the country. The neighbourhood Stadstuin Overtoom in Amsterdam was the first carbon neutral district to be built in the Netherlands in 2014. The concept is called Co-Green because of the supply-chain collaboration. The homes are energy efficient and consist of 132 social housing units and 22 commercial dwellings.[15] Currently a positive energy district in Buiksloterham is developed[16] with EU funding, as a part of the smart city project Atelier. Both Amsterdam and Bilbao (Spain) are lighthouse cities within the Atelier project. The Netherlands has another lighthouse city, Groningen, in another ongoing EU project on positive energy districts[17]. The Netherlands is also involved in the PED program, where Norway also occasionally participate in joint actions, and Spain has expressed its interest in[18].

There are also several national initiatives designed to support the transition of social housing associations. These include, for example, the Startmotor project[19] in which several corporations are working in partnership to accelerate the provision and building of 100,000 natural gas-free social houses for young people, and the Renovation accelerator initiative[20] in which housing associations in different regions jointly plan sustainability projects and purchasing of heat pumps, insulation, and other technologies. Moreover, national frameworks have been established for connections to neighbourhood heat networks (AEDES, 2019) in agreement with energy grid operators.

## Norway

The leading actors on SPENs and SPEN-related solutions in Norway are largely connected to the research centres on zero emission buildings (ZEB)[21] and zero emission neighbourhoods (ZEN)[22]. The centres represent long term research on low emission solutions for buildings and neighbourhoods, financially supported by the government (50 percent) and the partners (50 percent). One of the partners in ZEN is the innovation programme FutureBuilt, working in Oslo and the surrounding municipalities, but currently spreading to other parts of the country. FutureBuilt is a market force, moving the front end of the market by developing user friendly guidelines and criteria, as well as organising networks, knowledge arenas and processes to achieve high sustainability ambitions.

The Powerhouse concept has also developed to become well known in the Norwegian market. The Powerhouse-alliance mainly consist of partners from the ZEB-research centre. The powerhouse concept and strategy evolve around energy and emissions, buildings designed and constructed to achieve the Paris Agreement's 1.5-degree target[23]. The Powerhouse-alliance have demonstrated the concept through several

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[15] https://www.housingeurope.eu/blog-133/the-first-climate-neutral-neighbourhood-in-the-netherlands
[16] https://smartcity-atelier.eu/
[17] https://makingcity.eu/
[18] https://jpi-urbaneurope.eu/ped/
[19] https://startmotor wonen.nl/
[20] https://derenovatieversneller.nl/
[21] www.zeb.no
[22] www.fmezen.no
[23] https://www.powerhouse.no/en/what-defines-the-powerhouse-standard/

projects, mainly office buildings and schools. In 2022, they started the building of their first Powerhouse housings.

The research centres ZEB and ZEN started research on the topic in respectively 2009 (ZEB) and 2017 (ZEN). The centres have contributed to several best practice projects which has made it possible to tighten minimum requirements in the building code more rapidly. The demonstrated housings at ZEB-level include so far, the ZEB house Multikomfort Larvik (Sørensen, et al., 2017) and Skarpnes residential developments (Thyholt et al., 2012). In ZEN, there are several planned developments at ZEN-level. The completed projects so far, are detached houses.

Other research projects such as SEOPP[24] and OPPTRE[25] have focused on deep renovation of detached housings to a "close to nZEB level". However, nZEB has no national definition so far. When it comes to Positive Energy Districts (PED), a term commonly used in EU, this is investigated in projects such as +CityxChange[26] which has a demo project in Trondheim.

A project with similar ambitions as the syn.ikia demo project Verksbyen is underway, the project Oen by the housing developer OBOS. It is planned as a circular building with 150 flats and it will produce renewable energy to compensate for the greenhouse gas emissions from the operation of the building.

## Spain

The building code in Spain is quite strict and regarded as at nearly zero energy level (nZEB). But when it comes to neighbourhoods with ambitions similar to SPEN, there are less developments so far.

Spain aims to get involved in the PED program[27]. PED-concepts will be tested in the earlier mentioned project ATELIER in Bilbao[28], and Aparisi-Cerdá et al. discuss the opportunities for PEDs in urban water fronts in Valencia (Aparisi-Cerdá et al., 2022), but there has also been identified several obstacles for developing PEDs in Spain (Hearn & Castaño-Rosa 2021). There is a novel example of a positive energy building project in Grenada. This is also a H2020-funded project where it is planned a positive energy building with four stories and 30 flats. There will also be commercial activity on the first floor. The project aims to minimize energy demand and maximize consumption of own-produced renewable energy from solar PV and battery installations. EV charger, geothermal heating and a system that controls and couple the electricity and thermal energy production, storage and consumption is within the concept called NIVALIS. Moreover, the building incorporates rainwater catchment, a garden with food production and community interaction (Tuerk et al., 2021).

### 7.2.1 Summary of SPEN and SPEN related developments

The initiatives that do exist are often partly financed by the state and/or included in research projects. PEDs are more common than SPENs in the EU. In Norway, the ZEN concept is better known at the neighbourhood level. However, the Norwegian project Oen is the only SPEN project mentioned for the pilot countries, besides the syn.ikia demo projects.

[24] www.seopp.net
[25] www.opptre.no
[26] www.cityxchange.eu
[27] https://jpi-urbaneurope.eu/ped/
[28] https://smartcity-atelier.eu/about/lighthouse-cities/bilbao/

# 8. MARKET ANALYSIS OF EACH OF THE FOUR DEMONSTRATION CASES

In this chapter, we will investigate in more detail how the demo projects relate to key features of their national market. More details about the demo projects can be found in the syn.ikia report "Report on Stakeholder and User Engagement Activities" (Cortés, 2022).

## 8.1 Austria

### 8.1.1 GEWIN Gneis

The demo site built in Salzburg is developed by Heimat Österreich, a non-profit provider of social housing in specific regions in Austria.


*3D simulation of Gnice*

Heimat Österreich (HÖ) rents multiple flats and emphasizes sustainable solutions in their projects. The pilot project consists of 251 new flats and upgrading of 24 flats, a kindergarten, a doctor's office, a charity company, and community services, such as a café, co-working spaces, and common rooms, as well a smart parcel room.  In the building there are several flats for sale as well (approx. 50%). A mobility point facilitates sharing products, such as bicycle baskets and child trolleys, electric bikes, scooters, an electric cargo bike and an electric vehicle. 13 flats are monitored (ibid.).

### 8.1.2 Target market

*Who are the customers and how are they attracted?*

As a non-profit developer, besides selling flats on the market, HÖ is also committed to provide social housing and housing for people who are elderly or people that need assistance. Customers therefore include elderly people, people with disabilities, and people that need residential care.

According to an analysis on the affordability of housing in Salzburg made by SIR (Lüftenegger et al., 2021), for most people who already have housing, living is affordable (less than 40% of the household income is spent on housing). If we look at the situation among the people that are looking for housing, the landscape changes. Around 90% of the offers can be found in the most expensive housing categories (for both renting and purchasing homes). For high income households it does not pose a problem, however it restricts middle-income households a lot. For lower income households only subsidized rental homes are a possibility, and for the bottom 10% only if housing benefits is also received.

In a comparable housing project that was finished in 2019 the tenants were asked if the energy performance and the sustainability of the project was relevant for their decision to live there. One main finding was that people are more concerned about the location, view, traffic, and overall comfort than energy and sustainability per se[29] . These results are also found in similar investigations, for example in Norway[30].

This situation can change if the war in Europe continues, and the energy prices are kept high. Higher energy prices can make the SPEN concept more attractive for people. Now, due to higher investment costs and lack of information of advantages, it is only possible in houses with flats for rent that are owned by communities of non-profit housing associations. It would be very good for social housing because people with a low income get a benefit because of low heating costs, but the higher investment costs must be financed.

### 8.1.3 Market size and trends

*How is the potential market for SPENs considered, and how is the demo project aligned with this?*

Figure 11 shows, according to SIR's calculations, the potential for SPEN concepts in Austria. The white areas represent no potential and the red high potential. The basis for the calculation was an analysis of all 2 093 Austrian municipalities. The number of inhabitants was multiplied with the expected move in, the quality of the infrastructure (e.g., public transport) and the ambition of the municipality in the field of sustainable development (e.g., part of smart city, e5 or climate protection network). As visualised in the figure, the capital cities and the urban areas are especially suitable for the implementation of SPENs.

[29] https://smartcities.at/projects/monitoring-sglimberg-evaluierung-der-bereiche-energie-mobilitaet-und-soziales-in-den-ersten-zwei-jahren-nach-bezug/

[30] Skanska test of concept. Synhouse November 2021 (ppt)

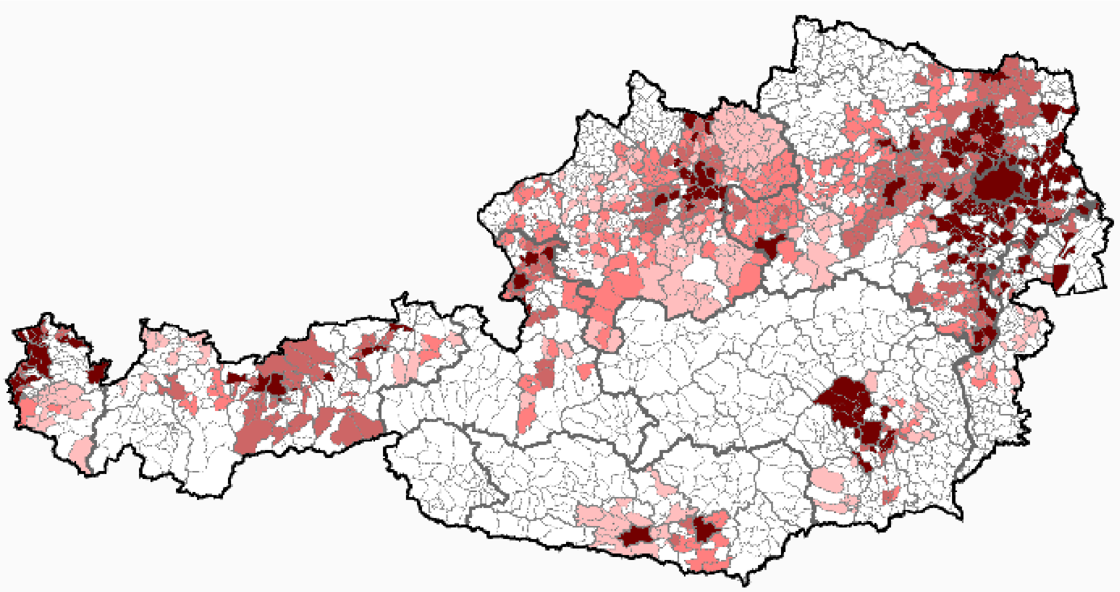

Figure 11: Visualisation of geographical parts of Austria where SPENs are most likely to succeed

### 8.1.4 Competition and cooperation

There is no competition in the non-profit housing market, and the agents are allies and strategic partners. The associations in Austria have a common base where experience and know-how are exchanged[31]. The non-profit organisations are also working very closely with for-profit housing organisations. If social housing is included in a project, the housing developer will look for a non-profit housing association to build and run the social housing flats. Since most SPEN relevant projects are only possible to be built with governmental or other subsidies, collaboration between for-profit and non-profit organisations, relevant stakeholders and whole communities are crucial. The Austrian demo has experienced the importance of experts (house technic, installations and building physics) for the development of the SPEN concept. A success factor is collaboration between actors in the value chain.

### 8.1.5 Barriers and drivers to entry

There are three main barriers to the development of the SPEN concept that were emphasized in the interviews for Austria. One is that taxes and/or subsidies do not reward sustainable solutions enough, and/or that the use of fossil energy sources is not punished harshly enough. Support schemes are also not coordinated between different authority levels. The second main barrier is that the SPEN concept is not attractive enough compared to other factors that influence residential development. One explanation is that the benefits, for example in the form of reduced energy use and costs, are not sufficiently well known. People are currently in general not familiar with the SPEN concept. A third barrier is technical. People expect that technical innovations will make living easier, but introducing new technologies is often linked to high investment costs and malfunction. Several of the informants believe that geothermal heat sources should be utilized more in Austria.

## 8.2 The Netherlands

### 8.2.1 Uden

[31] https://www.gbv.at/

The demo-project built in Uden is managed and owned by AREA Wonen, a social housing association that rents more than 8 700 homes in Uden, Veghel and the surrounding villages.

3D simulation of Loopkantstraat

AREA Wonen assigned the construction company Hendriks Coppelmans which is building an apartment complex with 39 flats on the Loopkantstraat in Uden. 16 of the flats are rented out to the healthcare organization Labyrinth Zorg & Werk. The complex consists of 3 floors and the flats are suitable for smaller households. They have a usable area of 46 m² (one bedroom) and 71 m² (two bedrooms) and have their own outdoor space. There will be a common room, EV-charging facilities, parking spaces, storage rooms, a bicycle shed and a collective garden. All 39 flats have monitoring, some more equipped with monitoring appliances than others. The concept is called “socially beautiful”, which means that all residents contribute to a sustainable community. Assigned ambassadors ensure that the harmony is maintained and receive a rental discount for the effort. All flats are connected to the electricity grid and have individual energy and ventilation systems.

### 8.2.2 Target market

*Who are the customers and how are they attracted?*

Consistently with the national mandate for social housing associations, AREA targets low-income people or people who are not able to access a safe shelter, often due to an inherent distance from the labour market. However, for this specific demo-site, AREA piloted a new concept called Socially Beautiful. Of the 39 flats, 16 flats are rented out to a local care organization ‘Labyrinth Zorg & Werk’. Labyrinth Zorg & Werk offers guidance to (young) adults with a mental and/or mild intellectual disability. The remaining flats are rented to people seeking social housing. However, in this socially beautiful concept tenants are recruited differently. Usually, tenants who are assigned a dwelling have been registered to a waiting list. In the pilot, the first 10 tenants are recruited based on their motivation letter. AREA opened a call for ambassadors, who are willing to help other residents in need and be a reference point for both AREA and Labyrinth. The ambassadors and Labyrinth had the opportunity to actively influence the development of the plans. They have set additional requirements, which has resulted in the use of other materials and a different design of the building. The goal of this concept is to create a pleasant living environment where residents, together with the neighbours, ensure a good atmosphere, and look after each other. The remaining home seekers are also required to form a residential community with all residents. They must make an active contribution to this sustainable residential community.

### 8.2.3 Market size and trends

*How is the potential market for SPENs considered, and how is the demo project aligned with this?*

There are only a very few initiatives in the Netherlands that can be classified as SPENs. They are also funded by research initiatives at the European level, rather than by private investments. The scarcity of initiatives, and the nature of these handful of initiatives, are, unfortunately, symptomatic of an immature market –at the time of writing – for SPENs. Trends that can be considered promising, are for example pilots and research towards prosumerisms, as well as legal transformations towards the abolition of the feed-in-tariff. The latter can, on the one hand discourage the purchase of PV panes, on the other, incentivise the adoption of energy storage technologies which are, in fact, a key enabling technology for the market uptake of SPENs. These trends, together with collective action which is increasingly being facilitated by the advent of new technological development –including digital platforms– could potentially accelerate the market creation of SPENs. However, the low participation witnessed in the past decade for the energy transition, is a treat as it has already been hampering the adoption of sustainable energy technologies in the built environment.

#### 8.2.4 Competition and cooperation

In the Netherlands social housing associations do not compete. They are not-for-profit enterprises, all driven by the same goal: housing low-income people or people who are not able to access shelter on their own. That implies that their motivation to contribute to the development of SPENs does not consist of financial gains, but of providing high quality of life to their tenants. Despite the little financial drives, intrinsic in their business models, social housing associations can be a front runner in the development of SPENs given their large asset, and their power in neighbourhoods' decision-making processes. By collaborating with construction companies, urban developers, and local municipalities, they can be a change agent, as already witnessed with the achievement of higher-than-average energy labels in the Netherlands.

#### 8.2.5 Barriers and drivers to entry

As for other social housing associations, there are currently many barriers to achieve SPENs. AREA was supported by syn.ikia to realize the pilot project in Uden. Otherwise, many of the innovations and initiatives would have been challenging. As an example; after syn.ikia is completed, it is still uncertain whether and how AREA and its tenants can benefit from the digital twin. Because of the institutional nature of the social housing sector, they are not allowed to join market driven initiatives. They are supposed not to register any profit and to re-invest their rent into their portfolio growth or housing maintenance. In some of our interviews a social housing representative mentioned "we are not an energy company" to highlight their lack of interest in being a player in the energy market, or in encouraging the creation of SPENs. Additionally, they perceive the responsibility of these initiative to be in the hands of the municipalities and of the grid operators.

### 8.3 Norway

#### 8.3.1 Verksbyen

The Arca Nova Group is a private property developer in the south of Norway. They develop properties for sale, and Verksbyen, the demo project in syn.ikia, is the first project with ambitions to become a SPEN.

Verket Panorama block A

Verket Atrium block K, L, M

The pilot project Verksbyen consists of 58 housing units, divided over two flat buildings right outside the city center of the Norwegian city Fredrikstad. The housing concept is called future living and includes smart house technologies and zero emission solutions. Among the shared facilities are parking spaces for cars and sheds for bicycles, EV-chargers, storage rooms, park areas including play and activity grounds and a community house. Arca Nova, which is the only developer in Verksbyen, has the ambition to create a sustainable neighbourhood. Verksbyen is in immediate proximity to walking and cycling paths, public transport, shopping areas and schools and kindergarten. There are photovoltaic installations on the roofs and façade surfaces, all flats in the demo will be connected to a central heating system and to the electricity grid. All the flats are built for sale in the private housing market. The buyer has the option to select some of the interior, such as parquet, tiles, wall colors, doors, kitchen furniture, bathroom appliances, lighting, and smart house option[32].

### 8.3.2 Target market

*Who are the customers and how are they attracted?*

The Norwegian demo project differs from the other demo projects because the buildings contain flats on the private market. The flats have so far attracted mostly elderly and middle-aged people, who, for example, have children who have moved out. The flats are sold at market price compared to other attractive flats in the region, both because the area has become attractive, and the developer also think they have developed an attractive concept. To attract families with children, there are two-floor flats in the project that are priced somewhat lower. The studio flats attract young couples without children.

The flats are organized as joint ownerships. The project is located just outside the city centre, with good access to public transport, the hospital, park area and grocery stores in the immediate area. The customer base varies greatly in preferences and knowledge regarding technical solutions. The customers appreciate lower energy costs, to have the opportunity to test new technology and help reduce greenhouse gas emissions.

### 8.3.3 Market size and trends

*How is the potential market for SPENs considered, and how is the demo project aligned with this?*

Traditionally, the housing market has been such that it typically is the elderly and middle-aged who move from detached houses to flats close to the city centre while the younger buyers acquire terraced houses and detached houses just outside the city. Arca Nova think that this has to some extent begun to level out, and more young people are buying flats. They are thus aiming their marketing broadly.

Arca Nova has experienced that awareness grows with use and testing of smart appliances. The customers do not necessarily know exactly what they are getting but have a feeling that they are part of the future and

[32] syn.ikia report "Communication, Dissemination & Stakeholder Engagement"

this excites them. Enthusiasm and awareness increase when they experience the practicality of the solutions. Corporate social responsibility and social development are taking a larger part in projects. The common Norwegian consumers are, however, not familiar with the SPEN concept and are not able to differentiate between SPEN and similar sustainable housing concepts. The marked is still characterized as immature. Notwithstanding, Arca Nova believes that they have developed an attractive project that can also work elsewhere in a few years.

Norwegian energy consumers have a long history of low energy prices and a stable energy supply. Norwegians are thus not used to energy saving and people in general do not have any notion about the effect of their consumption on load demand and peak load. This indifference to own consumption comes from low energy prices and the public narrative that energy is clean. Because of this, and lower temperatures than rest of Europe, Norwegians have a high energy consumption. Like one informant expressed it: ”*It [the lights] is lit at all hours of the day, we heat the driveway, stairwells, and the cabin when we are not there. Yet it is politically incorrect to urge savings".*

Due to the trend of overconsumption, the situation over the last few months has been extraordinary. The peaking prices have however forced Norwegians to reflect on their energy consumption, which is good news for SPEN developers. Arca Nova sees a need to create a separate energy company, or join an energy company, which will operate the energy system, which is too complex to be left to the condominium.

### 8.3.4 Competition and cooperation

*What actors are present at stage, and who are about to/likely to enter?*

Arca Nova is a regional housing developer mainly located in the south-eastern part of Norway. They consider competition in the SPEN market as low as there are currently few that have the same to offer their customers. Other housing developers usually comply with the current building codes, and do not try to exceed it. However, the market is immature and the SPEN-concept is new, both in Norway and internationally. OBOS is the largest housing developer in Norway and one of the largest in Skandinavia. They have several ambitious neighbourhood-projects in the pipeline, such as Oen and Furuset Village. Skanska is an international project development and construction group, controlling the entire value chain. As part of the Powerhouse-alliance Skanska is developing the first residential Powerhouse project, planned to be completed in 2023. All actors mentioned are private developers. However, public actors such as several municipalities and the Norwegian Directorate of Public Construction and Property (Statsbygg) has similar ambitions.

Arca Nova has made extraordinary agreements with the suppliers that states that their cooperation is part of a joint knowledge development, and that the mark-up is thus lower. Although Arca Nova hopes for a first mover advantage as the market matures, they see an advantage of open communication across the value chain and even with potential competitors, so that they can learn from each other. The demo project has additional costs of around €1,000 per square meter compared to conventional construction projects, and they state that the project would be difficult to realize if the only focus had been on profitability.

### 8.3.5 Drivers and barriers

*What are the main drivers and barriers to the further development of SPENs?*

Arca Nova mention the energy regulations that hinders energy sharing as their main barrier to the development of their SPEN concept. They have also had malfunction of their smart locks in the pilot project Verksbyen but has experienced goodwill from the users. Because the SPEN concept is complex, they may have problems communicating to the customers as well as within Arca Nova itself. A lack of knowledge is also observed in the consultant industry. Offering new technological solutions has an additional risk in that the suppliers are often start-up companies that are dependent on funding. Several of Arca Nova's suppliers have gone bankrupt.

By investing in energy-efficient solutions it is possible to be granted investment support from Enova[33], which is a public enterprise under the Ministry of Climate and Environment. The support, however, makes up a small proportion of the total investment. Such investments are also dependent on cooperation with the local government and the local energy suppliers. Arca Nova had several discussions with the local district heating company to be able to cooperate or avoid the mandatory connection to the district heating grid, since district heating will only be used as reserve or peak load in Verksbyen. The energy sources used for district heating in Fredrikstad is mostly municipal waste, with some electric boilers and fossil oil and gas as peak load fuels[34]. Using district heating for heating in Verksbyen would lead to a higher proportion of fossil fuels than the SPEN concept allows for. The district heating grid also has energy loss of 10-15%.

## 8.4 Spain

### 8.4.1 Santa Coloma de Gramenet

Catalan Land Insititute (Institut Català del Sòl-INCASÒL) is a public land and housing developer and entity of the Government of Catalonia (Generalitat de Catalunya). They administer  public heritage of land and houses under the restriction of the Housing Act.

*3D simulation of Fondo*

The INCASÒL pilot represent affordable rental housing  in the municipality of Santa Coloma de Gramenet.  The project is an urban regeneration  that includes road construction and a square in a highly densified urban area. The pilot has three key energy concepts: Saving/Generation/Sharing.

The pilot consists of 38 flats that will be managed by INCASÒL. The four-storey apartment building will be connected to a public building. 10 of the flats will be monitored. The project includes sustainable materials, energy efficiency solutions to the building envelope, and both buildings will have installed PV panels. An energy manager will monitor and optimise the energy production and consumption in the two buildings and share and assess the information with the residents. The pilot project is centrally located and can thus be connected to the district heating network and other nearby buildings (Cortés, 2022).

[33] https://www.enova.no/about-enova/
[34] https://www.fjernkontrollen.no/fredrikstad-fjernvarme/

The aim of the project is to contribute to digitalising the electricity grid and incorporate energy management in energy systems. This is to be achieved through monitoring, data analysis and communication with the users. Efficient communication includes training in the use of the equipment that controls energy production and use, and making the users understand their important role for energy flexibility.

### 8.4.2 Target market – the customers

*Who are the customers and how are they attracted?*

The Spanish demo project is an urban regeneration of a very dense and socially and urban degraded neighbourhood . This regeneration consists of the renovation of existing homes for the current residents that can afford rental homes

The tenant's priority, apart from the comfort and dignity of housing, is economic. The rent and prices of community services offered are much lower than the market prices for comparable goods. The tenant's profile is diverse, ranging from elderly people to young people or families with or without children or even single-parent family units, but all have low income in common.

To offer affordable housing to low-income households emphasis is placed on minimizing the expenses from the use of the homes. For this reason, even if energy saving or own production of renewable energy is not of great relevance to the tenants, it represents an important economic value saving for the housing developer.

The tenants are not particularly interested in the technical solutions that are part of the concept, like the smart solutions controlled by apps. They are currently indifferent of the opportunity to test new technologies and help reducing greenhouse gas emissions. However, they do appreciate lower energy costs.

### 8.4.3 Marked size and trends

*How is the potential market for SPEN considered and how does the demonstration project align with this?*

The SPEN concept is diverse, and the potential market for SPENs is thus also diverse. SPEN can be public or privately owned, for older or younger people, families or individuals, residential use or industries.

Fighting energy poverty and achieving clean energy use. thermal comfort, energy efficiency and saving are superior aims and standard concepts in urban everyday life.

### 8.4.4 Competition and cooperation

*What actors are present at the stage, and who are about to/likely to enter?*

In Catalonia and Spain, SPENs and nZEBs are promoted by public operators, whether they are Town Councils or developers of land and housing owned by the public entities. There are also certain cooperatives aligned with the objectives of the 2030/50 horizon.

Private developers will eventually incorporate these technologies and criteria. This uptake can be pused by the public institutions.

Urban planning developers are key actors for the further development of SPENs. They have the tools and measures to set parameters that favour and promote the energy transition by 2030/2050.

### 8.4.5 Drivers and barriers

*What are the main drivers and barriers to the further development of SPENs?*

The main drivers for development of SPENs in Spain are, according to the interviews, rising awareness of the need for a transition towards sustainability, public promoters are the engine to change, and the energy crisis promote energy efficiency measures. The main barriers are legislation that does not keep up with developments, large energy companies that hinder small producers, and high investment costs in energy-efficient solutions

In Catalonia and especially within the Metropolitan Area of Barcelona it is not very common to find centralized climate systems. The most common is to have individualised systems, which often are less energy efficient and subsequently also hinders access to certain financial aids.

### 8.5 Summary

The pilot projects in Austria, the Netherlands and Spain are non-profit social housing actors, while the Norwegian pilot represents the private market. All the projects have installed solar cells and offer shared solutions, such as electric vehicle chargers and common areas. In the Dutch demo they have a different recruitment process of some residents they call ambassadors. The selection is based on a motivation letter. The ambassadors make an extra effort for the community and get a reduced rent. The residents seem enthusiastic about contributing to the energy transition, testing technical innovations, and saving energy costs. There is no competition on the market for non-profit social housing, and the players work closely with suppliers and authorities. For the Norwegian pilot, collaboration has also been important, because the SPEN concept is under development, and they are dependent on knowledge and experience sharing. In the Norwegian pilot, cooperation with suppliers involves special agreements on joint development, against a lower mark-up. All the pilots see significant market potential, but in the medium to long term. As of now, the market is characterized as immature. Chapter 10.1 summarizes the drivers and barriers for SPEN, which are both experienced by the pilot owners and identified through interviews with market experts

# 9. PESTLE ANALYSIS

In the following sub-chapters, the result of interviews, the survey and findings in the literature is presented along the PESTLE-analysis framework. What implications have political, economic, social, technological, legal, and environmental issues to the development of SPENs in the four demo contexts? For policy/political and legal issues there is a fuller description in the syn.ikia report "Barriers and opportunities of plus-energy neighbourhoods in the national and local regulatory framework" (Boll, et.al., 2021).

We have collected joint findings and present them first in each of the sub-chapters. For some aspects, it has not been identified any country-specific findings in addition to the common ones.

## 9.1 Policy and political aspects

Main question to answer:

*How will the current political climate impact the development of SPENS?*

The EU policies on buildings' energy performance goes back 50 years, to the 70s. Regulations have developed over the decades into today's nearly zero energy building (nZEB) requirements. Although not defined in all the four demo countries, this makes an important threshold and a point of departure when developing neighbourhoods with high sustainability ambitions. The tendency in policies goes from energy efficiency and single buildings, towards energy markets integration and neighbourhoods/districts. Currently, the situation around soaring energy prices has induced a movement in policies and policy makers seem more inclined to exploit the energy potential connected to buildings and neighbourhoods such as energy efficiency and local energy production. However, the responsibility for a reliable grid is public and lies to the grid operators, and there is little incentive for households to manage their own energy demand and supply.

The national regulations are important drivers for ambitious concepts like SPENs. If the spatial planning in the communities would involve energy aspects more, there will be new regulations, and this may increase the awareness that energy supply and energy performance must be planned in a very early phase.

### Austria

Austria has a wide range of SPEN-related policies on different levels. These are covering energy efficiency, renewable energy generation and neighbourhood involvement[35]. The Austrian government is supportive of buildings sustainability by enacting laws such as the EAG (Renewable Energy Expansion Legislative Package) or the Renewable Heating Act, which could also offer incentives for the development of SPENs. Besides measures that support the generation of electricity from renewable sources (hydro, solar, wind and biomass), the laws support the creation of two types of energy communities: renewable energy communities, and citizens energy communities.

The government is also fostering a smart cities network, to create an avenue for information sharing between municipalities. Furthermore, the Federal Government has launched measures to make Austria more self-sufficient. Other political frameworks as for example the directive for housing subsidy, will be managed by the nine federal states separately.

### The Netherlands

SPENs are not yet a priority of the National government. Currently there is an emphasis on renovating individual buildings or building new buildings by meeting $CO_2$ standards. Studies of the most favorable roadmaps for the energy transitions of the Dutch built environment envision a shift from a centralized to a decentralized demand and supply management, in which current consumers become prosumers and energy is managed locally and not systemically. A decentralized storage scenario would contribute both to a more reliable energy provision with renewable sources –in preparation to highly fluctuating energy markets– as well as to lower energy bills, increasing the business case for the homeowners to install renewable energy sources and storage, and detach from the (gas) grids. In fact, as also confirmed by the interviewees of this study, initiatives for storage at the neighbourhood level seem more attractive than those at the individual housed level. When extended to the community, energy storage becomes not only a fundamental technical advancement for the energy transition but also an important social innovation, bringing benefits that go beyond economic and environmental values (Koirala, van Oost, E., & van der Windt, 2018).

However, on broader terms, energy positive districts are not mentioned yet in the Dutch policy for the energy transition. The national government wants to reduce $CO_2$ emissions by switching to sustainable energy. That is why, in principle, from 2050 it will no longer be possible to cook or heat homes on natural gas. Currently, there are subsidies for the purchase of these sustainable energy installations.

### Norway

The building code has been significantly reinforced since 2007 and is now described as at a "passive-house level". Neither the building code nor any other policy framework that are addressing SPENs or similar concepts are implemented yet, and the term nZEB remains to be defined at the national level.

The main heating technology for buildings is electricity produced by hydropower. Since hydropower is renewable energy and prices until recently were low, little effort has been made so far to reduce energy consumption or exploit the building mass to the benefit of the energy system. This is reflected in the debate in the parliament, as well as suggestions for changes in regulations. Recently it has been suggested that sharing of energy should be easier, and regulatory barriers are about to be eased to some extent. So far, a *plus customer agreement*[36] has been a solution for those who wants to produce power locally.

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[35] Syn.ikia report D5.1, 2021 "Barriers and opportunities of plus energy neighbourhoods of the national and local regulatory framework"

[36] A Plus customer is a grid-customer that both uses and produces electricity. A Plus customer need not pay the regular fixed tariff for supplying electricity to the grid.

**Spain**

The building code in Spain is at a nZEB level. The Spanish Long Term Renovation Strategy (LTRS) introduced the PED concept in 2017, but since then there have been few advances in defining or promoting the concept from either a political or a regulatory point of view.  Energy policies do not consider housing situations such as rentals, in which the landlord has no interest in investing. This is because the landlord does not receive any direct benefit and the tenant will not do so as they will not recover the investment within the period of the rental contract, and they risk landlords increasing the rent due to improvements in the homes.

Foreign policy can affect economic policy and, as a result, investment capacity. Higher demand in energy quality in construction can make the works more expensive and although it will affect the future buyer, there is a limit in the economic capacity to buy. However, an increase in energy prices can help raise awareness of the need to have positive buildings (more efficient and with local generation).

Another driver is public promoters: Promoters with social and environmental awareness are promoting actions above the current regulations to achieve transposable environmental and energy objectives to the rest of the promoters (private). They can be an engine of change.

## 9.2 Economical

Main question to answer:

*How are interest rates, exchange rates, taxes and prices/costs affecting the development of SPENs?*

The higher investment costs of some building components of SPENs affect their development, as these cannot be passed to the final user. Currently, a sustainable and low energy concept is a “nice to have” for getting the flats rent or sold, but until now it is still not the most important factor, as people still give more value to the price, location, and building quality. However, rising energy prices could change this situation, since potential owners and/or tenants is expected to become more interested in on-site energy generation. It would indeed be more profitable for the household to retain its energy rather then send it back to the grid, especially if the household can afford the capital expenditures of installing a heat storage technology.

Public incentives such as tax laws, subsidies, investment support and public funding would greatly benefit the deployment of SPENs. Policies such as higher taxes on fossil fuel-based heating and subsidies for low and plus energy buildings could significantly accelerate SPENs development.

**Austria**

One measure to make Austria more self-sufficient is an initiative giving grants to support wind and solar power projects was launched with a total funding of 250 million euros. This subsidy is part of a 4-billion-euro package aimed at easing the burden of high energy prices on Austrian people.

According to the SIR (Salzburger Institut für Raumordnung & Wohnen), the lifecycle assessment of several SPEN-related projects shows that they are usually cheaper than conventional/standard concepts, as shown in Figure 12.

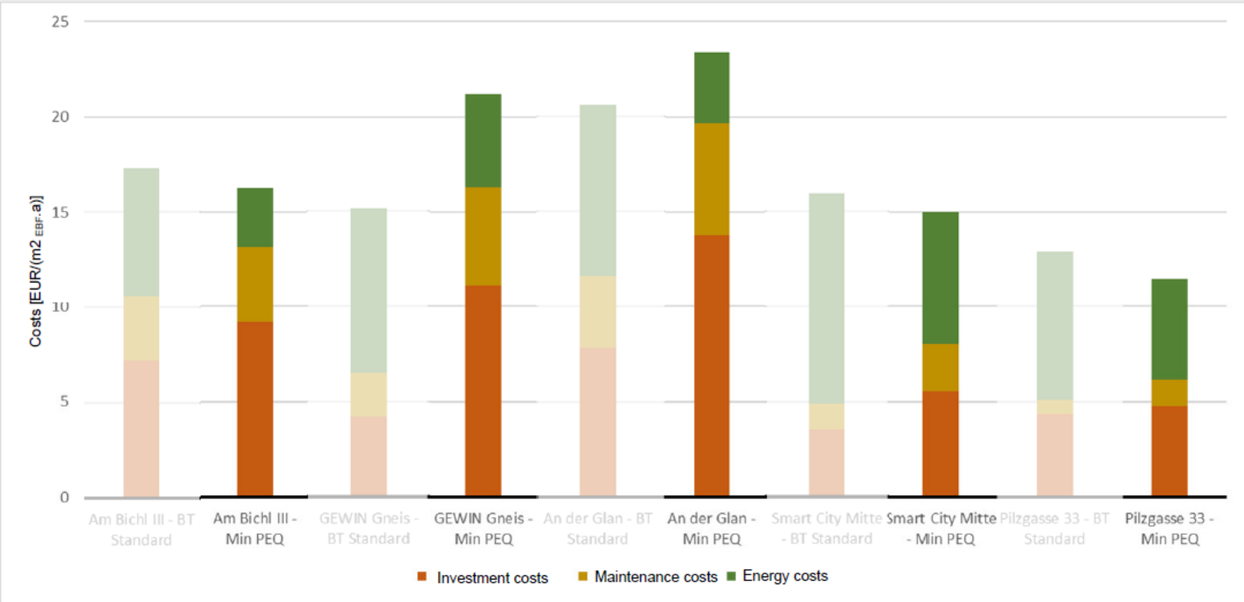


Figure 12: Zukunftsquartier Österreich (Tinkhof et al, 2022)

Even though investment costs are usually higher, and maintenance costs are comparable to standard projects the energy costs throughout the lifecycle of a SPEN could make up for the difference. In some cases, a SPEN ambition even makes developments cheaper when considering the whole lifecycle.

### The Netherlands

Among the economic barriers, besides the rampant energy poverty and household's economic situation, there is a shortage of capital to build and retrofit energy positive homes. This is particularly worrying as it seems that the Netherlands can hardly meet the target to renovate 200,000 houses by 2050. In the Netherlands, there are over 40,000 construction companies, but some 80% of them are freelancers of limited size. Few companies are currently equipped to do energy neutral renovation of houses. However, there are companies that can do a full energy neutral renovation of a terraced house in a week. With 4,000 renovations a week, assuming a company can do 10 houses at the same time, that means 400 companies involved, each of which will involve other sub-contractors. A barrier here, is the number of employees necessary to refurbish a house. With the current numbers the Netherlands falls dramatically short. Construction automation might be a solution, but the Dutch market might be too small to economically initiate and implement it.

Looking at the cost versus value perspective trends in the past decade, an average price for a zero-energy renovation in the Netherlands oscillated around € 80,000 on average. However, the energy savings of € 150-200 per month that such renovation provided, resulted in a payback time of over 30 years. The increase in housing value due to better energy performance has also not been that significant (Greco et al., 2017). These days it can be estimated that a similar house can increase in value by 1 to 2% per every energy label improvement. If we then consider that the average house value oscillates between € 160,000 (Groningen) and € 260,000 (North-Holland), we have that the renovation cost is equivalent to 25 to 45% of the value of the house. The values used here are including the price of the land, which is significant. Due to the newest geo-political events, there is a clear possibility that the business case for these interventions will be positive from next year. However, published evidence is not available yet.

A zero-emission energy network[37] has calculated that renovation costs are financially viable for housing corporations up to 35.000 euro. Which means, the cost should be reduced by half. This is a significant challenge. The Urgenda[38] renovation concept offers an alternative for 25-35.000 euro, but this has significant implications for comfort (e.g., you do not heat the first and second floor), which is not acceptable to the public (although this may change with the latest increase of energy price). Urgenda consist of a non-profit, science-driven energy activist group that also formed a centre of expertise for energy driven refurbishment. Their renovation concept mainly focusses on replacing installations (active measures) since these are cheaper than passive measures such as insulations.

If all these homeowners would like to have a zero-energy house –which is already a major challenge, getting loans for renovations is a challenge. Banks can't easily provide loans that are not hedged against a collateral of the same value (loan to value), especially if the investment is not economically attractive. And since about half the housing stock is already connected to a mortgage, many homeowners won't be able to use their own house as a collateral for the loan.

There are several subsidies to finance renovation and the implementation of different sustainable installations, such as PV panels (RVO, 2022[39]). While currently the average Dutch households are economically attracted to install PV panels, they are not incentivised to install heat storage technologies yet. But the development of new policies is expected to include incentives also for heat storage soon. There is a feed-in-tariff supporting energy production at a higher rate up to the amount of purchased energy, and a lower rate for the production exceeding the purchased energy. From 2023, the feed-in-tariff would be phasing out of 9% less each year. When the scheme would be fully completed, the household would then receive 6 cents per kWh for all energy put back to the grid. In that scenario, energy storage becomes one of the most attractive business models for the homeowner to profit from the energy market (Rövekamp, Schöpf, Wagon, Weibelzahl, & Fridgen, 2020). However, while this regulation could increase the incentives for people to install storage technologies, they could also be a barrier to the wider array of sustainable energy technologies by lowering the energy prices, as argued by Rövekamp et al. (2020).

### Norway

Prices in the housing market has steadily increased since 1990, especially so in urban areas. Increasing interest rates is expected to cool down the market, at least temporary.

Energy prices play an important role in the development of solutions. Traditionally, Norway has had low energy prices and investment in local renewable energy production has mainly been motivated by sustainability. Periods of high energy prices will be a driver for local energy production. More people are taking an interest in solar panels as the repayment period decreases. Load demand tariffs for households were implemented in Norway in 2021. Such tariffs reflect, to a greater extent than energy tariffs, the costs of energy transmission. Depending on the design, the tariffs can also contribute to a flexible energy system, and thus reduce the need for grid investments.

The Norwegian demo project in Fredrikstad and a similar project in Trondheim developed by Powerhouse sell their flats at market price. They have chosen to place the buildings in attractive areas, which have a high price, but they take a higher risk for the concept development. Even if sustainable construction is seen as a plus, customers are usually not willing to pay more for it. Enova, which is owned by the Ministry of Climate and Environment, can make a financial contribution to projects that cut emissions and develop new energy and climate technology. A developer also needs to be aware that the attractiveness of the building site

[37] https://stroomversnelling.nl/
[38] https://www.urgenda.nl/en/home-en/
[39] https://www.rvo.nl/subsidies-financiering

makes the customer segment limited because of the price. It is, especially in the capital, difficult for singles and low-income groups to enter the housing market.

When it comes to energy efficiency in buildings and neighbourhoods few effective incentives are in place. Discussions related to the state budget in the autumn 2022 indicates that companies doing energy mapping of their energy saving potential can receive support for this, and more support if measures are implemented. Households receive support of up till 90% of the electricity price above 7 cent/kWh in average over a month. This includes housing associations and condominiums. There is currently a national goal to reduce the energy need from the building sector by 10TWh within 2030. Studies argue that this goal will not be met with the incentives currently in place. It is also argued that the goal is too little ambitious (Sandberg, et al., 2022). It is likely that more incentives will be implemented mainly due to the extreme energy prices.

Without a concession to produce energy, you need an agreement for grid connection and use with the grid company, to be able to feed-in surplus energy. The grid companies need to plan the capacity to be able to handle the feed-in of energy. Prosumers make this planning more challenging, but local energy production is still welcomed. Everyone who is connected to the power grid is sharing the investment costs for the grid capacity through the grid tariff.

**Spain**

Investing in energy efficiency measures is expensive, especially in warm climates, and so it must be financially supported. The energy saving achieved is not high and therefore does not lead to significant economic savings. Unfortunately, some of the currently open aids (Next Generation Fund for rehabilitation) raises energy requirements at the building level, the fulfilment of which is practically impossible without investing in various elements of the thermal envelope simultaneously, which many neighbouring communities cannot afford, so indirectly it is favouring vertical owners with investment capacity or investment funds. There are subsidies, tax bonuses and initiatives such as NexGenEU and IBI and ICIO tax rebates that encourage the development of more efficient buildings and neighbourhoods with a significant incidence of renewable energies. No changes in the current tax regulation are expected short term. In the coming years all incentive policy goes through more demanding regulations or grant lines coming from NextGenEU.

In the case of rehabilitations, the situation is similar and, as already mentioned, even worse when the buildings are occupied by tenants and not by owners: very rarely tenants will invest in improvements in homes in which they are not guaranteed their continuity, nor will they ask for it in fear that the owners would raise their rent. On the other side, owners will not invest as they are not obtaining a direct profit as they do not take care of the energy bill of the house.

Given the current fragility/instability of the energy market, interest rates, exchange rates, taxes, and prices/costs positive energy neighbourhoods (and/or buildings) development are essentially affected.

Energy certification is not a relevant factor when buying a dwelling. The decision to buy is mostly based on the surroundings, benefits and comfort of the housing unit, etc. It is for this reason that the majority target customer cannot afford a home in a neighbourhood (and/or buildings) of positive energy today.

Most of the rehabilitation works are carried out at large scale in areas of high vulnerability as a tool to help reduce energy poverty. These rehabilitations are usually mostly publicly financed, but this is not sustainable to a larger extent.

## 9.3 Social

Main question to answer:

*What lifestyle, norms, customs and values or demographics could affect SPENs? (Including relevant businesses, partners and customers)*

Awareness in the population about energy performance and sustainability of a building and a neighbourhood could have a big impact on SPENs development. However, customers normally do not think about the lifetime cost and that it will probably be reduced in this type of building, partly because these buildings have more durable materials, and the energy consumption is reduced. This attitude, however, is about to change, with a push from high construction material and energy prices in the wake of the war in Ukraine.

### Austria

Recently, people have started demanding more "green houses" (houses that include the use of sustainable materials, PV panels, and energy management systems), since they have realized the importance of sustainability aspects in order to reduce energy consumption in a building. The municipality and community associations are very important strategic partners for SPENs, as they facilitate knowledge exchange. The nonprofit housing associations have a common base (gbv – Verband der gemeinnützigen Bauträger) where information is shared, which could represent an opportunity for SPENs development, since these associations could demand to federal and municipal governments the construction of better energy performing buildings. However, when it comes to the relevant stakeholders and professionals, there is a lot of resistance in the building sector; also many architects do not see the importance of new sustainable concepts.

### The Netherlands

There are many social aspects that can impact the implementation of SPENs. However, two are currently particularly salient in the energy transition debate: 1) societal acceptance, and 2) user behaviour. Social acceptance is seen as one barrier of concern for the implementation of SPENs. For social housing for example 70% of tenants need to give permission to make changes to a building such as energy retrofits[40] (Rijksoverheid, 2007). Besides, it is estimated that housing occupants' behaviour affects the energy performance of dwellings up to 27% (Kazmi et al., 2016). Therefore, it is crucial that tenants are involved in initiatives related to energy upgrades, prior, during, and after project execution (Greco & Long, 2022).

It is notable that the Netherlands is currently affected by what the Dutch people call "woningcrisis", i.e., *housing crisis* (Boelhouwer & van der Heijden, 2022). Such crisis consists of an alarming housing shortage and a peak in housing prices, making housing ownership largely unattainable for low *and* middle class. There are many factors that led to this crisis, but the main ones are related to the pace of population growth and the low construction rate. If these trends continue, there will be a gap of approximately 2,5 million houses needed for the upcoming 3-4 decades.

The rental market is also increasingly saturated. In the Netherlands, 70% of rented houses belong to housing associations, amounting to almost one-third of the total residential stock[41]. The remaining 30% of rental properties belong to the free private market. The target of free rentals are often people who do not manage to access social housing –either because their income is (slightly) above the limits for social housing eligibility, or because they might be on a waiting list. In many instances, the free sector reserves homes with a net* rent between €850 and €1,068 (price level 2022) for middle incomes. For a free sector rental home, it is estimated that eligible renters must earn at least 48 times the net rent per month, gross per year. For example, if the rent is € 1,100 net per month, the renter income should be at least € 52,800 gross per year. Such threshold makes the free rental market very competitive. Therefore, the rental properties are often of poor quality as homer are not incentivised to improve the quality of housing, since this would not influence

[40] https://www.rijksoverheid.nl/onderwerpen/woning-huren/vraag-en-antwoord/wat-zijn-mijn-rechten-bij-renovatie-van-mijn-huurwoning
[41] Centraal Bureau voor de Statistiek (2017). Doelgroepen woningtoewijzing sociale-huurmarkt 2015. From https://www.cbs.nl/nl-nl/maatwerk/2017/13/doelgroepen-woningtoewijzing-sociale-huurmarkt-2015.

their ability to rent the house given the anyways high demand. In fact, rentals, especially student housings, are in many instances affected by drafts, moisture problems, leaks, or mould.

### Norway

There is a trend towards reuse and sharing which can be seen in many development projects in Norway. Examples are the commercial building KA13 (Kristian Augusts gate 13) where circular principles were implemented to a large extent, and the planned Furuset Village exploring sharing solutions and social neighbourhoods, both are FutureBuilt projects[42]. The values associated with sharing and circularity seems intriguing to people and creates enthusiasm and engagement. This is promising for developments, such as SPENs. The customers have, however, different needs, interests and preferences, and a concept such as SPEN, can hardly meet all of them. Some want to own their car, and like it to be always fully charged. People have different opinions about what is a comfortable indoor temperature, some like to take long and hot showers and spend a lot of time cooking, while others don't. The building owner or operator cannot interfere in such matters. It is thus easier to control the energy consumption in commercial buildings. There is observed a lack of interest in and knowledge about the plus house concept. Today, people seem to be more concerned with energy costs and to some extent sustainability, but less interested in smart house technology. Furthermore, older people may find it difficult to adapt to new technology.

### Spain

At present, consumers do not trust or know enough about positive energy neighbourhoods (and/or buildings). For now, it is in general not a decision-making factor for buying or renting. Elements connected with SPENs can be very technical and far from the reality of the citizens, f.ex. how to understand Non-Renewable Primary Energy and compare this with their electricity bill.

Important drivers for change are social movements and demands against climate change. Currently, the environmental crisis has generated important social and citizen movements that call for solutions to alleviate climate change. This implies significant pressure towards the government and political organizations.

## 9.4 Technology

*Could new technology innovations disrupt or enhance the development of SPENs?*

The energy system in Europe is developing to become emission free in 2050. This also includes technologies such as hydrogen and batteries to handle excess energy from variable wind and solar power production (Statnett, 2020). SPENs can be a source of flexibility and reduced energy demand that can support the development of grid infrastructure. However, there are barriers related to how the system is organised and financed that are of a structural character and thus hard to change.

The market does not know much about the technological aspects required for SPENs, such as how to incorporate local renewable energy production in the system. New technologies such as AI or automation will have an impact on the ability to develop SPENs, but technology needs to be complemented by increased awareness and empowerment of citizens.

### Austria

New technologies such as the use of geothermal energy for district heating could enhance the development of SPENs. Smart energy management systems are starting to gain more relevance among the population and real estate developers for building energy performance (such as the case of GEWIN Gneis) and to accomplish the requirements of building standards certifications. In Salzburg, they consider innovation as a process and

[42] https://www.futurebuilt.no/English/Pilot-projects#!/English/Pilot-projects/Kristian-August-gate-13-Oslo
https://www.futurebuilt.no/Forbildeprosjekter#!/Forbildeprosjekter/Furuset-Village

not successive technological advancements. Intelligent use of electricity for example is much more important than the PV components itself. Simplicity and clear instructions on how to use built-in technologies for residents is essential to achieve meaningful results. Good use of incentives is also important to make sure advanced technologies are used well. For example, offering beneficial prices for some applications can create a big effect on behaviour of residents, such as already available Smart meters.

### The Netherlands

Technological factors such as sustainable innovation technologies and housing typologies play an important role in the implementation of SPENs. However, technological advancement is not to be blamed for the slow energy transitions of housing in the Netherlands. In fact, a plethora of technologies that can contribute to an energy positive built environment have been mature for decades (Greco, 2016). Technological acceptance is thus considered one of the main barriers for the transition of housing, especially in the context of social housing (Greco & Long, 2022). Social Housing association have the hybrid goal to alleviate poverty through housing and being financial sustainable and have thus not prioritized the adoption of sustainable energy technologies (Greco, Long, de Jong, 2022).

However, new developments are going towards the combination of digitalization and energy transition. Smart housing, and smart cities, are increasingly gaining traction the Netherlands (Tomor, 2022) as in other European cities (Varró & Bunders, 2020). A newer development is the use of digital technologies to facilitate citizens' engagement. Examples and pilots are increasingly seen in social housing, using decision-making tools (Ossokina, Kerperien, & Arentze, 2021). Another interesting technological development consists of the use of digital platforms to collectivize home renovation and unburdening homeowners who could be overwhelmed by the customer journey needed towards energy retrofits (Greco & Olivadese, 2022). These developments are however still emergent and require co-creation with the user, for user acceptance and market uptake (Greco, Nielsen, & Eikelenboom, 2023). Despite the newness of these technologies, they could be a promising mean to facilitate the creation and development of SPENs.

### Norway

There are different interpretations of what a smart house is, but normally it is associated with technological solutions, apps and automation[43]. Is it possible that technological solutions in the projects can be alienating to its inhabitants, and that technology makes it more vulnerable and more likely to malfunction? The solutions in SPENs need to be robust and user friendly for the benefit of the users and for the smart technology to work properly. Not all customers are interested in the technical solutions that are controlled in apps, for example sunscreens. Customers who take new solutions into use must tolerate that things do not always work in the beginning. Interest, however, rapidly drops if things do not work. For most customers the willingness to pay is higher for ready-made solutions, and the solutions should be user-friendly. This comes not only from the lack of interest, but also from lack of knowledge.

The SPEN concept also involves Smart charging of electric vehicles. Batteries in driveways and parking lots could be hooked up to the grid to also work as a flexibility measure.

### Spain

Centralized control systems such as air conditioning and lighting in public buildings can, instead of being part of the solution, pose additional problems: closed systems that always require the intervention of the technical assistance service itself, abusive prices for any changes, programming logics not reflected in the manuals delivered, difficulty in reprogramming, etc. There are also cases in which the programs to design the buildings as most positive in their passive form have not incorporated in their strategy the subsequent functionality of

[43] Powerhouse has made a guideline called Smart by Powerhouse

the building. An example is if it is designed automatic window openings to ventilate buildings in noisy streets. A balance needs to be found between automation and conscious manual use (back to manual switches).

Solutions can be difficult to replicate due to the complex situations. Each zone in a city is different and requires a specific study. This is particularly complex at the neighbourhood level. At a building scale, Mediterranean bioclimates solutions are more easily replicable.

## 9.5 Legal

Main question to answer:

*Could any new laws or regulations impact the development of SPENs?*

### Austria

The legislative environment in Austria is highly favourable for SPENs development. The country has recently enacted laws and legislation packages that support the transition to carbon neutrality by 2040. At a national level, they introduced the Renewable Energy Expansion Legislative Package – EAG – which enables the organization of energy communities, provides subsidies for renewable electricity generation, encourages sharing the energy produced in the community, and includes investments for the expansion of district heating. The update of the Electricity Industry and Organization Act in 2021, also introduces the concept of community generating plants, citizen energy communities, and renewable energy communities, among others. It also enables energy communities to act as energy market participants, and generate, consume, or store the self-generated energy. The Austrian Recovery & Resilience Plan 2020 – 2026 (enacted to support the national recovery after the Covid-19 pandemic) includes funding for thermal building renovations, to increase the energy efficiency in buildings and reduce greenhouse gases emissions. In addition, there is also a legislation proposal being analysed, the Renewable Heating Act, which aims to phase out fuel fossil heating systems by 2040. Austria would ban the installation of gas heating systems in new buildings from 2023 on instead of 2025, as earlier planned. In Salzburg, the new urban development plan – the REK NEU - Räumliches Entwicklungskonzept[44] – aims to transform Salzburg to become climate-friendly, focus on sustainable energy and rely on sustainable mobility. It supports small-scale energy production, the implementation of decentralized district heating, and climate adaptation measures to improve the microclimate.

### The Netherlands

The most important legal barrier identified through the interviews, is the lack of contractual laws to manage energy sharing in a district. Currently, energy bills and production are managed at the household level. There is thus no legal framework to manage energy sharing at the district level. In fact, in the Dutch demo-site, the energy produced by the PV panels is not distributed centrally among the different flats. Each flat is allocated 3 PV panels, to simply manage legal contracts at the individual level. Similar barriers are related to the common use of other types of sustainable energy technologies. For example, we know from past research (Greco et al., 2017), that private buildings are reluctant to install geo-thermal energy storage because of the legal obligation to share maintenance with adjacent buildings. According to real-estate investors, such obligations lower the value of the buildings and their chance to be sold in the future.

### Norway

Spurred by the developments in energy and material prices, policy makers seem more motivated to implement measures directed towards energy efficiency and renewable energy production and sharing. There is a growing interest in locally produced renewable energy, and particularly through solar PV, in

[44] https://www.stadt-salzburg.at/rek-neu/

Norway. Therefore, The Ministry of Petroleum and Energy proposes to establish a new scheme for sharing self-produced, renewable electricity for multi-family dwellings, flat complexes, and commercial buildings. This means that more people can produce electricity from, for example, solar panels on the roof and avoid grid tariffs and electricity tax for power they have produced themselves. The proposal involves exemption from the tax for power from renewable energy sources that are used on the same property as the production plant.

Todays plus customer scheme is primarily aimed at households with their own electricity production, and with a limited amount of surplus power that they want to feed into the grid (100 kW). Plus-customers do not pay a fixed rate for feed-in and can measure and settle feed-in and withdrawal at a common metering point. Electric power produced for own use is also exempt from electricity tax. Today, it is mainly single-family homes that are covered by the plus customer scheme, and it is not arranged for buildings with several electricity subscribers[45].

The threshold for the feed-in fee is proposed increased to 500 KW. The scheme is technology neutral, and it is permitted to let a third party, such as an energy company, handle the operation of the energy system. If the new scheme is introduced, it can provide a higher utilization of roofs for solar panels on buildings with several meters. No changes have been proposed for the neighbourhood scale (across properties) so far.

Currently dispensation is granted in the regulations for demonstration projects with potential societal benefits. The dispensation is granted for five years at a time, with the possibility of extension. It is testing for which a dispensation is granted, not the planning phase.

### Spain

The main barrier towards a broad implementation of SPENs is the current legislation which is outdated and do not generally provide for the necessary changes to achieve the 2030/50 targets. Fundamental regulations such as the low voltage regulation do not consider current energy needs and make the implementation of generation facilities impossible or very difficult.

Another barrier in Spanish cities is the perception of solar panels as a negative visual impact. The occupational health law contradicts the Regulation for Thermal Installations in Buildings code in setting operating temperature ranges in both summer and winter. We need to also consider the level of air renovations in the event of a pandemic. But the greatest barrier are the criteria of urban landscape on the subjective criterion of the aesthetics of renewable systems on roofs and facades, added to architectural decisions that do not consider the subsequent impact on energy consumption. Examples are 1) use and abuse of communicating double or triple heights without closing in public buildings that hinder the correct air conditioning of spaces and generate stratifications, 2) reluctance to install double gates at the entrance because they are not considered to the aesthetic standards, 3) lighting options are chosen due to aesthetics more than energy efficiency, etc.

While there is no environmental law that can directly affect the development of positive energy neighbourhoods (and/or buildings), all the provisions that are being worked on at the regulatory level, tend to go in this direction.

The Housing Act prepared by the state government plans to help contain rental prices, especially in what are known as "stressed areas" of major cities. More than 100 organizations in housing rights movement have already warned that the Housing Act is insufficient and will not succeed. This law regulates different areas of the real estate sector such as aid for access to housing, regulation of evictions, creation of affordable housing or the limitation of rental prices in "stressed areas".

[45] https://www.regjeringen.no/no/aktuelt/vil-etablere-ordning-for-deling-av-egenprodusert-strom-i-borettslag-og-naringsbygg2/id2922135/

The Spanish Building Technical Code poses important demands both at the level of building envelope and efficiency in thermal production equipment, but also demands a self-production of energy with renewables. These regulations represent a great improvement in terms of energy efficiency and self-consumption. Despite this, it is not enough with regulations of this type since the real origin of energy self-sufficiency comes from the new urban developments. For this reason, the current urban regulations already incorporate systems of both consumption reductions and production of renewable energy that complement the specific building regulations (Technical Building Code).

## 9.6 Environment

Main question to answer:

*Could climate change or other environmental issues affect SPENs?*

The rapid urbanization of previously rural areas, alongside the effects of global warming are contributing to the phenomena of the Heat Island effect. Cities are suffering from hotter temperatures compared to the countryside, which increases when buildings without any environmental considerations are built. SPENs could help to reverse this situation by providing green areas, sustainable materials, and on-site energy generation (therefore decreasing dependency on fossil fuels).

Security of energy supply has become a big concern in the population, given the consequences of climate change, which could also create an opportunity for SPENs development, as districts and neighbourhoods would be self-sufficient.

**The Netherlands**

From an environmental perspective, it is expected that SPENs will increase in the future. In fact, by 2050, the Dutch housing stock will have to be 100% $C0_2$ neutral. Hence, social housing associations are stakeholders capable of accelerating the transition by influencing the market for energy neutral construction and associated advances for more affordable technical solutions (Greco et al., 2017).

However, this target appears to be quite challenging to reach. To meet it, approximately 200,000 houses per year will need to become energy neutral, which would imply on average the refurbishment of about 4,000 houses per week (Greco & Long, 2022). However, the current rate of transformation of social houses is very low (Filippidou et al., 2017) and would need to increase by a factor of 20. If the current pace continues, the climate targets established by international policies will not be met (Filippidou et al., 2017). Main barriers include a general lack of economic capital and a shortage of construction companies equipped to perform the amount of building interventions needed (Faber and Hoppe, 2013). Given the characteristics of the Dutch built environment, the transformation of social housing plays a fundamental role in reaching these targets since social housing constitutes approximately one third of the total housing stock in the Netherlands[46]. However, social housing associations are not formally bound by any environmental duty, per se. Yet, they agreed on meeting an average of energy label B with the Dutch Energy Agreement (SER, 2013) by 2030.

**Norway**

More unpredictable precipitation is affecting the hydropower reservoirs and hydropower supplies 89,4% [47] of the energy needed by the households. More energy efficient as well as more flexibility on the demand

[46] Centraal Bureau voor de Statistiek (2017). Doelgroepen woningtoewijzing sociale-huurmarkt 2015. From https://www.cbs.nl/nl-nl/maatwerk/ 2017/13/doelgroepen-woningtoewijzing-sociale-huurmarkt-2015
[47] https://www.ssb.no/energi-og-industri/energi/statistikk/elektrisitet

side of energy can reinforce the energy system. As can also locally produced energy, especially if it also supplies energy in the coldest time of the year.

The Norwegian Green Building Council contribute to a green transition in the construction industry. Norwegians are using too much energy, produce too much waste and have a large unutilized potential for energy production on roof areas. The Norwegian Green Building Council is thus promoting reuse, the environmental label BREEAM and other certification schemes. Construction projects are becoming increasingly ambitious when it comes to mitigation. In such projects it has proved necessary to enter partnerships across the value chain, and especially between different disciplines to address the complex challenges.

**Spain**

Climate change and other environmental problems will affect neighbourhoods (and/or buildings) in general as well as SPENs, in the sense of higher temperature, greater number of tropical or even torrid nights, more frequent torrential rains, etc. requires different designs of buildings. Materials used have an impact on emissions, which is why "zero km materials"[48] tend to be used, especially in public buildings with sustainability ambitions.

Climate change will affect the operation of buildings and neighbourhoods, but it is unclear whether for better or worse. Climate change will lead to greater restrictions on mobility (due to fees and cost of CO2 and fuel) and this will enhance local markets of proximity and zero km. Climate change can promote positive business ethics and sustainability, albeit more by regulation than by free will.

We can offset our carbon footprint, necessarily by paying for $CO_2$ emitted and offsetting via projects elsewhere. In any case, the energy costs of public services (cleaning, waste management, and lighting of public buildings) should be offset by greater savings in efficiency and renewable energy.

## 9.7 Summary

The PESTLE mapping gives a snapshot of the situation in the four demo countries. The situation at the political level is comparable, but country specific situations such as the energy system, access to land areas and climatic zones gives different approaches to the common aims of carbon emission reductions. The economic incentives are reflecting the priorities that follows in the four countries. SPENs have higher investment costs followed by lower energy costs in the operational phase. Local energy production is incentivized but not necessarily to share excess energy with your neighbour. The legislation on this point seems to be in a phase of change, and so far Austria is ahead of the other three. Technological innovation seems to cause challenges as it is less robust and often not user friendly enough. Entrepreneurs are established but are at a higher risk of bankruptcy in the first years of business. Despite a rising awareness of necessities of action to combat climate change, knowledge about SPEN among both suppliers and customers are low.

[48] These are materials that can be purchased locally, do not need to be transformed and, at the end of their useful life, can be returned to the environment. That is, the movement encourages the use of local products and, preferably, that have not gone through large stages of industrial processing. The main objective of the Km 0 Architecture approach is to provide more sustainable, healthy, economic, socially accessible buildings that are strongly linked to the identity of the territories.

# 10. Discussion and analysis of drivers and barriers to the development of SPENs

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In this chapter, identified drivers and barriers throughout the previous chapters in the report are extracted and summarized along the same headlines as the PESTLE analysis. Towards the end of the chapter, the drivers and barriers are analyzed and discussed.

## 10.1 Summary of the drivers and barriers

One main barrier is the higher investment costs for SPENs. Technological innovations have higher costs and currently there are also higher costs of construction materials in all four demo contexts. This is particularly relevant for SPENs, since SPENs often require more and/or better construction materials to ensure energy efficiency and robustness of the buildings. Among the framework conditions that promote SPENs are subsidies for energy efficiency measures, renewable energy production and regulations that promote energy sharing. All four countries have different subsidy schemes that SPENs are eligible for. Norway has a subsidy scheme for concept development that come in handy, even though it covers only a small part of the total investment. The demo projects in Austria, Netherlands and Norway were granted favorable loans from the local banks, for concept development. Since there is an immature market for SPENs, grasping a first mover advantage has been the motivation for the SPEN development in Norway and partly in Spain. In such a phase, enthusiasts are often needed to realize projects such as SPENs. Enthusiasts are contributing to the realization of the demos in Austria, the Netherlands and Norway. The companies investing in SPEN projects take a higher risk since the concept is new and not yet known. The presence of a multitude of concepts that are partly overlapping is potentially confusing and might delay the market implementation. A risk factor mentioned in the interviews for the Norwegian context is that suppliers are often tech startups that are more susceptible to bankruptcy.

The occupants also take a risk buying or renting a SPEN unit, since technological solutions have a greater probability of malfunction. The attitudes of potential customers and suppliers are affecting the development of SPENs. Acceptance of new technical solutions is a driver for SPEN development, as mentioned in the case of Norway. In Spain, however, the residents show little interest in testing new technological solutions. This place additional demands on the technology providers, to make the solutions user-friendly and sometimes preferably package solutions where the functions are embedded. SPENs are currently not considered attractive enough. People seem to value price and other qualities of a house over SPEN solutions. SPEN relevant technologies, such as smart meters, may not be sufficiently deployed or functioning. This is explained in the interviews by both a lack of interest and knowledge. In the Spanish demo, the lack of knowledge is solved by hiring an energy manager to operate the energy system, which can be too complex for the average user. However, this results in an additional cost for the SPEN concept. Cooperation with the local energy company is also an option used in Norway. Cooperation across the value chain seems to be an important driver and success factor.

Since the banks in general do not provide loans for upgrading, a high share of ownership with non-outstanding loans can be a driver for SPEN development for renovation projects. Ownership status in itself may be a driver for SPENs, because the owner has a greater willingness to invest in solutions that induce saving for them in the long term. In the Netherlands, the tenants need to agree to renovation, which may be a barrier to SPEN development. The SPEN concept includes user involvement. In Austria (SIR, 2021) and the Netherlands the residents were included in the energy planning of the projects. In Austria the residents attended workshops and answered questionnaires, while in the Netherlands meetings were organized to explain to the tenants the importance of energy efficiency and allow them to state any concern or participate in a co-creational way. A high energy price also provides an incentive to invest in energy-efficient solutions. Example projects one can learn from, and success stories one can be inspired by, increase the development of SPENs. Here, Spain seems to be lagging, while Austria can be considered a pioneering country, helped by public construction projects that are leading the way. There are examples of SPEN-related development in all demo contexts except from Spain.

It is not known whether a high construction development rate also implies a higher share of concepts that exceed building codes. With a construction industry in crisis, and a great need for housing, as in the Netherlands, it may be that the contractors focus on solutions which they are more familiar with. Residents in all demo contexts are used to excessive electricity consumption. After a long period of production surplus and low electricity prices, Norwegians have become particularly dependent on electricity consumption also as a source for heating and mobility. The long period of unusually high electricity prices have served as a reminder that energy is a scarce good that must be used wisely. Load demand tariffs for households, which was introduced in Norway in 2022, can induce smarter energy consumption. The transition to more decentralized energy production is challenging to all, as the energy systems traditionally have been centralized. How infrastructure (in particular the electricity grid) developments are financed needs to support the transition. Payment focusing on load demand rather than energy demand is crucial. More attention is paid to sustainability in all countries, which is a driver for SPENs. A trend for sharing solutions and reuse are examples that indicate rising awareness and promote SPENs.

Austria is the only country that mentions communities in its legislation, and they provide support for smart city development. Several of the informants are calling for legislative developments that enable energy sharing, and this is about to happen in Norway. A ban on fossil heat, which we find in Austria, the Netherlands and Norway, drives development for renewable energy systems. It was mentioned in the interviews that the tax system should make fossil energy use even more expensive, relative to renewables. The government can also ensure strict building codes in terms of energy efficiency and a low carbon footprint, which promote SPENs. The feed-in tariff for renewable energy, which exist in the Netherlands and to some extent in Austria, is a driver for renewable energy production, but may be a barrier for investing in heat storage capacity. The need for regulation that promotes heat storage was expressed in the interviews. This is more efficient on a neighbourhood level. A need for neighbourhood concepts to be included in the assessment of the design of incentives was highlighted in the interviews. Legislation takes a long time to change, and several countries, such as Norway and Spain, mention that the legislation lags, and for the Norwegian demo exceptions must be made to the rules to realize the SPEN concept. This applies to the obligation to connect to the district heating grid and the possibility to share energy. In Spain, which has a warm climate, certification of buildings is hindered, because it requires investment in technology that the building does not need. Furthermore, In Spain, rules about aesthetics on facades and roofs prevent the installation of solar cells and energy storage solutions. In Norway, the municipality wanted shared solutions to be made available for a larger area in a Powerhouse project. Such interventions may be a barrier for SPENs, and in Austria it was mentioned that coordination of framework conditions at different levels of authority could be better.

One positive environmental impact of SPENs mentioned in the interviews is that SPENs are contributing to dampening the heat island effect in dense areas, because of the requirements for green areas in the neighbourhood. Table 3 and 4 summarize the identified drivers and barriers for the development of the SPEN concept from this study. The drivers and barriers are categorized according to the PESTLE-dimensions. If the driver or barrier exist or not in the pilot country, it is marked with "yes" and "no" respectively in the table. Some of the drivers and barriers are considered to only partly be present and are marked with "TSE" meaning "to some extent". In many cases where we describe drivers, the opposite can be a barrier. When this is the case, we have not included it in the barrier table.

Table 3: Drivers for the development of the SPEN concept from this study

| Driver category | Driver description | Austria | Netherlands | Norway | Spain |
|---|---|---|---|---|---|
| Political | Public initiatives for SPENs | Yes | TSE | TSE | TSE |

| | | | | | |
|---|---|---|---|---|---|
| | Incentives for heat storage | No | No | No | No |
| | Ban on fossil heating | Yes | Yes | Yes | No |
| | Government support for smart city development | Yes | TSE | TSE | No |
| Economic | Large ownership share | No | | Yes | Yes |
| | High energy prices | Yes | Yes | Yes | Yes |
| | Subsidy for energy efficiency measures | Yes | Yes | TSE | Yes |
| | Subsidy for renewable electricity generation | Yes | Yes | TSE | TSE |
| | Subsidy for renewable heating | TSE | Yes | TSE | Yes |
| | Subsidy for concept development | No | TSE | Yes | No |
| | Feed-in tariff | TSE | Yes | No | No |
| | Grant loan for renovation | No | No | No | No |
| | Load demand grid tariffs for households | Yes | Yes | Yes | No |
| | Favourable loan condition | Yes | Yes | Yes | No |
| | First mover advantage | No | No | Yes | TSE |
| Social | Large share of population living in flats | Yes | No | No | Yes |
| | High rate of building development | Yes | Yes | TSE | TSE |
| | Existing "best practise projects" to learn from | TSE | TSE | TSE | No |
| | Rising awareness of the need for a sustainable transition | Yes | Yes | Yes | Yes |
| | Sharing is trending | Yes | Yes | Yes | TSE |
| | Occupants' involvement in development of energy upgrading | TSE | TSE | No | No |
| | Enthusiasts | Yes | Yes | Yes | No |
| | Collaboration among the actors in the value chain | TSE | TSE | TSE | No |
| Technological | Simplicity and built-in results | TSE | TSE | TSE | TSE |
| | Acceptance of technological solutions | TSE | TSE | TSE | No |
| | Smart meters | Yes | Yes | Yes | No |
| Legal | Legislation covering energy communities | Yes | No | No | TSE |
| | Strict building codes | Yes | Yes | TSE | Yes |
| | Enable energy sharing | Yes | No | TSE | TSE |
| Environmental | High fossil share | TSE | Yes | No | No |
| | Reduce heat island effect | Yes | Yes | Yes | Yes |

Table 4: Barriers for the development of the SPEN concept from this study

| Barrier category | Barrier description | Austria | Netherlands | Norway | Spain |
|---|---|---|---|---|---|
| Political | Centralized energy production | Yes | Yes | Yes | Yes |
| | Lack of coordination between authority levels | Yes | Yes | Yes | TSE |
| | Requirement for local car sharing from the municipality | No | Yes | Yes | No |
| Economic | High mortgage/loan share | No | Yes | Yes | No |
| | High costs of construction material | Yes | Yes | Yes | Yes |

| | | | | | |
|---|---|---|---|---|---|
| | Customers are not willing to pay for sustainability | Yes | Yes | Yes | Yes |
| | Shortage of capital in the construction industry | Yes | Yes | TSE | No |
| | Shortage of labour in the construction industry | TSE | Yes | Yes | Yes |
| | Housing shortage | Yes | Yes | TSE | Yes |
| Social | Low renovation rate | Yes | Yes | Yes | Yes |
| | Tradition-bound professionals | Yes | Yes | Yes | No |
| | The SPEN concept is not attractive enough | Yes | No | Yes | Yes |
| Technological | Lack of knowledge | Yes | No | Yes | Yes |
| | Technological innovations have higher costs | Yes | Yes | Yes | TSE |
| | Lack of knowledge in the supply chain | TSE | Yes | Yes | No |
| | Technological innovations have higher risk of malfunction | Yes | Yes | Yes | No |
| | Need for an energy manager | Yes | Yes | Yes | Yes |
| Legal | Tenants need to agree to energy renovation | No | Yes | No | No |
| | Lack of contractual laws to manage energy sharing in a district | No | Yes | Yes | Yes |
| | Requirements for aesthetics on facades and roofs | No | No | Yes | TSE |
| | Mandatory connection to the district heating grid | No | No | Yes | TSE |
| | Outdated legislation and the need for exemption | TSE | Yes | Yes | Yes |
| Environmental | Warm climate | No | No | No | Yes |
| | Used to excess supply (low energy prices and overconsumption) | Yes | Yes | Yes | Yes |

## 10.2 Analysis and discussion of what would affect spread and wider uptake of SPENs

There are identified several drivers and barriers throughout the report. In this sub-chapter we do a discussion and analysis of the drivers and barriers to the further market uptake and spread of SPENs.

As the consequences of climate change becomes more evident, more people are concerned. **Rising awareness of climate change and the higher energy prices is favourable to the developments of SPENs**. This can make it easier for politicians and others to introduce changes to the benefit of the climate. When it comes to housing, **willingness to pay** is still higher for other qualities. The SPEN concept do not seem to be attractive enough yet. This can change when more projects are developed if the experience is good, and it is well communicated.

**Tenants are less incentivized** to make improvements in their homes as they may not earn back their investments. Likewise, landlords may not have the possibility to raise the rent in order to earn back investments they have made. However, social housing organisations can have a mission to offer energy efficient and/or energy positive housing to their clients. **Social housing can be a good place to start the implementation of the SPEN** concept because of the many advantages such as economies of scale and cost-effectiveness for building owners, district regeneration, unlocking investment opportunities and many services and techniques that may not be available on an individual building scale. Reduction of energy poverty has become more imminent over the last year, and SPEN can be one solution for this. There are some key success factors especially (but not only) related to social housing when it comes to SPEN. These are factors such as the importance of raising resident awareness, innovative and alternative financing options, trust and communication, economies of scale and the influence of larger social housing providers. Barriers to implementation and adoption of SPEN solutions related (but not confined) to social housing are lack of resident engagement, unclear understanding of users, financial risks, the novelty factor, inadequate policy support and technological complexities (McCabe et al., 2018). These issues from the literature makes reverberation to findings in the interviews and survey.

**Knowledge about SPEN**s is still low in all groups of society. It is necessary to inform about the advantages to a larger scale, not only about benefits to the environment, but also that the energy bill can be lower. The public facilitation and ownership of best practice projects are important to ensure competence building in the supply chain, and to demonstrate how these innovative concepts work. The policies implemented should be arranged to take care of the disadvantaged, which in the case of SPEN at the same time also is addressing sustainability at its broadest interpretation. As the demo owner INCASOL phrased it:

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*If climate change or environmental issues could affect the development of SPEN is difficult for us to answer. But for us, as a provider of social housings, our attitude must be exemplary and must serve to universalize the public model in private buildings.*

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Some residents appreciated the possibility to test new technologies to feel that they take part in the energy transition, while in e.g. Spain, the residents focus mainly on costs. This may be due to the difference in customer groups (social housing versus private market).

The **importance of land use and land planning should be reinforced** as it has a strong impact on the priorities and needs of the future. This includes where to locate the renewable power production and the protection of architectural qualities which must be considered up against sustainability goals. Even if a key aspect in SPEN is energy, resource efficiency is also central. This implicates energy consumption, aspects related to the building envelope, and its passive and active systems.

Policies and regulation are important to enable the socio-economic transition to the carbon neutral society. Even if the supranational framework is more or less similar to the four demonstration cases, the four countries in this study have different approaches to the development of SPENs and similar concepts. Building code, if and how nZEB is defined, how energy communities is encouraged are but a few examples of this. Also, it seems as if the climatic zones have different impact, where warmer climate seems to be the most challenging to SPEN developments.

It is important to understand and further **develop the role prosumers can play for flexibility** in the energy market. More locally produced energy can also contribute to increased energy security, but the transition from centralized systems to more distributed energy production is conditioned by the ability to do structural changes in long established structures. This is related to actors and their responsibilities, as well as how the grid infrastructure is financed and administrated. Because the renewable energy market is dependent on wind, solar radiation, and precipitation the energy prices fluctuate greatly. This is also a challenge to energy security. The anticipated (potentially accelerated) diffusion of renewables will necessitate alternative structures and modes of organizing for safeguarding the reliable provision of sustainable energy. Due to their intermittent and fluctuating nature, the wide diffusion of renewables will stress the functioning of the electricity grid. Concepts such as **SPENs can alleviate the strain on the energy infrastructure**.

This challenge is to some extent similar across the four national contexts– but the solutions, due to the different energy systems in the four countries, will have to be tailor-made to the national context. For now, especially in Spain, it seems as if the **incumbent actors in the energy value chain are struggling to keep their position** by refraining to lift barriers and open up the market for local energy production and exchange. There is a pressure by external factors such as the climate change threat, the war as well as directives and regulations from the EU that is overall an advantage to the development of SPENs. At the same time, there is a pressure from the growing number of entrepreneurs that are offering solutions and thereby can be seen as a threat to the established actors. These newcomers are developing, offering new solutions that will support the sustainable transition that is needed.

Even if investment costs of SPENs are higher than standard developments, **economy of scale is a major advantage of SPENs**, in particular when it comes to potential sharing of energy. Savings over a period can compensate for initial higher investment costs, as illustrated in figure 13 (Austria). This can be a selling point for social housing organisations that are building for rent, but for buyers the private economy do not necessarily take this into account. Green loans can be an incentive to overcome this barrier.

Climate change mitigation measures are strongly linked to the economy. Likewise, increasing taxes on $CO_2$ emitting activities can harm local production compared to others that are not subject to environmental taxation. This requires a common environmental fiscal policy throughout Europe. As the economies of the four demo countries are cooling down, capacity can be released to work on innovative concepts such as SPENs. The first implications of a new concept are likely to demand more time for planning as competence is built. Increasingly **suppliers of respectively the built environment and the residential energy value chains need to cooperate to solve the new challenges**. Since there are so many actors involved, different disciplines and innovations, it is important to define the concept early. Putting together a SPEN project requires planning.

New markets and solutions foster new businesses which are less robust in their first years of business, as exemplified in the Norwegian demo where many suppliers went bankrupt. The **changes necessary to mitigate climate change gives room for newcomers that can develop and challenge the incumbents**, and in some cases replace current actors. This can especially be the case if the more established organisations and businesses fail to see how to adapt to the new requirements needed to be sustainable.

# 11. CONCLUSION AND FINAL REMARKS

This report is highlighting key market characteristics of the four demo contexts of Austria, the Netherlands, Norway and Spain. What market factors influence the adoption of SPENs? What market-regulatory incentives, and socio-economic aspects will improve the market attractiveness of SPENs? Drivers and barriers to the further development of SPEN has been identified and elaborated upon. The focus has been SPEN ambitions within the built environment value chain and the residential energy value chain, with an extra eye on the importance of social housing.

Social housing organisations can be frontrunners in the further development of SPENs. SPENs comes with many advantages and seems particularly well suited for social housing. However, a SPEN is more likely to be successful if residents participate in the planning of a project. Knowledge building in all layers of the society is important to the spread of SPENs. This is particularly so for the planners in the local authorities that set the conditions for development of SPENs and similar concepts.

In all four demo-countries the political environment is transitioning in favour to the implementation of SPENs. However, this happens at different pace and with emphasis on different elements. Structural change is needed in some countries, in order to get a well-functioning local energy production and sharing. Well established actors do not necessarily embrace change if this is challenging how they operate. Eventually, if pressure on the unsustainable status quo is upheld, a sustainable transition in which SPEN is an important element, can become more widespread.

This report will give input to several consecutive reports in the syn.ikia project, in particular the report "Measures and strategies to achieve market uptake of 10 % plus energy neighbourhoods within 2030" due in June 2024.

# 12. Future updates

This report "Market analysis of each of the four demonstration cases" is the first market analysis undertaken in the syn.ikia project. The approach in this report will be further extended and elaborated upon in future syn.ikia reports, in particular in D6.6 **Evaluation of existing business models as well as identification and design of novel business models** (due in June 2023) and in D6.4 **Measures and strategies to achieve market uptake of 10% plus energy neighbourhoods within 2030** (due in June 2024).

Several syn.ikia deliverables will have an influence on developing the final report on market uptake of SPENs due in June 2024. They are listed here in chronological order of delivery so that the reader has an overview.

- D7.11 Dissemination and Communication Strategy & Plan (due December 2022)

  This report will include updates on the change in approach to expose and promote innovations from syn.ikia to attract interests and investors.

- D6.6 Evaluation of existing business models as well as identification and design of novel business models (due June 2023)

  This report will provide business cases for the long-term viability of sustainable plus energy neighbourhood (SPEN) concept, evaluating sources of revenues and identifying opportunities to capture value for customers.

- D6.5 An overview of financing opportunities and a strategy to link them to syn.ikia innovations and investors (due December 2023)

  This deliverable will provide an overview of financing schemes and mechanisms in close connection to syn.ikia innovations.

- D5.3 A report on the identified measurable benefits of sustainable plus energy buildings and neighbourhoods and their potential impact (due February 2023)

  This report will consist of an overview of the multiple benefits of energy efficiency and a shortlist of the most relevant benefits for the pilot cities.

- D6.4 A report on the measures and strategies to achieve market uptake of 10% plus energy neighbourhoods within 2030 (due in June 2024).

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# 14. Appendix A – Glossary of Terms:

A glossary can help stakeholders interpret technical and non-technical terminology used in a requirements document (Abbreviations and acronyms)

Table **5**: Glossary of Terms

| Term | Description | Further references |
|---|---|---|
| Circular principle | A circular economy is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature | https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview |
| EAG | Renewable Energy Expansion Legislative Package. Enables the organization of energy communities and provides subsidies for renewable electricity generation. | https://www.lexology.com/commentary/energy-natural-resources/austria/schoenherr/eag-legislative-package-finally-adopted-whats-new |
| Heat Island effect | Heat islands are urbanized areas that experience higher temperatures than outlying areas. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. | https://education.nationalgeographic.org/resource/urban-heat-island |

| Term | Description | Further references |
|---|---|---|
| HÖ | Heimat Österreich gemeinnützige Wohnungs- und Siedlungsgesellschaft m.b.H. | www.hoe.at |
| LTRS | The Spanish National Long Term Renovation Strategy | https://www.mitma.gob.es/el-ministerio/planes-estrategicos/estrategia-a-largo-plazo-para-larehabilitacion-energetica-en-el-sector-de-la-edificacion-en-espana |
| Non-renewable primary energy | Primary energy has not been subject to any human engineered conversion process. There are four major types of non-renewable energy resources: oil, natural gas, coal, and nuclear energy. | https://en.wikipedia.org/wiki/Primary_energy |
| PEDs | Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability. | https://jpi-urbaneurope.eu/wp-content/uploads/2020/04/White-Paper-PED-Framework-Definition-2020323-final.pdf<br><br>https://jpi-urbaneurope.eu/wp-content/uploads/2021/10/setplan_smartcities_implementationplan-2.pdf |
| PESTLE | A PESTLE analysis describes a framework of macro-environmental factors often used to understand external influences to an organization. | https://www.cipd.co.uk/knowledge/strategy/organisational-development/pestle-analysis-factsheet#7986 |
| Plus energy house / building | A plus energy house produces more energy from renewable energy sources, over the course of a year, than it imports from external sources. | https://en.wikipedia.org/wiki/Energy-plus_building |
| Powerhouse concept | The Powerhouse concept is a new standard for the buildings of the future, based on the Paris Agreement's 1.5 degree target. | https://www.powerhouse.no/en/what-defines-the-powerhouse-standard/ |
| SIR | Salzburger Institut für Raumordnung & Wohnen | https://www.salzburg.gv.at/dienststellen/sonstige-einrichtungen/sir |
| SPEN | The syn.ikia definition of a Sustainable Plus Energy Neighbourhood (SPEN) follows a similar procedure as described for buildings, but the geographical boundary is expanded to the entire site of the neighbourhood development, A Sustainable Plus Energy Neighbourhood SPEN is a highly energy efficient and energy flexible neighbourhood | An evaluation framework for Sustainable Plus Energy Neighbourhoods: Moving beyond the traditional building energy assessment, Energies, 2021, 14, 4314.<br><br>https://doi.org/10.3390/en14144314 |

| Term | Description | Further references |
|---|---|---|
| | with a surplus of energy from renewable sources. | |
| ZEB | The Research Centre on Zero Emission Buildings | www.zeb.no |
| ZEN | The Research Centre on Zero Emission Neighbourhoods | www.fmezen.no |

# 15. Appendix B – List of informants

Table 6: List of informants

| Country | Firm/organisation | Name | Position | Why this informant? |
|---|---|---|---|---|
| Austria | Urmann Radler Architekten | Martin Urmann | Architect | Representing designer in Austria. |
| | SIR Salzburger Institut für Raumordnung & Wohnen | Oskar Mair am Tinkhof | Senior researcher | Representing research and government side and pilot representative. |
| | Leitgöb Wohnbau | Philipp Konrad | Project manager | Representing commercial investors. |
| | Housing association Salzburg Wohnbau | Thomas Gruber | Project manager | Representing commercial investors |
| Netherlands | TNO | Casper Tigchelaar | Senior Scientist | Expert on energy transition of social housing in the Netherlands |
| | AREA | Thijs van den Oord | Project Manager | Representing housing association pilot owner |
| | TNO | Angela Greco | Medior Scientist | PhD in Dutch Social Housing |
| | AREA | Maaike van Orsouw | Coordinator Liveability | Representing housing association pilot owner social inclusivity |
| Norway | Arca Nova | Ole-Edvin Utaker | Project manager | Representing pilot owner |
| | RME[49] | Ingvild Grøtterud Birkeland | Department engineer | Key actor regulating the energy system |
| | Green Building Authority | Anders Nohre-Wallden | Senior advisor sustainability | Key actor on sustainability in the building sector |

[49] The Norwegian Energy Regulatory Authority

| | | | | |
|---|---|---|---|---|
| | Skanska | Kim Bundgård | Project manager | Managing the first powerhouse residential project in Norway |
| Spain | INCASÒL | Joan Estrada | Project manager | Representing demo owner and promoter |
| | INCASÒL | Carles Mas | Project Manager | Representing demo owner and promoter |
| | INCASÒL | Fernando Aranda | Building Engineer | Representing demo owner and promoter |

# 16. Appendix C– interview guide

Semi-structured interview guide for the market analysis (D6.3)

*Mark that every interview will have to be adopted to the interviewee. The questions below will not be relevant for all.*

*We are interviewing experts such as project manager of the demo, a competitor/supplier of similar concept on the market, and representatives from the government/regulator. 3-5 interviews per demo-country, including the project-manager of the syn.ikia demo.*

About the interviewee and market for SPENs

1. Start by telling about syn.ikia and the concept of SPEN (if relevant). Tell about the demo-projects and what we aim to achieve.
2. About the interviewee, his/hers position and responsibility.
3. Description of concept/business model (if they offer a concept similar to SPEN). Tell about the development (size, features, own or rent, value proposition). How are the prices compared to other developments in the area/country?
4. Target market – who is (going to) live there. Why would they prefer this project before another?
5. Market size – Potentially how do you think that SPENs or similar developments will evolve forward?
6. Are there trends or developments that affects the market to demand more SPENs ahead?
7. Are there someone delivering the same or similar concept as you? Who are your competitors? Who are your strategic partners?
8. What are the most important drivers and barriers towards entering the market for SPENs?

The market part is supplemented by a PESTLE analyses, i.e. a macro analysis that evolve around 6 areas. Please take a look at the slides that gives ONE main question for each of the six categories. The main questions must be answered. But each slide also gives additional suggestions for more questions, if regarded relevant. There is likely to be some overlap between the market part and the PESTLE analysis. This will be delt with when compiling the report. The main questions of the PESTLE analysis are:

Table 7: The main questions of the PESTLE analysis

| | |
|---|---|
| **Politics/policy** | How will the current political climate impact the development of SPENS? |
| **Economical** | How are interest rates, exchange rates, taxes and prices/costs affecting the development of SPENs? |
| **Social** | What lifestyle, norms, customs and values or demographics could affect SPENs? (Including relevant businesses, partners and customers) |
| **Technology** | Could new technology innovations disrupt or enhance the development of SPENs? |
| **Legal** | Could any new laws or regulations impact the development of SPENs? |
| **Environment** | Could climate change or other environmental issues affect SPENs? |

# 17. Appendix D -The EU taxonomy and SPENs

The EU taxonomy and SPENs

The EU taxonomy for sustainable finance is a classification system which sets science-based criteria for sustainable economic activity. The EU taxonomy will direct investments towards sustainable activities by defining sustainable activities, encouraging transparency to avoid greenwashing, harmonizing reporting on sustainability, and enabling comparison between activities. The taxonomy covers non-financial companies and financial market participants offering products within or into the EU. The taxonomy has six main environmental objectives, climate change mitigation, climate change adaptation, protection and restoration of biodiversity and ecosystems, transition to a circular economy and sustainable use and protection of water and marine resources. Nine sectors are considered in the taxonomy, and construction and real estate activities and the energy sector is among them. Economic activity that aligns with the taxonomy is substantially contributing to one of the environmental objectives, while they simultaneously do no significant harm to any of the other environmental objectives. The activities also need to satisfy minimum safeguards, such as respecting human rights.

The nine sectors covered in the taxonomy is given in figure 13, and the sub-categories for the construction and real estate activities are displayed in figure 14. The financial sector is represented by non-life insurance products, but they are not considered sustainable activity themselves, but enablers of sustainable activity in the nine sectors in figure 13.

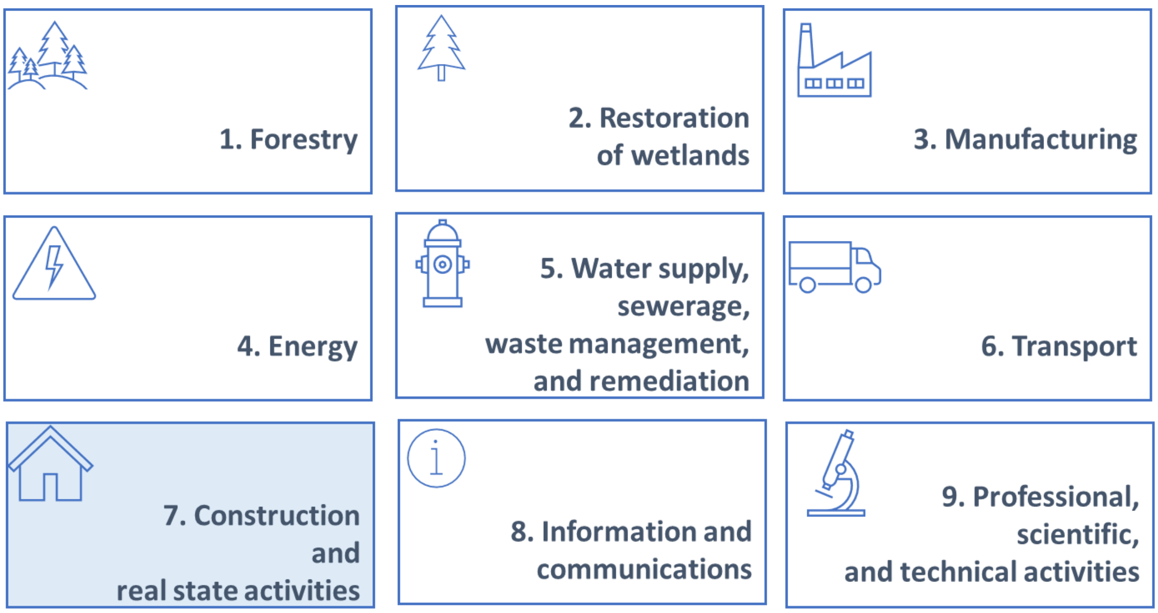


Figure 13: The nine sectors covered in the EU taxonomy for sustainable finance

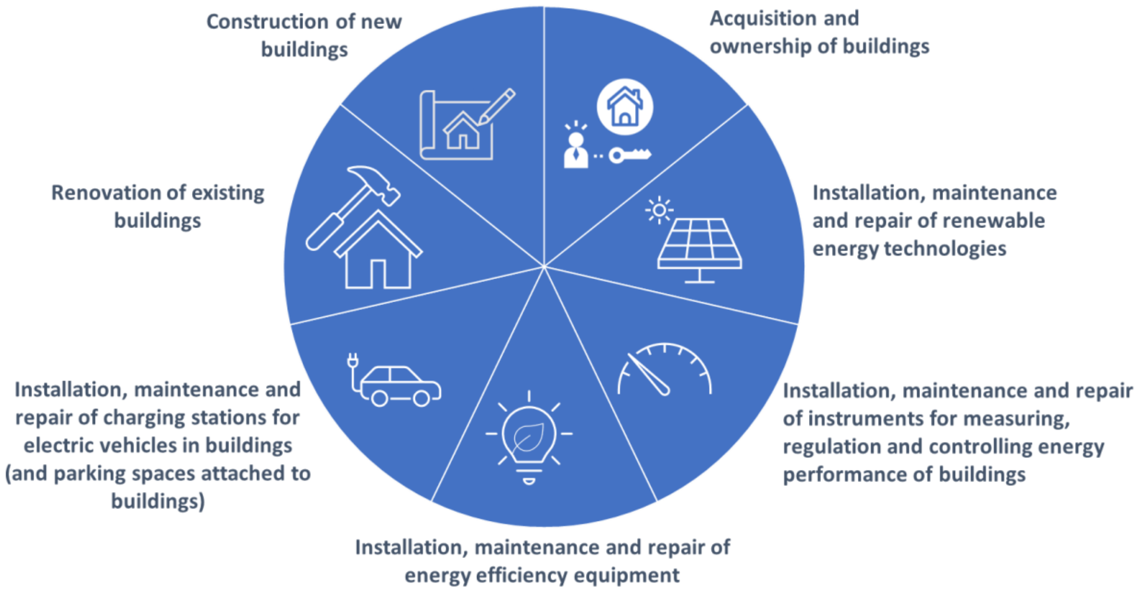


Figure 14: The sub-categories for the construction and real estate activities in the EU taxonomy for sustainable finance

The economic activities and their sub-categories are given technical screening criteria, which have been given for two of the main environmental objectives so far, climate change mitigation and climate change adaptation. The taxonomy does not mention concepts on a neighbourhood scale or district level, such as SPENs, ZENs and PEDs. The entire value chain for SPENs is, however, affected by the taxonomy, and there are guidelines for, for example, production of building components, production of electricity from solar PV, transmission and storage of electricity and thermal energy, use of electric vehicles and processing of data.

The criteria for substantial contribution to climate change mitigation for new buildings to align with the taxonomy is that the primary energy demand needs to be at least 10% lower than the threshold set for nearly zero-energy buildings. Renovation of buildings should lead to a 30% reduction in the primary energy demand. Extra strict requirements are imposed on buildings larger than 5 000 $m^2$, such as quality controls and calculation of life cycle global warming potential of the building. The do no significant harm criteria for new buildings covers all the five other environmental objectives, while renovation of buildings do not include ecosystems. To ensure lower water consumption there are requirements for different water appliances, at least 80% (by weight) of the excess construction materials must be prepared for reuse or recycling, the construction materials must not contain environmental toxins and the taxonomy does not allow construction in areas with protected species or areas with a particular rich biodiversity. Both current and scenarios for future climate (including worst case) must be considered in the planning stage of the construction process.

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syn.ikia

NTNU
Norwegian University of Science and Technology

DTU
Technical University of Denmark

BPIE

SINTEF

HOUSING EUROPE

IREC
Shaping Energy for a Sustainable Future

ARCA NOVA GRUPPEN

area

INCASÒL
Institut Català del Sòl

TNO innovation for life

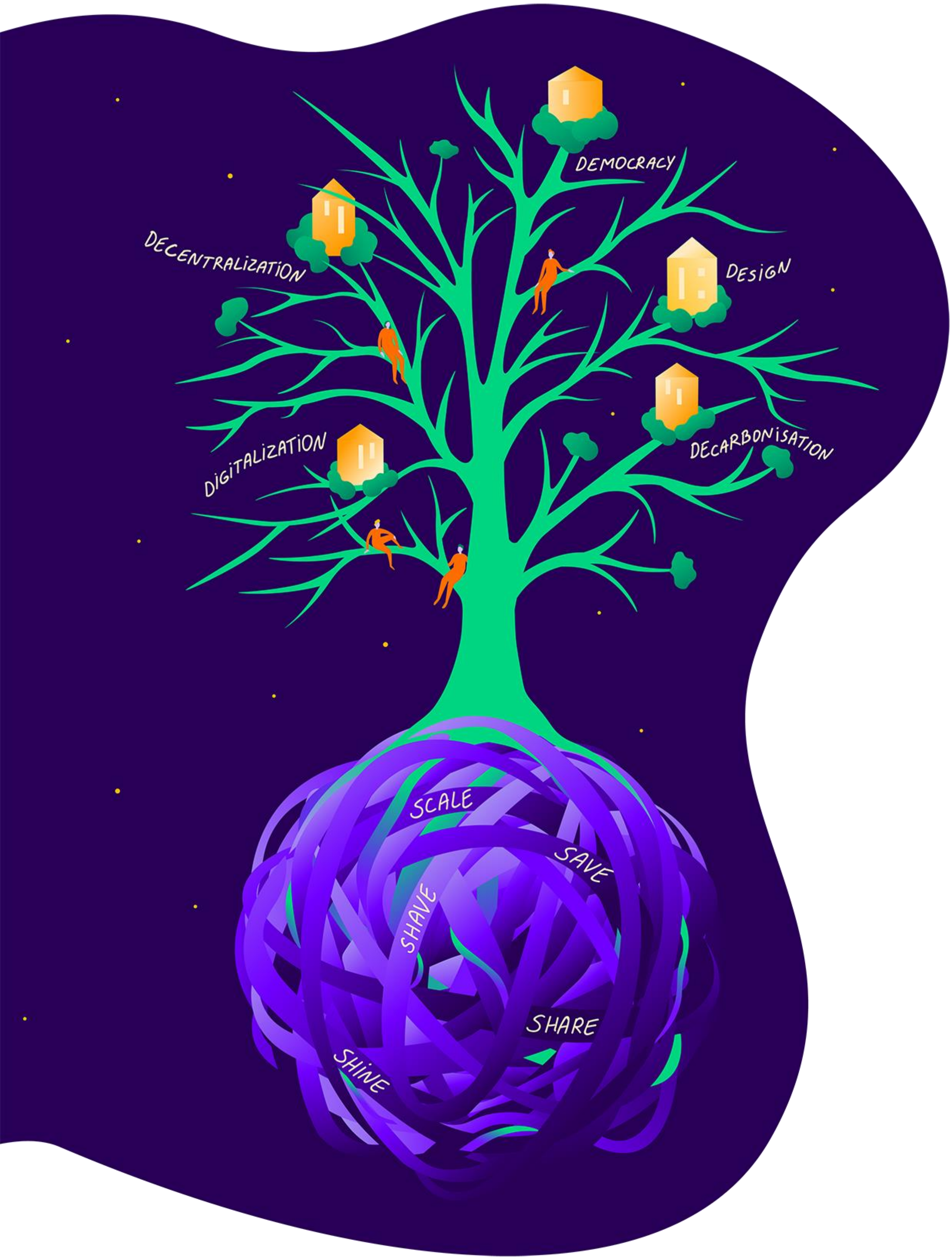
ENFOR

ABUD
Advanced Building & Urban Design

HEIMAT ÖSTERREICH

SIR
SALZBURGER INSTITUT FÜR RAUMORDNUNG & WOHNEN

ECA
ENERGY CONSULTING AUSTRIA


DEMOCRACY
DECENTRALIZATION
DESIGN
DIGITALIZATION
DECARBONISATION
SCALE
SAVE
SHAVE
SHARE
SHINE