A case study analysis of Positive Energy District concepts between Switzerland and Norway

Matthias Haase [1] and Daniela Baer [2]

[1] Zurich University of Applied Sciences, Am Grüental, Wädenswil, CH, Switzerland
[2] SINTEF, Strindveien 4, Trondheim, NO, Norway

Abstract

Reaching for the Global Sustainability Goals, urban areas play a crucial role, as they are identified as the main area for global emissions. Cities do play a prominent role to put global goals into local policies and means and at the same time embedding it in local context with site specific demands and settings. The Positive Energy District (PED) concept is currently evolving based on the Strategic Energy Transition (SET) plan of the European Union member states and contributions from different initiatives. As the first PEDs are developing all over Europe, we have little knowledge on how the PED concept is implemented nationally and how first PED projects develop within the specific national contexts. We ask: What are the concepts and approaches towards PED developments in Switzerland and Norway? What are the implementation strategies and how are functional issues addressed?

By looking at different recent developments of PEDs in Switzerland and Norway, we describe the characteristics of national approaches towards PEDs. By deepening the description of two respective case studies in the two countries, we analyzed how PED approaches are implemented within the specific context. We compare the PED concepts, local implementation and functional issues to analyze the approaches. Our research is based on literature and document analysis and qualitative interviews.

The results show that different implementation concepts require different measures. From the analysis of the results, the conclusions are that integrated energy planning is more important than ever. Understanding the different dimensions of sustainable development in combination with energy supply and consumption is important to plan and realize settlements that not only contribute significantly to reducing energy consumption and securing the location of energy infrastructure (generation, distribution, storage), but also in terms of long-term sustainable development and specifically climate neutrality. shows/highlight the importance of integrated and cross-sector approaches of PEDs that are implemented and operated in multi-stakeholder settings.

Keywords

positive energy districts, country comparison

1. Introduction

Climate change challenge the ambitious goals that regulators have put in place by setting higher building and community energy-related requirements based on the Sustainable Development Goals of the UN. In the European Union (EU), reaching for the climate gas reduction goals of the Paris Agreement, stakeholders on all geographical and organizational levels from nations, regions, cities and communities are challenged. Following bottom-up approaches for energy planning on the neighborhood level is a promising attempt to reduce energy demand, increase efficiency and lower the carbon footprint in a multi-stakeholder approach [1].

Proceedings Name, Month XX–XX, YYYY, City, Country
EMAIL: Matthias.haase@zhaw.ch (A. 1); Daniela.baer@sintef.no (A. 2)
ORCID: XXXX-XXXX-XXXX-XXXX (A. 1); XXXX-XXXX-XXXX-XXXX (A. 2); XXXX-XXXX-XXXX-XXXX (A. 3)

Recently, the concept of PEDs have been introduced as a mean to accelerate the Strategic Energy Transition of the European Union. Positive Energy Districts are envisioned as "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." [2].

PEDs can include all types of buildings and they are not isolated from the energy grid [2]. In the research community PED has recently gained much attention, as it is seen as promising to transform cities into carbon neutral communities in the near future [3].

2. Approaches towards PEDs on different (governance) levels

In many countries, the necessary legal and strategic frameworks for the implementation of PEDs are not yet in place. Very often, there is also a lack of a planning culture in city administrations or the personnel resources available might be insufficient. In particular, the transformation of large (brownfield) areas to climate neutral city districts has a big potential for the development of PED but needs cooperation between administration, industry, and research. That is because a PED should not only aim to achieve an annual surplus of net energy. Rather, it should also support minimizing the impact on the connected centralized energy networks by offering options for increasing onsite load-matching and self-consumption, building on technologies for short and long-term storages, and providing energy flexibility with smart control.

The successful implementation of PEDs requires a distinct understanding of the actual situation as well as a vision of the future district to be able to develop suitable pathways for the transition. Different scenarios, which include new construction to different levels of energy efficiency, major renovation of all or some buildings, comprising building stock under consideration with deep energy retrofit of these buildings, minor renovations with energy-related scope of work, or demolition of some old buildings are needed in order to be able to implement the plan.

In this respect, it is interesting to analyze and compare different aspects (certification, social and functional aspects) of PED implementation and their contribution to success in two national setting. We therefore rise three research questions (RQs):

1. What are the concepts and approaches towards PED developments in Switzerland and Norway (RQ1)?
2. How are the PED concepts implemented in the respective case studies? (RQ2)
3. How are functional issues addressed? (RQ3)

3. Methodology

This research adopts a qualitative comparative case study method. Qualitative-comparative analysis is useful for highlighting similarities and differences between cases through the study of phenomena in various contexts [4]. This approach enables a comparison of two national PED programmes in Norway and Switzerland, from which we draw insights on the implementation approaches towards fostering of PED development plans in the respective national context. Our research is based on literature and document analysis and six qualitative interviews with relevant stakeholders.

4. Case descriptions

While there is a lot of research going on in Europe, it was interesting to have closer look at concrete implementation initiatives in Norway and Switzerland as front-runners of PED development [10].

4.1. Norway

Norway is in a unique position regarding PED developments to investigate early-stage implementation of PEDs. Not only is Norway's power system based on renewable energy with the electricity production based mainly on hydropower, but the initiative for energy efficiency in Norway comes from the highest policy levels and influences research and innovation programs, aiming for to position Norway as a European leader in a decarbonized electricity system. Furthermore, in the Norwegian context, energy efficient solutions should become the preferred choice for consumers in the future [5]. For the time being, Norway is leading the number of PED projects in Europe as a consequence of that [6; 10].

As there are no specific national approaches towards PED in place, research and innovation programs do form the actual basis for PED concept development in Norway. Here to name the Research Centre on Zero Emission Neighborhoods in Smart Cities (ZEN Centre) as a Norwegian approach towards PED development, besides other initiatives as the Horizon 2020 projects +CityXChange in Trondheim or Triangulum in Stavanger. We introduce the ZEN Centre as it is the base for case analysis.

The ZEN Centre at the Norwegian University of Science and Technology will last eight years (2016-2024), with private and public user partners along the value chain of PED deployment in Norway. The goal is to develop and implement solutions for future buildings and neighborhoods with no greenhouse gas (GHG) emissions through energy efficiency, flexibility and storage embedded in a holistic approach towards build environment development including e.g. mobility and spatial qualities. GHG emissions will be compensated for through plus energy production during operation time of the district.

The ZEN Centre incorporates a series of neighborhood-scale demo sites, which will act as innovation hubs and a testing ground for the solutions developed in the ZEN Centre. They are geographically limited areas in Norway in which the Centre's researchers, together with the user partners test new solutions for the construction, operation and use of neighborhoods in order to reduce the GHG emissions on a neighborhood scale towards zero.

4.2. Switzerland

The 2000-Watt Society is a vision for a liveable future [7]. The idea of the 2000-Watt Society builds on the vision for high quality of life for its inhabitants that meets the goals of sustainability. This vision is based on the view that a future society should represent a sustainable and socially just society. For every person on earth, 2000 Watt of continuous power (primary energy) are available. This must be enough to ensure prosperity and a high quality of life. Today, the primary energy consumption per capita worldwide is on average 2500 W – with enormous country-specific differences. At present, each Swiss inhabitant uses about 4700 W. The CO2 emissions caused by 2000WS level of energy consumption must not exceed 1 tonne per person per year [7].

A «2000-Watt Site» certificate allows to evaluate large site developments in terms of building quality, density, mixed usage and mobility [8]. The total energy consumption of a certified site is optimized to the targets of the 2000-Watt society. The aim for low resource consumption is achieved by energy-optimized buildings in a well-functioning urban development context.

A 2000-Watt-Site (2000WS) has achieved a reputation for energy efficiency, renewable energies and climate friendliness The core idea of the 2000WS is an ongoing evaluation process of a site's sustainability in terms of energy consumption in planning, implementation and operation. Certificates are issued for a limited time period and must be renewed periodically. They are awarded in two stages: As a «site under development» until at least half of the total living space is in use, and after that as a «site in operation».

The concept of a 2000WS takes an integrative view of the entire site rather than individual buildings. It opens up the perspective by depicting the whole living environment.

5. Results

The differences between the two approaches towards PED development, the ZEN Centre and the 2000-Watt-Society approach, are shown in Table 1.. We present the results to the research questions: concept and approach (RQ1), implementation and learnings from pilots (RQ2), and functional issues (RQ3).

Table 1
Summary of findings

Dimension	ZEN centre	2000 W Society
A. Concept and approach (RQ1)		
Integrated approach	Value chain integration approach of the construction sector	Measurable contribution to resource conservation and climate protection
PED Definition	Development of own ZEN definition during lifetime of ZEN centre, including challenge to apply ZEN in demo sites as long as definition is not finalized	Own definition and certification criteria.
System boundaries	Static geographical system boundary	Static geographical system boundary
Guidelines and tools	Own definition of PED including KPIs as guiding principles for planning and design, Toolbox development of relevant tools	Own definition and certification criteria. A planning tool is available
Energy flexibility	Intra-district energy flexibility	Intra-district energy flexibility
B. Implementation (learnings from pilots) (RQ 2)		
Integrative urban transformation process	Urban transformation process based on experimental approach and stakeholder involvement	The quality characteristics are useful for marketing and image-building.
PED competencies	Professional competencies	Professional competencies
Steering and process leadership	(Mainly) public steered demo sites	Private steered process. users enjoy a high standard of housing and living
Holistic process of developing and deploying PEDs	Planning and design phase focused	Planning and design phase focus, but additional new programme focusing on transformation of existing sites
Approach to open innovation and stakeholder interaction	Open innovation is mainly driven by public sector as main project owner (8 of 9 projects are public owned)	Implementation of proven technology
C. Functional issues (RQ3)		
Functional sub-divisions in district	Diverse functions, ranging from residential areas with social infrastructure, mixed-used neighborhoods, university campus areas	Often mixed use, with residential, office, and other functions
Stakeholders involved on site	Diverse, depended on the context (phase of development and function)	creates added value for all stakeholders – for investors, planners, users, law enforcement agencies and authorities:

5.1. Concept and approach

The 2000WS certificate creates added value for all stakeholders – for investors, planners, users, law enforcement agencies and authorities: users enjoy a high standard of housing and living. The certificate provides the assurance that the site and its inhabitants are contributing to resource conservation and climate protection. Thus, Investors and owners are interested in value-preserving sites offering a high quality of living and working. In such a way, the quality characteristics are useful for marketing and image-building. Due to the high level of acceptance, cooperation with authorities is much easier. For local municipalities it helps them to bring their concerns to bear at an early stage. The certificate is a guarantee of successful commercial implementation of their energy and climate-policy goals. The certificate was designed as part of the federal program EnergieSchweiz. The Swiss Federal Office of Energy (SFOE) is thus promoting the implementation of national energy policy in the areas of energy efficiency and renewable energy. With the SwissEnergy program, the SFOE supports specific projects at municipal level.

For Norway, one of the key focus of the ZEN Centre is the development of a definition for zero emission neighborhoods for the Norwegian context and above including key performance indicators (KPIs). This work in progress is meant to result in a certification scheme for neighborhoods.

5.2. Implementation

The ZEN demo sites are all part of a larger research initiative and thus a progressive academic environment. Previous research projects with ambitions goals have shown that on the technical side it is relatively easy to get new technology used, especially when their economic benefits are communicated. It is more complicated to ensure that social practice is implemented. This implies a societal acceptance of the goals and that individuals follow those goals. In the ZEN Centre the demo sites approach, the involvement of inhabitants individually results in diverse approaches towards citizen involvement, capacity buildings and learning.

In Switzerland, the discussions of the 2000-Watt Society have formed the basis for a large support of the ideas connected to it. Several companies have identified business models around it as e.g. the 2000WS certification scheme. This scheme forms the structure and the social character of the district. People creating 200WS or moving to them are convinced that what they are doing is good in the sense of “good for society and good for the planet” (quote from one interview). In some 2000WS there are groups of inhabitants active that promote a “sufficient” lifestyle, offer sharing options and promote an alternative way of living (relying less on fossil fuel, vegetarian food, etc.). And car sharing options are available in many sites, together with strict rules for owning cars (and restricted parking space). These are rules in place that inhabitants have to agree to before moving onsite. So there is a possibility for segregation implemented in the system.

5.3. Functional issues

In a typical district exists several heating, or cooling loops and many electrical subdivisions (distribution boards) on top of various end uses of energy. The different concepts are explained in more detail in Haase (2020) [9].

The energy related operation processes are usually in the control of facility managers and technical staff of each building. Multi-owned districts often lack professional skilled workers. A multitude of performance indicators can be related to this structure. Some performance indicators are important in the design and commissioning of the systems, others are of use in the day-to-day running of the buildings. When we look at the performance indicators for implementation, it becomes obvious that with the 2000WS certification scheme developed and applied exclusively in Switzerland, the implementation of ambitious districts has come more explicit than in Norway, where a certification scheme based on the ZEN definition and its KPIs is under development. In the ZEN Centre the demo sites present different context from rural to urban and functionalities involved as residential, mixed-use,

university campus, etc. Stakeholders involved vary as well as responsibilities for process management and development towards PED deployment.

6. Conclusions

From the results and discussion of the differences between Norway and Switzerland approaches towards PEDs we can conclude that due to its unique approach in each country, there is room for learning from each other in specific areas and for the PED approach in general.

6.1. Concept and approach

When we look at the system for implementation, it becomes obvious that with the 2000WS certification scheme this is an assistance tool as well as supporting the acceptance for PEDs. In Norway, a certification scheme based on the ZEN definition and its KPIs is under discussion with regard to related standards and regulations.

6.2. Implementation

In terms of acceptance and information dissemination the 2000WS have gained some public interest. Many different stakeholder groups have engaged in implementing 2000WS. There are construction companies totally specializing on the construction of 2000WS solely.

6.3. Functionality

However, when it comes to the criteria that need to be fulfilled, 2000WS do not aim for a "net zero emission" balance. The goal is to reduce energy use to (constant?) 2000W power per person. With 8760h/a this corresponds to 17500 kWh/a. The amount of GHG emissions that this energy use corresponds to depends on the GHG emission factor of the energy used and varies for the different purposes. Gray energy is not automatically accounted for in these calculations. However, the goals of the 2000WS are currently under revision in order to become completely compatible with the energy policy goals of Switzerland (Bundesrat). This means that stricter rules are needed but it remains to be seen if these imply a rigorous accounting of GHG emissions throughout the lifetime and certain amount of requested renewable energy production on-site as it does in the ZEN/PED approach.

On the other hand, 2000WS have a system in place to account for energy use of mobility and it even explores potential to induce a behavior change to use less transport systems (by offering car-sharing services and by not allowing to own a private car) and more fossil free transport systems. E.g. is parking area within the 2000WS normally restricted and the exemptions rare.

6.4. Further work

We see therefore a need for further research on a roadmap for PED implementation and operation. We see benefits in using case study analysis in this early phase of PED development to learn from front-runners, as done in this paper.

7. Acknowledgements

This paper has been written within the Research Centre on Zero Emission Neighbourhoods in Smart Cities (FME ZEN). The authors gratefully acknowledge the support from the ZEN partners and the Research Council of Norway. It was also written as part of the IEA EBC Annex 83. Financial support from ZHAW (ASF) is greatly acknowledged.

8. References

[1] David, M.; Schönborn, S. Bottom-Up Energy Transition Narratives: Linking the Global with the Local? A Comparison of Three German Renewable Co-Ops, Sustainability, 2018.

[2] JPI Urban Europe/ SET Plan Action 3.2. White Paper on Reference Framework for Positive Energy Districts and Neighbourhoods. Key lessons from national consultations. Available online: https://jpi-urbaneurope.eu/app/uploads/2020/04/White-Paper-PED-Framework-Definition-2020323-final.pdf (accessed on 13.02.2021).

[3] Brozovsky, J., Gustavsen, A., & Gaitani, N. (2021). Zero emission neighbourhoods and positive energy districts – A state-of-the-art review. Sustainable Cities and Society, 72, doi:https://doi.org/10.1016/j.scs.2021.103013.

[4] Hopkin, J. The Comparative Method. In Marsh, D. and Stoker, G. (eds), Theory and Methods in Political Science: Third Edition, Houndmills: Palgrave Macmillan, 2010, pp. 285–307.

[5] Royal Norwegian Ministry of Petroleum and Energy. Norwegian Government. Update of Norway's nationally determined contribution under the Paris agreement. Available online: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Norway%20First/Norway_updatedNDC_2020%20(Updated%20submission).pdf (accessed on 23.08.2020) Available online: https://www.regjeringen.no/contentassets/ca446f4845bf473ea3ae82d1bb63454d/consultation-on-the-review-of-energy-efficiency-directive.pdf (accessed on 13.08.2020).

[6] Shnapp, S., Paci, D. and Bertoldi, P., Enabling Positive Energy Districts across Europe: energy efficiency couples renewable energy, EUR 30280 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21043-6, doi:10.2760/452028, JRC121405.

[7] 2000-Watt-Society, https://www.2000watt.swiss/en/english.html, access date: 09.06.2021

[8] 2000-Watt_Areal, Handbuch zum Zertifikat 2000-Watt-Areal Ausgabe 2019, 2000WA_Handbuch_2019_V1 0_191101_DE.pdf (2000watt.swiss), Zugriff: 12.01.2021

[9] Haase, M., (2020). Requirements for representative models for comfort and energy simulations in districts, p.16-23; In: Georges et al. (Eds.) BuildSIM-Nordic 2020 Selected papers - International Conference Organised by IBPSA-Nordic, 13th–14th October 2020, OsloMet, SINTEF Proceedings, SINTEF Academic Press, ISBN: 978-82-536-1679-7, sintef.brage.unit.no/sintef-xmlui/handle/11250/2683176, access date: 18.oct 2020

[10] Bossi, S.; Gollner, C.; Theierling, S. Towards 100 Positive Energy Districts in Europe: Preliminary Data Analysis of 61 European Cases. Energies 2020, 13, 6083. https://doi.org/10.3390/en13226083