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TRANSFORMING CITIES THROUGH POSITIVE ENERGY DISTRICTS

TRANSVERSAL ANALYSIS OF **TRANS-PED CASE STUDIES**

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INTRODUCTION

This document summarises key insights emerging from the transversal analysis of the TRANS-PED case studies and translates them into a concise set of policy recommendations and guiding questions. TRANS-PED was a 2-year pilot project to develop a governance approach for PED stakeholders to realise deep changes to cities. The TRANS-PED consortium consists of 12 partners from Sweden, Austria and Belgium including stakeholders from 5 PEDs:

- **Abattoir**, Anderlecht (Belgium)
- **Brunnshög**, Lund (Sweden)
- **Graz-Reininghaus**, Graz (Austria)
- **Hammarby Sjöstad**, Stockholm (Sweden)
- **Sonnendorf**, Tyrol (Austria)

Work Package 3 of the TRANS-PED project involved the development of case studies for each PED. The situated characteristics of each PED have a significant influence on their approach and achievements. Relatedly, each PED is actively developing context-specific approaches that leverage opportunities to overcome barriers to energy innovation. This document summarises the main insights obtained through a transversal analysis of the case studies.

In a first step to describe and analyse the PEDs, the project team developed a case study framework. This included a case study template that served as a guide to collect and structure a wide range of information on the PEDs.[1] The five dimensions of the template include:

- **time**
- **space**
- **social**
- **energy (and other metabolic flows)**
- **governance and policy context**

These dimensions are also used to structure this transversal analysis. In addition to the case studies, this analysis draws upon findings from site visits to each PED that involved discussions with stakeholders and subsequent discussions with the project team (figure 1).

The material thus collected was discussed at workshops during the Swedish and Austrian PED labs. Based on these workshops and follow-up discussions and research, the following insights and related recommendations are formulated.

figure 1: workshop with PED stakeholders at Abattoir, September 2021 (Tessa Boeykens)

1 The template and case studies are available on the project website: trans-ped.eu.

TIME

This dimension describes the evolution of the PED, its context and, potentially, its relation to preceding or subsequent PEDs. It includes both achievements from the past and ambitions for the future. By positioning each PED in a specific phase of development, it becomes easier to compare and contrast PEDs.

1. EXISTING DISTRICTS, NEW CONCEPTS

The PEDs have a long, often turbulent history, ranging from more than ten years to several decades. For instance, Hammarby Sjöstad builds upon an urban renewal project initiated in the early 1990s. The time horizon of the PEDs also extends several decades into the future. For example, the PED ambitions that were established for Brunnshög in 2012 assume a development period of at least 40 years.[2]

All five PEDs were established before the PED concept was introduced. Therefore, none of the projects are built around the PED concept, let alone derive their identity from it. The PEDs do, however, recognise themselves in the ambitions of the PED concept (see also below in point 2) and utilise it in their further development, sometimes in combination with other (often older, regional or national) concepts and standards such as Zero Emission Neighbourhoods in Scandinavia and the Klima-Aktiv certificate in Austria. As the PED concept is gaining traction, projects that are specifically built around the PED concept will undoubtedly be developed. Even then, however, it is important to be aware of the impact of the long time span of the projects, their ambitions and the conceptual framework in which they are established.

2. THE PED CONCEPT AS A CATALYST

Throughout their long development trajectory (see point 1 above), the PED plans and ambitions were changed and updated. Since the PEDs refer to the PED concept, it is used as a tool or reason to reflect on the energy objectives and make them more ambitious and more concrete. However, PEDs are not bound by the PED concept. The PEDs also focus on other objectives beyond energy. In addition, the maxim-like definition of a PED - 'consume less than is (sustainably) produced' - constitutes a very clear and very ambitious objective, but each PED adapted the actual ambitions to their respective context. The different parts of the definition (energy production, energy efficiency, energy flexibility and the guiding principles)[3] and their interrelation are perceived as a clear approach to make energy production and consumption more sustainable.

2 City of Lund, *Fördjupning av översiktsplanen för Lund NE/Brunnshög* [policy document]. Lund: City of Lund, 2013.

3 Several definitions of the PED concept exist. This research mainly draws on the definitions that can be found in:
JPI Urban Europe / SET Plan Action 3.2. *White Paper on PED Reference Framework for Positive Energy Districts and Neighbourhoods.* Vienna: JPI Urban Europe / SET Plan Action 3.2, 2020: pp. 6-9. https://jpi-urbaneurope.eu/ped/.PED white paper.
A reflection on the PED definition can be found in:
Magnussen, Dick, and Harald Rohracher. *A typology framework for positive energy districts.* s.l: 2022.
https://trans-ped.eu/wp-content/uploads/2022/06/typology_framework_web.pdf.

SPACE

Information from this layer of the TRANS-PED Case Study Framework situates the PED within its geographical and morphological context and describes the PED's spatial and functional characteristics.

3. A DIVERSITY OF CONTEXTS

The five PEDs are located in very different contexts including a small residential neighbourhood in an Alpine village (Sonnendorf, figure 2), a brownfield district (Hammarby Sjöstad 2.0), an urban extension (Graz-Reininghaus and Brunnshög, figure 3), and a historic industrial site in the city centre (Abattoir). The contexts include different topographies, street layouts, and building types.

figure 2: the Sonnendorf PED
(David Schreyer)

figure 3: the Brunnshög PED under construction
(City of Lund)

On the one hand, this demonstrates the versatility of the PED concept, and a widely shared sense of urgency around the energy transition. The PED framework provides guidance to address energy issues at a scale that is manageable and impactful. On the other hand, this does not always make it easy to transfer insights and experiences from one PED to another, let alone to compare PEDs. After all, the spatial context (like the social context, see later) has a major influence on the opportunities and possibilities of a PED. This includes the PED boundaries, the type of energy flows that are included, applicable energy generation and storage technologies, opportunities to limit energy consumption by improving building performance, and so on.

The most obvious parameter to compare PEDs is energy performance but this provides minimal insights on the quality of the environments created by PEDs and the extent to which the PED concept's guiding principles have been addressed.[4]

4 These guiding principles are: quality of life, inclusiveness (with special focus on affordability and prevention of energy poverty), sustainability, resilience, and security of energy supply.
JPI Urban Europe / SET Plan Action 3.2. White Paper: p. 8.
DUT partnership. Driving Urban Transitions to a Sustainable Future: Roadmap: Vienna: DUT partnership, 2022: p. 28. https://dutpartnership.eu/wp-content/uploads/2022/09/DUT-Roadmap-2022-komprimiert.pdf.

4. A DIVERSITY OF DEVELOPMENT TYPES

Another major difference concerns the types of development. Within TRANS-PED, the PEDs include greenfield developments (Sonnendorf and Brunnshög), brownfield developments (Graz-Reininghaus, Hammarby Sjöstad) and renovation developments (Abattoir). In many cases, the emphasis is not just on constructing new infrastructure, but rather on establishing a platform for innovation and experimentation in the existing city fabric. Not surprisingly, ambitions and outcomes differ from one PED to another, with new construction and reconversion developments achieving higher energy performance when compared existing infrastructures. This is reflected in discussions about diversifying the PED definition to accommodate different contexts and development types. It also raises questions about whether it is appropriate to target greenfields to achieve energy and climate goals.

5. THE NEED FOR A WELL-BALANCED PROGRAMME

The programmes envisaged in the PEDs are mostly limited to housing and related services. Abattoir is the only PED that diverges from this, with the inclusion of production, processing and selling of fresh food. As houses account for more than a quarter of Europe's final energy consumption, the residential focus is logical.[5] At the same time, the focus on only one function means that opportunities for complementarity are not available. Matching consumption and production rhythms is largely achieved in PEDs via storage technologies, via the distribution grid and, although rather limited, control by smart technologies. In addition, several projects rely on the availability of residual energy from nearby (industrial) processes, but do not include the energy demand of these processes in the PED's energy balance. Aligning housing with other functions, and identifying and implementing synergies between different activities could lead to efficiency gains and a more desirable energy balance.

6. DENSITY AND THE NEED TO BALANCE CONSUMPTION AND ENERGY POTENTIAL

Finally, the density of a PED is also a major point of attention. It can create a tension between project profitability and energy balance, something that was specifically noted in each of the greenfield and brownfield developments. Only a certain area of a site to be developed is suitable for renewable energy generation (usually the rooftops for PV and open space for geothermal). It is therefore easier to provide local renewable energy within low to mid-rise developments. At the same time, investment in collective forms of neighbourhood-level energy production is only profitable with a minimum energy demand (and thus density). Several of the PEDs included strategies to increase profitability by increasing density but the resulting increase in energy demand makes it more difficult to achieve a positive energy balance. Ensuring a balance between density, profitability and the energy balance of a PED is therefore a key challenge throughout project development.

5 EUROSTAT. *Final Energy Consumption by Sector (ten00124)* [data set]. Luxembourg: Eurostat, 2022. https://ec.europa.eu/eurostat/estat-navtree-portlet-prod/BulkDownloadListing?file=data/ten00124.tsv.gz

SOCIAL

This layer describes the socio-economic and socio-cultural context of PEDs and identifies relevant social conditions and initiatives that characterise the urban environment and energy systems.

7. WHO ARE PEDS FOR?

While collecting information on the cases, the social dimension proved to be the least tangible and the least straightforward for PED stakeholders to characterise. Several stakeholders indicated that they were not that concerned with the social aspects of their project because there were no users yet (in the case of new developments) or because they could not influence these aspects.

8. THE IMPORTANCE OF EVERYDAY PRACTICES

Several PED stakeholders explained how embedding sustainable energy production and consumption practices in the everyday life of (future) residents and users was crucial to the success of their PED. The work in Hammarby Sjöstad was initiated because making the neighbourhood's infrastructure more sustainable alone had not produced the desired results. To further reduce the energy consumption and to make the energy production more sustainable, the work now starts with the concrete needs and opportunities of the residents and users of the district. Similarly, Graz-Reininghaus stakeholders developed a ‚manual for resource-efficient living' to raise awareness while also informing and motivating residents to make the switch to resource-efficient living.

9. THE IMPORTANCE OF THE COLLECTIVE

In the manual for Graz-Reininghaus, there is a strong emphasis on the collective dimensions of the neighbourhood scale. This scale is seen as optimal to realise more sustainable lifestyles. Hammarby Sjöstad stakeholders also emphasise the importance of a collective approach, with housing associations to identify and address the shared interests of the neighbourhood's residents. At Abattoir, the collective dimension can also be found in the adjacent neighbourhoods that have socio-economic challenges. Resident initiatives have been established that can be linked to energy transition strategies and allow Abattoir to have positive impacts beyond its site boundaries.

10. WHO ARE WE MAKING PED PROJECTS FOR? (BIS)

Reflecting on the aforementioned ideas, the PED stakeholders observed that the social dimension was indeed an important part of their work, but acknowledged that they often address this dimension intuitively. This highlights the need to reflect upon the intended beneficiaries of PED activities. Many PEDs target (upper) middle class residents while struggling to support the lives of socially and economically deprived residents. Energy transitions need to benefit everyone and working towards inclusive modes of transition is essential to address in all PEDs.

ENERGY
(AND OTHER METABOLIC FLOWS)

Multiple energy flows are addressed in PED activities including electricity, heating and cooling, transport, and embodied energy. These energy flows relate to other relevant metabolic flows including water, waste, and food.

11. THE MANY GUISES OF ENERGY

Each PED in this project identified specific energy flows to be included in their respective energy balances. In each PED, the main focus is on electricity and district heating and cooling services. Natural gas is either being phased out or is avoided in the PEDs due to its carbon emissions. Apart from existing natural gas uses for cooking, heating and industrial processes, none of the PEDs accounts for the consumption of combustibles. The majority of PEDs have a look at mobility within the district, but do not quantify its energy consumption.

Several projects work with residual energy from external (often industrial) processes or energy obtained from waste processing. The extent to which the energy required to obtain this residual energy is included in the calculation of a PED's energy balance varies. In Abattoir, for example, industrial food processing for meat, fresh fruits, and vegetables represents the largest energy demand and optimising these processes is central to achieving a desirable energy balance. In contrast, the residual energy from research facilities at Brunnshög) and from the steel furnace at Graz-Reininghaus are not included in energy balance calculations. Different forms of energy are difficult to include in a comprehensive energy balance and it is difficult to establish boundaries for relevant energy flows.

12. A CLEAR RANGE OF TECHNOLOGIES

A limited number of production and storage technologies are employed in the five PEDs. The most common technology are undoubtedly the PV panels. Several projects also rely on geothermal energy for heat and electricity, heat pumps, and aggregated home batteries. The choice of technologies and the exact way they are installed is dependent upon specific geographical, socio-economic and governance conditions.

The actual technologies and how they were combined to achieve PED goals project are easy to identify. However, it is more difficult to characterize strategies of implementation, use, maintenance, and management of these technologies. Here, again, specific physical and social conditions play a significant role. This suggests that it is necessary to reconcile technological solutions and socio-spatial conditions by adopting a sociotechnical perspective.

13. A NEED FOR DATA AND MONITORING

Many PEDs start with a lack of data regarding energy production, storage, consumption and potential for renewables. Instead, they rely on assumptions that are not always reliable or accurate. Even when data becomes available over time, it is often difficult to compare this the current conditions to baseline conditions such as a business-as-usual scenario or the surrounding neighbourhoods. PED stakeholders rely on public administrations, grid operators and energy suppliers for datasets. Also beyond the implementation of PEDs, the availability of standardised energy data and monitoring strategies would help to support targeted energy policies.

14. CONNECTING ENERGY WITH OTHER METABOLIC FLOWS

As noted in point 1 (above), none of the PEDs in this project were established with the PED concept. In addition to energy, each PED works on related issues such as water management, waste treatment, and mobility that have synergies with renewable energy strategies. This can be seen, for example, in the well-publicised ‚Hammarby Model' of a „cyclic metabolism" (see figure 4). While this model did not produce the desired results in practice,[6] it indicates how different types of waste and water collection can be used for local energy production. In addition, some PEDs also work on the theme of resource efficiency by emphasizing building materials. This work tends to be based on design principles rather than a quantified life cycle assessment of the entire project. The emphasis on resource efficiency situates energy transitions in a broader perspective and adds additional considerations to particular interventions. For example, a building equipped with the high-efficiency energy technologies but low-quality building materials can hardly be categorised as sustainable in the long term.

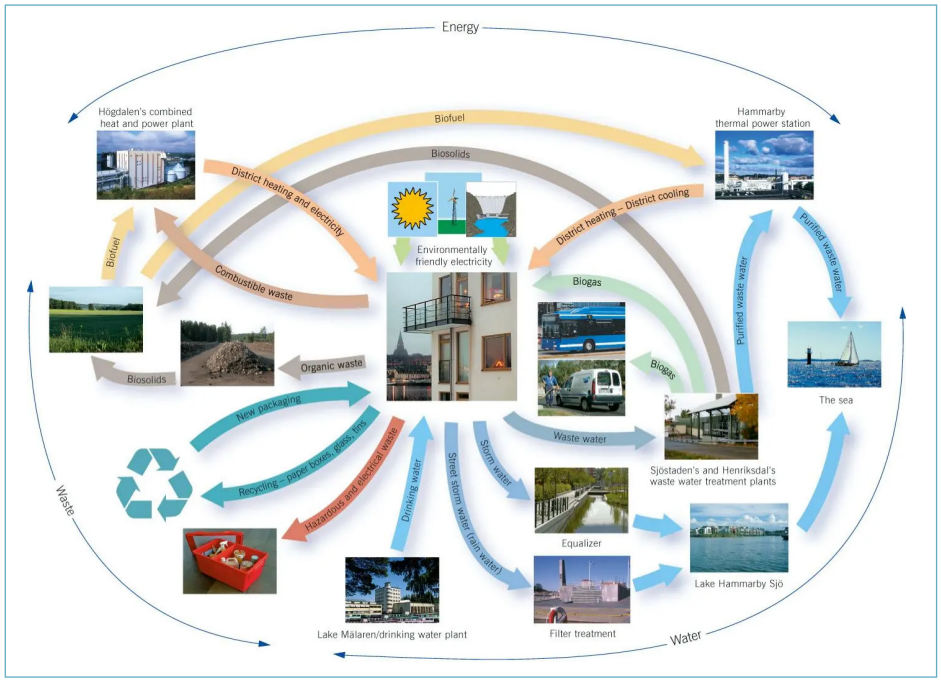

figure 4: the metabolism model that was developed for the first phase of the redevelopment of Hammarby Sjöstad

6 This failure was a primary motivation to initiate the second phase of Hammarby Sjöstad.

GOVERNANCE AND POLICY CONTEXT

The broader management of PEDs is mapped in this layer as well as the different relations between stakeholders and the (policy) contexts in which they operate.

15. DIVERSE PARTNERSHIPS BETWEEN DIVERSE ACTORS

The organisational structure of PEDs varies greatly. Conventional structures involve local governments who contract out development tasks to private companies while using innovative tools to maintain control over the development and subsequent use of the site (Brunnshög, Graz Reininghaus). Alternative structures include citizen-driven platforms that collaborate with private companies (Hammarby Sjöstad), design firms that partner with regional governments (Sonnendorf), and property owners that use site redevelopment processes to connect with neighbourhoring sites (Abattoir).

Even more diverse than the organisational structures are the active and passive partners involved in setting up the PED. This illustrates the strategic and impactful potential of PEDs and their tendency to transcend energy to involve a wide range of sustainability issues. Thus, there is a need to engage with stakeholders whose interests are not closely aligned with energy transitions.

16. CITIES, COMPANIES AND CITIZENS IN THE LEAD

The five PEDs in this project reveal a wide range of stakeholders. Local governments, private companies, and citizen associations all have the potential to lead PED activities. Moreover, they always do this in collaboration with other stakeholders. Thus, urban energy transition do not necessarily need to be led by policymakers and public administrations. However, there is a need for a clear vision and guiding framework to steer these stakeholder coalitions. Oftentimes, public authorities are the most suitable stakeholder to drive co-production or co-creation processes.

17. OVERCOMING TEETHING CHALLENGES WITH NEW LEGAL FRAMEWORKS

From a regulatory perspective, PED stakeholders are apprehensive about new legislative frameworks that are being implemented at national and regional levels as a response to European directives. These frameworks clarify how energy can be produced collectively and exchanged between individuals and within communities. They provide legal mechanisms for PED stakeholders to achieve their energy ambitions. In this way, they help PED stakeholders in finding legally sound ways to develop their project. However, these frameworks can also create new barriers for PED stakeholders. Examples include the significant increase in tariffs to be paid to distribution network operators in Austria when energy exchanges between users at the district scale. The sharing of locally produced renewable energy is more expensive when compared to the conventional regional or national grid model. At Abattoir, the exclusion of certain types and sizes of actors within energy communities creates barriers to the development of energy generation and consumption strategies with neighbouring land owners. PED stakeholders need to adapt to these new frameworks so that all opportunities are provided to support the energy transition in a sustainable and socially responsible manner. dimension was indeed an important part of their work, but acknowledged that they often address this dimension intuitively. This highlights the need to reflect upon the intended beneficiaries of PED activities. Many PEDs target (upper) middle class residents while struggling to support the lives of socially and economically deprived residents. Energy transitions need to benefit everyone and working towards inclusive modes of transition is essential to address in all PEDs.

MAIN REFERENCE(S)

- DoppelPlus website (in German and English)
- Statistik Austria, *Erweiterte Betrachtung der Energiearmut in Österreich, Hohe Energiekosten bzw. Nicht-Leistbarkeit von Energie für Wohnen.* Vienna: Statistik Austria, 2021. (in German)

GENERAL CONCLUSIONS: A PED IS NEVER JUST A PED.

The transversal analysis of the five PEDs in this project show that **'a PED is never just a PED'**. The measures and infrastructures that can produce a positive energy balance are closely intertwined with the physical and social context of the district. Realising a PED involves interventions in the urban context and consdideration of issues that go far beyond energy. In other words, energy is part of a broader urban renewal project in each district. This leads to several recommendations as well as guiding questions for PED stakeholders as summarized below.

With respect to the long duration of ambitious renewable energy projects at the district scale, it is important to elaborate **a clear, coherent and broadly supported vision and concept**. This includes the formulation of both concrete objectives and guidelines on how these objectives can be updated throughout the development process and within what margins. It is also important to appoint an individual or team to **monitor the compliance with this vision and objectives during the entire trajectory of the PED** (from the study phase to an evaluation and adjustment phase after delivery). This role should be fulfilled with relative independence from political or economic factors.

In addition, the district scale is central to the implementation of **collective structures for the production, storage, and consumption of renewable energy**. Purely based on economies of scale, the district offers optimal efficiency when compared to individual facilities. However, this efficiency can be further enhanced by establishing and maintaining effective systems of local energy production and consumption. These structures embed the energy transition in the social dynamics and everyday practices of the district and can also connect to other contextual opportunities. Such collective structures of provision and use can enhance the impact and success of PEDs.

A well-defined PED programme can leverage **complementarities and synergies** to achieve a positive energy balance. Volumes and rhythms of energy production and consumption can be aligned to minimize the need for storage facilities and complicated grid management schemes. In many cases, PED programme are limited to housing and supporting functions. Broadening this programme to include offices, hospitality services, and industrial activities can provide additional opportunities for energy transitions.

Finally, sufficient consideration should be given to the possible densities of a PED. **PED density** affects economic viability, the expected energy demand, and the potential for local production of renewable energy. Density is therefore an important factor within both the achievement of a positive energy balance and the economic feasibility of a project. It is therefore necessary to define the PED density at the start of development processes.

The PEDs demonstrate how energy transitions are being realized in a wide range of contexts. A PED is always more than just a PED. This open-endedness makes it difficult to provide explicit guidance on how to establish a new PED. However, the following questions can provide a frame of reference.

- Which energy flows will be included in the PED energy balance calculation? How will these flows be delimited and by which standards will they be monitored?
- Which material flows and other resources (such as sustainable material use, reuse of the existing building stock, and land development) are included in the assessment of a PED project?
- Which stakeholders can play a leading role in PED development and how can the interests of all stakeholders be safeguarded?
- Which stakeholders should be involved in the development of the PED and how can they contribute to the realization of an inclusive energy transition?

These questions reveal an enduring tension between PEDs as a technical endeavour of energy optimization versus PEDs as 'urban project' that embeds the energy question in a holistic perspective on sustainability. The former approach sets clear ambitions and evaluation criteria while the latter embeds the concept in the rich multi-layeredness of the urban condition. The technical focus of the former ignores the social challenges associated with the energy transition while the latter replaces the PED notion with a vague (and often complex or debatable) description of 'good practice'.

In the future, it will therefore be important to clearly indicate which energy and material flows need to be evaluated, how to delimit these flows, and which standards must be followed when calculating the energy balance. The PED concept can serve as a catalyst for energy transitions, even for district developments that may not be classified as full-fledged PEDs. And finally, it is essential to address the urban dimensions of energy transitions and provide concrete entry points as well as quantitative and qualitative evaluation criteria to use PEDs as vehicles for a more sustainable and just tomorrow.

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All about the Trans-PED project

Check out the Trans-PED website for details on the project, the international consortium of partners, as well as the participating PEDs.

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