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Abstract. The development of Positive Energy Districts (PEDs) is a complex process that involves the integration of various technologies, stakeholders, and policies. To facilitate this process, a database for PEDs has been developed as a joint effort of COST Action 'PED-EU-NET', IEA EBC Annex 83, and JPI Urban Europe. This paper reports on the realization of the PED-Database framework and its online implementation as a modular web interoperable platform, giving details on the development life cycle since the scoping phase up to the testing phase. The PED-Database offers a variety of implementation strategies and conceptualizations for the PED concept, making it a valuable resource for urban planners, policymakers, and researchers. The testing phase has shown that there is no one-fits-all solution for PED implementation, and the overall PED framework definitions require further detailing in the local context. However, the database allows users to visualize and compare different PED scenarios by customizing their selection, accessing to the information provided by real PED cases that best meets their expectations and goals. Overall, the PED-Database provides a valuable tool for the development of sustainable and energy-efficient urban areas.

1. Introduction and aim

Positive Energy Districts (PEDs) should be designed in a highly structured manner, considering local resources and specific challenges, while involving urban stakeholders at a high level and strongly linked to global governance models, where all factors are important [1].

Several factors are critical to Positive Energy Districts (PEDs) and involve both technological and non-technological elements that impact the three main components of energy: efficiency, renewable energy production, and flexibility with storage and demand side management. The PED concept emphasizes the decentralization of the energy system, which enhances energy security and resilience, actively involves end-users in energy management, and transitions urban environments towards fossil-free and climate-neutral solutions.

Successfully embedding PED solutions in existing urban contexts presents a significant challenge, as it requires addressing differences in geographical, historical, economic, social, and cultural backgrounds. Achieving this objective requires concepts that go beyond technical feasibility and embrace a diversity of different approaches.

The capacity building process is essential for stakeholders to develop each element of the PED in close collaboration with partners, which underscores the need for a shared strategic vision among all actors involved in the process. While previous studies have focused on identifying specific aspects of PEDs such as energy or social [2;3], while other authors have also identified PED challenges and barriers [4] there is clearly a gap of finding good examples of PED developments [5]. A tool is missing that helps to map, filter, sort, and compare PED experiences while providing a balanced overview of the technological and non-technological solutions adopted in different PED projects. Zhang et al. started to develop a dedicated database that must be further expanded/interoperated through an interactive dashboard [6]. It reports and visualizes the initial analytical results of 60 existing PED projects in Europe about their main characteristics, including geographical information, spatial-temporal scale, energy concepts, building archetypes, finance source, keywords, finance model and challenges/barriers. The IEA EBC Annex 83, COST Action 'PED-EU-NET', and JPI Urban Europe, all of which are pioneer initiatives conducting research on Positive Energy Districts (PEDs), collaborated to develop a tool called the 'PED Database'. The tool aims to map, filter, sort, and compare PED experiences, providing a balanced overview of the technological and non-technological solutions adopted in different PED projects that require the cooperative involvement of multiple stakeholders. The capacity-building process encourages the participation of all stakeholders involved, including researchers, policymakers, industry experts, and community members.

The aim of this work is reporting on the realization of the PED-Database framework and its online implementation in the form of a web interoperable platform [7]. Municipalities can benefit from the Database as a tool for browsing different practices, searching for similar examples, and accessing practical information and insights. Similarly, researchers and practitioners, such as architects, urban planners, engineers, and economists, can use the Database to seek information, compare and analyse data, identify patterns and narratives, and share knowledge.

An important task for JPI Urban Europe, through its operational program, the "Driving Urban Transitions Partnership," will be to communicate the content and findings of the Database to policy- and implementation-related target groups in an appropriate and effective manner, including municipalities, urban practitioners, and end-users [8].

2. Methodology

In the framework of the PED-Database development, a core aspect is the subdivision of the development process into a series of phases (also referred to as the *database development life cycle (DDLC))*. The database development moves through this life cycle starting with the Scoping Phase of establishing requirements expressed as a statement of requirements with the aim to create a framework for data collection from demo cases.

Then follows the implementation process, based on an online template, which was structured to collect the relevant info. Close cooperation within the three involved initiatives and their working groups was ensured by iteratively elaborating on the template.

A well-structured data collection was conducted. This task required external assistance from PED developers who are in charge and responsible for the gathered information (e.g., researchers, energy vendors, DSO (distribution network operators), TSO (transmission system operators), aggregate, technology providers, etc.), auditors (e.g., technical architects in charge, energy audit company, consulting expert) or any other actors within a public–private partnership who are actively involved in the projects. Finally, a testing phase was initiated as the last part of the DDLC.

2.1. Scoping phase

The main scope of PED-Database is to provide data on the state-of-the-art development in PED model in order to devise methods to characterize these districts, but also recommend concepts, solutions, strategies, and best practices for their effective grounding in different geographical contexts and according to multiple stakeholders' needs and expectations.

As explained above, the PED EU NET Database is the result of collaboration of many researchers and practitioners in the PED field. The included parameters are designed to comprehensively characterize the PED concept and enable a learning process by the PED community. The database currently, consists of two main blocks structured into six strictly interrelated sections (Fig.1):

- A central nucleus that collects information about PED/PED-relevant case studies and PED Labs. This part is structured in the following three sections: 'Section A' (*i.e.,* A1. Global Characteristics, A2. Technological Aspects and A3. Non-technological Aspects), 'Section B' (*i.e.* B1. PED Case studies in detail and B2. PED Labs in detail) and 'Section C' (*i.e.,* C1. Drivers and barriers). Currently, a total of 109 parameters and 455 options are collected in this block and implemented in the online platform.
- A supporting nucleus of information related to PED concept is structured in three complementary sections: 'Section D' on General Projects/Initiatives, 'Section E' on National Policies and Strategies and 'Section F' on Technological and Non-technological related Solutions/Innovations. 'Section D' has been fully developed and integrated into the online platform, consisting of 16 parameters and 7 options. As regards 'Sections E' and 'Section F' are under development, and further sections may be added in the future, following the logic of modularity and ability of implementation of the Database.

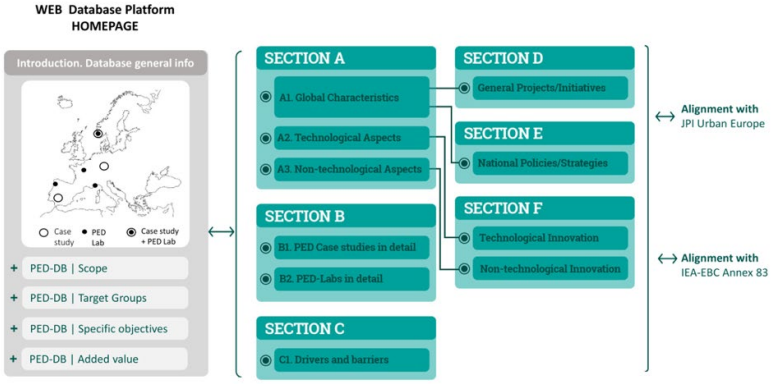

Figure 1. Structure of the PED database

2.2. Implementation phase

2.2.1. Selection phase

Based on the characteristics of the existing PEDs and PED Labs as well as the available bibliography, a first selection of the entries that should be collected by the database was made. This selection was expanded and agreed upon by the different working groups of the initiatives involved, resulting in a list of variables required in different sections of a survey to characterize each case study. Subsequently, these entries were validated by providing this list to groups outside the development of the PED-Database that had real cases. These groups assessed the questions in each section of the survey and provided their comments, indicating what they thought was missing or what they believed was redundant. This review led to filtering and refinement of the survey in each of its sections through much more precise and specific questions. This process has resulted in a PED-Database that allows the maximum possible information to be extracted from each case, structured in sections as explained in the scoping phase.

2.3. Data collection phase

Data collection is the process of gathering information for use in strategic planning, research, and other purposes. In this case, it is a crucial step to comprehensively characterize the PED concept, as effective data collection provides the necessary information to answer questions, analyze performance or other results, and predict future trends, actions, and scenarios. The data collection process is carried out in three main stages.

- **In the first stage**, a data collection plan is created, and specific DB guidelines are developed, and the main actors are identified. Two main collaborative roles are involved: the PED Database Editor and the Input Form Editor. The DB Editor is responsible for establishing effective communication with key PED/PED Lab case study contact persons to encourage their participation as input editors in the PED database. At this stage, the DB Editor invites Input Editors via web links to complete PED project and case study forms. Before issuing an invitation, the DB Editors can check in the DB backend which Input Editor has already been invited. The DB Editors' register is then updated with a record of the projects and case studies assigned to each DB Editor.
- **In the second stage**, appropriate data sources are identified, and Input Form Editors fill in the required information through online forms. The DB Editor provides advice to the input editors as needed. When the input form is submitted, the project/case status changes from draft to pending. A standard has been developed for entering individual entries into the PED database.
- **In the third stage**, completed information is evaluated prior to publication on the PED-EU-NET website. The DB Editor checks the completeness and accuracy of the information filled in the different input forms (case studies & projects). Major changes and clarifications will be discussed between the DB Editor and the Input Form Editor before authorizing the publication of the PED projects/cases in the database. The status will change from pending to published in the backend DB. Once published, the information is accessible through the front-end design of the PED Database. The home page allows users to view the maps and tables of the PED cases and associated projects without having to register [9].

2.4. Testing phase

In this phase the fundamental thing is to make the necessary tests to verify that the database is in agreement with the introduced data as well as not going to have errors with respect to the applications and tools that other users are going to use.

To begin with it is important to have a group of people with independent responsibilities both for entering the data; that would be the editors, as well as another group of people who are able to verify that the data entered have been stored successfully and used in accordance with the technical specifications of the database [9].

In this way there is a phase prior to the testing that would be to obtain the data of the case studies to be entered into the database; these data, which will be provided by other users and collaborators of the database itself, will be the fundamental part of this web tool.

The next step would be for the database editors to enter all the case studies that have been received in constant coordination with the subject that has provided that case study.

Finally, this phase of testing is done once again in coordination with the people who have offered their case study, making a verification that the editors of this database have entered the case study of a person in coordination with that person will verify as an external user to the database that all data have been entered correctly and are available to everyone who is interested in making free queries in this database, in this way has been validated each case study PED separately, once all are validated will have been tested the PED database [10]. In this phase, the fundamental objective is to conduct necessary tests to verify that the database accurately reflects the entered data, and to ensure that there are no errors with respect to the applications and tools that other users will be using.

3. Results

The platform is set up and running, a first round of data collection is being performed both at case study and project level.

The designed PED-Database introduces definitions and insights that will guide cities' stakeholders in the creation of capacity at different levels as well as by defining core capabilities. The developed framework provides an understanding of PED concepts, planning values, and functionality criteria to create a learning environment for capacity building and, at the same time, to establish a vision for future districts.

Dedicated Database Editors will review the gathering of data assuring their consistency and transform them into an understandable, common language that will be displayed in the platform. The sustainability of the Database is critical in terms of contributions and research, and, for this reason, the three initiatives - COST Action PED EU NET, IEA EBC Annex 83 and JPI UE - have planned to maintain the Database after the Action lifetime, as it will be adopted by another host that works closely with Action group. The DDLC will be repeatedly revisited.

The structure developed by this database has generated an interface that shows the results stored in a differentiated way in map or table view. Each of the stored PED developments can be assessed in detail or even compared with other cases, facilitating the identification of common or differentiating elements. Another aspect to highlight is that this web platform facilitates quick access to general project information, as well as identifying the PED cases associated with each project.

4. Conclusions

The database for PEDs is a joint effort of COST Action 'PED-EU-NET', IEA EBC Annex 83 and JPI Urban Europe to provide a wealth of information about new and refurbished urban environments aiming to produce more energy than they consume. This paper reports the realization of the PED-Database framework and its online implementation in the form of a web interoperable platform, which has been designed in a modular way, allowing the division of the general survey into smaller and independent sections that facilitate data entry and subsequent processing. The internal peer-review process for the data entry through the editors assures that the data in the database is sourced from reliable and verified information, ensuring its accuracy and reliability.

The development process moves through a database development life cycle (DDLC) starting with the scoping phase of establishing requirements expressed as a statement of requirements with the aim to create a framework for data collection from demo cases. Finally, a testing phase has been initiated and these are the main conclusions extracted from this first analysis:

- There is no one-fits-all solution for PED implementation. Overall PED framework definitions require further detailing in the local context [11]. The PED Database provides an overview of not only different implementation strategies, but also existing different conceptualizations and approaches for the PED concept.
- Thanks to contributions, all inputs are collected in the Database, the users of the platform can visualize and compare different scenarios of PEDs by customizing their selection. Before exporting, it can be displayed in the user-friendly frontend of the PED-EU NET Database that covers each KPI resulting from the gathered information by DB editors. Then, the selected comparison can be saved as an output file and successively can be exported as a .csv format file. In this way, users of the tool can select and work on the information that best meets their expectations, goals, and then build their own further storytelling.

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References

[1] JPI Urban Europe (2020). Europe Towards Positive Energy Districts. A compilation of projects towards sustainable urbanization and the energy transition. https://jpi-urbaneurope.eu/wp-content/uploads/2020/06/PED-Booklet-Update-Feb-2020_2.pdf
[2] Clerici Maestosi, P., Andreucci, M.B. & Civiero, P. (2021), Sustainable Urban Areas for 2030 in a Post-COVID-19 Scenario: Focus on Innovative Research and Funding Frameworks to Boost Transition towards 100 Positive Energy Districts and 100 Climate-Neutral Cities. Energies; 14(1), 216. https://doi.org/10.3390/en14010216
[3] Gouveia, J. P., Seixas, J., Palma, P., Duarte, H., Luz, H., & Cavadini, G. B. (2021). Positive Energy District: A Model for Historic Districts to Address Energy Poverty. Frontiers in Sustainable Cities, 3(April), 1–18. https://doi.org/10.3389/frsc.2021.648473
[4] Hearn, A. X., & Castaño-Rosa, R. (2021). Towards a just energy transition, barriers and opportunities for positive energy district creation in Spain. Sustainability, 13(16), 1–18. https://doi.org/10.3390/su13168698
[5] Gohari, S., Steemers, K., Konstantinou, T., Soutullo, S., Liu, M., Giancola, E., Prebreza, B., Ashrafian, T., Murauskaitė, L., & Maas, N. (2021). Positive energy districts: Identifying challenges and interdependencies. Sustainability, 13(19). https://doi.org/10.3390/su131910551
[6] Zhang X, Penaka SR, Giriraj S, Sánchez MN, Civiero P, Vandevyvere H. Characterizing Positive Energy District (PED) through a Preliminary Review of 60 Existing Projects in Europe. Buildings 2021; 11: 318
[7] PED EU NET PED Database, https://pedeu.net/map/ [accessed 25.04.2023]
[8] Bossi S, Gollner C, Theierling S. Towards 100 Positive Energy Districts in Europe: Preliminary Data Analysis of 61 European Cases. Energies 2020; 13: 6083.
[9] Turci G, Alpagut B, Civiero P, Kuzmic M, Pagliula S, Massa G, Albert-Seifried V, Seco O, Soutullo S. A Comprehensive PED-Database for Mapping and Comparing Positive Energy Districts Experiences at European Level. Sustainability 2022; 14(1):427
[10] Brozovsky J, Gustavsen A, Gaitani N. Zero Emission Neighbourhoods and Positive Energy Districts—A State-of-the-Art Review. Sustain. Cities Soc. 2021; 72: 103013.
[11] Derkenbaeva, E., Yoo, H.K., Hofstede, G.J., Galanakis, K., & Ackrill, R. (2022), 'Positive Energy Districts in Europe: one size does not fit all'. In: 8th IEEE International Smart Cities Conference (IEEE ISC2 2022), Paphos, Cyprus, 26-29 September 2022.