

# Understanding Stakeholder Perspectives: Towards the Design of a Serious Game for Positive Energy Districts

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**Abstract:** Positive Energy Districts (PEDs) are highly energy-efficient urban areas that manage a surplus production of renewable energy. Recognising the key role they can play in the transition to a less carbon-dependent society, the European Commission launched its PED Programme in 2018, to implement and support the development of PEDs. However, as PEDs are still a relatively new concept, their implementation can be challenging, and local administrators often lack clear guidance and reference points for their design, implementation and evaluation. To address this issue, the Positive RObust PED Localities (PROPEL) project has among its main objectives the design of a serious game to provide practical insights and user-friendly tools for local administrators interested in implementing and developing PEDs. Indeed, by drawing on the power of digital games to set goals and allow the player to autonomously define a strategy to achieve them within a set of constraints, serious games can be a very powerful tool to support local administrators in their decision-making process, enabling them to explore multiple scenarios and to evaluate the results of their choices. This paper outlines the design principles and the main features of a serious game aimed at supporting local administrators in the implementation of PEDs. These design principles and features are derived from a research process comprising several steps. Firstly, the drivers and barriers to the adoption of a serious game among local administrators were identified. This was done through in-depth interviews with local administrators and PEDs experts from the different countries involved in the PROPEL project, namely Italy, Sweden, and Turkey. Secondly, a comparative analysis of serious games developed for related research purposes was carried out. This provided further suggestions for the features of the serious game. The findings underscore the significance of incorporating real data, adopting a modular structure to emulate the systemic complexity of PEDs, and ensuring accessibility across multiple devices as paramount features that the serious game should have.

**Keywords:** Serious Game; Design Principles; PED; Sustainability; Case Study; In-depth Interviews.

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## 1. Introduction

A cornerstone of the European Union's efforts in fighting climate change is the transition to a less carbon intensive society, achieving carbon neutrality by the year 2050. A key challenge is the decarbonisation of the energy system and the built environment. Against this backdrop, numerous EU plans aim at creating the conditions for the development of initiatives that accelerate decarbonisation of the sector, while ensuring a high-quality of life for citizens and the achievement of social and economic objectives, such as addressing energy poverty (European Commission, 2020). In this context, the EU introduced the framework of Positive Energy Districts (JPI Urban Europe, 2020).

PEDs are energy efficient and energy flexible urban areas (or interconnected groups of buildings) which produce net-zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy (Hedman *et al.*, 2021). Therefore, the defining characteristic of a PED is a technical and environmental one: Groups of buildings with a surplus annual energy balance and net-zero GHG emissions. However, the PED framework also places heavy emphasis on social outcomes and in particular the quality of life of citizens and tackling energy poverty.

Due to the urban nature of the concept, the task of developing PEDs falls largely on local administrations. However, they face numerous barriers to the implementation of PED policies and measures. Chief among them is the lack of relevant data and tools for monitoring PED development. Collecting data on environmental, economic, and especially social indicators that can inform PED strategies and progress can be challenging for

local administrations, and often proxies need to be used (Caballero *et al.*, 2021). The lack of data can lead to ineffective decision-making and a lack of targeted development towards PED benchmarks across possible scenarios for the district's development.

The PROPEL project aims to address the data limitations of local municipalities through the use of a Decision Support System (DSS). This system aims to operate as a data exchange platform for innovation in processes and business models, providing data-driven analytics. The DSS will allow for the local exchange of granular energy consumption data, allowing consumption forecasts for residential and commercial customers to be greatly improved.

However, such an approach is not without its shortcomings. The use of the tool relies on an antecedent understanding and willingness to engage with the technology. Towards this end, the PROPEL project aims to foster the use of the tool through the inclusion of gamification features. The integration of game elements in the DSS is intended to enhance accessibility and guidance for stakeholders who are not familiar with these types of simulation tools. The objective of this study is to identify the factors that either facilitate or hinder the adoption of a gamified approach as a means of disseminating content related to PEDs and supporting informed decision-making among a target audience of stakeholders.

## 2. Background

PEDs foster interaction between buildings, users, and regional energy, mobility, and ICT systems to ensure a sustainable balance of social, economic, and environmental factors. There are many possible configurations that a PED can take, and while there is no single consensus on a taxonomy, the European Energy Research Alliance (EERA) proposes the following categorisation: Autonomous PEDs, Dynamic PEDs, and Virtual PEDs. Autonomous PEDs are entirely self-sufficient in energy production and consumption within defined boundaries, while Dynamic PEDs allow for the import/export of energy to balance production and consumption. Virtual PEDs expand boundaries to include energy production and storage outside the district, maintaining a positive annual energy balance. Additionally, there are PED-like areas that aim for energy positivity but may still rely on grid imports or non-renewable sources.

The building blocks of the PED concept can also be varied. The Strategic Energy Technology Plan (SET PLAN, 2018) highlights the following six interdependent elements: Renewable Energy Sources, Energy Efficiency, Energy Flexibility, Electric Mobility, ICT Deployment, and Affordability. These elements work synergistically to support the district's energy goals, emphasising the use of renewable energy, efficient consumption, flexible management, electric vehicle integration, advanced ICT systems, and affordability to ensure a fair transition for all citizens.

Initial EU-level plans for PED development were enshrined in the Commission's plans to develop 100 PEDs by the year 2025 (JPI Urban Europe, 2020). The aim is for 100 districts to be in "concrete planning, construction, or operation, synergistically connected to the energy system in Europe by the year 2025" (SET PLAN, 2018). The generally flexible PED framework makes it difficult to conclusively monitor the advancement of PEDs in Europe towards this goal. The PED-Database<sup>1</sup> of the PED-EU-NET, which maps PED case studies included in EU projects, reports 25 entries as of May 2024, while a 2020 publication proposes up to 61 PED-like case studies in Europe (Bossi, Gollner and Theierling, 2020). It is at least abundantly clear that the policy objective at the EU level is for PED areas to significantly increase in the immediate future, alongside other overlapping smart city concepts such as the emergence of Energy Communities.

However, several barriers to the implementation and evaluation of PED projects exist. For example, there is uncertainty about the best incentive structure conducive to PED development, namely under which tariff conditions can an electrified PED be sustained and in what weather conditions (Bruck, Díaz Ruano and Auer, 2022). At the local level, the unavailability of important data to evaluate PED scenarios and monitor the progress of PED policies stands out as a significant challenge. The ambiguity of concepts and the fact that there is no one-size-fits-all solution makes it so that assessing the advancement of a PED at the local level is difficult. Though various projects have attempted to provide frameworks for PED evaluation (Huovila *et al.*, 2017; Caballero *et al.*, 2021) the collection of accurate data on energy consumption, environmental indicators, and social well-

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<sup>1</sup> <https://pedeu.net/map/>

being (reduction in energy poverty), amongst others, represents a significant barrier for local administrations wanting to evaluate their projects against the specific requirements of the PED framework. The PROPEL project aims to develop a tool that can, to some extent, address these data limitations by establishing a data-sharing platform that can support local decision-makers (DSS tool).

Given the crucial importance of decision-making in PEDs implementation, and the need to make it as accessible and understandable to a broad audience of stakeholders, who in some cases are not experts, the PROPEL consortium planned to integrate game elements in the DSS tool.

The implementation of serious games or gamified applications is a frequently employed strategy for the purpose of supporting and enhancing the decision-making process (Mullinix *et al.*, 2013; Rhodes *et al.*, 2017). This is due to the fact that such applications allow for the direct experimentation of decision-making processes, thereby enabling the testing of alternative sets of choices in a cost-effective and non-risky manner (Rissanen *et al.*, 2020). This approach has been adopted in the most diverse fields, like the medical one (Vallefuoco, Mele and Pepino, 2019), the business one (Grund and Meier, 2016) or the environment management one (Furber, Medema and Adamowski, 2018). In the field of spatial planning, the use of gamification has been employed, particularly in the context of environmental adaptation to climate change. The objective is to enhance the comprehension of the underlying logics of negotiations and agreements between stakeholders (Poplin, 2011; Berni *et al.*, 2022; Kavouras *et al.*, 2023). One case where this approach was developed specifically for energy planning is the UrbEN project. The creation of sustainable urban energy systems necessitates the engagement of a broad spectrum of stakeholders from both the public and private domains. It is therefore essential to be able to navigate intricate networks of interactions at regional, national, and European scales.

UrbEN is an educational simulation tool that employs a role-playing tabletop game format to facilitate the study of sustainable urban energy management. This ensures that future urban planners are equipped with the essential competencies and insights to address the complexities of transitioning towards sustainable urban energy systems (Lami *et al.*, 2023).

Although the positive impact of introducing game elements with the aim of facilitating decision-making has been extensively studied (Mullinix *et al.*, 2013; Rhodes *et al.*, 2017; Rissanen *et al.*, 2020), further research is required in terms of drivers and barriers influencing the adoption of such methodology among the specific target of local administrators and PEDs experts. Moreover, in the PROPEL project, stakeholders are principal actors in the design process, with the objective of enhancing the utility and efficacy of the project's final outcomes. Consequently, they were also engaged in the process of delineating the fundamental principles and pivotal attributes that a serious game designed to assist local administrators in the implementation of PEDs should possess.

Therefore, the research questions this paper aims to answer are as follows:

RQ1: What are the main drivers and barriers to the adoption of the PROPEL serious game among stakeholders in the PED field?

RQ2: Which are the main design principles to be taken into account when designing a serious game for stakeholders in the PED field?

### **3. Method**

In order to address the research questions, a qualitative approach was employed, comprising two main steps.

Firstly, the drivers and barriers to the adoption of a serious game among local administrators were identified. This was achieved through semi-structured in-depth interviews with local administrators and PEDs experts from the countries involved in the PROPEL project, namely Italy, Sweden, and Turkey. Furthermore, interviewees were requested to identify the principal characteristics that the PROPEL serious game should possess in order to be beneficial for the final target audience.

Secondly, a comparative analysis of serious games developed for related research purposes was conducted with the objective of identifying the most commonly adopted game elements.

#### **3.1 In-depth Interviews**

Six in-depth interviews were conducted with the objective of exploring a range of topics, including: attitudes and expectations, learning needs, and desired features and functionalities. Two researchers were present during

each interview, one acting as the interviewer and the other as an assistant. Each interview began with an introduction about the purpose of the research, then, the interviewer, following an interview guide, asked the interviewee several open-ended questions. The interviews lasted 25–35 min. and were audio-recorded and transcribed verbatim.

Data collected through the interviews were analysed according to the methodological frameworks for content analysis (Weber, 1990; Hsieh and Shannon, 2005; Bardin, 2013). Qualitative content analysis, as described by Hsieh and Shannon (2005), involves the systematic coding and identification of themes or patterns in the textual data for subjective interpretation. The chosen analytical approach comprised six main steps: (1) knowledge of the data through repeated readings; (2) identification of the units of analysis; (3) grouping of the units of analysis into categories (themes) in line with common characteristics; (4) review of themes; (5) determination and naming of themes; (6) composition of the study report. To facilitate data analysis, the software Atlas.ti (<https://atlasti.com/>) was used. Three reviewers, one with a background in distance learning and educational technology, one with a background in games and gamification studies and one with a background in PEDs, individually evaluated and examined the interviews' transcripts. Afterwards, the results were discussed, and any disparities were addressed to reach a consensus.

### 3.2 Comparative Analysis of Serious Games

To generate additional insights for refining the design of the PROPEL serious game, a comparative analysis of serious games developed for similar purposes was carried out. An extensive online search was conducted with the objective of identifying serious games developed with the aim of disseminating knowledge on environmental impact, energy conservation, and urban planning dynamics. This search resulted in the identification of ten serious games that shared significant similarities to the one to be designed in the framework of this research. The identified serious games were analysed by two researchers, one with a background in distance learning and educational technology and one with a background in games and gamification studies. This analysis was conducted using the video game structural characteristics proposed by King et al. (2010) as a reference.

## 4. Results

### 4.1 Main Findings From In-depth Interviews

After performing the thematic analysis of interview transcripts, the themes and sub-themes presented in Table 1 were identified. The subfields have been proposed based on the literature, but the final list was defined on the basis of basic coding and discussion among researchers.

**Table 1: Themes and sub-themes revealed in the content analysis of the interviews**

Themes (# of comments)	Sub-themes	# of comments	Sample quotes
<b>Expected advantages and/or opportunities of gamification/serious game (38)</b>	Improves performance and/or learning outcomes	5	"Another [advantage] is awareness of these tools for improvement. Let's say an overview of what the opportunities are, maybe even a cost-benefit analysis or a SWOT analysis to be able to assess the benefits for one's community." (Respondent 4)
	Enhances the level of engagement in the learning process	6	"The key to behavioural change lies with engaging a broad scope of individuals." (Respondent 6)
	Enhances the level of motivation to learn	1	"[To] give a little more element than the classic workshops where one is only asked to brainstorm ideas and to compare but where there is no mechanism of competition or reward for those who work best." (Respondent 3)
	Fosters the adoption of positive behaviours	7	"Because frankly, right now, the decision-makers, they think here, right here, right now, it costs this much. They don't look further down in a few years. So I think that will be really good." (Respondent 5)
	Improves the attitude toward the learning process and/or the subject matter	9	"I believe the engagement strategy is sound for and fitting for the objectives." (Respondent 6)
	Provides immediate feedback	2	"Since the data collected this way supposedly will be digital, it will be much more accurately collected. So it will be more comparably refined." (Respondent 6)

Themes (# of comments)	Sub-themes	# of comments	Sample quotes
	It's more enjoyable and fun than traditional learning	6	"Definitely curiosity. The first impact would be this because the interesting thing is always to try to find an application that brings an input of positivity with respect to something that may be new, hostile, not perfectly in line with the knowledge already acquired, etc. In this case, gamification in my opinion is a good tool to open up new horizons, new knowledge that otherwise a classic approach would still involve more effort." (Respondent 2)
	Suitable for large and diverse target groups	2	"We're a big municipality. We have about. In Sweden, we have about 150,000 inhabitants and we have about 10,000 employees in the municipality, from schools, and elderly care to what I do. And I think we can all benefit from it." (Respondent 5)
<b>Expected disadvantages and/or risks of gamification/serious game (20)</b>	Not suitable for an in-depth analysis	1	"Let's say that perhaps a malus might be a somewhat too superficial approach compared to a tighter and more systematic analysis of the data, which, at least in the start-up phase, needs to be done in order to set up a PED well." (Respondent 2)
	Generates negative emotions (i.e. anxiety, aversion)	1	"[The use of game elements could cause] seeing these issues as negligible or otherwise not generating the impact that gaming and PEDs could have on cities." (Respondent 4)
	May not be well received by some of the participants	10	"On the other hand, on the not-so-good side, maybe, is it working? Can we trust this gamification? Is it too much like a video game? That is just something that we use that people don't trust." (Respondent 5)
	Has technical issues	5	"The issue of privacy is the main one, i.e. the fact that it is not something for personal use, that is, without the data being disclosed in any way whatsoever, etc., in my opinion, it is still useful." (Respondent 1)
	No prior experience	3	"To clarify the definition of PED, which is not clear to everyone and therefore what it means, that you can also get there step by step and this is important, i.e. you can also get close to PED without being perfectly in line with what the requirements are and that it is worth taking a slightly longer view anyway [...]." (Respondent 1)
<b>System Specifications (46)</b>	System purpose	6	"[It should be] a scalable tool or otherwise adaptable to various contexts, even customisable." (Respondent 4)
	Scope/Exclusions	10	"The approach might be the same on all project areas, but different urban-peripheral-rural dynamics should be mentioned when making these comparisons." (Respondent 6)
	Policies/Regulations/Constraints	7	"Sweden, Italy and Turkey examples seem diverse enough in terms of these dynamics, so it would be great if this could be leveraged." (Respondent 6)
	Functional requirements	12	"[...] so let's say we are somewhere between the tablet and the computer, with the advantage that the computer can also be used in a more convivial context." (Respondent 3)
	Non-functional requirements/Quality attributes	11	"Then I think it should be easy and kind of self-explanatory, but also really the hard fact, some balance between that. I'm not really sure how to be, but the extension span of our politicians or decision-makers is really narrow." (Respondent 5)

## 4.2 Comparative Analysis of Serious Games

Appendix 1 presents a list of the ten serious games that were identified and analysed in this stage of the research process. Table 2 identifies the number of serious games (out of ten) that exhibit each of the video game structural characteristics proposed by King et al. (2010).

**Table 2: Most common game structural characteristics included in environmental Serious Games**

Feature type	Sub-features	# of analysed serious games including the feature
Social features	Social utility features	0
	Social formation/institutional features	0
	Leader board features	3
	Support network features	6
Manipulation and control features	User input features	0
	Save features	3
	Player management features	7
	Non-controllable features	6
Narrative and identity features	Avatar creation features	0
	Storytelling device features	5
	Theme and genre features	9
Reward and punishment features	General reward-type features	4
	Punishment features	6
	Meta-game reward features	2
	Intermittent reward features	4
	Negative reward features	5
	Near miss features	1
	Event frequency features	9
	Event duration features	7
	Payout interval features	4
Presentation features	Graphics and sound features	6
	Franchise features	1
	Explicit content features	0
	In-game advertising features	0

N=10

The findings revealed that the selected serious games could be classified into three main genres: managerial games, city builders or simulative (urban planning). Indeed, the majority of the games (nine out of ten) adopt a role-playing approach, in which players assume a managerial role and are tasked with improving a specific territory under their control, frequently a city.

Players are usually endowed with resources (Player management features) that can be incremented, managed and spent in order to achieve specific improvements and to accomplish certain goals, always taking into account some constraints (i.e., cost-effectiveness or time limits).

Scripted events (Non-controllable features) are often foreseen as a way of implementing an element of chance in the serious games, requiring for the player to react to unexpected events and challenges and to adjust their strategy accordingly.

Most of the serious games (nine out of ten) are designed to allow for unlimited replayability of the game (Event frequency features) in order to offer to the players the opportunity to experiment different decision paths and therefore evaluate the effectiveness of different strategies.

Often, the selected serious games (seven out of ten) present a modular structure, allowing for brief playing sessions (Event duration features), with the possibility for players to know in advance an estimate of the duration of the single game session.

## **5. Discussion**

To answer the RQ1, it has been noticed that, according to the answers collected for the present research, the perceived drivers (38 quotes) resulted to be more present and relevant compared to the perceived barriers (20). Among the most mentioned advantages, it is possible to highlight the contribution to the improvement of the attitude toward both the learning process and the subject matter, followed by the ability to foster the adoption of positive behaviours. Also, the enhancement of learning and performance are considered to be appealing for the adoption of the PROPEL serious game, as well as the perception of a funnier learning activity. On the other hand, the main concerns regarded mostly the possible sceptical attitude towards a system that includes game elements. Some minor observations implied possible issues in terms of privacy, which is considered a relevant topic in the public administration context. To overcome the scepticism related to the peculiarity of the serious game, some interviewees suggested the use of traditional communication media to introduce the serious game to the final target audience.

Lastly, in reference to RQ2, the conducted interviews highlighted the need for a serious game built on a simulative engine, which the DSS is, so as to be as faithful as possible to the real scenarios implying the implementation of a PED. To achieve the best result from this simulative approach, a modular structure has been suggested, divided into different scenarios, each one representing a specific peculiarity of real PED contexts. Furthermore, given the multi-coloured target, the respondents draw attention to the ease and clarity of use both in terms of mechanics and interface of the serious game. Finally, the most quoted devices to access the PROPEL serious game were tablets or computers. These findings can help us to interpret what resulted from the analysis of the ten case studies. In fact, among the most adopted game features there is "role-playing" (nine out of ten cases) which support the engagement of the target audience, and the unlimited replayability (nine out of ten cases), which can be easily obtained in the simulation thanks to procedural programming based on real data. In this sense, seven out of ten cases allow the management of multiple resources, also expression of real complex systems. Lastly, seven out of ten of the serious games examined foresee a predetermined duration for the game scenario, which is highly compatible with the short amount of time that decision makers usually can devote to these activities.

## **6. Conclusion**

The aim of this research was twofold; on one side it aimed to identify the main drivers and barriers to the adoption of the PROPEL serious game by interviewing a panel of stakeholders in the PED field, and, to inform the serious game design in the field of PEDS, including but limited to the PROPEL one. This has been possible thanks to the information derived from both the stakeholders' interviews and the analysis of ten serious games, similar in their features to the PROPEL one. The interviews conducted showed that the use of a serious game to support the use of a decision system in the PEDs field is expected to improve the engagement and the adoption of positive behaviours as well as the attitude toward the learning process in general. Minor concerns were expressed mostly regarding privacy management. The most important design feature resulted to be the adoption of a simulative engine, able to replicate real dynamics in the serious game context. Lastly, a modular approach to valorise different PEDs contexts resulted to be much appreciated. These findings matched with the most popular features that emerged from the case studies analysis: the inclusion of "role-playing" elements and the division of the whole serious game experience into shorter scenarios would be appreciated by the target

audience. Lastly, the complexity characterising the PEDs sector can be expressed by managing multiple resources through a simulation engine, the latter also allowing procedural generation of scenarios that could be played multiple times.

In general, these results confirm the general appreciation of serious games as support to the decision-making process, also in regard to PEDs implementation. These insights are the first step of the design process that will guide the creation of the PROPEL serious game. Next steps in this research will imply a first draft of the game design document that will be validated by experts. After this phase a first scenario, to be tested with users, will be prototyped and a testing phase will be conducted. Results will be finally evaluated to verify if the premises discussed in this paper will be confirmed.

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## Appendices

### Appendix 1. List of selected serious games

#	Name
1	Energy Cat
2	Smartainability The Game
3	SimCity BuildIt
4	PowerHouse
5	My Green City
6	Clim' City
7	BLOCK'HOOD
8	Carbon City Zero
9	Anno 2070
10	UrbEN