Smart-BEEjS

Human-Centric Energy Districts: Smart Value Generation by Building Efficiency and Energy Justice for Sustainable Living

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Executive Summary

Policymakers wishing to develop Positive Energy Districts (PEDs) need to be mindful on how these may affect energy poverty. This awareness needs to be present not only after a PED project is developed, but already from the design phase of specific policies.

Towards this end, the present report aims to provide guidance to policymakers on how to design innovative PED policies that address energy poverty. Starting from a simple policy stages framework and two practical examples, we highlight actions at each stage of policy design that policymakers should take to include the needs of citizens, in particular vulnerable citizens, in the design of PED policies.

We propose multiple methodologies that policymakers may embrace towards this end, including adopting a system thinking approach, carrying-out representative interviews to draft policy objectives, creating living labs to co-create solutions with citizens, and using modelling approaches that can give an idea of how policies impact environmental and social conditions in the district.

We finalize by describing interactions between the different stages of policy design, suggesting that the design of policies needs to be a recurring process based on cooperation and comprising multiple discussions with the population. Our aim is that this report can provide initial guidance district-level policymakers looking to implement innovative PED policies that tackle energy poverty, and who are willing to embrace a cooperative, iterative process of policymaking in this domain.

1 Introduction

In this report we will consider the design of policies for Positive Energy Districts (PEDs), paying particular attention to how these policies can be designed to tackle energy poverty. The intended audience of this report are district-level policymakers who wish to adopt PED concepts, mindful of balancing the technical, and environmental objectives of PEDs with its social objectives, namely offering a good quality of life to all citizens.

Energy poverty is a widely adopted term that is used to describe the inability of households to attain appropriate levels of energy consumption conducive to a good quality of life, including being unable to afford or access enough energy for cooking, lighting, heating, and appliance use (Boardman, 2009). The drivers of this particular type of poverty are typically considered to be inefficient appliances or dwelling fabric, high energy costs, and low household incomes (Thomson et al., 2016). A range of contributory factors that affect energy needs have also been considered, such as health problems or disabilities (Snell et al., 2015). As these affect energy use and behaviours, they can be broadly categorized as a behavioural fourth driver of energy poverty (Kearns et al., 2019).

A PED on the other hand is a smart-city concept included in the European Strategic Energy Technology Plan (SET-Plan), with the explicit aim of creating 100 such districts by the year 2050. A PED can be described as a district within a city that generates more energy than it consumes on an annual basis (Hedman et al., 2021). While this definition of a PED is strictly technical and specific to reducing grid-reliance and promoting self-sufficiency, the objectives of a PED are also explicitly social as they are expected to contribute to a good quality of life and ensure the wellbeing of citizens. Specifically, social concerns such as inclusiveness, justice, and the tackling of energy poverty are considered to be fundamental to PED development (Hedman et al., 2021). The evaluation of PED impacts across different dimensions is explicitly considered in Caballero et al. (2021).

A large literature considers policies designed to tackle energy policy, which can be broadly categorised as financial interventions, measures for consumer protection, energy savings and RES interventions, and information provision (Kyprianou et al., 2019). However, the role of PEDs has only been explicitly considered in Marggraf et al. (2021). As PED principles will likely be a cornerstone of the energy transition, it is important that policymakers consider how to design policies that can support the development of PEDs, and how they might tackle energy poverty.

There is a thorough literature on policy design, some of which we will detail in this report. For this reason, our contribution will not be to propose a new framework, but rather offer propositions on what actions policymakers can take at each of the stages of policy design to formulate innovative PED policies that address energy poverty.

In particular, the report is structured as follows. In chapter 2 we will provide a brief overview of the **policy stages framework**, the main theoretical framework we will adopt to discuss the design of PED policies. After synthesising the framework and providing practical examples, we propose 3 main macro-stages for policy design that emerge from the discussion, which we adopt during the remainder of the document. These are:

1. Project preparation, definition of the status quo, and policy objectives.
2. Data collection and policy assessment.
3. Modelling and policy selection.

In chapters 3 to 5 we will explore each of these macro-stages for the specific case of energy poverty and PEDs. In each case, we will detail what actions need to be taken to design effective policies and suggest ways that policymakers may implement them. Then in chapter 6 we will conclude the report.

2 Literature on policy-design frameworks

The policy-stage framework and practical applications:

Many policy-design frameworks exist in the literature that offer a rich conceptualization of the policy process and go beyond the "textbook" approach to policy design as discussed by Jordan & Adelle (2012). However, many of these frameworks often do not conclude in a series of concise, practical advice for policymakers and practitioners, which causes policy theory and practice to be somewhat disconnected (Cairney, 2021). As our aim in this report is to offer practical guidance to policymakers on how they might design innovative policies that tackle energy poverty through PEDs, we will adopt a simple policy-design model and describe a few practical applications of it. In particular, we will consider the Policy Stages Framework.

This framework encompasses different types of policy models. The conceptualization we will consider in this report is that of Hoefer (2021). In particular, he describes a 5-stage model to the policy process: agenda setting, policy formulation, policy selection, policy implementation and program evaluation. In this report we will particularly consider the first three stages as we believe these encompass the process of policy-design most accurately.

The questions that need to be answered in each of these stages are:

- Agenda setting: what issue should the policy-maker work on?
- Policy formulation: what possible policies (solutions to the chosen issue) can be developed?
- Policy selection: How can the policymaker choose a policy and with what criteria?

The policy stage framework has many benefits, the key one for our purposes being that it is simple and focuses on the practical aspects of policy design. As Hoefer describes it "It is mainly a description of what happens, rather than an explanation" (p. 1). The focus on describing the policy process also provides policy-makers as well as researchers with a generalisable model to draft policy action (Smith & Larimer, 2018).

However, as many critics point out, the framework also has the notable short-coming of being based on the assumption of rational policy-making (Hoefer, 2021), particularly at the stage of agenda-setting. Namely, under this type of framework there is the assumption that all interest groups have been considered in drafting the agenda. However, when considering an issue such as the energy transition, which is expected to have a disproportionate impact on the most vulnerable and politically under-represented, this may not always be the case. For example, neo-pluralist scholars argue that businesses have a privileged position when setting the agenda for environmental policy, and that citizen concerns take a secondary place (Judge, 1979). To accommodate for this, when we adopt this model in our discussion, we will explicitly consider the actions that policymakers should take to collect and include the needs of citizens, in particular vulnerable citizens, in the design of policies.

We now discuss two practical guidelines that, although not explicitly adopting this model, reflect the same stage-by-stage approach to policy-design, adding detail on the actions that need to be taken at each stage.

The Economic Research Centre (ERC)[1] offers a comprehensive public policy design methodology which they apply in their consulting work. The process includes five stages: the preliminary and planning stage, situation analysis, data collection, policy design and involving interest groups in the policy design process. Key importance is placed in their framework on identifying interest groups and involving them from the outset of policy formulation. Methodologies such as semi-structured interviews and focus groups are to be used to collect data on the preferences, opinions, and positions of interest groups, towards the issues of the policy to be designed. Furthermore, interest groups are to be consulted again during the final policy design stage, where they play a key role in helping formulate the current situation and future desired outcomes of the policy.

Figure 1: ERC stages of policy design

[1] Economic Research Centre. (2007). Public Policy Design: Shared Vision To Reality. Retrieved June 9, 2022, from https://www.erc.lt/userfiles/about-public-policy-design-methodology.pdf

This policy design stage proposes policy modelling as a core methodology, based on the concept of systemic change (Wolfram & Frantzeskaki, 2016). This involves modelling the current and desired situations in as much detail as possible, using both inputs from qualitative and quantitative methods. Under this framework, policy is considered to follow naturally, filling the gap between current and future scenarios. Specifically, the task of policy design at this stage becomes an exercise of forming policy objectives based on the surveyed information and policy goals and identifying what actions should be adopted to reach those objectives, given the present situation. Once more, the present and future situations that are the basis for the modelling must be informed by the interaction with interest groups.

Other examples, such as that adopted by the World Bank in their Global Roadmap of Action Towards Sustainable Mobility Report (GRA)[2], take a more high-level approach, drafting action plans based on how a particular policy measures rank in terms of score when compared to others. The report proposes first scoring potential policy measures based on impact against multiple policy objectives, and then contextualizing via country-relevance scores. This highlights another important aspect of policy design: having reliable, context-specific insights on how policies are expected to perform. In our view the GRA example specifically considers the third stage of the Policy Stages Framework, policy selection. However, they further acknowledge the importance of public consultation and engagement with the public. In a similar vein to the ERC example, the role of these public consultations is to "understand the needs of affected communities, and to reduce any adverse impacts" (pg. 38). They also propose involving the public at the initial outset of the policy project and setting up a plan for continuous consultation during implementation.

It is clear from the two examples highlighted here that involvement of the public is a key requirement for the development of inclusive, effective policies. This is of course particularly important for policies that are expected to have an impact on the most vulnerable, such as the energy poor. Reaching and including this demographic is difficult, but an essential step of policy design.

Proposed stages:

Informed by the policy-stage framework and practical examples where it is applied, we identify three macro-stages (which we will refer to simply as stages for the reminder of the report) for policy design: **(1) project preparation, definition of the status quo and policy objectives, (2) data collection and policy assessment, and (3) modelling and policy selection**. These correspond roughly to the stages of agenda-setting, policy formulation, and policy selection. We choose to adopt these titles because, as the practical examples highlight, it is important when offering guidance to policymakers to be specific on what actions should be taken. Hence, we specify at each stage the key actions that need to be undertaken.

The bounds of these stages are also not intended to be narrowly defined, and indeed we will later discuss how the stages also feed into one another, leading to an iterative policy design process. The objective of this categorisation is only to provide a logical structure to the actions that policymakers should aim to take when designing policies in the domain of energy poverty and PEDs.

[2] Sustainable Mobility For All. (2019). Global Roadmap of Action Towards Sustainable Mobility. Retrieved June 9, 2022, from https://thedocs.worldbank.org/en/doc/350451571411004650-0090022019/original/GlobalRoadmapofActionTowardSustainableMobility.pdf

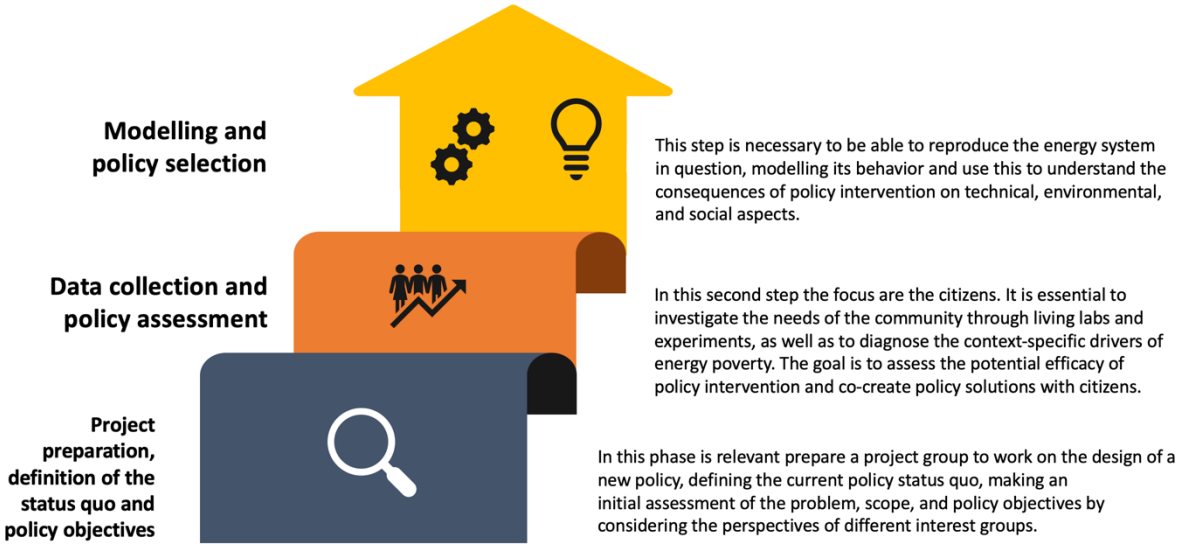

Figure 2: Macro-stages of policy design to address energy poverty through PEDs

The first stage includes all preparatory steps that must be taken, including the creation of a working group, the identification of key interest groups (with particular attention to marginalized groups), and the collection of all relevant documentation. Other important steps are the definition of the policy status quo, the formalization of the specific problem that needs to be tackled, and an initial drafting of objectives. It is important that already at this stage the opinions of key interest groups are considered, including citizens.

The second stage includes all steps that should be taken to assess the feasibility of policy measures and collect relevant data on what aspects are important to consider. Policy makers should at this stage also carefully diagnose the drivers of the problem that they want to address (in our case, energy poverty). Co-creating potential policy solutions will be key during this stage, and a particular emphasis should be placed on the role of living labs.

Finally, the last stage includes all modelling steps that should be taken to link the current situation to the desired future scenario. This modelling can take various forms, but it's important that it is informed by the previous stages and that the interests of citizens and vulnerable groups be considered. In this report we will specifically consider energy modelling techniques (simulation and optimisation models) and how measures of energy poverty and geographical features may be included in these models.

In the next three sections we will consider each of our proposed stages of policy-design, detailing the actions that should be taken during each step for the specific case of policies tackling energy poverty through PEDs. Our ambition is not to define an exhaustive list of actions that should be taken during each stage, but rather provide general guidance on factors that may often be ignored.

3 Project preparation, definition of the status quo and policy objectives

During this preparatory stage, policymakers wishing to design innovative PED policies that address energy poverty should consider the following sets of actions:

- Identify the problem and scope of policy action, organise a project team, identify and involve interest groups.
- Assess the current policy status quo at different levels.
- Define preliminary policy objectives and evaluation metrics.

The initial preparatory steps to the development of a PED policy are likely to be similar across numerous policy domains. As highlighted by the ERC report, it is important that initially local authorities organise themselves around a specific problem or policy area that they wish to tackle. At this stage basic questions should be answered such as: what level of policy can we act on (e.g.: European Commission, National Government, or local authority)? Are we interested in creating a completely new policy, or rather fixing problems in existing policy (or somewhere between the two extremes)? And, crucially, what are the interest groups that may be affected by a policy area we are trying to act in?

It is crucial that the definition of the interest groups occurs very early in the process, and before the formal definition of policy objectives. As detailed in Caballero et al. (2021), for the case of energy poverty and PEDs, key interest groups who need to be involved are: municipal authorities (or regional and national if relevant), citizen population (citizens living in the district), vulnerable citizens (the energy poor, other marginalized groups), energy utilities, industry and businesses. While not essential, it is highly recommended that also academic bodies be brought into the policy design process from an early stage.

Numerous methodologies can be employed to involve interest groups. These include primarily qualitative methods such as semi-structured interviews, focus groups or workshops. It is important that purposive sampling methods (Campbell et al., 2020) are applied at this stage. This means that for each identified group, a representative group of people be interviewed, ideally leaders of their respective groups. Furthermore, it is crucial that policymakers engage in a real dialogue with interest groups, specifically citizens, and avoid relying solely on modalities of public engagement that avoid collective expressions of concerns – such as quantitative surveys. The work by Yoo et al. (2020) provides guidance on how to break these so-called “silos of representation”. The authors encourage policy makers to try and understand citizens’ concerns on a deep level, and repeatedly at different stages (as proposed by both the ERC and GRA methodologies). They also propose taking innovative community engagement techniques, such as consultancy on the street or events other than traditional meetings. These methodologies should also be replicated in the context of a living lab during the following stage when assessing potential policy actions. At this stage the main goal of engagement is to define the problem and the scope of potential solutions.

We also note the difficulty in engaging with certain interest groups, particularly at a preliminary stage. Citizens, and in particular vulnerable citizens, will be hard to involve. On this regard, what is crucially important is trying to engage with the vulnerable through **trusted intermediaries**. As highlighted in DellaValle & Czako (2022), intermediaries play a key role in connecting different level-actors and empowering energy citizenship across the population, particularly the energy poor. Trusted intermediaries can take many forms, but are often community organizations, charitable organizations,

or trusted energy advisors. The important aspect is that that the intermediary has a strong bond of trust with the interest group we desire to reach (Amann & Sleigh, 2021).

Once these preliminary steps are taken, a diagnostic of the current policy status quo needs to be undertaken. Through documentation, desk research, or interviews with field workers or policy experts, the present policy landscape needs to be assessed. Considering different geopolitical levels and their interaction is crucial to understand what scope of actions policymakers should take. In this regard, the concept of multi-level governance is key. Understanding the different levels of policy intervention and how they interact with one another is necessary to begin to understand what is being done and what still needs to be done, particularly in relation to the energy system (Hofbauer et al., 2022).

For example, concerning energy poverty, the EU has made it a policy priority to tackle energy poverty in its Clean Energy for all Package[3]. EU countries are required to act to tackle energy poverty wherever it is identified, and vulnerable consumers must be protected. Member states are also mandated to assess the number of households in energy poverty and tackle the issue through their energy and climate plans. Therefore, the role of the EU in this regard is mostly that of setting mandates and offering support (through institutions such as the Energy Poverty Advisory Hub, or the Energy Poverty Observatory). The definition of energy poverty and identification of context-appropriate solutions needs to occur at the national and local levels. Local institutions have the important role of improving building stock, promoting innovative and collective use of energy services and raising information, as highlighted by a recent Energy Poverty Advisory Hub (EPAH) report[4] on inspiring local actions to energy poverty.

Once the preliminary steps have been taken and the status quo of policy assessed, policymakers are advised to clearly diagnose the problem they are trying to tackle and the objectives they want to achieve. This involves setting clear problems and objectives, informed by the interaction with different interest groups, as well as the local context. Ultimately, the identification of problems and objectives will partly be an iterative process that will need to be revisited in future stages.

For the case of energy poverty and PEDs, it is crucial when defining objectives for PED implementation that there is acknowledgement on how this might affect energy poverty in the district. Marggraf et al. (2021), identify a few **must-read factors** to be considered in this regard, four of which should specifically be considered at the planning phase of PED policies. In their report they also offer practical advice to policymakers as to how to design PEDs in ways that are conducive to the tackling of energy poverty for each must-read factor. These are:

- Positive Impact Redevelopment vs. Gentrification: revitalising urban areas while avoiding negative impacts of gentrification by adopting a clear regulatory framework that is communicated to the population.
- Fair and inclusive financing for the deep energy renovation of existing districts: the adoption of alternative and inclusive financial models that promote deep energy renovation.
- Encouragement and empowerment of energy communities: adopting energy community concepts in policy design that encourage greater participation of the most vulnerable.

[3] European Commission, Directorate-General for Energy, Clean energy for all Europeans, Publications Office, 2019. Retrieved July 7th from https://data.europa.eu/doi/10.2833/9937

[4] Energy Poverty Advisory Hub (2021). Tackling energy poverty through local actions – Inspiring cases from across Europe. Retrieved July 16th from: https://energy-poverty.ec.europa.eu/system/files/2021-11/EPAH_inspiring%20cases%20from%20across%20Europe_report_0.pdf

- Avoiding, shifting, improving transportation: adopting residential urban concepts that aim to mitigate traffic and promote suitable and accessible transport.

Finally, it is also important at this early stage to set relevant KPIs for the evaluation of a policy. As mentioned before, we will not consider during this report policy evaluation, however it is important at the policy design stage that there are clear indicators on how the success of a particular policy or intervention will be evaluated, and that these indicators be clearly communicated to citizens and wider academic community. These KPIs will also be used during the modelling stage to select policies based on how they are expected to perform across different dimensions. Please refer to Caballero et al. (2021) for a comprehensive list of KPIs that could be used to evaluate the impact of PEDs. In summary, it is important to consider three dimensions distinctly: environmental, economic, and social (including the current energy poverty context).

4 Data collection and policy assessment

Once the preparatory stage has been completed, the problem been identified, and the preliminary policy objectives been outlined, the next stage in our proposed framework involves the collection of relevant data and the assessment of potential policies. The main objective of this stage is to **provide policymakers a robust, evidence-based indication of what factors are important to consider for the development of a particular PED policy and its implications on energy poverty, as well as the potential impact that policymakers expect**. Another objective of this stage is to contextualize potential policies to a specific district, to avoid “off-the-shelf" implementation of measures without understanding why they are or are not effective.

We explore two sets of actions that could be undertaken at this stage to assess the feasibility of PED policies and their impacts on energy poverty:

- Carry-our desk research to **diagnose the drivers of energy poverty** in their specific district context, and **how it intersects with PED policy**.
- Assess the **potential impact of different policies** by **involving interest groups.**

With regards to diagnosing the drivers of energy policy, policymakers should engage in desk research and work with local experts in the field to assess the energy poverty landscape in their district and context-specific drivers. The identification of context-specific drivers will be crucial and will inevitably inform preliminary objectives drafted during the previous stage.

The specific drivers of energy poverty can be many. As highlighted above, the literature tends to focus on energy expenses, household income, inefficient dwellings and behaviours as key drivers. However, as highlighted by the EPAH[5] all six aspects of vulnerability should be considered: access, affordability, flexibility, energy efficiency, needs and practices. This reflects the multidimensional nature of energy poverty. They further explain that not all these factors may be relevant in every context, and the weight assigned to different factors may vary across contexts. Most authors agree that it’s important to look at geography patterns, characteristics of the energy poor population, location, infrastructure, politics and government (Mashhoodi et al., 2019).

[5]Energy Poverty Advisory Hub (2022). Bringing Energy Poverty Research into Local Practice: Exploring Subnational Scale Analyses. Retrieved July 10th from:
https://energy-poverty.ec.europa.eu/system/files/2022-03/EPAH_Bringing%20Energy%20Poverty%20Research%20into%20local%20practice_final.pdf

The natural question then becomes how policymakers can assess and measure the drivers of energy poverty in their specific context. Towards this end, the EPAH provides a number of practical advices for all the challenges that policymakers might face. For example, policymakers will often have a hard time finding specific data on energy poverty at a granular level. For this, the advisory hub suggests repurposing existing data and metrics, such as that collected at advice points, helpdesks, social services, etc. However, it is important that vulnerable groups be explicitly considered, as these groups may often fail to participate in the data collection process (once more, trusted intermediaries will be key in this regard).

With regards to context-specificity, the EPAH suggests that policymakers adopt a comprehensive view of energy poverty, focusing on different indicators that assess a wide array of problems, including building stock and equipment, energy performance and efficiency, socioeconomic characteristics, thermal comfort, and wellbeing, amongst others. From here, expert opinion and interviews with relevant groups can be employed to determine if all these aspects are relevant, or some can avoid be considered. The use of metrics at this stage is crucial. When choosing indicators to assess the current state of energy poverty, it's important that policy makers adopt not only expenditure-based metrics or direct measures based on indoor temperatures, but also consensual-based indicators (based on self-reported experiences, such as indicators collected as part of the EU-SILC).

Once data has been collected on the current situation of energy poverty and other relevant aspects, policy makers should aim to identify a series of feasible potential policy actions. These should be co-created with citizens, and their potential impacts be tested in a controlled environment to get a sense of how they might perform. Here several methodologies could be adopted, such as lab experiments, and living labs.

Laboratory experiments are a type of behavioural experiment not held in the field. They are often framed in abstract terms and have the objective of testing a treatment on a specific population (Chapanis, 1967). They are different from Randomised Controlled Trials (RCTs) which instead are experiments carried out in the field, usually on the target population of a particular policy.

Typically, the gold standard for pilot testing policies is considered to be RCTs (European Commission. Joint Research Centre, 2013).While we concede that they are important tools (and later in the text we suggest integrating them in living labs), we agree with Lunn & Choisdealbha (2018) that it is at least equally, and often more important for the purposes of generalising results, to additionally run laboratory experiments. This is because laboratory experiments can take advantage of tight experimental controls to carefully test the mechanisms which lead a policy to be effective or not effective. In other words, laboratory experiments have high internal validity.

An example of a laboratory experiment in the domain of residential energy use can be found in Caballero & Ploner (2022). Here, the authors test the effectiveness of two distinct types of interventions on energy management behaviours in high- and low-income households, shedding light on the importance of cognitive processes for the design of effective behaviour-change interventions. Their results highlight another important benefit of laboratory experiments: they are well-suited for the study of underlying psychological mechanisms. In this spirit, lab experiments and RCTs should both have a place in the policy design process, ideally in an iterative fashion. For example, several policy measures could first be tested in the lab to give an initial idea of how effective they might be and what cognitive aspects are important to consider. Promising policy measures could then test in an RCT to see if the initial results hold, which might inform further lab experiments.

Differently from lab experiments, **living labs** are grounded in the field. They are defined as open innovation and user centred spaces that foster innovative collaborations between businesses, citizens, government and academia (Bergvall-Kåreborn & Ståhlbröst, 2009). As highlighted in Della Valle et al. (2021), living labs (specifically, urban living labs) can be important policy instruments to foster local sustainable innovation and public support. In their article the authors discuss an urban living lab carried-out in the city of Trento where numerous stakeholders got together for a workshop to discuss and co-design a last mile e-mobility logistic centre.

Living labs can help collect data that informs the current and future desired situations that are necessary for the modelling approach carried-out in the next stage. Living labs in this stage play a similar role to that of interviews, and focus groups in the ERC example highlighted in chapter 2. However, data collection methods employed in the living labs don't necessarily need to be limited to qualitative, quantitative methods of data collection could also be employed within the context of a living lab, such as RCTs or surveys (though one-way dialogues should be avoided). If the policy-relevant population is involved in the living lab, and professional experimentalists involved, RCTs can provide policymakers with reliable data on how you might expect a policy intervention to perform when scaled-up. Furthermore, living labs can help re-define the problem or objectives laid out initially in the first stage. This process of co-creation of policy goals through communication and interaction with different interest groups is a key feature of living labs. Moreover, it is important that policymakers and academics working in the development of the living lab take a multidisciplinary perspective in their implementation, relying on the **systems thinking approach** (Yoo et al., 2020). This avoids narrow interpretations of the results of the living lab and prepares project leaders to coordinate across boundaries of separate academic and administrative traditions and practices (Park & Benson, 2013).

Through discussion with interest groups and the testing of potential policies, living labs can be a very effective tool to co-create policies and get a sense of how they might perform in the field. It is crucial however, to address energy poverty, that urban living labs be designed as **inclusive social spaces**. Policymakers must be mindful of not using the living lab methodology to simply promote "acceptance" of proposed solutions, but that effective collaboration is encouraged.

5 Modelling and policy selection

Once policymakers have identified and assessed the efficacy of policy solutions, the final stage of policy design in our proposed framework culminates in the selection of policies to implement. Here we highlight the usefulness of using modelling approaches, informed by previous evidence on the effectiveness of policy action, as well as the co-creation of present and future desired scenarios through citizen interactions. One of the goals in this stage is to map the expected impact of policies on key indicators, to decide which policies are best suited to reach that desired future scenario. It is crucial to consider not only purely technical aspects, but also environmental, economic, and, crucially, social indicators (such as the prevalence of energy poverty). Some of the actions policymakers should take in this stage involve:

- Leverage data collected in the previous stage to model the current and future desired situation, paying attention to the metrics and objectives defined in the first stage.
- Utilize modelling techniques, informed by previous experimentation, to assess the expected impact of policies on technical, environmental, economic, and social indicators.

In the context of positive energy districts, a key example of what modelling approaches could be taken is the modelling of the energy system. The main aim of such methods is to provide a simplified version of the reality focusing only on the elements that are important for the specific task. Modelling the energy system is a key aspect when it comes to investigating paths towards decarbonisation. Additionally, the relevance of such approaches relies on the fact that using these tools allows for better planning and designing of energy systems for the future, suggesting pathways to reach desired environmental targets.

However, as already mentioned, these tools should also consider economic and social aspects to provide a more realistic overview of the situation under scrutiny. These tools should allow policymakers to investigate the impacts of selected policies on all these dimensions, to understand which of them could be most effective overall, and to avoid unintended social consequences of PED interventions (such as increasing energy poverty for example). There are many approaches that can be used in this sense and all of them come with their advantages and disadvantages. Several studies performed detailed literature reviews on them, including Chang et al. (2021), Horschig & Thrän (2017), Martínez-Gordón et al. (2021) & Prina et al. (2020).

In the context of analysing energy systems, two main modelling approaches are predominant: optimization and simulation. Both the approaches have advantages and disadvantages and may be more relevant depending on the final goal of the analysis. Table 1 presents a comparison of the two modelling approaches considered in this report.

Table 1 Optimization & Simulation modelling approaches. Adapted and inspired from Lund et al. (2017).

	Optimisation Approach	Simulation Approach
Definition & Purpose	The model makes use of a mathematical formulation to find oud the optimal solution of a given problem	The model is mathematical representation of a system to reproduce and understand its behaviour, under given conditions, without looking for an optimal solution
Solving Logic	Decision are made by the optimizer based on built-in rules and problem constraints. Solving logic is usually not intuitive.	Decisions are made by the modeller who set up solving logic depending on the main purpose of the problem. Solving logic is often simpler to understand.
Technical Characteristics	Detailed modelling of the system and all its components. Normally requires long computational time to find the solution	Solving logic may be less detailed than optimisation and simpler. Model are normaly less detailed but can have a higher temporal resolution and lower computational time.
Target Users	Well suited for engineers and technical expert given its high levels of details	Well suited for a collaborative situations with the interactions of politician and citizen as well.

Given the purpose of this report, the simulation approach is particularly well-suited as it allows for the investigation also of non-optimal solutions and the to assess the consequences of specific policy choices. Additionally, the simplification of the system considered facilitates the representation of the social implications of policy measures. Nonetheless, it is important to remember that the two approaches are not independent, but they can well be used in synergy so that users can understand how far non optimal solutions are from the optimal one.

Another important aspect is that these tools can be used as direct consequences of the previous steps presented in the framework. Thus, the results derived from the data collection and assessment should be used to inform these models and allow them to depict those social aspects and implications that are often missing from these instruments. Crucially, these models can be parametrized to assess the impact of policy action on energy poverty in the district-specific context. In this regard, the modelling approach must be informed by the collection of data and metrics diagnosing the current energy poverty situation in the district, which is undertaken during the previous stage.

These tools should then be used in conjunction with a series of KPIs decided prior to the analysis which will help evaluate the potential impacts of the policies in question. Examples of which KPIs can be used for this evaluation can be found in Caballero et al. (2021). We also propose the use of scoring metrics using standardised approaches. Scoring potential policies based on their expected impacts on environmental, social, and economic dimensions can provide a useful **decision-rule** for policymakers to adopt and select effective PED policies based on available information collected during the previous stages. In this way, modelling techniques can be used to inform policy makers of which policies could be best suited to tackle energy poverty and decarbonise their specific districts.

6 Discussion and Conclusions

In the present report we have presented propositions for policymakers to follow when designing inclusive PED policies that address energy poverty. Starting from a simple Policy Stages Framework, we have defined three general stages of policy design that policymakers should go through when designing innovative policies, informed by the existing literature and practical examples. Following these stages policymakers should set policy objectives, formulate, and test the feasibility of potential policy action, and select the best policies for their respective context. For each stage, we have proposed actions that policymakers should take to specifically address energy poverty when developing PEDs, detailing the methodologies they can adopt. At each step we have highlighted the need to interact with multiple interest groups, in particular vulnerable populations who are most at risk of suffering from energy poverty.

While the stages were presented in this report in a sequential order, in practice policy design will be an iterative process. As mentioned above, initial policy objectives drafted in the preparatory stage will more than likely be re-visited once data on the problem is collected and feasible solutions are co-created with citizens. Furthermore, results from the modelling approach can help get a better grasp of the scope of possible solutions and highlight aspects that policy actions could be at risk of neglecting (for example, the degree of energy poverty in a district). This could then motivate another round of engagement with the citizens or other interest groups, aiming to better understand and address the neglected dimension, as well as the collection of new data to improve the model. Evaluation emerging from the modelling approach could also recommend the adoption of different metrics and KPIs.

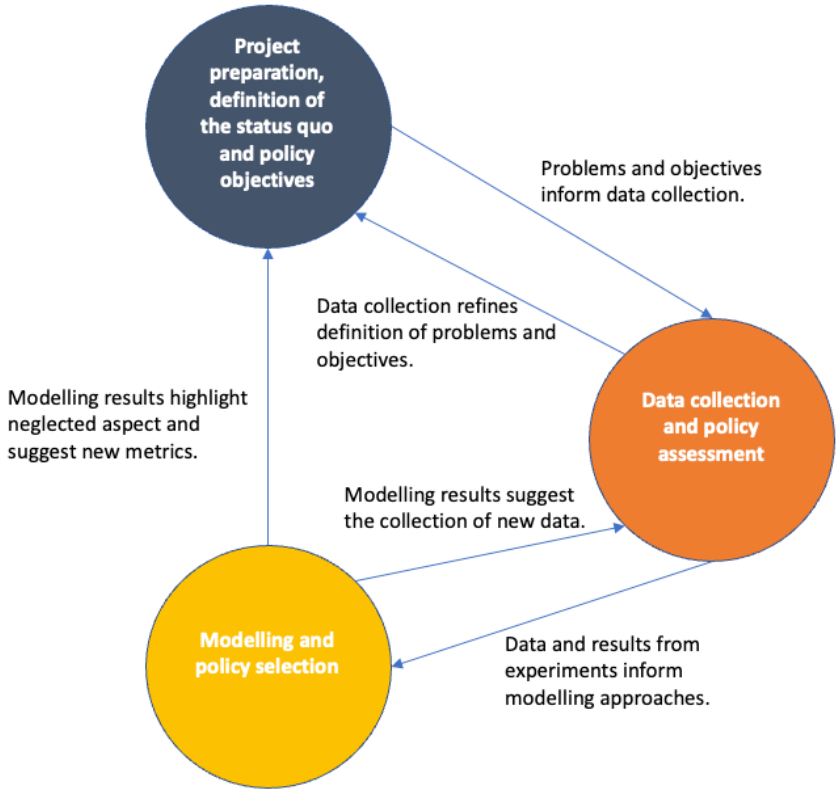

Figure 3: Interaction between different stages of policy design.

Methodologically, the different stages also feed into one another. For example, data collection methods such as interviews and workshops that happen at the outset of the project to define initial objectives, should then be replicated within the living labs. This methodological overlap should not be viewed as a negative by policymakers, as it provides them with the opportunity to refine data collection methods throughout the process, enriching their understanding of how to design inclusive PED policies.

While this report is not intended to be conclusive, and further research should explore more deeply the methodological implementation of the approaches we highlight above, we believe it offers a useful first step for policymakers to start considering more deeply the design process of their energy transition policies. Each stage should be elaborated and contextualized to a specific district, and the actions we highlight here should be included in the final PED policy plan whenever possible. We hope that this report will encourage more policymakers to consider the needs of the energy poor and engage with them at each stage of the policy-design process.

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About the Smart-BEEjS Project

Energy transition is supported in the EU by legislative developments, such as the Strategic Energy Technology Plan that aims to transfer power to consumers by decentralising the energy eco-system at the local district-level. However, this transition occurrs at a time of increasing wealth inequality, energy poverty, and gender difference. Thus, the long-term vision of the Smart-BEEjS project is **to design transformational pathways** that tackle **Energy Poverty and Justice**, providing evidence and using the decentralised nature of **'Positive Energy Districts'** and **'Networks of Districts'** as the central platform of transformation, whilst recognising the economic, social and environmental challenges faced. Tackling the issue of energy injustice and poverty is an essential pillar for contributing to the **decarbonisation of our economies** without leaving large parts of the population behind.

Behind any decision or intervention – whatever the field of expertise, technological, business or policy – are **people**. Therefore, **the overarching training aim of Smart-BEEjS** is to provide, through a multilevel, multidiscipline and interdisciplinary training platform, a programme to produce the technology, policy making or business oriented **transformative and influential champions of tomorrow**; educated in the personal, behavioural and societal concepts needed to deliver the success of any technological proposition or intervention under the human-centric perspective of energy justice.

The Smart-BEEjS project recognises that the new level of decentralisation in the energy system requires the **systemic synergy of different stakeholders**, who are **inseparable** and interrelate continuously to provide feasible and sustainable solutions in the area of **energy generation and energy efficiency**. They balance attention towards technological and policy-oriented drivers from a series of perspectives:

- **Citizens and Society**, as final users and beneficiaries of PEDs;
- **Decision Makers and Policy Frameworks**, in a multilevel governance setting, which need to balance different interests and context-specific facets;
- **Providers of Integrated Technologies, Infrastructure and Processes of Transition**, as innovative technologies and approaches available now or in the near future;
- **Value generation providers and Business Model Innovation (BMI)** for PEDs and networks of districts, namely businesses, institutional and community-initiated schemes that exploit business models (BMs) to provide and extract value from the system.

In order to introduce cooperation and shared thinking, Smart-BEEjS presents a balanced consortium of beneficiaries and partners from different knowledge disciplines and different agents of the energy eco-system, **to train at PhD level** an initial generation of **transformative and influential champions** in policy design, techno-economic planning and Business Model Innovation in the energy sector, **mindful of the individual and social dimensions,** as well as the **nexus of interrelation between stakeholders** in energy generation, technology transition, efficiency and management.

The overarching aim of the project is to boost knowledge sharing across stakeholders, exploiting a human-centric and systemic approach to design Positive Energy Districts (PEDs) for sustainable living for all.

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