Smart-BEEjS

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

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WP5

D5.2 Development of a Standardised Method for Impact Evaluation of Positive Energy Districts

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Executive Summary

This report presents propositions for the elaboration of a standardised method of impact evaluation for Positive Energy Districts (PEDs). Based on previous experiences seeking to capture, through a series of KPIs, the impact of different smart and sustainable city concepts, we propose an indicator-centric approach to evaluate measures against specific PED objectives.

This approach is intended to be used by interested entities (primarily local policy-makers, as well as researchers or practitioners) to evaluate how specific PED experiences perform relative to benchmarks and other experiences, and to identify the most successful set of solutions for the development of a PED. Another aim of this approach is to allow for the assessment of the distribution of PED benefits across environmental, economic and social dimensions. In this way, policymakers can be aware of how their PED responds to different needs, and adapt their policies accordingly.

We start by presenting a number of important KPIs within each dimension, which are important to assess in the context of PED evaluation. We continue by offering a target-based framework to turn unprocessed data on KPIs into qualitative information describing how specific PED developments perform relative to identified targets. We provide standardised bandwidths for the scoring of indicators, and further elaborate the approach by providing weights to aggregate each indicator score within dimensions. We then show how these dimensions can be aggregated to generate overall scores for PEDs or PED interventions.

The complementary Excel-based tool (Standardised method of impact evaluation tool, SMIE tool) can be used by evaluators to assess dimension-level scores and/or overall PED scores following this approach, and get rapid graphical representations of the results in the form of radar graphs. Furthermore, the attached playbook included in Annex II can be used to communicate the approach to different evaluators and interested parties in an engaging manner.

In using this approach, a number of stakeholders must be involved to ensure access to the necessary information, including citizens, vulnerable energy consumers, energy utilities, and municipal authorities. This inclusive approach promotes cooperation between different entities at the evaluative stage of a PED intervention. It is our hope that this standardised method of evaluation can be used by policymakers with the intent of evaluating PEDs and PED interventions not only to assess their local measures, but also communicate with and include different stakeholders at this stage of the energy transition.

1 Introduction

The European Union (EU) has, in recent years, evolved and intensified efforts against climate change, from the first common energy plan, "An Energy policy for Europe, 2007" (European Commission, 2007) to signing and championing the Paris Agreement, to the "European Green Deal" (European Commission 2020). These plans introduce or expand support for processes and legislation that aim to decarbonise the European economy and initiate structures to encourage and coordinate bottom-up and grass roots actions. Under the latter perspective and direction, the EU integrated the concept of Smart Cities into the climate fight, introducing the concept of Positive Energy Districts (PEDs) (JPI Urban Europe, 2020), with an ambition to develop 100 PEDs in the EU by 2025.

1.1 PED framework and characteristics

Following the framework proposed by JPI Urban (JPI Urban Europe, 2020) PEDs are energy-efficient and energy flexible urban areas, or groups of connected buildings, which produce net-zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require the integration of different systems, infrastructure and interaction between buildings, users and regional energy, mobility and Information and Communications Technology (ICT) systems while securing the energy supply and good living conditions for all, in line with social, economic and environmental sustainability.

Hence, the framework provides a flexible approach regarding geographical boundaries of the district, the nature and location of energy production and its relationship with the main grid. This flexibility has led to the following classification of types of PED by the European Energy Research Alliance (EERA) (Wyckmans et al., 2019):

1. **Autonomous PED:** the district is characterised by specific geographical boundaries and is entirely self-sufficient in terms of energy production and consumption. Import of energy is not foreseen but excess energy may be exported. Thus, demand is covered by energy supply located within the boundaries of the district.
2. **Dynamic PED:** The district is characterised by specific geographical boundaries. However, in order to balance energy production and consumption, both import and export of energy are foreseen, and a significant degree of supply resources are located within the boundaries of the district.
3. **Virtual PED:** In this case, even though the geographical boundaries of the district are defined, it is possible to have energy production sites and storage facilities outside the boundaries of the system, exploiting a system of renewable energy and carbon credits. However, the balance should still be positive.

As the process towards the implementation of PEDs is continuously evolving, to open the analysis also to those districts that are working towards energy positiveness "PED-like areas" are included, having the following characteristics:

4. **PED-like:** These are existing districts that are working towards becoming a PED. However, the renewable energy sources available (both on and off site) are not sufficient to cover demand. Thus, the district must import energy from the grid or produce it with non-renewable energy sources.

Within PEDs it is possible to identify six, interdependent, building blocks that contribute to the characterisation of a PED (SET PLAN, 2018).

- ***Renewable Energy Sources:*** a PED is a district that is embedded in an urban and regional energy system that should be driven mainly by renewable energy sources (RES), to be able to achieve both energy positivity and net zero emissions.
- ***Energy Efficiency:*** a high level of energy efficiency is crucial to keeping consumption lower than the energy produced by RES.
- ***Energy Flexibility:*** linking to the aforementioned dimensions, flexibility options are essential to optimise the use of locally produced renewable energy and reduce energy-wastage. This refers to the ability of the system to manage supply and demand, by providing measures such as peak shaving, load shifting, demand responses, sector coupling and a reduction in curtailed energy from RES.
- ***Electric Mobility:*** PEDs should also enable the deployment of mobility solutions which can reduce greenhouse gas emissions such as Electric Vehicles (EVs). Hence, in a PED there should be enough charging stations to allow for the use of EVs. They should use locally-produced electricity as far as possible for these purposes.
- ***ICT Deployment:*** in order to make the most of the above building blocks, the use of an advanced management system based on ICT technologies is essential. Deployment of ICT should also allow for increased interaction and involvement of users and citizens of the district.
- ***Affordability:*** PEDs should have a particular focus on providing these changes in the system that guarantees a fair and just transition, offering affordable living conditions to all the citizens.

1.2 Structure and Aim of the Report

Given the variety of aspects that are involved in PEDs, we identify a standardised method for evaluating their impact. The objective of this report is to provide an evaluation approach that integrates economic, social and environmental dimensions in an attempt to improve the understanding of the impact of PEDs in these three dimensions, in light of the wider scope of climate actions.

Aiming at this, the structure of this report is as follows:

In Chapter 2 a framework for evaluation is presented. For each dimension – social, economical and environmental – key aspects and indicators are presented. Here we propose a points-based evaluation framework based on these aspects and indicators. The equations for calculating any quantitative indicators can be found in Annex I.

Chapter 3 introduces the application of the framework by presenting the Playbook on the Standardised Method of Impact Evaluation, which is then included in its entirety in Annex II.

Finally, in Chapter 4 we conclude by providing recommendation and by suggesting possible adaptations.

2 Dimensions of PED Evaluation

Climate change mitigation actions are often evaluated based on three dimensions of impact: environmental, economic and social (Akella et al., 2009). Based on previous studies and cases, this report identifies existing indicators relevant to these dimensions of impact evaluation. The following subsections offer methodological insight related to the tasks of:

- Selecting relevant indicators[1] and a scoring system for each one: For each indicator, relevant quantitative data are collected. Based on published targets from the EU or other international organisations, we provide targets (or target range) in relation to either the indicator with a horizon of 2030 and 2050, or the relative position from the initial baseline. Using these recognised targets, the quantitative data are converted into a scoring scale from 1-5. This scale describes **progress of a certain indicator in relation to the specific target of achievement**: significantly underperforming (score of 1), lagging target (score of 2), target achieved (score of 3), target surpassed (score of 4) and significantly over-performing (score of 5). When possible (i.e. when a 2030 and 2050 target set by EU is available) the score of 3 refers to the achievement of that 2030 target, while the score of 5 refers to the achievement of the 2050 target. Thus, the score of 3 represents the achievement of the pre-defined target and already indicates excellent performance. However, these targets and the respective bandwidths must also be realigned over time, to be able to use this evaluation methodology as policy targets change.
- Identifying the type of data and mode of collection, to develop a complete set of evaluation indicators across the three dimensions.
- Synthesising the indicators for measuring each impact dimension under the PED concept. The indicators of each dimension will be aggregated in order to provide an overall score for that dimension. Each indicator will be given a specific weight. Following the experience of ESG scores (e.g. MSCI, 2018), the aggregation will be performed on the basis of the weighted impact of each indicator (Equation 1).

$$Dimension\ Score = \frac{\sum_i (KPI_i \cdot weigth_i)}{\sum_i weight_i} \qquad \text{Equation 1}$$

[1] Indicators are chosen based on the following criteria:

- The indicator must be explicitly related to **one or more of the PED building blocks** as outlined by the SET Plan. There must be literature and/or expert opinion directly linking the indicator to the development of one of the PED building blocks.
- The indicators must be standardised and, as far as possible, be useful for comparison across districts.
- There must be literature and/or expert opinion on the indicator which allows a **target or a target range** to be identified. A target range may be set by users if the indicator is crucial enough to PED concept that it merits specific consideration.
- The targets chosen as indicators must be either (i) equal or related to EU targets, (ii) based on past project experience, or (iii) based on existing research. Indicators may be defined by users if they are considered crucial enough to the PED concept to merit specific consideration.
- The data necessary to compute the indicator must be **easily available**. The data could be generated from project documentation or interviews with project leaders. In some cases, it may come from surveys or published reports.

2.1 Environmental Dimension

Environmental impact indicators are vital for any infrastructure related project (e.g. Angelakoglou et al. 2019, Angelakoglou et al. 2020, SwissEnergy 2019, STARDUST 2018) and relate to the UN Sustainable Development Goals (SDGs, United Nations 2021). For the purpose of this work, we consider the following indicators: Greenhouse Gas Emissions Reduction, Share of Local Renewable Energy Generation, Energy Savings in Final Energy Consumption, Waste Recycling Rate. These indicators have an equal weighting in the aggregate formula (each gets a 0.25 weight in Equation 1).

GHG Emissions Reduction – (EN-1)

Measuring the reduction of greenhouse gas (GHG) emissions enables the contribution of a PED project to be assessed in terms of fighting climate change and achieving environmental sustainability goals.

Typically, there are two ways of presenting this indicator: in absolute values [*tonnes/year*], or as a percentage reduction [%]. In both cases two values are needed, the starting value of emissions per year in *tonnes/year* and the final or expected value of emissions once the project is fully deployed. All values will be converted into CO_2 Equivalent using the corresponding Global Warming Potential (GWP), as proposed by IPCC (IPCC, 2014).

The EU is aiming at emissions neutrality by 2050. This will require an 80-100% reduction of GHG emissions. Thus, the EU has set as a 2030 target a reduction of 55% relative to the base year of 1990 (European Commission, 2020b). Converting these measurements to the qualitative evaluation system we propose a series of target ranges.

Table 1. GHG Emission Reduction Scale

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-30%	30-50%	50-60%	60-80%	80-100%

Share of Local Renewable Energy Generation – (EN-2)

PED projects contribute tofighting climate with local actions. It is therefore important to evaluate how the project contributes to increasing the share of local renewable energy production. This indicator shows the locally produced energy that is consumed locally, which helps in understanding the flexibility potential of the energy system under consideration (Angelakoglou et al., 2019).

To calculate this indicator, values of local energy generation by source, before and after project implementation, are needed. In this way it is possible to evaluate the share of renewable energy in total generation. For this KPI, the EU 2030 target is 32% (for total energy) or 65% (for electricity; European Commission, 2020b).

Table 2 Share of Renewable Energy in Total Energy Generation.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-15%	15-30%	30-35%	35-65%	65-100%

Energy Savings in Final Energy Consumption – (EN-3)

Energy consumption includes all forms of energy (electricity, heat/cooling, fuels) for all uses (transport, industry, buildings, etc.) and represents the actual consumption of end-users.

Its reduction represents the energy savings of a system. This indicator is measured as percentage, derived from the energy consumed before and after project implementation. The EU 2030 target for this specific indicator is of a 32.5% reduction (European Commission, 2020b).

Table 3 Energy Savings in Energy Consumption

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-15%	15-30%	30-35%	35-65%	65-100%

Average Waste Recycling Rate – (EN-4)

This indicator provides information on how the district behaves in terms of waste recycling. By providing information on the recycling rate see how close the project comes to being a local circular economy. Even though there are indicators that could be more significant (e.g. material productivity [€/tonne]), these would have data requirements which are currently unavailable at the district level. We thus choose the Average Waste Recyling Rate, calculated as the share of total municipal solid waste generated that is recycled, on average, in the district. The choice of considering the district average is to balance different behaviours within the district.

The European Commission in 2018 set new ambitious targets, of 55% by weight by 2025, 60% by 2030, and 65% by 2035 (European Commission, 2018).

Table 4 Average Solid Waste Recycling Rate

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-30%	30-55%	55-65%	65-80%	>80%

However, it is also important to emphasize another aspect related to the concept of circularity. In fact, even though recycling has a lot of impacts both on the environmental and social aspects, these should also be coupled with a reduction on use of materials.

Weighing of environmental indicators:

The final step is to assign weights to each indicator. Given the complementarity of the chosen indicators, an equal weight is assigned to each.

Table 5 Weight of the different indicators of the environmental dimension.

GHG Emission Reduction	Share of local renewable energy generation	Energy Savings in Final Energy Consumption	Average Waste Recycling Rate
0.25	0.25	0.25	0.25

2.2 Economic Dimension

Existing economic evaluations of climate-change mitigation strategies are diverse and consider a range of economic aspects. They can be techno-economic and focused towards assessing the cost effectiveness of pro-environmental measures (Chapman et al., 2018); they can be more focused on socio-economic impacts such as employment generation from renewable energy sources (Karytsas et al., 2020); or, if the intervention is of a large enough scale, they can assess the macroeconomic impacts of environmental policies (Ierland, 1993). The scale and focus of these evaluative dimensions need to be adapted to the specifics of a PED concept, with its particular building blocks and small-scale implementation.

In evaluating the economic impacts of PED actions at district-level, we avoid considering macroeconomic indicators. Most of the literature on regional-level economic impacts of environmental measures takes this approach (such as regional-level evaluations of RES; Jenniches, 2018). We believe that taking a micro-level view for evaluation is more useful for policymakers interested in district-level impacts, as it accounts explicitly for the nature of different economic effects. For example, if we are interested in understanding the economic impact of RES investments, we look at employment opportunities generated, returns for community investments, and financial benefits for end-users. Moreover, we focus selection on **those indicators that will be important at the local level**.

A reminder is in order at this stage: PED implementation may take different economic routes and utilise different business models. For example, energy production will fall on a spectrum of (de)centralisation. Accordingly, different business models will have different outcomes on how the costs and benefits of RES projects will be distributed and the mechanisms for distributional concerns. Therefore, the targets we specify in this section, while informed by previous research and smart city solutions, should be considered in specific cases where PED developments fit past experiences, or when the solutions adopted do not fit pre-specified categories. Ultimately, the decision about adopting or adapting the provided thresholds for economic evaluation will fall on local process leaders.

Use of Local Workforce – (E-1)

PEDs encourage local, decentralised energy production systems that can offer financial benefits to the community, not only in terms of energy savings, but as a direct result of local investments in human and physical capital. In the case of RES, regional-level studies frequently consider **employment impacts** of local investments in renewables (Jenniches, 2018).

A relevant, comparable indicator across districts which can be used as a proxy for the **use of local workforce**[2] **is the share in total project cost that has been spent on local suppliers, contractors, and service providers (% share of euros)**. Based on past project experiences, the CITYKeys (CITYKeys, 2017)

[2] Locality is loosely defined as “from the city or region”, as deemed appropriate for the situation.

project **identified 40-60% as a target**. This indicator is to be assessed at the end of the project's implementation, counting all core investments. One of the strengths of this indicator is that it enables comparisons across different types of districts and projects. One weakness is that it does not measure job creation itself, but instead uses budget share spent on local suppliers as a proxy.

Table 6 Share of total project cost that has been spent on local suppliers, contractors, and service providers.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-20%	20-40%	40-60%	60-80%	80-100%

Public authority support – (E-2, E-3)

Involvement by municipal bodies and other public authorities is to be expected in new PED developments. Support can be financial, often taking the form of subsidies, grants or loans, or it can be more involved, such as in the case of technical assistance or regulatory oversight. While financial support from the municipality or district authority will facilitate PED developments by covering upfront costs, a strong reliance on public financial support alone is not necessarily desirable, as it might increase the perception of risk for private investors, create uncertainty in project developments, or create a culture of reliance on the public sector. Because the support granted by public authorities can be so diverse, recognising the appropriate level of support must be contextualised.

We define here two indicators that can capture the extent of public authority support in PED developments, one more qualitative, capturing perceptions of local authority involvement in general, and one more quantitative, based on effective financial support.

Adapting a previous KPI by CITYKeys (CITYKeys, 2017), we identify an indicator for the perception of the **'quality' of the municipal involvement (E-2)** based on a 5-point Likert scale. This should be completed by the project evaluator based on project documentation and **interviews with project leaders.** It is important to note that a score of 5 will be awarded based on what is identified as an **instrumental** level of involvement from public authorities. This may not always reflect the maximum level of feasible involvement, but rather recognise that **the right extent and type of support is being provided**. This indicator is of course subject to a degree of subjectivity when interpreting appropriateness of involvement, and hence while it can be a very valuable qualitative indication of the public role in PED developments, it may be less suited to comparability across districts.

Table 7 Quality of municipal Involvement (to be assessed by evaluators).

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
1	2	3	4	5

Note: 1: the local authority is not involved in the development of the project, 2: the local authority is insufficiently involved in the development of the project, at maximum one department is involved, 3: the local authority is somewhat involved in the development of the project, with more than one department contributing constructively, 4: the local authority is clearly and constructively involved in the development of the project, more than two departments are involved. 5: The local authority is instrumental in the development of the project. It is a policy priority, and the integrative character of smart city projects is reflected in the large number of departments involved (e.g. through an interdepartmental steering committee).

Another indicator that can be used to evaluate public authority involvement in a PED project is **share of subsidies in total costs (E-3)**. The indicator is defined as **the percentage of subsidies as a share of total investment of the project**. The logic behind the scoring of this indicator is that heavy reliance on external funding is undesirable, as it may create uncertainty in project development. Implemented solutions are expected, as much as possible, to rely on a 'sound business model', independent of subsidies. Therefore, CITYkeys (CITYKeys, 2017) assigned this indicator higher scores to smaller shares of subsidies. We adapt their scoring into our framework as follows:

Table 8 Share of subsidies in total project costs.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
100-80%	80-60%	60-40%	40-20%	20-0%

This quantitative indicator has the advantage of being more easily comparable across districts than the previous qualitative evaluation, as it is an objective measure of the proportion of public investment relative to overall investment. Its disadvantage however is that choosing an appropriate target will be less straightforward, as different innovations at various levels of maturity will require different levels of funding. It also cannot capture the full range of potential forms of public support, which may not be financial. In contrast, the indicator for quality of municipal involvement can assess whether an appropriate level of support is given by local authorities in that specific context, but is open to some subjectivity when evaluating.

To balance out the shortcomings and strengths of both indicators, we propose weighing the two indicators together, as can be seen in Table 12.

Returns and Distribution of Revenues – (E-4, E-5)

There are multiple different pathways to the development of PEDs, balanced between more centralised or decentralised energy systems. While the PED definition is not restrictive in relation to what business model needs to be adopted to consider a district positive, its aims of providing a high quality of life for citizens, including increasing social cohesion and generating social capital (Hedman et al., 2021), suggests decentralised energy systems have a clear advantage when evaluating applied solutions in relation to PED objectives. Furthermore, decentralised, community-owned energy systems favour local generation (Walker, 2008), an important cornerstone of PED implementation.

In light of this, when considering the financial returns of a project, it will also be important to assess what proportion of generated revenues are distributed within the community. Key indicators are therefore **annual returns on investment (ROI) (E-4)** (this indicator is intended to assess the overall financial performance of the project) and the **share of generated revenues in the local community (E-5)** (this indicator is intended to assess the distribution of returns that are generated by members of the local community)[3].

ROI is defined as the ratio between the total incomes/net profit and total investment of a PED project. This indicator is used extensively in evaluations of smart city solutions, PEDs, and other aspects related to the urban energy transition. Target ROIs will depend on the nature of the adopted solution, assets considered, and relevant timeframe. For PV for example, we consider annual ROIs of >20%. In large-scale projects with multiple interventions, this may be a wide range such as in the case of STARDUST (9-40% depending on solutions). We consider research expert opinion[4] which **identifies ideal annual**

[3] Once more, we define locality quite generally as "from the city or region", as seen fitting with the situation.
[4] https://onlinebusiness.northeastern.edu/blog/does-investing-in-green-energy-produce-great-returns/. Accessed: 12/07/2021

ROI from RES projects with current technology to be between 20-25%. This range of annual returns is also identified in a recent IEA report (IEA, 2021).

Table 9 Annual Returns on Investment.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-10% / < 0%	10-20%	20-25%	25-35%	>35%

We can define the **share of generated revenues in local community** as the proportion of revenues, out of total project revenues, which are distributed between local community actors. The indicator does not discriminate in relation to the specific nature of the revenues (dividends from a share in community-owned energy assets, landowner benefits from the lease of land for the project, etc.) but rather groups all revenues from project activities that are generated and distributed within the local community. It then computes the proportion of these revenues in relation to total project revenues. To avoid issues of double-counting, we ignore revenues relating to the use of the local workforce (including local contractors, and other service providers) as these will be counted in the above mentioned indicator.

To our knowledge, this indicator has not been defined before and there is therefore no related literature to set a target. However, we believe it is crucial enough to the PED objectives of locality that it merits evaluating in the context of a standardised framework. Owing to the lack of existing targets, we normalise scoring of this indicator. Each band, from 1 to 5 will capture an incremental range of 20% increases in the share of generated revenues in local community. With this normalisation, we are assuming that a larger share of locally distributed revenues is always beneficial in relation to PED objectives, which we consider a valid assumption considering the above discussion on PEDs and decentralised energy systems.

Table 10 Share of generated revenues in local community.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0-20%	20-40%	40-60%	60-80%	80-100%

As previously, these two indicators are assessed together in our framework, as they each display marginally different aspects of financial returns of a PED project which are equally important to evaluate: overall returns, and distribution of revenues. This weighing can be seen in Table 12.

Change in the Share of Housing Costs Relative to Income – (E-6)

The development of PED building blocks is also expected to impact the **average cost of housing** in the district. A large literature exists documenting the capitalisation of energy efficiency in house renting prices (e.g. Kholodilin et al., 2017). Furthermore, issues of gentrification that could occur from inadequate PED implementation (Hedman et al., 2021), or sudden increases in prices resulting from new, energy efficient housing, risk leaving low-income or marginalised groups unable to secure affordable housing. **Affordability of housing is a key objective of PED developments**, as highlighted by the building blocks in the SET plan, and the provision of affordable housing for marginalised groups is thus a key objective in PED implementation. Deliverable 5.3 provides further information on must-read factors to achieve affordable housing in PEDs.

We identify an indicator of affordable housing conditions as the **change in the share of housing costs compared to income**. This is defined in **percentage point deviations**. This is calculated using the equation in Annex I.

We note here that cost of housing may differ between owner-occupiers (lower) and tenants (higher). This indicator is concerned with assessing average housing costs within a district, without discriminating between different types of ownership/renting structures. While this makes the indicator easy to calculate and comparable across different regional and national contexts, it will also necessarily be impacted by housing situations in the district, i.e.: if occupants are primarily renters or owners. As this is unlikely to change within a district during the lifecycle of a project, the indicator will still be a valid measure of changes within the district. However, when evaluating different districts, evaluators must be aware of how the indicator is affected by different housing contexts.

Based on previous project experience emerging from CITYkeys (CITYKeys, 2017), we consider a **percentage point reduction from baseline share of housing costs in income of about 5% to be an ambitious target for housing affordability** following the implementation of PED solutions.

Table 11 Percentage point reduction of share of housing costs in income relative to baseline.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
≤ 0 pp	0 – 3 pp	3 – 5 pp	5 – 8 pp	> 8 pp

Note: This is percentage point reduction from a baseline pre-project condition. Increases in average housing costs in income (percentage point increase) will also be awarded a 1 in this framework.

Note that the costs of housing considered here does not account for energy bills, which will be considered in the following indicators.

Financial Benefit for End-Users – (E-7)

Reduced reliance on the grid, whether from higher levels of self-consumption and self-sufficiency (Hedman et al., 2021) or changes in energy demand, will generate significant energy savings. These generated savings, in terms of kWh, will be considered in our framework in the environmental dimension. Maximising this indicator will have several benefits beyond the financial, such as increasing flexibility and reliance of the grid. However, in the context of an economic evaluation of PED measures, it is also important to consider how the generated energy savings will translate into **financial benefits for end-users**, as this will likely be an important political motivator for the development of a PED and will moderate how likely the applied solutions are to gain community acceptance.

This indicator is calculated in terms of **total cost savings in euros for end-users per household per year**. We note that this indicator will be important to measure specifically for households affected by PED solutions (retrofitting, RES, etc.) however, given the small scale of the PED concept, we assume this indicator can be approximated considering all households in the district.

We define a target for financial benefit to end-users by **considering energy savings according to our environmental targets for energy savings in final energy consumption.** Considering a target range of

30-35% savings in final energy consumption, a median cost per unit of energy of 0.24 €/kWh (Artola et al., 2016) and an annual energy consumption for all end-uses of 14,318 kWh per active dwelling[5] , we consider €1050-1200/household/year to be an ambitious target for financial benefit to end-users.

Table 12 Total cost savings in euros for end-users per household per year.

1 – Significantly underperforming	2 – Lagging target	3 – Target achieved	4 – Target surpassed	5 – Significantly overperforming
0 -500	500 - 1050	1050 - 1200	1200 - 2200	> 2200

Weighing of Economic Indicators:

The final step, following our established methodology, is to provide the framework to aggregate the results together, to obtain the overall score of the economic dimension.

We consider all aspects relevant in the evaluation so apply equal weighing to aspects. When an aspect is evaluated using two indicators (as is the case for returns and distribution of revenues, and public authority support), each indicator is given half the weight, to highlight the fact that they are representing different facets of the same underlying aspect:

Table 13 Weight of the different indicators of the economic dimension.

Use of Local Workforce	Annual ROI	Share of returns in the community	Municipality Involvement	Share of subsidies in total costs	Change in share of housing costs in income	Financial Benefit for End-users
0.20	0.10	0.10	0.10	0.10	0.20	0.20

2.3 Social Dimension

A PED must also be evaluated in relation to the standard of living it offers citizens. As illustrated by the PED guiding principles detailed in the White Paper(JPI Urban Europe, 2020), PED development must always be carried-out with the social dimension in mind, including quality of life, inclusiveness, justice and the prevention of energy poverty. It is key that planners include the social dimension also in evaluating the impacts of measures to develop PED building blocks, and that the optimal measures are identified which not only constitute a positive environmental and economic impact, but also a positive social impact. With most PED developments being in the early planning stages, there is a perfect opportunity to plan districts from the start with these guiding principles in mind.

Methods to evaluate social impact can be divided broadly into reliance on official data (eg census, income) or using social survey methods to collect data directly from residents. Both of these approaches have benefits and shortcomings. Reliance on official data may well obscure important information which may simply not be gathered using current means. Likewise, surveys may attempt to capture data, but may not be filled out by all residents or may be filled out incorrectly/misinterpreted. For these reasons we suggest a combination of official data with social

[5] https://ec.europa.eu/energy/eu-buildings-database_en?redir=1 Accessed 12/07/2021.

surveys, supplemented by interviews with residents and NGOs to obtain more in-depth and insightful data on how the different aspects of PEDs are being implemented and experienced, especially given that PEDs are at an early stage of development. It is therefore important to first collect relevant qualitative data, to then develop more robust valid and comprehensive surveys.

Energy Affordability and Energy Poverty – (S-1, S-2)

The eradication of energy poverty is a key objective of PED implementation (Hedman et al., 2021). When developing a PED, it is important that policymakers are aware of the impact of PED actions on energy poverty indicators. Deliverable 5.3 sheds further light on how PED policies can be designed to tackle energy poverty.

We define two indicators regarding energy affordability and poverty (percentage point reduction in average share of energy expenses in income, and reduction of households identified as energy poor), which are complementary, hence we aggregate their weighting relative to other aspects in the social dimension. Both indicators are based on information regarding the proportion of energy expenditure out of total income.

For energy affordability, we are interested in assessing the **percentage point reduction in the average share of energy expenditure in income (S-1)**. We consider the average by accounting for all households in the district affected by PED solutions. As a target we use standardised thresholds set by CITYKeys (CITYKeys, 2017) and consider a percentage point **reduction in the average share of energy expenses in income of 2.0 pp to be a short-term target**. This is given a score of 3 for the indicator, with a percentage point reduction in average share of energy expenses in income of 5.0 pp to be a more ambitious target and which is therefore given a score of 5. In theory, PED interventions could increase the share of energy expenses in income; these cases are assigned a score of 1.

Table 14 Percentage point reduction in average share of energy expenses in income.

1	2	3	4	5
< 0 / 0 pp	0 – 1.5 pp	1.5 – 2.5 pp	2.5 – 5 pp	> 5 pp

Note: Increases in average share of energy expense in income (percentage point increase) will also be awarded a 1 in this framework.

While this indicator will give policymakers an indication of how solutions are affecting the affordability of energy, they will also want to evaluate how the solutions are affecting the proportion of citizens suffering from energy poverty. We **identify the proportion of energy poor households of the district based on the 2M indicator definition**, one of the primary indicators for energy poor identified by EPOV[6]. The indicator identifies a household as being energy poor if the share of energy expenditure in income is more than twice the national median share. We choose the 2M indicator instead of other primary indicators of energy poverty because it is based on easily accessible data which will also need to be calculated for the energy affordability indicator. Our key indicator here is the percentage **reduction in the number of households identified as being energy poor following the 2M definition (S-2).** Once more, we report the equation in Annex I.

In accordance with the EU's target of eradicating energy poverty with the "Clean Energy for All Package", we **identify a 100% reduction in the number of households in the district identified as**

[6] https://www.energypoverty.eu/indicator?primaryId=1460. Accessed 12/07/21.

energy poor as an optimal target. However, it is important to note that this should not be an incentive to 'push' all poor households outside the district. Following this risk, evaluators should check this indicator together with the E-6 indicator. A situation where housing costs increase, and energy poor disappear through displacement would be a serious cause for concern. Furthermore, in principle, a PED could worsen the situation of energy poverty in a district, if not implemented correctly, leading to an increase in the proportion of households identified as energy poor.

Following these two potential risks, we assign a value of 1 to this indicator in all cases where (i) there is an increase in the number of energy poor in the district, or (ii) there is a reduction in the number of energy poor in the district, but there is an increase in the share of housing cost in income (i.e.: E-6 is scored 1). Beyond these two cases that merit a score of 1, the reminder of the scores are assigned uniformly as bands of 25pp reductions in the number of households identified as energy poor, from 0 to 100%.

Table 15 Percentage reduction in the number of households identified as energy poor following the 2M definition.

1	2	3	4	5
< 0 /0 %	0 – 25 %	25 – 50 %	50 – 75 %	75 – 100 %

Note: Assign a 1 to this indicator in all cases where (i) there is an increase in the number of energy poor in the district, or (ii) there is a reduction in the number of energy poor in the district, but there is an increase in the share of housing cost in income (i.e.: E-6 is scored 1).

Thermal Comfort – (S-3)

In the context of a project driven to pursue the energy transition at urban level, an important aspect to evaluate from a social perspective is the **quality of the delivered heating/cooling**. Even though this could be considered a purely technical aspect, thermal comfort also provides greater quality of life for the community. This will also be related to the indicators on energy affordability and energy poverty.

As highlighted by Angelakoglou et al. (2019), this indicator can be evaluated through survey items, in particular using Likert scales. The results should also be evaluated by asking the level of comfort prior the implementation of the project, to make it possible to evaluate how the project impacted the community. We propose **using survey items to collect data on thermal comfort experiences of citizens affected by PED solutions**. To standardise our approach linking responses in the survey to bandwidth scores, the Likert scale should be on a 5-point basis.

We assign bandwidths based on what answers are reported by surveys. We assign **a score equal to the mean answer reported once all surveys have been counted**. Ideally, the surveys should capture all households in the district affected by the implemented solution, or if this is not possible, a significantly large representative survey should be undertaken. Like previous indicators based on Likert scales, this indicator suffers from a certain degree of subjectivity in the responses.

If the mean reported score is 5, indicating greatly improved thermal comfort relative to baseline conditions, then a score of 5 is assigned to this indicator. If however the mean reported score is a 2, indicating only satisfactory levels of thermal comfort relative to baseline conditions, a score of 2 is assigned to the indicator. We standardise the bandwidths therefore based on mean answers reported to the collected surveys.

Table 16 Thermal Comfort (evaluated as part of citizen survey).

1	2	3	4	5
Mean answer reported equal to 1	Mean answer reported equal to 2	Mean answer reported equal to 3	Mean answer reported equal to 4	Mean answer reported equal to 5

Note: 1: Bad thermal conditions relative to baseline or no change in thermal conditions relative to baseline. 2: Satisfying thermal conditions relative to baseline. 3: Noticeably better thermal conditions relative to baseline. 4: Very improved thermal conditions relative to baseline. 5: Extremely improved thermal conditions relative to baseline.

Participation of Vulnerable Groups – (S-4)

How successful a project is in explicitly involving vulnerable groups will be an important aspect to consider in PED implementation. Particularly when considering PED objectives to reduce energy poverty, it would be ideal that policies aimed at making living conditions better for vulnerable groups also involve them in the creation and implementation of these activities. Other groups whose opinions and contributions are not reflected well enough in society (women, elderly, minorities, the disabled) will require special attention, enhancing social cohesion and diversity.

The evaluation of this indicator will be based on a five-point Likert scale. Given that vulnerable groups are often harder to reach, the assessment will be based on interviews with NGOs and local associations that represent these groups, rather than surveys directly with citizens.

This measure will capture **the extent to which vulnerable groups have been involved in the implementation and planning of the process.** We define here “vulnerable” in general terms, as different socio-cultural contexts will have different minorities that will need to be addressed and included as “vulnerable”. In any case, this category must always include those living in energy poverty or energy vulnerable conditions.

Table 17 Participation of vulnerable groups (assessed via interviews with NGOs and local associations).

1	**2**	**3**	**4**	**5**
Mean answer reported equal to 1	Mean answer reported equal to 2	Mean answer reported equal to 3	Mean answer reported equal to 4	Mean answer reported equal to 5

Note: 1: Participation of groups not well represented in society has been harmed due to the project or unchanged. 2: Participation of groups not well represented in society has been slightly improved due to project. 3: Participation of groups not well represented in society has clearly been improved due to the project. 4: Participation of groups not well represented in society has been considerably improved due to the project. 5: Participation of groups not well represented in society has been greatly improved due to the project.

Citizen Engagement – (S-5)

Another important aspect to be considered is the general level of citizen engagement within the community. This reflects the ability of the project also to strengthen the sense of community. Additionally, when coupled with ICT solutions, the engagement of citizens can be seen as an optimal way of developing human centric solutions that have a technical starting point, but are likely to have social impacts as well.

Also in this case the evaluation of this indicator will be based on survey answers in the form of a Likert scale. As suggested by Angelakoglou et al. (2019), this measure will capture **the extent to which**

residents/users have been involved in the implementation and planning of the process in terms of influence and opportunities to participate. Similarly to thermal comfort, the score for this indicator will be assigned based on the mean answer emerging in a 5-point survey item contained as part of a post-intervention citizen survey.

Citizen engagement must also include participation of vulnerable groups, captured by the indicator S-4, in order to ensure the views and opinions of all citizens are incorporated into the engagement process. In order to ensure a positive citizen engagement score is assigned only when vulnerable groups are represented, we assign a 1 to this indicator in all cases where the score for S-4 is lower than 3. This is to reflect that no just engagement process can take place if vulnerable groups are not participating.

Table 18 Local community involvement in the implementation phase (evaluated as part of citizen survey).

1	2	3	4	5
Mean answer reported equal to 1	Mean answer reported equal to 2	Mean answer reported equal to 3	Mean answer reported equal to 4	Mean answer reported equal to 5

Note: 1: the project planners have failed to empower community actors to manage the project implementation (no collaboration or consultation with citizens). 2: the project planners have empowered community actors somewhat to manage the project implementation (no collaboration but consultation). 3: project planners have considerably empowered community actors to manage the project implementation (consultation and collaboration on several activities). 4: project planners have greatly empowered community actors to manage the project implementation (consultation and collaboration in most activities). 5: project planners have fully empowered community actors to manage the project implementation (consultation and collaboration on all activities). Assign a 1 to this indicator in all cases where the score for S-4 is lower than 3.

Weighting of indicators:

The final step is to provide the framework to aggregate the results together, to obtain the overall score of the social dimension.

We consider all aspects relevant in the evaluation and apply equal weighting to all aspects. When an aspect is evaluated using two indicators (as is the case for energy affordability and poverty), each indicator is given half the weight, as distinct but equally important facets of the same underlying aspect:

Table 19 Weight of the different indicators of the social dimension.

Energy affordability	Energy poverty	Thermal comfort	Participation of vulnerable groups	Citizen engagement
0.125	0.125	0.25	0.25	0.25

3 Application of the Framework

A key benefit of using a standardised approach is in turning unprocessed quantitative data into metrics that can provide evaluators with qualitative information to assess the performance of applied solutions. In our framework, scoring of indicators is based on how an indicator performs relative to a target which is chosen to be ambitious, but consistent with the objectives of a PED project.

The use of this framework is explained and presented as a playbook, available in Annex II. In the playbook, the main objectives and targets are also presented, as can be seen from this extract:

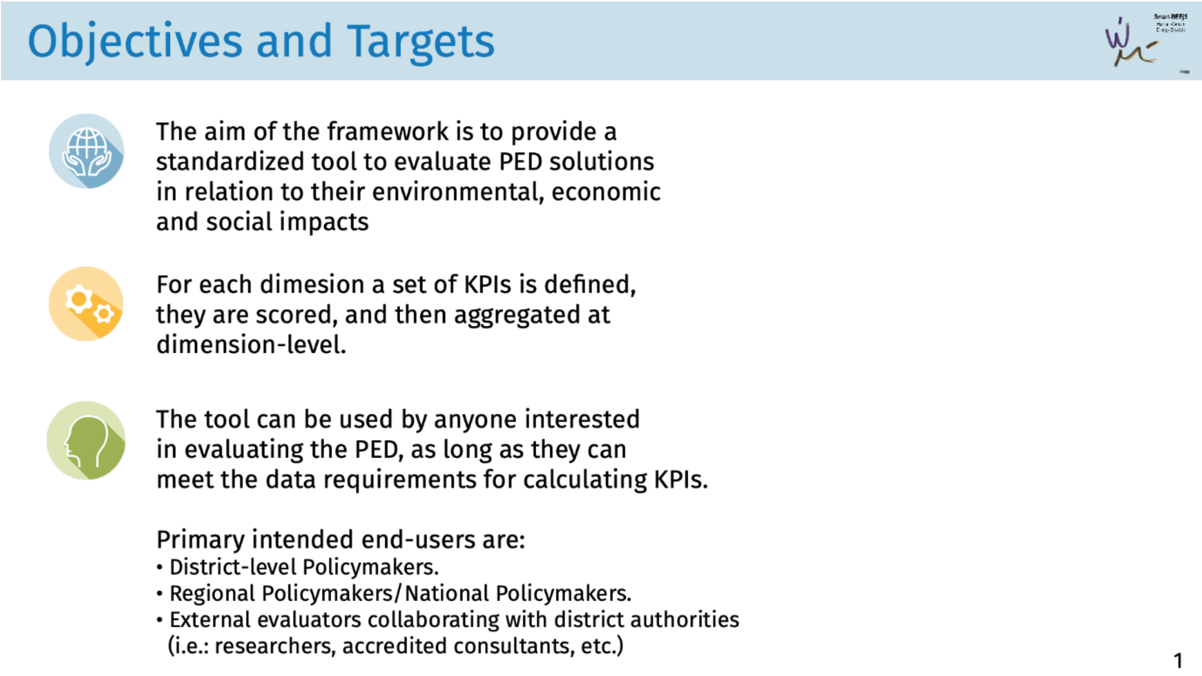

Figure 1 Objectives and Targets of the Framework.

4 Conclusions

In this report, we have presented propositions for the development of a standardised method for impact evaluation of PEDs. Based on similar frameworks applied to the concept of smart and sustainable cities, we have adopted a score-based approach that can be used to compare different PED measures and/or different districts on several levels. Policymakers, planners and other stakeholders can use the framework to evaluate how different indicators perform in relation to targets associated with PED objectives. They can aggregate at the dimension level to understand where the benefits of PED solutions are distributed between environmental, economic, and social dimensions. Finally, they can compare different PED solutions or districts based on their overall scores.

The starting point for this work has been selecting KPIs based on formalised criteria. Crucially, the KPIs selected needed to be explicitly related to the PED building blocks and/or objectives. Through a process of extensive desk research and internal discussions with PED experts, we identified 4 indicators of relevance in the environmental dimension, 7 in the economic dimension, and 5 in the social dimension. We created scoring bandwidths that could qualitatively describe the performance of each indicator in relation to pre-established targets. These targets were chosen based on EU targets, existing PED experiences, or elaborated by the authors in relation to PED objectives.

Our approach then aggregates the indicators at the dimension level, with differing weights which were elaborated and discussed by the authors. The SMIE tool provided can be used to transform KPI scores into dimension scores, and then aggregate these dimension scores to calculate an overall score for the PED/PED intervention. The playbook provided in Annex II explains how to use this tool to create graphical representations of the results. It also goes inTO more depth as to the objectives of the approach and its possible users.

With this work, our objective has been to provide a tool to standardise the evaluation of PEDs and PED measures. Basing our selection of KPIs on the PED building blocks and objectives, we ensure that the impact indicators selected are relevant to this emerging concept. We also ensure the data needed to evaluate the districts under our approach would be readily available or relatively straightforward to collect directly. This work, applied in real world contexts, will support policymakers in designing and adopting PEDs, offering a simple tool to evaluate the performance of different PED solutions.

Annex I – Calculation Methodologies

Table 20 Calculation methodology for environmental indicators.

Indicator	Calculation	Data sources	Expected availability of data
EN–1	$CO_2\,reduction = \left(\frac{(\sum_i en\_cons_i \cdot k_i)_{post} - (\sum_i en\_cons_i \cdot k_i)_{ante}}{(\sum_i en\_cons_i \cdot k_i)_{ante}}\right) \cdot 100$ Where *i* represents each energy carrier (i.e. natural gas, biomass etc…) and k_i the respective GWP that allows to convert everything in CO_2 equivalent. *En_cons* represents the energy consumption of each carrier within the district.	Ex ante values should be available from statistics or previous monitoring activities. Ex post values can come from monitoring and technical characteristics	
EN–2	$LRG = \left(\frac{Energy\ Generated\ from\ RES}{Total\ Energy\ Generation}\right)$	Values available from monitoring and technical characteristics.	
EN–3	$ES = \left(\frac{Tot\_cons_{ante} – Tot\_cons_{post}}{Tot\_cons_{post}}\right) \cdot 100$ Where Tot_cons represents the final energy consumption of the full project ex ante and ex post implementation.	Ex ante values should be available from statistics or previous monitoring activities. Ex post values can come from monitoring and technical characteristics	
EN–4	$WRR = \left(\frac{Recovered\ waste}{Total\ easte\ generated}\right)$	From monitoring and municipality statistics.	

Table 21 Calculation methodology for economic indicators.

Indicator	Calculation	Data sources	Expected availability of data
E-1	*Use of local workforce*: $\frac{Costs_{local\ workforce\ in\ project}}{Costs_{total\ workforce\ in\ project}} \cdot 100\%$	Retrieved from PED project documentation and/or interviews	The budget is well documented but extra effort will be needed to make sure documentation

	Source: CITYKeys (CITYKeys, 2017)	with project leader or actors involved.	exists on the share to local suppliers/workforce.
E-2	*Quality of municipality involvement*: Likert scale assessed by evaluators based on documentation/interviews: 1: the local authority is not involved in the development of the project. 2: the local authority is insufficiently involved in the development of the project, at maximum one department is involved. 3: the local authority is somewhat involved in the development of the project, with more than one department contributing constructively. 4: the local authority is clearly and constructively involved in the development of the project, more than two departments are involved. 5: The local authority is instrumental in the development of the Source: CITYKeys (CITYKeys, 2017)	To be derived from project documentation and/or interviews with project leader and other team members.	Most projects will have paid specific attention to relations with city administration, If there is no documentation available, involved actors/stakeholders and the project leader should be able to provide insights upon which assessors can base the score.
E-3	*Share of subsidies in total cost*: $\frac{Subsidies\ received}{Total\ investment\ or\ cost} * 100\%$	Project documentation, grant agreement, interviews with project leader.	Likely available.
E-4	*Return on Investment*: $ROI_T = \frac{\sum_{t=1}^{T}\left(In_t - TAC_{after_t}\right) - I}{I}$ Where ROI_T = Return on Investment (%) T = Duration of the economic analysis period (depends on common practice in the area, for a standardised application must compare with projects using same T i.e.: T = 10). In_t= Income in year t	Project documentation and/or interviews with the project leader and other actors involved.	As financial concerns are a main motivator for project implementation, it is expected that this information will be available.

	TAC_{after}=total annual energy cost of the system after the intervention (i.e.: energy operation and maintenance, financial, etc.) I= total investment in project Source: SCIS, Angelakoglou (2019)		
E-5	*Share of returns in community*: $$\frac{Local\ Revenues}{Total\ Project\ Revenues}$$ Source: Authors own elaboration based on PED objectives.	Retrieved from PED project documentation and/or interviews with project leader or actors involved.	Total revenues will be well documented. Extra effort will be needed to discern what distribution of those revenues is earned by members within the district.
E-6	*Change in share of housing costs in income*: Decrease: $$\frac{HC_{pre} - HC_{post}}{HC_{pre}} * 100$$ Increase: $$\frac{HC_{post} - HC_{pre}}{HC_{pre}} * 100$$ Where HC= fixed housing costs in terms of EUR/year. Source: CITYKeys (CITYKeys, 2017)	Project documentation, marketing material for real estate brokers. Gross household income can be derived from city or regional statistics.	Household income data may be difficult to get with granular geographical detail. Estimates or proxies may be used instead.
E-7	*Financial Benefit for End-users*: $$Tot\ Cost_{before} - Tot\ Cost_{after}$$ In EUR/household/year. Where, TotCost represents the total direct costs before/after the implementation of the project Source: Angelakogolou (2019), CITYKeys (CITYKeys, 2017), SCIS	Project documentation, interviews, or surveys with project leader and/or end-users.	As this will often be a main motivator for the implementation of a project, it is expected that this information will be available.

Table 22 Calculation methodology for social indicators.

Indicator	Calculation		
S-1	*Percentage point change in income spent on energy:* $$\frac{EC_{pre}}{HI} * 100 - \frac{EC_{post}}{HI} * 100$$ Where EC= Direct Energy costs and HI=Gross household income.	Data on the average household income may be obtained from the city statistical office. Energy prices (metered prices) can be obtained from local energy provider(s).	Most difficult will data on the (average) household income in the neighbourhood of the project. Often data are not available with geographical detail. Estimates or proxies may be used instead. This other data should be easily available.
S-2	*Percentage change in number of people identified as energy poor:* Decrease: $$\frac{\# EP_{pre} - \# EP_{post}}{\# EP_{pre}} * 100$$ Increase: $$\frac{\# EP_{post} - \# EP_{pre}}{\# EP_{pre}} * 100$$ Where # EP = number of citizens in the district identified as energy poor following 2M definition. Source: Authors own elaboration. Based on definition of energy poverty as in 2M indicator.		
S-3	*Thermal comfort:* Mean answers emerging from items in citizen survey. Survey item Likert Scale: 1: Bad thermal conditions relative to baseline or no change in thermal conditions relative to baseline. 2: Satisfying thermal conditions relative to baseline.	Survey responses.	

	3: Noticeably better thermal conditions relative to baseline. 4: Very improved thermal conditions relative to baseline. 5: Extremely improved thermal conditions relative to baseline. Source: Items elaborated by authors. Indicator identified by Angelakogolou (2019).		
S-4	*Participation of vulnerable groups:* Mean answers emerging from items in citizen survey. Survey item Likert Scale: 1: Participation of groups not well represented in society has been harmed due to the project or unchanged. 2: Participation of groups not well represented in society has been slightly improved due to project. 3: Participation of groups not well represented in society has clearly been improved due to the project. 4: Participation of groups not well represented in society has been considerably improved due to the project. 5: Participation of groups not well represented in society has been greatly improved due to the project.	Interviews with NGOs	
S-5	*Citizen Engagement:* Mean answers emerging from items in citizen survey. Survey item Likert Scale:	Survey responses.	

	1: the project planners have failed to empower community actors to manage the project implementation (no collaboration or consultation with citizens). 2: the project planners have empowered community actors somewhat to manage the project implementation (no collaboration but consultation). 3: project planners have considerably empowered community actors to manage the project implementation (consultation and collaboration on several activities). 4: project planners have greatly empowered community actors to manage the project implementation (consultation and collaboration in most activities). 5: project planners have fully empowered community actors to manage the project implementation (consultation and collaboration on all activities)		

Annex II - Playbook

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PLAYBOOK ON STANDARDISED METHOD FOR IMPACT EVALUATION OF PEDs

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Part of Deliverable 5.2 of the SMART BEEjS Project

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Objectives and Targets

The aim of the framework is to provide a standardised tool to evaluate PED solutions in relation to their environmental, economic and social impacts.

For each dimension a set of KPIs is defined, they are scored, and then aggregated at dimension-level.

The tool can be used by anyone interested in evaluating the PED, as long as they can meet the data requirements for calculating KPIs.

Primary intended end-users are:

- District-level Policymakers.
- Regional Policymakers/National Policymakers.
- External evaluators collaborating with district authorities (i.e.: researchers, accredited consultants, etc.)

Stakeholders Involvment

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The stakeholders that need to be involved can be divided in two macro areas:

Stakeholders that must be included to calculate KPIs:

- Municipal authority (if not already acting as evaluators)
- Citizens affected by interventions (potentially all district citizens)
- Vulnerable citizens (energy poor, other marginalized groups)
- Energy utilities (information on energy savings, prices, etc.)

Stakeholders that ideally should be included but not strictly necessary:

- Regional, national authority (if not already acting as evaluators)
- Professional researchers/Academia (can offer technical assistance)
- Industry and business

Environmental Dimension

Goals and tasks:

Evaluate the impact of PED solution on the local environment focusing also on how it contributes to achieve the local sustainable goals and on concepts of circularity.

Who is involved?

- Municipal Authority
- Energy Utilities
- Professional and technical experts
- Citizens affected by intervention

Measurements	Target	Data Sources
GHG Emission Reduction	55%	National/Regionalstatistics, monitoring activities and technical characteristics
Share of local renewable Energy Generation	32%	Monitoring activities and technical characteristics
Energy Savings in Final Energy Consumption	32.5%	National/Regionalstatistics, monitoring activities and technical characteristics
Average Waste Recycling Rate	55%	Monitoring activities and municipality statistics

Economic Dimension

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Goals and tasks:

Evaluate the impact of PED solution on the economic aspects adopting a micro-level view. Focus is on the impact at the local level, looking at the financial benefits from different perspectives as well as the involvment of public authorities.

Who is involved?

- Municipal authorities.
- Local and/or regional statistical offices.
- Economists, economic consultants.
- Project officers and leaders.

Economic Dimension

Measurements	Target	Data Sources
Use of Local Workforce	40-60%	Project documentation and/or interviews with project leader or actors involved.
Quality of Municipal Involvment	3*	Project documentation and/or interviews with project leader or actors involved.
Share of Subsidies in Total Project Costs	60-40%	Project documentation, grant agreement, interviews with project leader.
Annual ROI	20-25%	Project documentation and/or interviews with project leader or actors involved.
Share of Generated Revenues in Local Community	40-60%	Project documentation and/or interviews with project leader or actors involved.
Change in share of housing costs in income	3-5%	Project documentation, marketing material for real state brokers, City/regional/national statistics.
Financial Benefit for End-User	1050-1200 €/household/year	Project documentation and/or interviews with project leader or actors involved.

** the local authority is somewhat involved in the development of the project, with more than one department contributing constructively*

Social Dimension

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Goals and tasks:

Evaluate the impact of PED solution at the social level to understand if and how a just and fair transition is involved. The focus in on concepts related to inclusiveness, quality of life, energy justice and prevention of energy poverty.

Who is involved?

- Municipal authorities.
- Citizens.
- Professional researchers/survey experts.

Social Dimension

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Measurements	Target	Data Sources
Energy Affordability*	1.5-2.5 pp	City/regional/national statistics, local energy provider
Energy Poverty**	25-50%	City/regional/national statistics, local energy provider
Thermal Comfort	3[1]	Survey Responses
Citizen Engagement***	3[2]	Survey Responses
Participation of Vulnerable Groups	3[3]	Interviews with NGOs

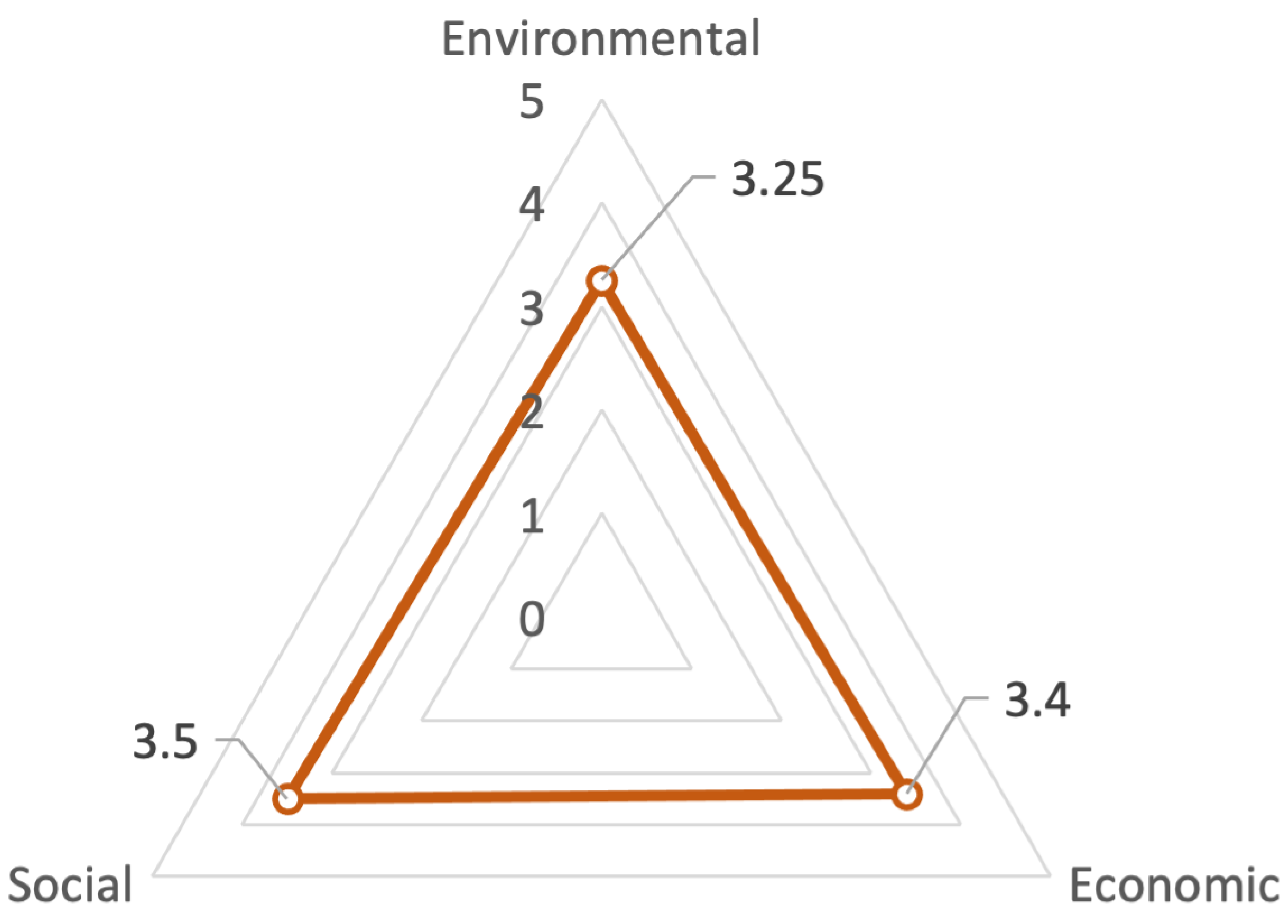
** percentage point reduction in the average share of energy expenditure in income*
*** Percentage reduction in the number of households identified as energy poor following the 2M definition.*
To note that we assign a 1 to this indicator in all cases where (i) there is an increase in the number of energy poor in the district, or (ii) there is a reduction in the number of energy poor in the district, but there is an increase in the share of housing cost in income
**** To note that we assign a 1 to this indicator in all cases where the score for Participation of Vulnerable groups is lower than 3*

1 Noticeably better thermal conditions relative to baseline
2 project planners have considerably empowered community actors to manage the project implementation
3 Participation of groups not well represented in society has clearly been improved due to the project.

Presentation of the Results

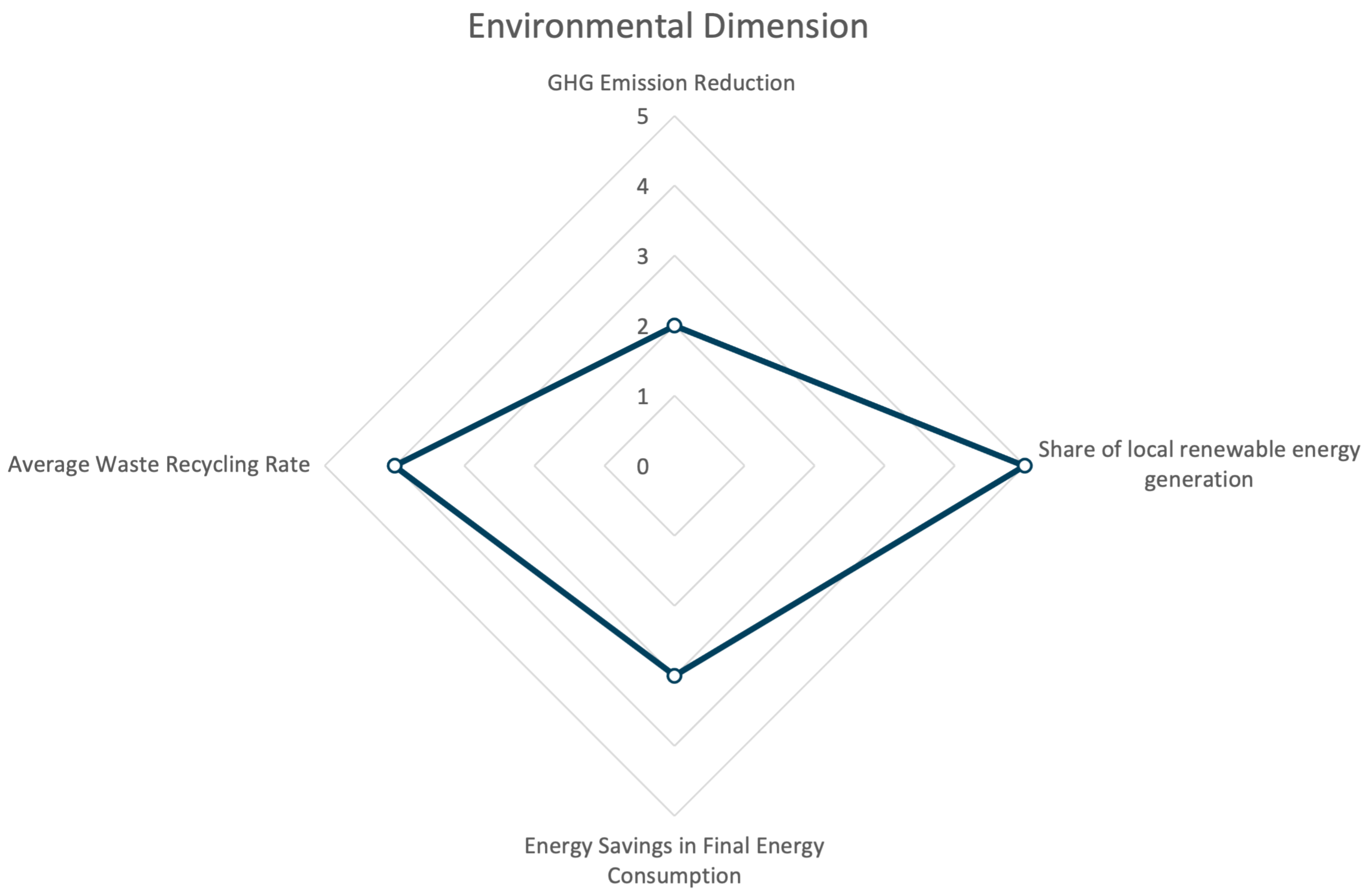
Once the KPIs are calculated the respective score is inserted in the Standardised Method of Impact Evaluation (SMIE) tool.

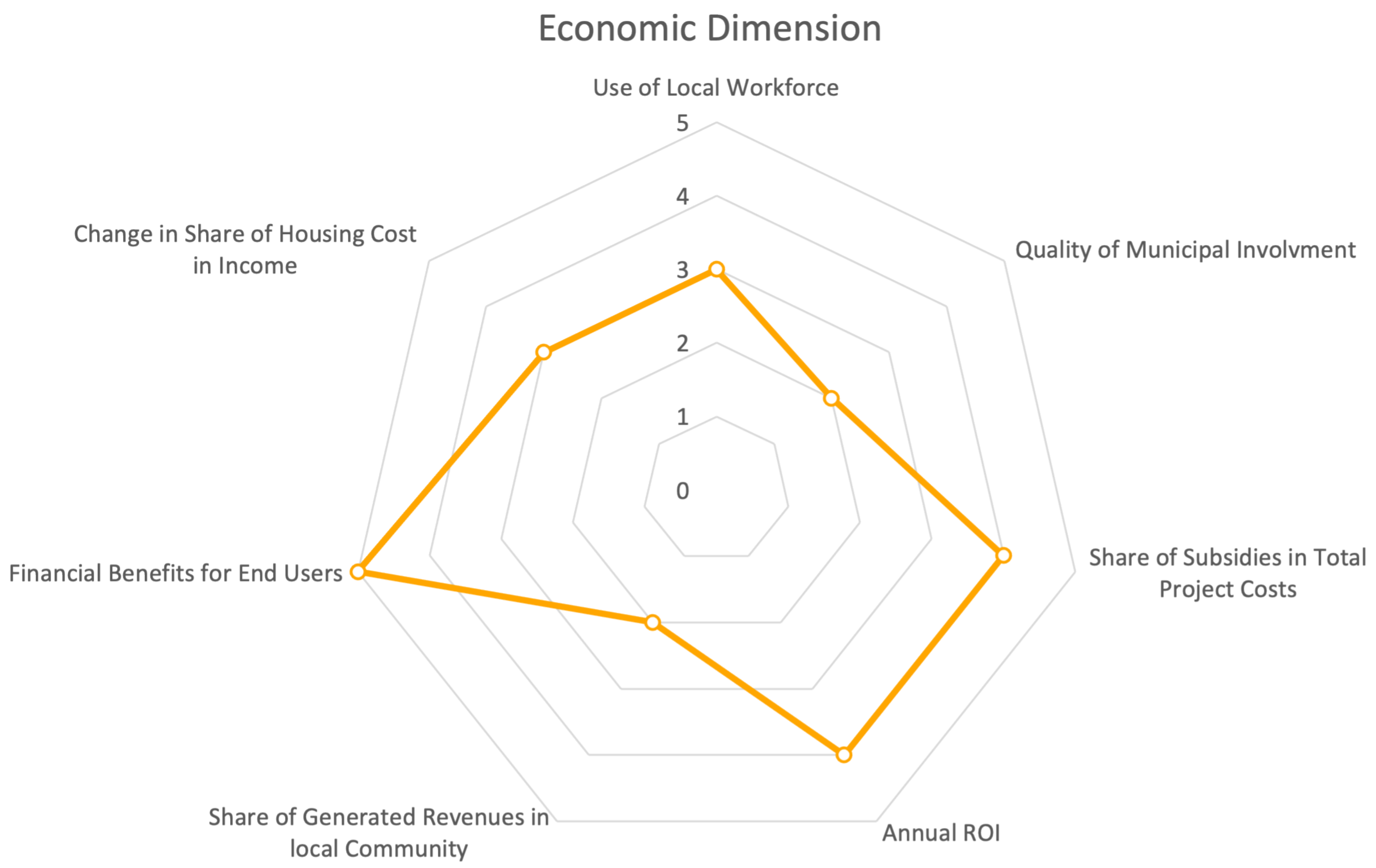
This will generate the following overall results:

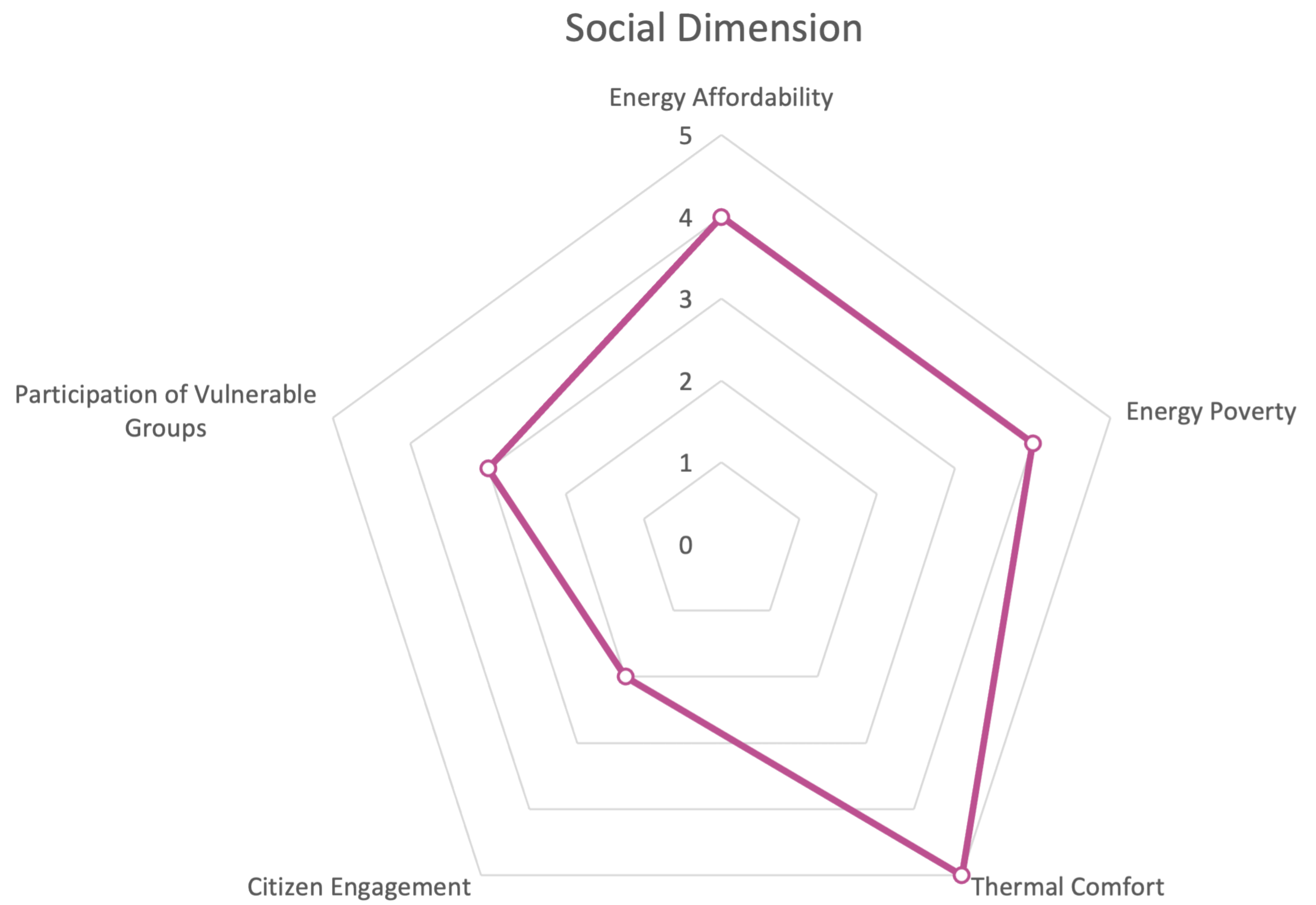


Presentation of the Results

As well as dimension specific results:







Take Home Messages

1. An overall score of 3 suggests that on average the PED solution managed to achieve the targets defined. This highlights that the project already reached important results.

2. An overall score between 4 and 5 suggests that the PED Project is overperforming compared to the initial targets. This reflects excellent performance.

3. An overall score between 1 and 2 may suggest that the impact of the PED Project is lower than expected indicating it underperformed.

4. The target set and the respective bandwidth can be adapted and remodelled in the future, in order to allow use of this framework in future years.

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This project has received funding from European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Actions, Innovative Training Networks, Grant Agreement No 812730

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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 occurs 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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