D1.6 Visualization framework for assessing city performance

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Description of the related task and the deliverable. Extract from DoA	**T1.3 Visualization framework for assessing city performance (Suite5) M6 – M24** This task has the objective of providing an appropriate visualization environment (D1.6) building up on the methodology developed in T2.1, based on CITYkeys SCIS and CIVITAS actions. This will allow any city to measure the performance of its Positive Energy Districts/Blocks, and, in the long term, to track its own progress in its urban transformation pathway and corresponding implementation process of the underlying measures to achieving the city vision. To this extent it is envisioned the creation of a tool (e.g. performance measurement system) that permits both the calculation and the evaluation of KPI's, considering the prioritization criteria concluded during the city diagnosis phase (Task 1.1). This framework will also be adapted to quantify the level of achievement of the milestones defined in Roadmap, and ultimately of the desired scenarios. Even more, the Visualization framework is expected to act as an additional Communication and Dissemination means of the project, allowing all key stakeholders and city authorities around the EU, to continuously monitor the progress of the SPARCs demos against the baselines defined in T2.2 and easily identify highly-effective interventions that can be applied into their unique contexts. This will be done in close collaboration with the WP5 Replication by Fellow Cities, particularly under the task 5.1. Replication Strategy. The definition of the visualization framework and monitoring tool will be developed in close interaction with the WP2 Monitoring and Impact Assessment, considering that this WP will deliver detailed KPI's technical definitions and appropriate tools for data collection.				
Participants	VTT, ESP, LPZ, CMM, RVK, KLD, KFS, LVIV, SPI, OR, VERD, NECU, LCE				
Comments					

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About SPARCS

Sustainable energy Positive & zero cARbon CommunitieS demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen centred zero carbon & resource efficient economy. SPARCS facilitates the participation of buildings to the energy market enabling new services and a virtual power plant concept, creating VirtualPositiveEnergy communities as energy democratic playground (positive energy districts can exchange energy with energy entities located outside the district). Seven cities will demonstrate 100+ actions turning buildings, blocks, and districts into energy prosumers. Impacts span economic growth, improved quality of life, and environmental benefits towards the EC policy framework for climate and energy, the SET plan and UN Sustainable Development goals. SPARCS co-creation brings together citizens, companies, research organizations, city planning and decision-making entities, transforming cities to carbon-free inclusive communities. Lighthouse cities Espoo (FI) and Leipzig (DE) implement large demonstrations. Fellow cities Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) prepare replication with hands-on feasibility studies. SPARCS identifies bankable actions to accelerate market uptake, pioneers innovative, exploitable governance and business models boosting the transformation processes, joint procurement procedures and citizen engaging mechanisms in an overarching city planning instrument toward the bold City Vision 2050. SPARCS engages 30 partners from 8 EU Member States (FI, DE, PT, CY, EL, BE, CZ, IT) and 2 non-EU countries (UA, IS), representing key stakeholders within the value chain of urban challenges and smart, sustainable cities bringing together three distinct but also overlapping knowledge areas: (i) City Energy Systems, (ii) ICT and Interoperability, (iii) Business Innovation and Market Knowledge.

Partners

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LIST OF ABBREVIATIONS

API	Application Programming Interface
AQI	Air Quality Index
DMP	Data Management Platform
Dx.y	Deliverable x.y
DoA	Description of Action
EU	European Union
EC	European Commission
FC	Fellow City
GA	Grant Agreement
ICT	Information and Communication Technologies
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
KPIs	Key Performance Indicator(s)
LHC	Light House City
Mx	Month x
PED	Positive Energy Districts/Blocks
PEB	Positive Energy Blocks
SCIS	Smart Communities Information System
SPARCS	Sustainable Positive and zero cARbon CommunitieS
SVF	SPARCS Visualization Framework
Tx.y	Task x.y
WP	Work Package

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EXECUTIVE SUMMARY

The present deliverable D1.6 - "Visualization framework for assessing city performance" provides a report on the activities performed within the context of T1.3 "Visualization framework for assessing city performance". The main scope is the definition of the envisioned visualization environment through the delivery of appropriate mockups. To this end, the current deliverable provides the design considerations and the methodology followed towards prioritising the KPIs to be presented in the SPARCS Visualization Dashboard. As an outcome of these activities, the final mockups of the dashboard are presented, describing in detail its functionalities and the envisioned user flow. The mock-ups will form the basis for the design and delivery of the first stable release of the SPARCS Visualization Dashboard due in M30 of the project's implementation.

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1. INTRODUCTION

1.1 Purpose of the document

The present deliverable D1.6 entitled "Visualization framework for assessing city performance" forms part of the activities performed within the context of T1.3 "Visualization framework for assessing city performance". Its main scope is the provision of mock-ups of the indicator's visualization that fulfil the project's LHCs needs and requirements. Such mockups will be utilised for the design of the SPARCS Visualisation Framework and associated dashboard.

As explicitly stated in the DoA (2019), through the provision of appropriate dashboards, the SPARCS Open Information Management and Monitoring Toolkit will enable LHCs to measure the performance of its Positive Energy Districts/Blocks (PEDs/PEBs), and in the long term, to track its own progress in its urban transformation pathway and corresponding implementation process of the underlying measures to achieving the city vision. Such a dashboard will enable performance measurement through the calculation and the visualization of appropriate KPIs identified during the holistic assessment of the SPARCS interventions in the projects demo sites, carried out in the context of T2.1; and selected upon consideration of the LHCs prioritization criteria and the LHCs action indicators identified during the city diagnosis phase, undertaken in the context of T1.1.

The SPARCS Visualization framework is also anticipated to support the projects' communication and dissemination activities, by enabling key stakeholders and city authorities around the EU, to monitor the performance of the SPARCS LHCs against the baselines identified in T2.2 "Ex-Ante Lighthouse Demo Analysis and Detailed Baselining" and easily recognise the most effective interventions, that could be applied into their own cities context.

Under this context, the present deliverable provides the updated design considerations for the development of the SPARCS Visualization Framework and presents the final set of mock-ups that will form the basis for the design of the envisioned dashboard.

Lastly, it should be noted that the actual delivery of the SPARCS Visualization Framework and the associated dashboards, will be provided along with the first stable release of the SPARCS Open Information Management and Monitoring Toolkit (D2.5), due in M30 of the project's implementation.

1.2 Relations to other activities

Deliverable D1.6 details the activities performed in task T1.3 "Visualization framework for assessing city performance" and its main scope is to provide an appropriate visualization environment (D1.6) that will enable the SPARCS LHCs to measure their Positive Energy Districts/Blocks performance, and, in the long term, to track their own progress during their urban transformation journey towards achieving the city vision.

For the design and implementation of the activities and outcomes described in this document, the current deliverable has strong inter-relations and receives input from the following SPARCS tasks and associated deliverables:

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- T1.1 “City diagnosis, data collection & preliminary analysis” that developed a city diagnosis process allowing to accurately understand the ground conditions and the prioritization criteria of each LHCs, and which will be utilized in D1.6 to identify the cities’ specific needs and visualization requirements.
- T2.1 “Demo Evaluation, Impact Assessment and Cost-Benefit Analysis Framework and Associated Key Performance Indicators”, defining a framework for the holistic assessment of the project’s interventions in the LHCs and FCs and the detailed KPI’s technical definitions
- T2.2 “Ex-Ante Lighthouse Demo Analysis and Detailed Baselining”, defining the baselines to be used in the project's assessment.
- T2.3 “Data gathering from demonstration activities for evaluation” where the initial design specifications for the SPARCS Open Information Management and Monitoring Toolkit have been defined, along with the process for gathering the various types of data from the demonstration activities required for the SPARCS Impact Assessment
- T5.1 “Developing packaged, neutral and interoperable solutions” where D1.6 will be built on the input and in collaboration with the partners and Fellow Cities involved in the replication activities of WP5.
- Furthermore, D1.6 will be utilised as input in T2.4 “Socio-economic, environmental and technological Impact Assessment”; where a holistic evaluation of the project activities will be performed, along with assessment of the impact achieved by the project interventions in the lighthouse city demos, as well as in the replication potential of SPARCs framework in WP5.
- T8.1 “Communication and Engagement Strategy”, which includes involving the target audiences and specific stakeholders (topical and local SMEs, industry, start-ups, citizens, municipalities) to create a community around the project and its implementation to build the space for future replication and uptake. By displaying the main results and recommendations from the Visualisation Dashboard we could further improve the dissemination activities. The website would add links to the relevant parts of the dashboard (e.g., the charts displaying the KPIs, priorities, etc.) in order for the visitor to gain access to the details as needed.

The outcome of D1.6, i.e the visualization mock-ups, will receive further valuable feedback by the LHCs and FCs key stakeholders during the initial WP3 and WP4 demonstration activities, to be refined prior to the actual delivery of the SPARCS Visualization Framework in the context of D2.5 (M30).

1.3 Structure of the document

In order to address all the aspects relevant to the scope of D1.6 the remaining of the document is structured as follows:

- Chapter 2 elaborates on the benefits deriving from city data visualization.
- Chapter 3 presents the methodology followed for the prioritization of the KPIs to be visualized in the SPARCS Visualization Dashboard along with additional design considerations for the dashboard creation.
- Chapter 4 presents the visualization mock-ups that will be used for the design of the SPARCS Visualization Dashboard.
- Finally, in chapter 5 the conclusions are provided.

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2. VISUALIZATION OF CITY DATA SOURCES

In general, data visualization entails the presentation of raw data via the use of graphical representations (such as bar diagrams, distribution curves, box plots, scatter plots, pie charts, etc.) that enable viewers to explore the data and draw significant insights. The use of visual formats is widely considered as a more effective and faster method of conveying information, since it is much simpler for human minds to understand information provided through visuals rather than reading through reports or tabular formats (such as spreadsheets). As such, data visualization provides an effective way to communicate complicated information and detect patterns in the data.

Under this context, this section presents the benefits of data visualization dashboards which in the case of SPARCS will enable the holistic monitoring and assessment of the LHCs performance, enabling cities stakeholders to identify their cities performance along with the impact of the planned interventions.

2.1 Benefits of data visualization

Within relevant literature data visualization is greatly endorsed when it comes to communicating information deriving from data. This is also evident, from the plethora of existing visualization tools utilised in various domains for the purpose of communication, information exploration and analysis, as well as decision support; where the dashboard is identified as the most typical medium used for data visualization.

Data visualization through dashboards enables a clearer understanding of data, reducing the required time to comprehend it. A summary of the most important benefits offered through data visualizations/dashboards (2018) is presented as follows:

- **Quick and easy interpretation of data**; through the use of visualization dashboards users are enabled to understand information deriving from big volumes of data at a glance, rather than just looking numbers in reports or spreadsheets.
- **Acquisition of crucial data in real time**; since visualization dashboards are typically intended to operate in real time and continuously update their content with the latest available information.
- **Enhanced user engagement**; via interactive dashboards users can delve deeper into the causes and trends, rather than just looking numbers.
- **Faster decision-making**; with the presentation of contextualised (or comparable) data via visualisation dashboards, users are able to understand the significance of the data faster, extract patterns and even discover hidden relationships or trends; which in the case of tabular forms/reports would normally take more time and effort and also might lead to different conclusions.

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2.2 Visualization in SPARCS

In the context of SPARCS, a vast amount of data deriving from the project's demo sites (both from the Lighthouse and Fellow cities) is expected to be collected and become available to its stakeholders throughout the project's implementation.

Utilizing the collected data, numerous Key Performance Indicators can be calculated, as captured in the SPARCS Monitoring and Impact Assessment framework defined in the context of T2.1. A total number of 151 impact assessment indicators are identified, spread into 8 categories, as shown in Table 1 below.

Table 1 Number of KPIs extracted per category (2021b)

Category	Number of KPIs
Energy	34
Economy	13
Social	25
Environmental	6
Technology	19
Governance	20
Mobility	11
Citizens' engagement	23

Calculating those KPIs and keeping track of the progress achieved throughout the project's lifetime and beyond, poses a huge challenge, since the impacts of the 44 different interventions in the Lighthouse Cities of Espoo and Leipzig, as well as the overall impacts of the SPARCS project need to be considered. In addition, the separation of the indicators into City, physical and virtual demo sites based on their relevance, is essential to fully comprehend the relation and the progress of the deployed actions.

To overcome this complexity and to avoid viewing the project's impact assessment through complex and difficult to comprehend reports, in the context of SPARCS, data will be visualized as part of the SPARCS Visualisation Framework. Through the envisioned dashboard, indicators will be grouped among others, into their different relevance levels, the different categories, and their corresponding interventions. In that way, platform users such as citizens and city stakeholders, will have the capability to better understand the data, the impact of individual interventions at different levels and that of the complete SPARCS project. That will engage citizens and the stakeholders of the city, in actions towards altering their energy consumption patterns and smart decision making based on energy efficient planning respectively.

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3. SPARCS VISUALIZATION FRAMEWORK

While a first attempt to document the initial design considerations for the SPARCS Visualization Framework (SVF) is provided in D2.4 (2020b), this chapter presents the methodology followed in designing of the mock-ups that will set the foundations for the overall design of the SVF and its corresponding dashboards. In addition, the latest design considerations and requirements for the SVF are also presented, based upon the initial feedback received from the partners and LHCs representatives and upon an analysis of the LHCs' profiles aimed at identifying of their needs and requirements.

3.1 Methodology

This section presents the overall methodology followed to define and create adequate mock-ups that will serve as a basis for the design of the SPARCS Visualization Framework. The overall methodology is depicted in Figure 1, where as described below three different steps were followed; leading to the prioritisation of the indicators to be visualised through the SVF and to the delivery of the mock-ups that will be used as guidance for the design of the SPARCS Visualisation Dashboard.

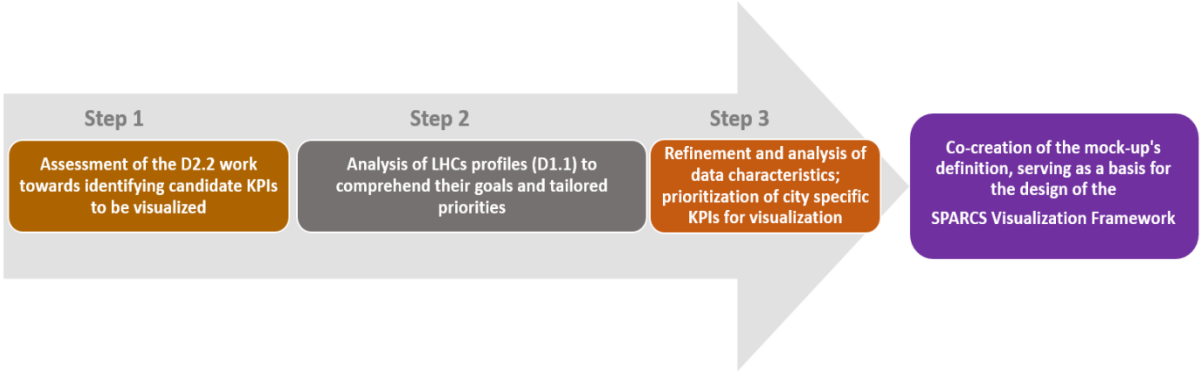

Figure 1 Mock-up design methodology

- **Step 1**:

  The first step in the methodology consisted of an internal analysis of the KPIs presented in D2.2 (2021b) related both to the project's impacts indicators and to the interventions indicators (both at city and district level). Through this analysis, it was possible to identify the pool of KPIs that fulfil the key objective of the envisioned SVF, i.e., to enable performance measurement of the LHCs' PEDs and support them in their urban transformation journey towards achieving their city vision.

  These KPIs, derived from the work done in the context of D2.2, are presented below.

  Table 2, presents KPIs derived from a top-down SPARCS impact analysis performed, while in Table 3, KPIs defined through a bottom-up and technical interventions analysis are listed. All indicators are used to specifically evaluate either the overall impact of the SPARCS actions, or achievements from specific interventions carried out in the Lighthouse Cities. It should be noted that to avoid repetition, only an indicative sample of the intervention KPIs is presented here, and more specifically the indicators for the intervention E1 of Espoo are shown in Table 3. For more information and for

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the complete list of KPIs enabling the SPARCS holistic assessment (both for Espoo and Leipzig), the reader is referred to deliverable D2.2 (2021b).

Table 2 KPIs derived from Impact Analysis

#	KPIs	Impacts	Level
1	Reduction of eCO2 emissions	General Impacts, Impact 1, Impact 6	Macro/District
2	Air quality	Impact 1, Impact 6	Macro /District
3	Share of RES increase	General Impacts, Impact 2	Macro /District
4	Excess Heat recovery ratio	Impact 2	Macro /District
5	Increase of integrated systems	Impact 2	Macro /District
6	Decrease of energy import share	Impact 3	District
7	Total energy demand reduction	General Impacts	Macro /District
8	Total heating demand reduction	General Impacts	Macro /District
9	Increase of Citizens participation in market	Impact 4	District
10	Self-consumption rate increase	Impact 4	District
11	EV car sharing rate increase	Impact 5	Macro /District
12	Increase of EVs share in local transportation	Impact 5	Macro /District
13	Transport behaviour	Impact 5	Macro /District
14	Increase of EV (smart) charging points	Impact 5	Macro /District
15	Utilization of charging stations	Impact 5	District
16	Energy Storage Increase	Impact 2	District
17	Peak load (electricity) reduction	Impact 4	District
18	Peak load (heating) reduction	Impact 4	District
19	Onsite Energy Ratio (OER)	Impact 4	District
20	Total generation curtailment	Impact 4	District
21	Utilisation of charging stations	Impact 5	Macro /District
22	Replication strategy	Impact 7	City
23	Annual number of new patents	Impact 8	Macro
24	Job creation	Impact 9	Macro /District

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25	Increase citizens quality of life, health and well-being	Impact 10	Macro /District
26	Annual number of contributions to European Standardization Organizations	Impact 11	Macro
27	ROI	Overall Impact	Macro /District
28	Payback time	Overall Impact	Macro /District
29	DSCR	Overall Impact	Macro /District

Table 3 Espoo's Intervention- E1 KPIs

KPI	Data
Share of RES (electricity)	Total Energy consumption (electricity) (MWh)
	Energy production using RES (electricity) (MWh)
Share of RES (thermal)	Total Energy consumption (thermal)(MWh)
	Thermal energy production using RES (thermal) (MWh)
Excess Heat Recovery Ratio	Total waste heat (MWh)
	Utilization of waste heat (MWh)
Building energy efficiency measurement	Total energy demand (MWh/m2)
	Total Demand Electricity (MWh/m2)
	Total Demand Heating annual (MWh/m2)
	Total Demand Cooling annual (MWh/m2)
Energy Storage type	Type
Energy Storage number of equipment	Number
Energy Storage capacity	thermal (unit to be defined)
	electric battery (MW/MWh)
Total flexibility available (KW)	Total flexibility available (KW) considering EV charging points
Onsite energy ratio OER	Energy production using RES (MWh)
	Total energy demand (MWh)

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Annual Mismatch Ratio (AMR)	District Energy import (MWh)
	Energy production using RES (MWh)
	Total energy demand (MWh)
Energy costs per m2	Energy costs per m2

- **Step 2:**

  As a second activity, a thorough review of the LHCs (Espoo & Leipzig) profiles was carried out, by re-examining both cities' indicators and the Action Fields Analysis presented in D1.1 (2020b). This revealed the current performance of the LHCs in various sectors (such as energy, political dynamics, mobility, building transformation, governance and ICT), along with potential areas for improvement. This information was correlated against the list of KPIs that can be utilised in the envisioned dashboard and which will make it possible to monitoring of the cities performance in the aforementioned domains.

  For example, in the case of Espoo, the analysis revealed that its performance in the mobility sector could be improved, by enhancing the connectivity of public transport system, or promoting active mobility as a mode of transport, or even incentivising intramodality and sharing systems. This information was correlated with the KPIs defined in D2.2, in order to extract appropriate KPIs and prioritise them in terms of visualization. For this example, indicative KPIs that would make it possible to monitor Espoo's performance in the mobility sector include: increase in availability of shared EVs, increase in EVs share in local transportation, etc.

  The KPIs extracted through the aforementioned process that are related to the action fields analysis for both Espoo and Leipzig are presented in Table 4 and **Error! Reference source not found.** respectively.

Table 4 Action Fields and related KPIs - Espoo

Category	Espoo assessment	Related KPIs
Mobility	Better road management needed to drive the modal shift	Modal Split
	Need to actively develop car free areas	Clean mobility utilization Noise pollution Improve air quality

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Category	Espoo assessment	Related KPIs
	High potential of intervention through adapting the prices of alternative modes of transport	Increase of EVs share in local transportation Level of utilization of EV charging stations Increase of citizens using EV modes Transport behaviour
	City's mobility plan includes cycling and pedestrian movement as key elements.	District EV parking/charging places (car and bicycle)
		Clean mobility utilization
	Need to design actions for promoting active mobility	EV car sharing rate increase Increase in shared EVs availability
		# of youngsters using environmental friendly modes
		Education and teaching activities focused on energy transition and well-being
Political Dynamics	Actively seeks expertise from local stakeholders	Professional stakeholder involvement
	Availability of inter-institutional bodies with the needed knowledge and competence regarding urban sustainability issues.	Professional stakeholder involvement evaluation
	Political partiers within its political mandate that encourage and support digital issues.	Stakeholder and citizen engagement through digital technologies
Building transformation	Measures for efficient construction processes are in place	Integration of energy transition solutions into new neighbourhood developments
		Increase of integrated systems share (smart control/ VPP/ storage)
	The need to develop construction management concepts related to old buildings, the use of rain water in construction , and life-cycle analysis processes	Sustainability aspects in procurement
		District CHP Heat Generation increase (waste heat)

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Category	Espoo assessment	Related KPIs
	Need to encourage and incentivise buildings refurbishments	
	More than 10% of the office buildings are certified by one of the green building certification systems (LEED, DGNB)	
	Need to enhance the city's regulations in buildings energy performance through employing visualization tools for building energy performance	Increase of simulations executed via the Virtual Twins concept
ICT	E-tools for the participatory governance of energy services are missing	Increased number of persons using Espoo 3D city model
	Real-time information is not used for the development of intelligent traffic management system	Share of integrated systems (smart control
Energy	Switch to 100% use of renewable energies in public buildings and infrastructures	Share of RES (electricity) Share of RES (thermal)
	Energy efficiency has been improved in public buildings and infrastructures	Total electricity demand reduction Total heating demand reduction Energy costs per m2 Increase of district thermal energy export share Onsite energy ratio OER Open District Heating increase rate Utilization of batteries; % of energy stored and used from the battery
	Opportunity of action to use the city's progressive renewable energy share of supply to enhance their utilization in different fields	Onsite energy ratio OER
	Need for more promotion for the use of renewable energies among citizens	Local community involvement in planning / implementation phase
		Participatory planning initiatives for positive energy districts

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Category	Espoo assessment	Related KPIs
Governance	City's aptitude for the implementation of sustainable policies	Stakeholder awareness and social learning
	Existence of long-term strategy and sustainable vision for resilience	Stakeholder awareness and social learning
	integration of citizens in political processes	Engagement of citizens and stakeholders Experienced satisfaction of the co-creation participation Increase of Citizens' participation in market
	Indicator system to trace the city's sustainability performance	Utilization of energy system planning on the new urban development planning

Table 5 Action Fields and related KPIs – Leipzig

Category	Leipzig Action Fields assessment	Related KPIs
Mobility	Good scoring in road management, intramodality and sharing systems	EV parking/charging places (car and bicycle) Monetary gains for EV user Increased level of utilization of EV charging stations
	Optimized road network and transport routes for traffic distribution with provision of alternative routes	Increase of citizens using EV modes
	Strategically linked public transport nodes	Transport behaviour
	Increasing provision of e-mobility infrastructure in the city	EV car sharing rate increase Increase of EVs share in local transportation Increase of integrated smart EV charging units

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Category	Leipzig Action Fields assessment	Related KPIs
		Increased level of utilization of EV charging stations
	Need for redeveloping areas and create more public green spaces, as well as identifying and reconciling key danger areas for cyclists and pedestrians	Sustainability aspects in procurement
		Budget spent on green space management
Political Dynamics	Political willingness and openness to new opportunities and to innovate	Stakeholder awareness and social learning
	Formed coalitions/political mandates focusing on sustainability issues	Increased citizens' awareness for energy efficiency Professional stakeholder involvement evaluation Professional stakeholder involvement
	Digital platforms as for public participation through ICT	Stakeholder and citizen engagement through digital technologies Number of digital platforms used
	Has implemented control systems of corruption, is debating on future urban transformation strategies and long-term energy/decarbonization solutions	Organizational changes and new processes
Building transformation	Many regulations aiming to minimize pollution, noise and traffic through construction	eCO2 reduction Air quality Reduction of NOx, small particulates, tHC Noise Pollution

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Category	Leipzig Action Fields assessment	Related KPIs
	Control mechanism adjusted to assure that the building standards are met, and energy performance improved	Energy costs per m2 Increase of Citizens' contribution in BM creation
	The rates of refurbishment of municipal and private building stock should be improved, e.g., with financial incentives	Increased citizens' awareness for energy efficiency
	Lack of information regarding construction management.	Stakeholder awareness and social learning
ICT	E-tools for the participatory governance of energy services are missing	# of digital platforms used
	Leipzig uses real-time data from road traffic and public traffic systems while implementing intelligent traffic management	Share of integrated systems (smart control)
Energy	Implementation and use of smart grid technologies missing	Self consumption rate Increase Increase of integrated systems share Increase of Citizens participation in market
	Need for improvement in communal energy management and energy efficiency of industry	Share of RES increase Decrease of energy import share in the district Fossil fuels Energy Generation decrease Demand from all EV mobility modes

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Category	Leipzig Action Fields assessment	Related KPIs
		District self-consumption rate Citizens co-ownership of energy utilities Creation of community energy funds Integration of citizen-led organizations/associations in the co-creation for Positive Energy Districts)
	Renewable energy sources are not implemented on a large scale especially recovering heat from the sewage systems, geothermal and environmental are viable options.	Share of RES increase annually Share of RES increase (heat, solar thermal) Heat Recovery Ratio Decrease of energy import share Decrease of thermal energy import share
	Public buildings and infrastructures could be optimized with smart grids and switch to renewable energies	Onsite energy ratio OER District self-consumption rate Peak Load Reduction
		Organizational changes and new processes
	Need for incentives for the implementation of renewable strategies	Renumeration due to flexibility delivered (Euro)
		Increase of district thermal energy export share Total energy demand reduction Energy Storage number of equipment Increase District self consumption rate

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Category	Leipzig Action Fields assessment	Related KPIs
Governance	Outranging performance in municipal climate change management/mitigation and in defining a long-term vision and goals for sustainable cities development.	Monitoring and reporting Innovation potential
	Cooperation with key stakeholders from different sectors	Stakeholder and citizen engagement through digital technologies # of digital platforms used
	Need for more testing of innovative technologies and solutions	Energy transfers through blockchain transactions Volume of exchanges/ transactions (monetary) over blockchain
	Defined regulations and restrictions pursuing modal shift e.g., speed limits or implemented priority lanes for buses and trams	Consultation plan
	Need for new structures for cross-sectoral cooperation's and joined responsibilities within the municipality	Co-creation initiatives (lead by partner cities) on energy positive district
		Local community involvement in planning / implementation phase
	Set of higher social and environmental standards useful through negotiated and voluntary agreements, e.g., to convey higher building standards and higher sustainable measures	Participatory planning initiatives for positive energy districts Knowledge sharing and access to information to increase citizens and stakeholders' engagement

- **Step 3:**

  During the third step, the input from the two previous activities was utilised to prioritise the KPIs to be visualised in the envisioned dashboard. More specifically the activities focused on refining and prioritising the KPIs identified in the previous steps, by taking into consideration aspects such as their granularity and application level (i.e., Macro/City/District), as well as the overall design and development specifications of the SPARCS ICT ecosystem defined in D2.4.

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Prioritisation of the KPIs was based on the analysis of their data characteristics; KPIs with "High" granularity are those that can be calculated more frequently, since the data for their calculation is expected to be collected in the SPARCS Data Management Platform at more regular intervals (i.e per minute, per hour, per week). On the other hand, KPIs with "low" granularity are those that are calculated more sporadically, since the required data are expected to be collected monthly or yearly or even consist of static values. It should be noted that as the project progresses, the granularity of the collected data is expected to change, thus the prioritisation of the KPIs to be visualised will change accordingly.

While all KPIs identified in D2.4 (2021b) could be potentially visualised in the SPARCS dashboard, through their "visualisation prioritisation" it was possible to focus on the KPIs which were identified as most important (i.e., with the highest priority) since their data availability/granularity allows for more frequent performance measurement.

Table 6 below presents a list of impact indicators for the case of Espoo along with their application level and their granularity as identified in D2.2 (2021b). Accordingly, Table 7, presents the granularity for the KPIs list of Espoo's E1 Intervention and Table 8 presents the granularity level of the Espoo's Energy action fields related KPIs.

Once again, to avoid repetition, only the KPIs related to the main impacts and those of just one of Espoo interventions, namely E1, are presented here, accompanied by the Espoo's energy action field-related KPIs. The reader is referred to D2.2 for the KPIs relating to the rest of Espoo's interventions and for similar lists for Leipzig.

Table 6 Granularity of Espoo's impact indicators

#	KPIs	Impacts	Level	Granularity
1	Reduction of eCO2 emissions	General Impacts, Impact 1, Impact 6	Macro/District	Low
2	Air quality	Impact 1, Impact 6	Macro /District	Low
3	Share of RES increase	General Impacts, Impact 2	Macro /District	High
4	Excess Heat recovery ratio	Impact 2	Macro /District	High
5	Increase of integrated systems	Impact 2	Macro /District	Low
6	Decrease of energy import share	Impact 3	District	High
7	Total electricity demand reduction	General Impacts	Macro /District	High
8	Total heating demand reduction	General Impacts	Macro /District	High

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9	Increase of Citizens participation in market	Impact 4	District	Low
10	Self-consumption rate increase	Impact 4	District	High
11	EV car sharing rate increase	Impact 5	Macro /District	Low
12	Increase of EVs share in local transportation	Impact 5	Macro /District	Low
13	Transport behaviour	Impact 5	Macro /District	Low
14	Increase of EV (smart) charging points	Impact 5	Macro /District	Low
15	Utilization of charging stations	Impact 5	District	Low
16	Energy Storage Increase	Impact 2	District	Low
17	Peak load (electricity) reduction	Impact 4	District	Low
18	Peak load (heating) reduction	Impact 4	District	Low
19	Onsite Energy Ratio (OER)	Impact 4	District	Low
20	Total generation curtailment	Impact 4	District	Low
21	Utilization of charging stations	Impact 5	Macro /District	Low
22	Replication strategy	Impact 7	City	Low
23	Annual number of new patents	Impact 8	Macro	Low
24	Job creation	Impact 9	Macro /District	Low
25	Increase citizens quality of life, health and well-being	Impact 10	Macro /District	Low
26	Annual number of contributions to European Standardization Organizations	Impact 11	Macro	Low
27	ROI	Overall Impact	Macro /District	Low
28	Payback time	Overall Impact	Macro /District	Low
29	DSCR	Overall Impact	Macro /District	Low

Table 7 Granularity of Espoo's intervention- E1 KPIs

KPI	Data	Granularity
Share of RES (electricity)	Total Energy consumption (electricity) (MWh)	High
	Energy production using RES (electricity) (MWh)	

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Share of RES (thermal)	Total Energy consumption (thermal)(MWh)	High
	Thermal energy production using RES (thermal) (MWh)	
Excess Heat Recovery Ratio	Total waste heat (MWh)	High
	Utilization of waste heat (MWh)	
Building energy efficiency measurement	Total energy demand (MWh/m2)	High
	Total Demand Electricity (MWh/m2)	
	Total Demand Heating annual (MWh/m2)	
	Total Demand Cooling annual (MWh/m2)	
Energy Storage type	Type	Low
Energy Storage number of equipment	Number	Low
Energy Storage capacity	thermal (unit to be defined)	Low
	electric battery (MW/MWh)	
Total flexibility available (KW)	Total flexibility available (KW) considering EV charging points	Low
Onsite energy ratio OER	Energy production using RES (MWh)	Low
	Total energy demand (MWh)	
Annual Mismatch Ratio (AMR)	District Energy import (MWh)	Low
	Energy production using RES (MWh)	
	Total energy demand (MWh)	
Energy costs per m2	Energy costs per m2	Low

Table 8 Granularity of Espoo's energy action fields related KPIs

Category	Espoo Action Fields assessment	KPIs	Granularity
Energy	Switch to 100% use of renewable	Share of RES (electricity)	High

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	energies in public buildings and infrastructures	Share of RES (thermal)	High
	Energy efficiency has been improved in public buildings and infrastructures	Total electricity demand reduction	High
		Total heating demand reduction	High
		Energy costs per m2	Low
		Increase of district thermal energy export share	Low
		Onsite energy ratio OER	High
		Open District Heating increase rate	Low
		Utilization of batteries; % of energy stored and used from the battery	Low
	Opportunity of action to use the city's progressive renewable energy share of supply to enhance their utilization in different fields	Onsite energy ratio OER	Low
	Need for more promotion for the use of renewable energies among citizens	Local community involvement in planning / implementation phase	Low
		Participatory planning initiatives for positive energy districts	Low

Having identified the pool of cities' indicators/KPIs to be visualised in the envisioned dashboard and upon consideration of their granularity and application level, Table 9 below presents the extracted priorities for the non-exhaustive lists of KPIs presented in Table 6, Table 7 and Table 8Table 8; where the following three priorities were considered:

- **P1**: High priority - denotes KPIs that are either related to the project's impact (Step 1) or those identified through the LHCs Action Fields Analysis (Step 2) and are of high granularity. These KPIs will be presented at the top of the list of the main KPIs presented in the dashboard.

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- **P2:** Medium priority - denotes KPIs that are either impact related (Step 1) or those identified in Step 2 that are of low granularity; OR KPIs that are neither impact related, nor identified in Step 2 and of high granularity.
- **P3:** Low priority - denotes KPIs that are neither impact related (Step 1), nor identified in Step 2; and of low granularity. These KPIs will be only visible to the users upon scrolling to the bottom of the presented list.

Table 9 Prioritisation of KPIs to be visualised in Espoo

KPI Name	Impact or Target KPI	Granularity (High)	Priority
Reduction of eCO2 emissions	Yes	No	P2
Air quality	Yes	No	P2
Share of RES increase	Yes	Yes	P1
Excess Heat Recovery Ratio	Yes	Yes	P1
Increase of integrated systems	Yes	No	P2
Decrease of energy import share	Yes	Yes	P1
Total electricity demand reduction	Yes	Yes	P1
Total heating demand reduction	Yes	Yes	P1
Increase of Citizens participation in market	Yes	No	P2
Self-consumption rate increase	Yes	Yes	P1
EV car sharing rate increase	Yes	No	P2
Increase of EVs share in local transportation	Yes	No	P2
Transport behaviour	Yes	No	P2
Increase of EV (smart) charging points	Yes	No	P2
Utilization of charging stations	Yes	No	P2
Total flexibility available (KW)	No	No	P3
Energy Storage Increase	Yes	No	P2
Energy Storage type	No	No	P3
Energy Storage number of equipment	No	No	P3
Energy Storage capacity	No	No	P3
Peak load (electricity) reduction	Yes	No	P2
Peak load (heating) reduction	Yes	No	P2
Onsite Energy Ratio (OER)	Yes	No	P2
Total generation curtailment	Yes	No	P2
Utilization of charging stations	Yes	No	P2
Replication strategy	Yes	No	P2
Annual number of new patents	Yes	No	P2
Job creation	Yes	No	P2
Increase citizens quality of life, health and well-being	Yes	No	P2
Annual number of contributions to European Standardization Organizations	Yes	No	P2
ROI	Yes	No	P2
Payback time	Yes	No	P2
DSCR	Yes	No	P2
Share of RES (electricity)	Yes	Yes	P1
Share of RES (thermal)	Yes	Yes	P1
Total electricity demand reduction	Yes	Yes	P1
Total heating demand reduction	Yes	Yes	P1

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Energy costs per m²	Yes	No	P2
Building energy efficiency measurement	No	Yes	P2
Increase of district thermal energy export share	Yes	No	P2
Onsite energy ratio (OER)	Yes	Yes	P1
Open District Heating increase rate	Yes	No	P2
Utilization of batteries; % of energy stored and used from the battery	Yes	No	P2
Excess Heat Recovery Ratio	Yes	Yes	P1
Local community involvement in planning / implementation phase	Yes	No	P2
Participatory planning initiatives for positive energy districts	Yes	No	P2
Annual Mismatch Ratio (AMR)	Yes	Yes	P1

Following the same approach, the exercise to track the granularity of all related indicators in the city of Leipzig, as well as the table with the priorities of the KPIs to be visualized, can be found in ANNEX A.

It is expected, that the methodology followed to prioritize the indicators, taking into account the data granularity information available at this stage of the project, will be executed again, once the intervention implementation in the Lighthouse cities is finalized and updated information about the data availability and granularity becomes available.

As an outcome of this three-step methodology, adequate mock-ups were created (see chapter 4) while additional design considerations that were extracted and will drive the overall design of the SPARCS Visualization Dashboard are presented in the following section.

3.2 Design considerations

In addition to the first set of design requirements identified in D2.4 (2020b), this section presents supplementary ones that shall be followed during design of the SPARCS Visualization Dashboard. These requirements are largely based on utilising the outcome of the KPIs visualisation-priority activity and which are described as follows:

The SVF will provide visualisation of KPIs through two main dashboards:

- Cities Indicators; here KPIs will be visualised at city level (e.g., Espoo or Leipzig) and at demo site level. When at demo-site level , users will be able to filter the KPIs according to the interventions of each demo site. In addition, by selecting the "Categorised Indicators" tab, they will be able to view the KPIs grouped into predefined categories.
- Cities Comparison, here users will be able to view KPI comparisons among the project's LHCs, through visualisation of similar KPIs. This functionality is largely based on the normalisation methodology described on D2.2 (2021b).

High priority (P1) and medium priority (P2) KPIs shall be presented first to the users and provided at city-level. As an example, in Figure 2 depicting the envisioned dashboard, users will be able to select their city of interest (e.g., City 1) via the dropdown menu on the left-hand side of the screen. The use of a dropdown menu is preferred as it will allow

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the addition of further cities and/or demo sites (in the form of a list) without the need to noticeably change the dashboard design.
The KPIs denoted as P1 will be the ones presented first in the list, followed by the KPIs of medium (P2) priority, which will be visible by scrolling down the page.

It should be noted that the extracted priorities of the KPIs (i.e., P1, P2, P3) will not be visible to the dashboard users, as the overall scope of the visualisation prioritisation activity was aimed precisely at removing such burden from the users by presenting the most meaningful KPIs first.

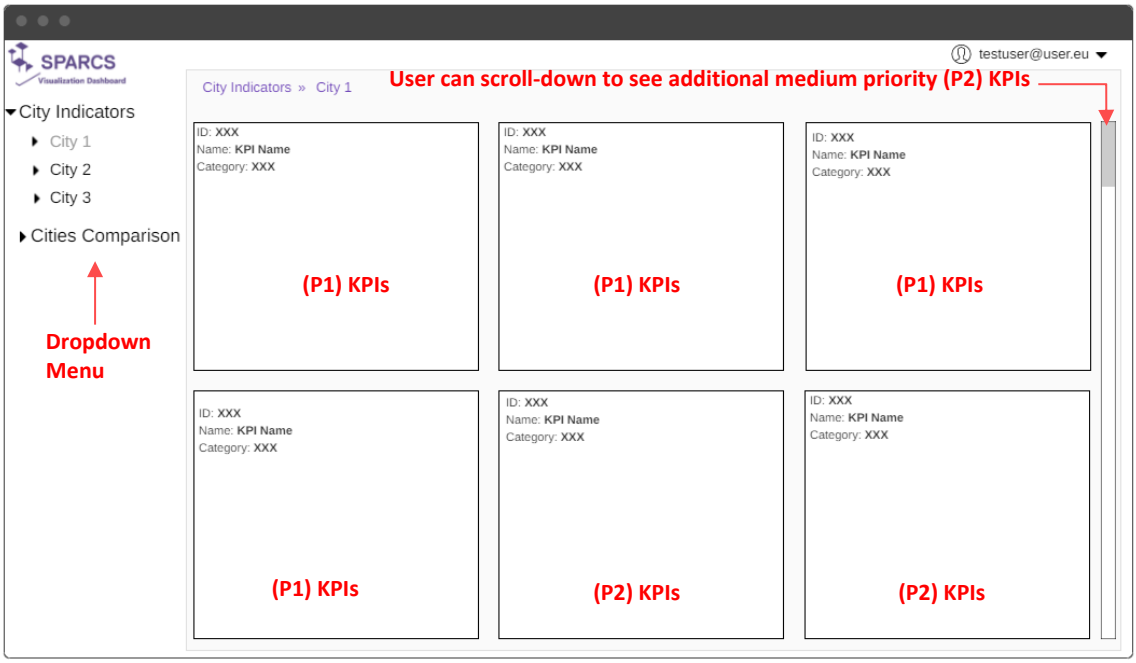

Figure 2 City level indicators (P1, P2)

As regards the low (P3) priority KPIs, these shall be visible only when the users select a city-specific demo site (i.e only at demo-site level). As shown in Figure 3, upon selecting a city of interest (e.g., City 1) and a specific demo site (e.g., Demo-site 1), users will be able to view all the KPIs related to the demo site's and filter according to the interventions taking place there. KPIs denoted as P1 will be presented first at the top of the page, followed by medium (P2) and low (P3) priority KPIs, which can be seen by scrolling further down.

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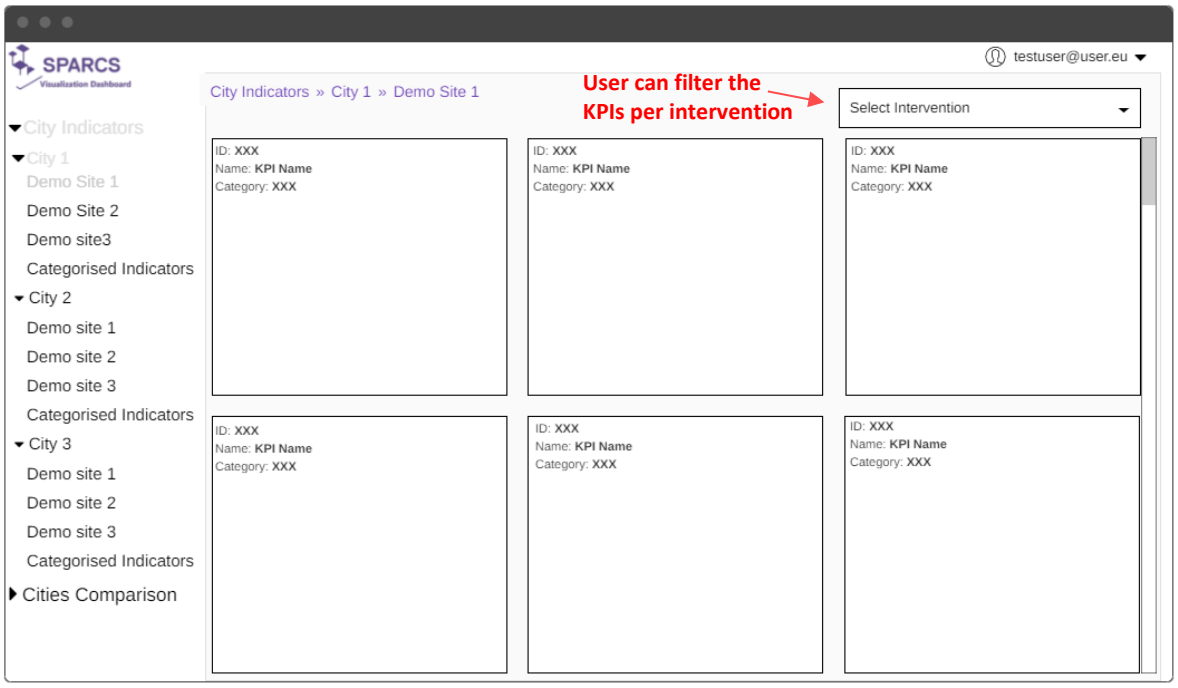

Figure 3 Demo site level indicators (PI, P2, P3)

As an additional option, (see Figure 4) users will be able to view the complete list of KPIs listed by priority, selecting the "Categorised Indicators" tab; where they can also filter the KPIs according to predefined categories.

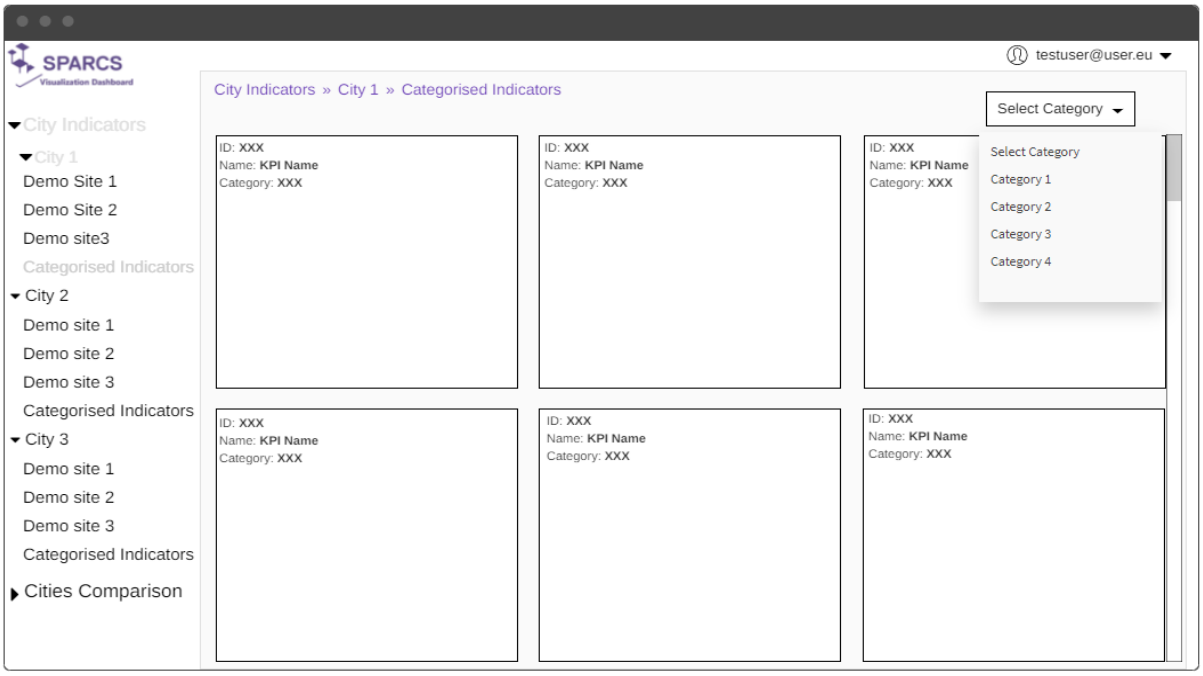

Figure 4 Categorised indicators

Visualisation of the KPIs shall be communicated to their audience as effectively as possible. To this end, supplementary metadata will be also made available to the users when presenting a KPI. This metadata could include the timestamp when the data was collected and/or last updated, as well as further information related to the specific KPI such as its category, level of application, measurement unit and method of calculation.

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4. SPARCS VISUALISATION MOCK-UPS

The following sections present the latest mock-ups of the SPARCS Visualization Framework, generated in an effort to graphically depict how the overall SPARCS Visualization Dashboard will be designed and how the KPIs will be presented in its first stable release. To this end, a usage walkthrough is provided with mock-ups of the individual functionalities of the dashboard, as an outcome of the aforementioned methodology and considering the SVF stakeholders and technical requirements (as documented in D2.4) and design considerations described in this document, as well as the initial feedback received from the LHCs partners.

It should be noted that dummy data have been used to generate of the mock-ups depicting indicative KPIs visualisations, while the actual dashboard to be delivered in M30 will incorporate all the data collected in the SPARCS Data Management Platform deriving from the LHCs distributed sources.

4.1 Landing page - Open Access Dashboard

As shown in Figure 5, the landing page of the SPARCS Visualization Dashboard, presents the dashboard's main objective along with some basic information on the scope of the SPARCS project. A link to the SPARCS project's website[1] is also provided, towards increasing reachability, as well as usefulness and traffic for both.

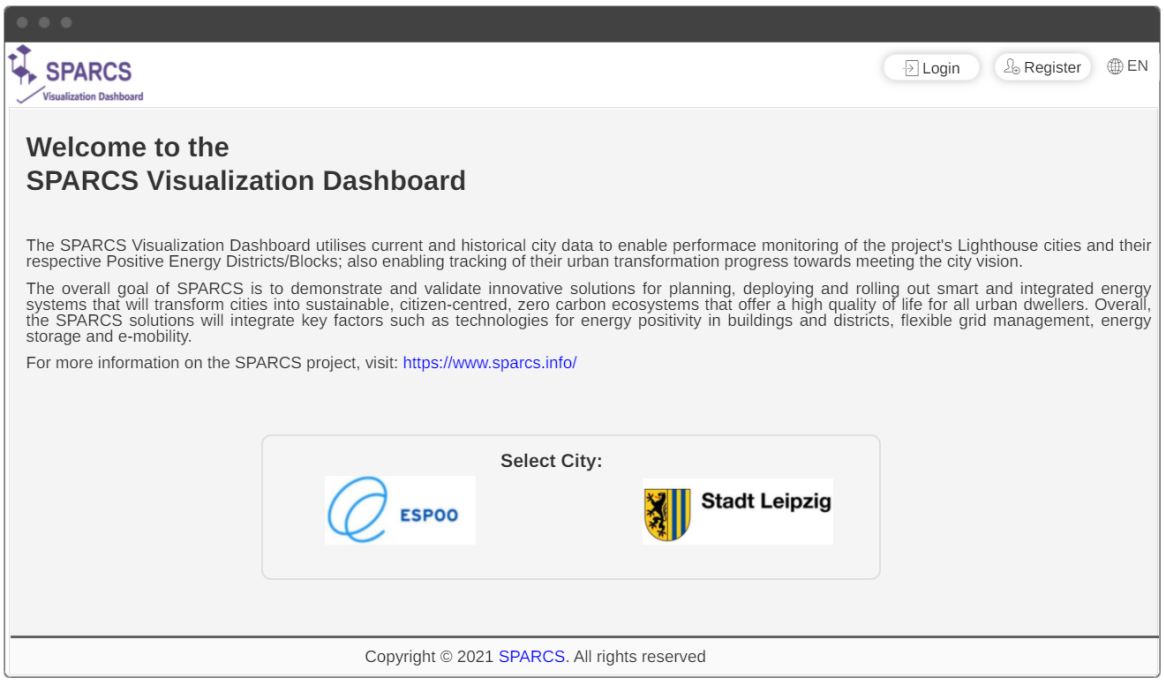

Figure 5 SPARCS Visualization Dashboard – Landing page

Once the users select their city of interest (i.e Espoo or Leipzig) they are directed to the respective city's open-access dashboard. For example, as shown in Figure 6 below, by selecting the city of Leipzig, users will be able to see a brief summary of the city's goals, as

[1] http://sparcs.info/

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well as visualizations of basic KPI's and city's indicators (such as weather conditions, and air quality index (AQI)), providing context to the user in regard to the city's performance. For viewing all the available city's indicators and delving deeper into visualizing each city's districts/interventions indicators, users are prompted to Login/Register, by using the respective button.

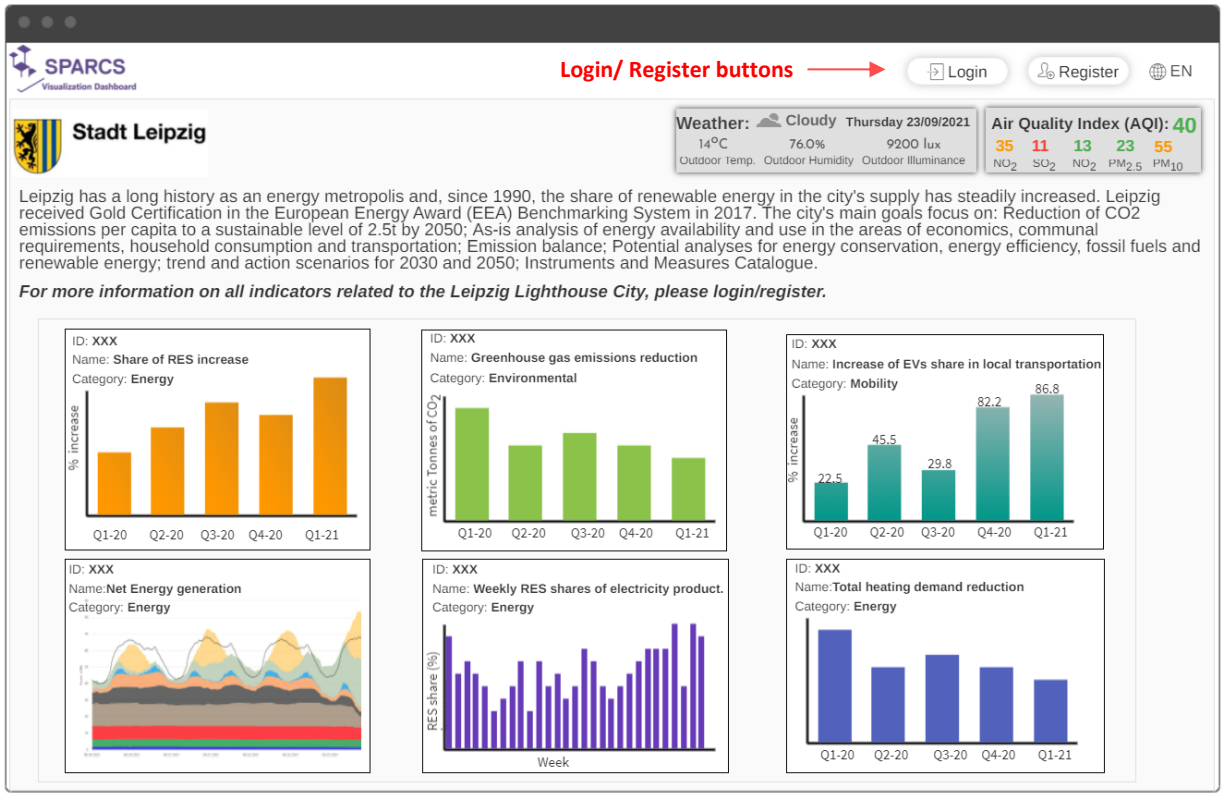

Figure 6 Leipzig Lighthouse City -Open Access dashboard

4.2 Registration & Authorisation

Through this dashboard (see Figure 7) users will be able to manage their account. In general, the registration process is delivered in a semi-automatic way, where users provide their preferred username, email and password in order to create their account.

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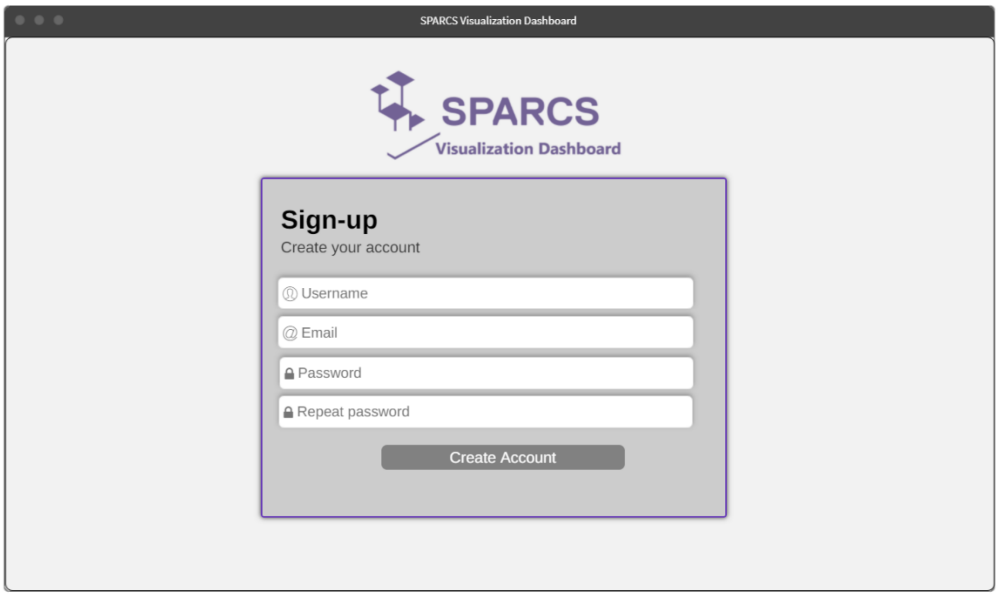

Figure 7 Sign-up page

Once signed-in, the users will be able to login to the SPARCS Visualization Dashboard, by providing the username and password entered during the sign-up process and by clicking on the Login button (see Figure 8). Form here, user can also retrieve their password, e.g., if forgotten.

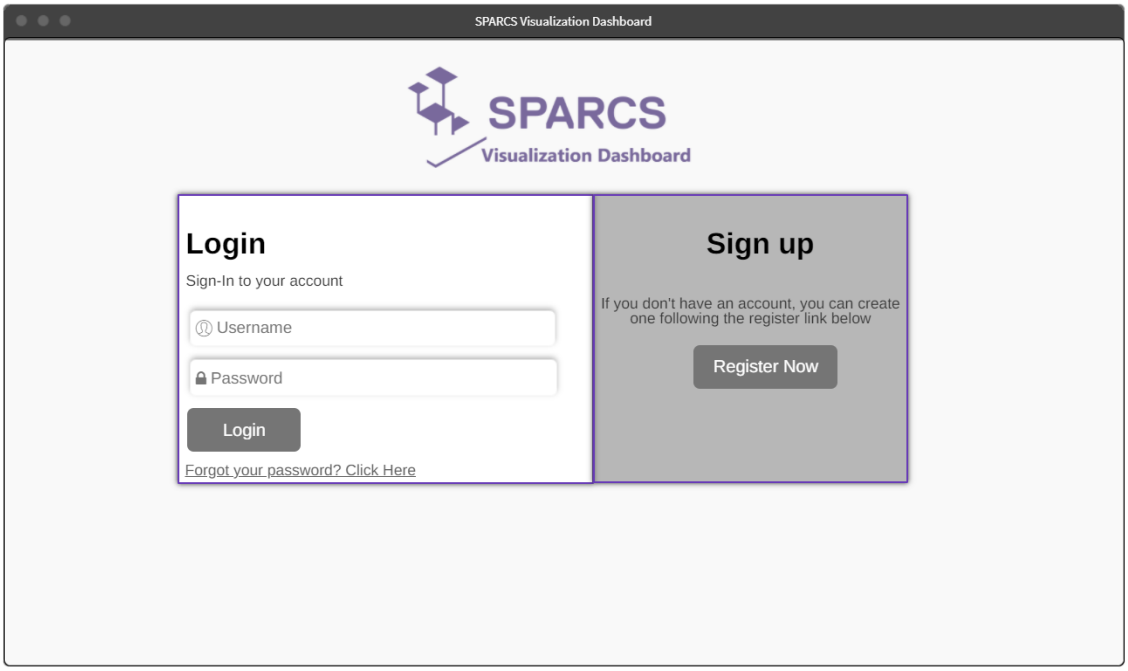

Figure 8 Log-in Page

4.3 City Indicators

As shown in Figure 9, once a user is logged-in, he/she will be directed to the "City Indicators" page. Here users can select their city of interest from the left-side dop-down menu to view all the relevant KPIs.

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In this example, the city of Espoo is selected and the user can see visualization of various KPIs of different categories As detailed in section 3.2 the KPIS here are listed in a descending order based on their visualisation priority, where KPIs denoted as P1 are presented first, followed by P2 which can be seen by scrolling down the page.

Figure 9 City Indicators – City level (Espoo) screen

To provide as much context as possible to the dashboard users, once they click on a specific KPI (e.g., Share of RES increase), they will be able to view a larger screen of the visualisation (see Figure 10) supplemented by additional information related to the KPI, such as its category, application level, description, granularity, calculation formula and measurement unit, the timestamp when the data were last updated, and where applicable the target values.

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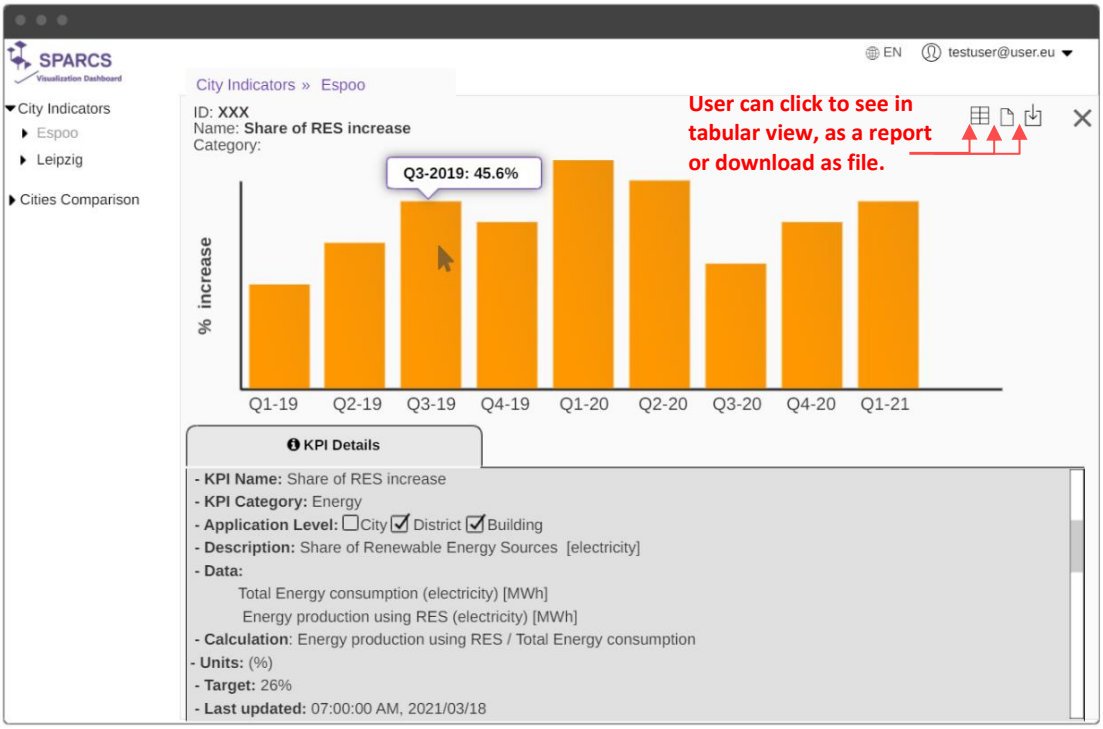

Figure 10 City Indicators – KPI detailed view

Hovering over the chart will be provide additional details, while users can click on the buttons provided to have a tabular view of the values, see it as a report or download as file (e.g., xls, csv, etc.). At any time, the user can close this window, which will direct him/her to the previous screen (Figure 9).

Further to the above and with a view to allowing users to quickly understand a KPI, by hovering over a KPI of interest, users will see a popup window summarising the KPI's details (see Figure 11). Users will be able to close this windows at any time, by clicking on the X button.

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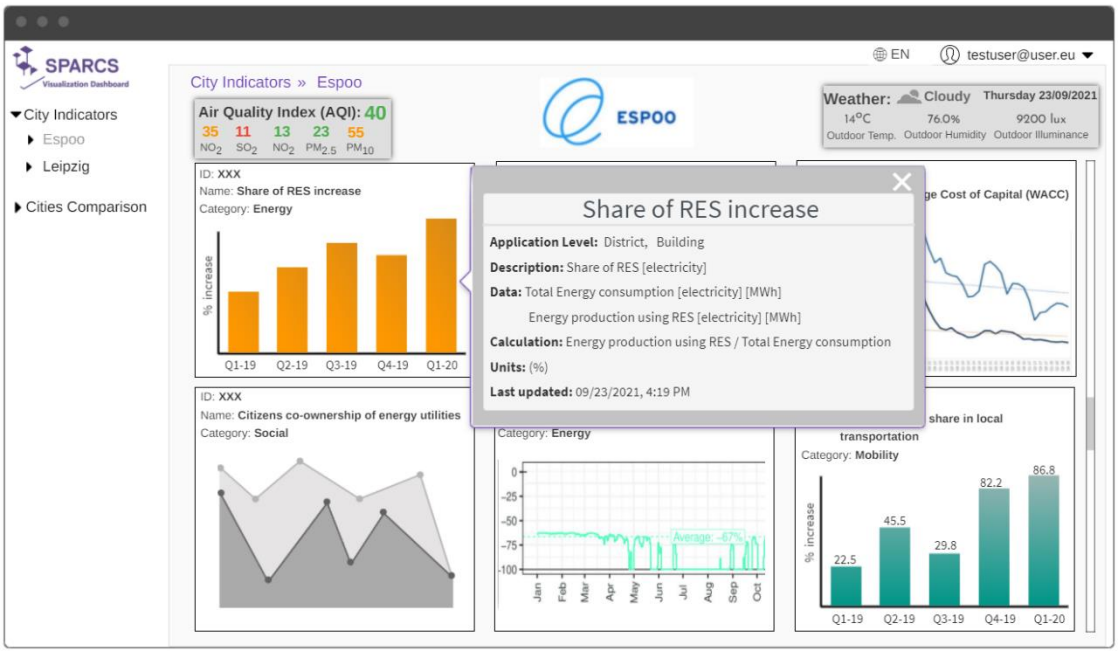

Figure 11 City Indicators – KPI information view

The SPARCS Visualization Dashboard also enables users to delve deeper into each city by selecting their city-specific demo-site of interest. As shown in Figure 12, through this screen, users will be provided with all the KPIs related to the demo site select (e.g., Espoo-Lippulaiva), while they can also filter the KPIs by interventions specific to them demo, by selecting one from a predefined list, provided in the upper right-hand corner.

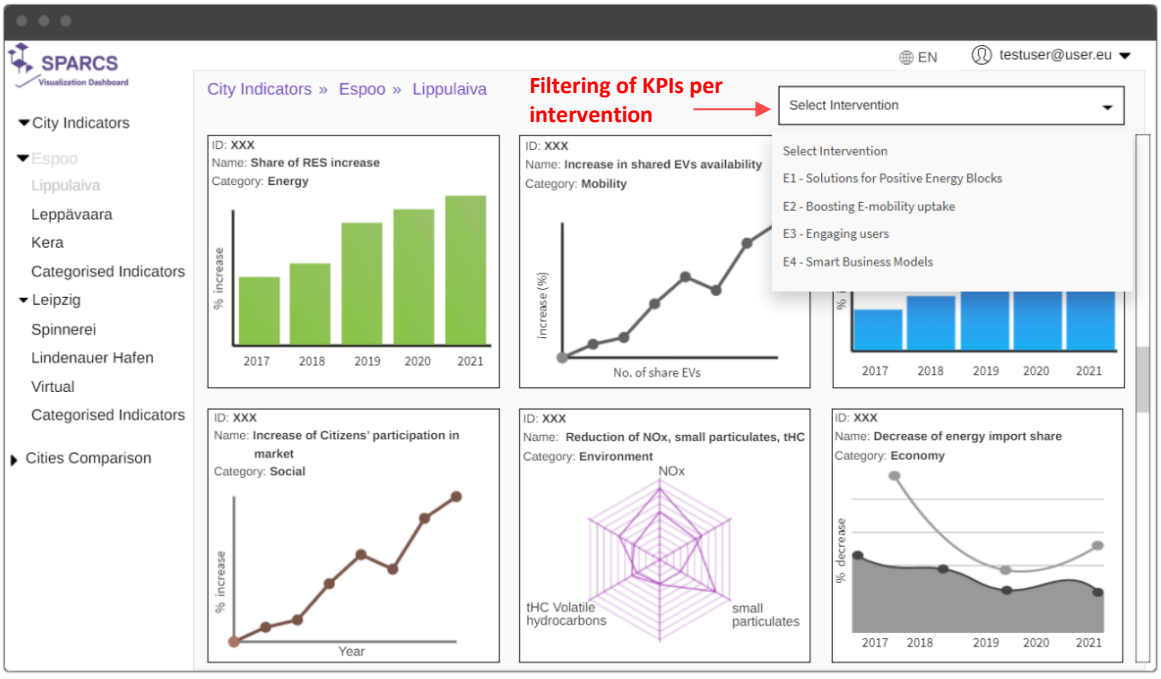

Figure 12 City Indicators-Demo site level (Lippulaiva) view

When selecting the "Categorised Indicators" (see Figure 13), users will be able to view all the KPIs related to the selected city (e.g., Espoo) and grouped into predefined categories. These categories are based on the KPIs categorisation defined in D2.2, and are namely:

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Citizen Engagement, Economy, Energy, Environmental, Governance, ICT, Mobility, and Social.

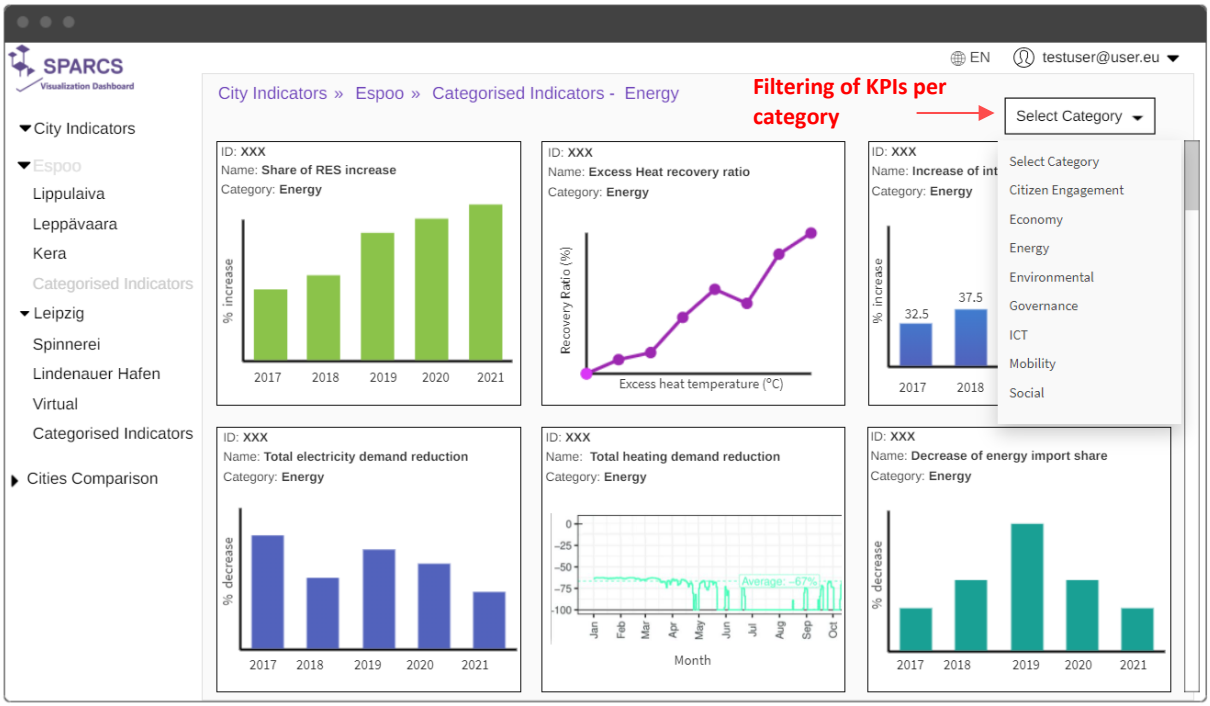

Figure 13 City Indicators – Categorised Indicators view

4.4 Cities Comparison

The second main functionality of the SPARCS Visualization Framework enables a direct comparison between the project's Lighthouse Cities (at least in its first stable release) by presenting the LHCs impact KPIs. The KPIs to be presented in this case, derived from the normalisation process (described in D2.2), are aimed at removing the particularities and exogenous characteristics of cities in order to enable a direct KPI comparison for individual cities.

As shown in Figure 14, once the user selects the "Cities Comparison" from the dropdown menu, he/she will be able to view how the project's LHCs are performing with respect to specific comparable KPIs, which are presented one next to each other. The users will be also able to filter the KPIs by category.

A detailed list of comparable indicators will be identified as the project progresses, based on the provision of the final data assets and the related city characteristics required for the normalisation process. Possible enhancements and additions of the visualization concept will be carried out as required, in order to cover the specific needs.

It should be noted at this point, that in addition to the data that will be made available from the interventions implemented in the Lighthouse Cities, similarly, data input will become available from the Fellow Cities, enabling the calculation of KPI for the main impacts and for specific interventions. Making it possible to compare indicators derived from multiple cities or being able to select the cities under comparison, are visualization enhancements that need to be considered based on the needs. Visualisation

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enhancements to be considered based on requirements will make it possible to select cities for comparison and to compare indicators derived from multiple cities.

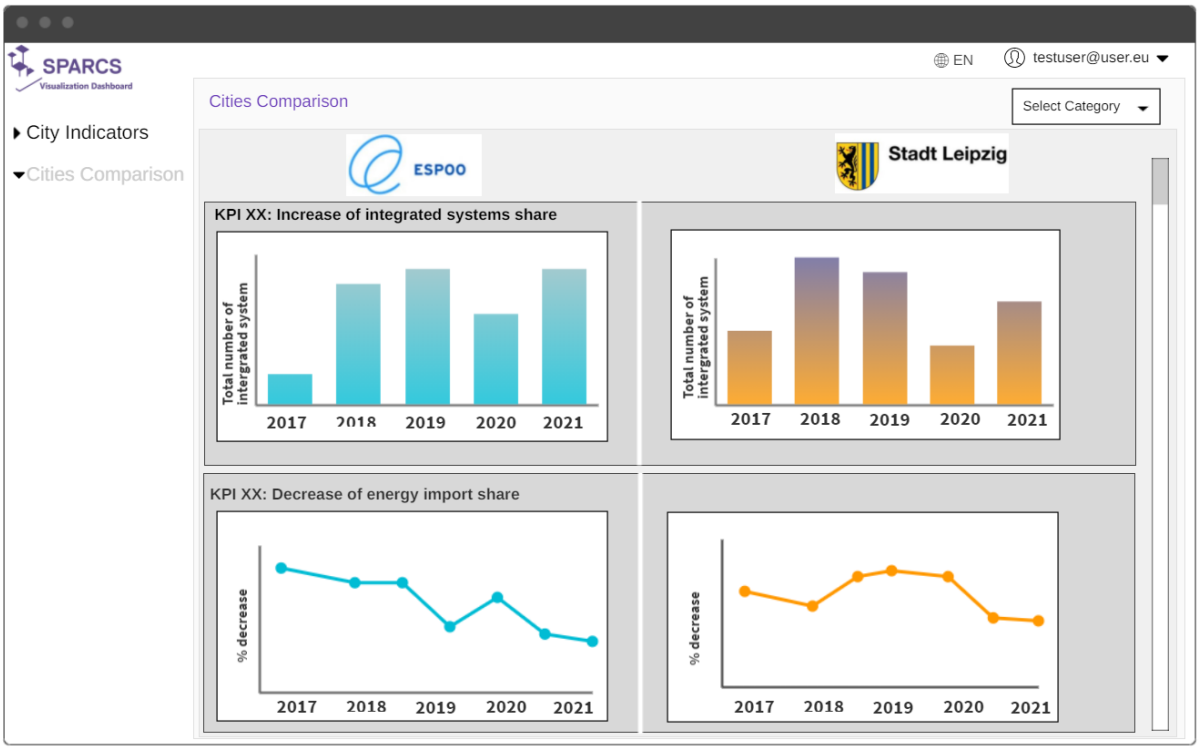

Figure 14 Cities Comparison view

Lastly as shown in Figure 15, at any time by clicking on the user's account (top right), a Settings menu is provided. Here users can either select the "Personal Profile" to manage their account (e.g., reset their username, password, etc.) or log-out from the dashboard.

Figure 15 Setting Menu / Logout

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5. CONCLUSIONS

The current deliverable D1.6 – Visualization framework for assessing city performance, provides a thorough description of the envisioned SPARCS Visualization Framework by providing further design considerations and the final set of mock-ups that shall be used for the design and delivery of the respective SPARCS Visualization Dashboard. This dashboard will utilise the datasets collected in the SPARCS Data Management Platform and following processing, will deliver meaningful KPI visualisations to all key stakeholders, thus enabling continuous monitoring and evaluation of the project's progress and its LHCs' performance.

To this end the current document elaborated on the benefits of the visualisation in the context of SPARCS project and delivered a final set of design considerations and mock-ups that will be used as the basis for the development and delivery of the first stable release of the SPARCS Visualization Dashboard, due in M30 of the project.

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APPENDICES

ANNEX A

Granularity of basic impact, L1 intervention and energy action fields related indicators for the city of Leipzig is presented in the next tables, followed by a table that presents the prioritisation of KPIs to be visualised.

Table 10 Granularity of Leipzig's impact indicators

#	KPIs	Impacts	Level	Granularity
1	Reduction of eCO2 emissions	General Impacts, Impact 1, Impact 6	Macro/District	Low
2	Air quality	Impact 1, Impact 6	Macro /District	High
3	Share of RES increase	General Impacts, Impact 2	Macro /District	Low
4	Excess Heat recovery ratio	Impact 2	District	Low
5	Increase of integrated systems	Impact 2	Macro /District	Low
6	Decrease of energy import share	Impact 3	Macro/District	Low
7	Total electricity demand reduction	General Impacts	Macro /District	Low
8	Total heating demand reduction	General Impacts	Macro /District	Low
9	Increase of Citizens participation in market	Impact 4	District	Low
10	Self-consumption rate increase	Impact 4	Macro/District	Low
11	EV car sharing rate increase	Impact 5	Macro /District	Low
12	Increase of EVs share in local transportation	Impact 5	Macro	Low
13	Transport behaviour	Impact 5	Macro /District	Low
14	Increase of EV (smart) charging points	Impact 5	Macro /District	Low
15	Utilization of charging stations	Impact 5	District	Low
16	Energy Storage Increase	Impact 2	District	Low
17	Peak load (electricity) reduction	Impact 4	District	Low

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18	Peak load (heating) reduction	Impact 4	District	Low
19	Onsite Energy Ratio (OER)	Impact 4	District	Low
20	Total generation curtailment	Impact 4	District	Low
21	Utilization of charging stations	Impact 5	District	Low
23	Annual number of new patents	Impact 8	Macro	Low
24	Job creation	Impact 9	Macro	Low
25	Increase citizens quality of life, health and well-being	Impact 10	Macro	Low
26	Annual number of contributions to European Standardization Organizations	Impact 11	Macro	Low
27	ROI	Overall Impact	Macro /District	No
28	Payback time	Overall Impact	Macro /District	No
29	DSCR	Overall Impact	Macro /District	No

Table 11 Granularity of Leipzig's Intervention- L1 KPIs

KPI	Data	Granularity
Energy Storage number of equipment Increase	#	Low
Energy Storage capacity Increase	KWh	Low
Peak Load Reduction	Peak demand (kW)	Low
Reduced System Average Interruption Duration Index (SAIDI)	System Average Interruption Duration	Low
Reduced System Average Interruption Frequency Index (SAIFI)	System Average Interruption Frequency	Low
Demand from all EV mobility modes; impact on the grid	A sum of the demand from all EV mobility modes Considering EV Smart chargers (Sum of peak demand of all charging stations)	Low

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User satisfaction of minimum charging level in EVs	User Satisfaction of minimum charging levels in EVs Likert survey results	Low
monetary gains for user (charging costs vs flexibility revenues)	EV User charging costs	Low
	EV flexibility revenues for the user	Low
satisfaction of minimum charging level for commercial Evs (for carrying out their daily routes)	satisfaction of minimum charging level for commercial Evs (for carrying out their daily routes) Likert survey results	Low
Accuracy of Generation forecasting	Predicted generation compared to the actual generation	Low
Accuracy of storage utilization	The storage utilization predected compared to the actual utilization of the storage	Low
Increase in shared EVs availability	#EVs available for sharing	Low
increase of integrated smart EV charging units	# of smart EV charging stations	Low
Increased level of utilization of EV charging stations	∑kWh charged	Low

Table 12 Granularity of Leipzig's energy action fields related KPIs

Category	Leipzig Action Fields assessment	Related KPIs	Granularity
Mobility	Good scoring in road management,	EV parking/charging places (car and bicycle)	Low

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Category	Leipzig Action Fields assessment	Related KPIs	Granularity
	intramodality and sharing systems	Monetary gains for EV user	Low
		Increased level of utilization of EV charging stations	Low
	Optimized road network and transport routes for traffic distribution with provision of alternative routes	Increase of citizens using EV modes	Low
	Strategically linked public transport nodes	Transport behaviour	Low
	Increasing provision of e-mobility infrastructure in the city	EV car sharing rate increase	Low
		Increase of EVs share in local transportation	Low
		Increase of integrated smart EV charging units	Low
		Increased level of utilization of EV charging stations	Low
	Need for redeveloping areas and create more public green spaces, as well as identifying and reconciling key danger areas for cyclists and pedestrians	Sustainability aspects in procurement	Low
		Budget spent on green space management	Low
Political Dynamics	Political willingness and openness to new opportunities and to innovate	Stakeholder awareness and social learning	Low
	Formed coalitions/political mandates focusing on sustainability issues	Increased citizens' awareness for energy efficiency	Low
		Professional stakeholder involvement evaluation	Low

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Category	Leipzig Action Fields assessment	Related KPIs	Granularity
		Professional stakeholder involvement	Low
	Digital platforms as for public participation through ICT	Stakeholder and citizen engagement through digital technologies	Low
		Number of digital platforms used	Low
	Has implemented control systems of corruption, is debating on future urban transformation strategies and long-term energy/decarbonization solutions	Organizational changes and new processes	Low
Building transformation	Many regulations aiming to minimize pollution, noise and traffic through construction	eCO2 reduction	Low
		Air quality	High
		Reduction of NOx, small particulates, tHC	High
		Noise Pollution	Low
	Control mechanism adjusted to assure that the building standards are met, and energy performance improved	Energy costs per m2	High
		Increase of Citizens' contribution in BM creation	Low
	The rates of refurbishment of municipal and private building stock should be improved, e.g., with financial incentives	Increased citizens' awareness for energy efficiency	Low

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Category	Leipzig Action Fields assessment	Related KPIs	Granularity
	Lack of information regarding construction management.	Stakeholder awareness and social learning	Low
ICT	E-tools for the participatory governance of energy services are missing	# of digital platforms used	Low
	Leipzig uses real-time data from road traffic and public traffic systems while implementing intelligent traffic management	Share of integrated systems (smart control)	Low
Energy	Implementation and use of smart grid technologies missing	Self consumption rate Increase	Low
		Increase of integrated systems share	Low
		Increase of Citizens participation in market	Low
	Need for improvement in communal energy management and energy efficiency of industry	Share of RES increase	Low
		Decrease of energy import share in the district	Low
		Fossil fuels Energy Generation decrease	Low
		Demand from all EV mobility modes	Low
		District self-consumption rate	Low
		Citizens co-ownership of energy utilities	Low
		Creation of community energy funds	Low
		Integration of citizen-led	Low

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Category	Leipzig Action Fields assessment	Related KPIs	Granularity
		organizations/associations in the co-creation for Positive Energy Districts)	
	Renewable energy sources are not implemented on a large scale especially recovering heat from the sewage systems, geothermal and environmental are viable options.	Share of RES increase annually	Low
		Share of RES increase (heat, solar thermal)	High
		Heat Recovery Ratio	Low
		Decrease of energy import share	Low
		Decrease of thermal energy import share	Low
	Public buildings and infrastructures could be optimized with smart grids and switch to renewable energies	Onsite energy ratio OER	Low
		District self-consumption rate	Low
		Peak Load Reduction	Low
		Organizational changes and new processes	Low
	Need for incentives for the implementation of renewable strategies	Renumeration due to flexibility delivered (Euro)	High
		Increase of district thermal energy export share	Low
		Total energy demand reduction	Low
		Energy Storage number of equipment Increase	Low
		District self consumption rate	Low

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Category	Leipzig Action Fields assessment	Related KPIs	Granularity
Governance	Outranging performance in municipal climate change management/mitigation and in defining a long-term vision and goals for sustainable cities development.	Monitoring and reporting	Low
		Innovation potential	Low
	Cooperation with key stakeholders from different sectors	Stakeholder and citizen engagement through digital technologies	Low
		# of digital platforms used	Low
	Need for more testing of innovative technologies and solutions	Energy transfers through blockchain transactions	Low
		Volume of exchanges/ transactions (monetary) over blockchain	Low
	Defined regulations and restrictions pursuing modal shift e.g., speed limits or implemented priority lanes for buses and trams	Consultation plan	Low
	Need for new structures for cross-sectoral cooperation's and joined responsibilities within the municipality	Co-creation initiatives (lead by partner cities) on energy positive district	Low
		Local community involvement in planning / implementation phase	Low
	Set of higher social and environmental standards useful through negotiated and voluntary agreements, e.g., to convey higher building standards and higher sustainable measures	Participatory planning initiatives for positive energy districts	Low
		Knowledge sharing and access to information to increase citizens and stakeholders' engagement	Low

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Table 13 Prioritisation of KPIs to be visualised in Leipzig

KPI Name	Impact or Target KPI	Granularity (High)	Priority
Reduction of eCO2 emissions	Yes	No	P2
Air quality	Yes	Yes	P1
Share of RES increase	Yes	No	P2
Excess Heat recovery ratio	Yes	No	P2
Increase of integrated systems	Yes	No	P2
Decrease of energy import share	Yes	No	P2
Total electricity demand reduction	Yes	No	P2
Total heating demand reduction	Yes	No	P2
Increase of Citizens participation in market	Yes	No	P2
Self-consumption rate increase	Yes	No	P2
EV car sharing rate increase	Yes	No	P2
Increase of EVs share in local transportation	Yes	No	P2
Transport behaviour	Yes	No	P2
Increase of EV (smart) charging points	Yes	No	P2
Utilization of charging stations	Yes	No	P2
Energy Storage Increase	Yes	No	P2
Peak load (electricity) reduction	Yes	No	P2
Peak load (heating) reduction	Yes	No	P2
Onsite Energy Ratio (OER)	Yes	No	P2
Total generation curtailment	Yes	No	P2
Utilization of charging stations	Yes	No	P2
Annual number of new patents	Yes	No	P2
Job creation	Yes	No	P2
Increase citizens quality of life, health and well-being	Yes	No	P2
Annual number of contributions to European Standardization Organizations	Yes	No	P2
ROI	Yes	No	P2
Payback time	Yes	No	P2
DSCR	Yes	No	P2
Energy Storage capacity Increase	No	No	P3
Reduced System Average Interruption Duration Index (SAIDI)	No	No	P3
Reduced System Average Interruption Frequency Index (SAIFI)	No	No	P3
User satisfaction of minimum charging level in EVs	No	No	P3
Monetary gains for user (charging costs vs flexibility revenues)	No	No	P3
Satisfaction of minimum charging level for commercial EVs (for carrying out their daily routes)	No	No	P3
Accuracy of Generation forecasting	No	No	P3
Accuracy of storage utilization	No	No	P3
Fossil fuels Energy Generation decrease	Yes	No	P2
Demand from all EV mobility modes	Yes	No	P2

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Citizens co-ownership of energy utilities	Yes	No	P2
Creation of community energy funds	Yes	No	P2
Integration of citizen-led organizations/associations in the co-creation for Positive Energy Districts)	Yes	No	P2
Share of RES increase annually	Yes	No	P2
Organizational changes and new processes	Yes	No	P2
Renumeration due to flexibility delivered (Euro)	Yes	Yes	P1

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