D5.12 Project Development Report Lviv

30/09/2024

Yurii Polianskyi[1], Maksym Terletskyi[1], Roman Kinder[2] Taras Mazur[2]

[1] Municipal institution City Institute
[2] LCE "Lvivavtodor"

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Deliverable administration

No & name	**D5.12 Project Development Report Lviv**				
Status	Released	**Due**	M60	**Date**	2024-09-30
Author(s)	Municipal institution City Institute				
Description of the related task and the deliverable. Extract from DoA	**T5.4 Project Development in Fellow City (BABLE) M1 – M60** The goal of this task is to support the Fellow Cities to bridge the gap between writing the Implementation Plan and starting with implementations. 2 out of the 10 projects from the Implementation Plan will be taken through a structured project development process consisting of initial scoping, market consultation, detailed planning, and securing investment, all of which will result in unlocking investments into positive energy blocks on a local level. This report gives detailed plans for up to 2 projects from the Implementation Plan including: list of functionalities suited to local needs, technologies to be implemented, costs of planned implementation measures, suitable funding and business models, key timescales, lead partners, risks & risk mitigation measures, Local governance & coordination structure.				
Participants	BABLE, LVIV (until 14.3.2024), MI-CI				
Comments					

V	Date	Authors	Description
0.1	06/02/2023	LVIV (until 14.3.2024), BABLE	Draft Template
0.2	03/07/2024	MI-CI	First internal draft
0.3	24/08/2024	MI-CI	Send for internal review to WP leader
0.4	27/09/2024	WP leader	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1.0	30/09/2024	VTT	Coordinator submits the deliverable to the EC

Dissemination level

PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

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

Table of Contents

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The city of Lviv is one of the first in Ukraine which has initiated the development of the concept of climate neutrality in the urban system. Lviv is one of the five Fellow cities in the SPARCS project. Since 2019 SPARCS has been an accelerator for achieving climate neutrality targets and designing innovative solutions for creating energy-positive districts in the city. Since SPARCS, Lviv has had a great opportunity to approach a new but very important topic: achieving the status of a climate-neutral city by 2050 and creating –positive energy districts.

The project helped to launch the first 9 ideas that were to be implemented within the city, but due to the Russian federation's invasion of Ukraine, the plans were drastically changed. Energy efficiency and sustainability became the top priority for the city’s and began to be actively developed within different parts of the city's infrastructure.
At the strategic level, Lviv’s transformation to climate neutrality in 2050 has been shaped by the following projects:

1. Spatial Energy Plan and
2. Data-Driven Sustainable Mobility Plan,

within which unique software was purchased to enable the city to calculate large amounts of data. This data is an integral part of the future formation of Energy Positive Districts within our city and community.

1. INTRODUCTION

1.1 Purpose and target group

The SPARCS Fellow Cities (FCs) are committed to implementing 2 out of the 10 projects from the Implementation Plan. To ensure effective implementation, the projects are taken through a structured project development process consisting of project scoping, market consultation, detailed planning, and securing investment.

The objectives of this Project Development Report include:

1. Provide a step-by-step overview of the process taken in the implementation of up to two positive energy district (PED) projects
2. Outline the list of functionalities suited to local needs, technologies implemented, costs of planned implementation measures, business models, funding mechanisms, risks, and risk mitigation measures
3. Demonstrate the contributions from partners both within and outside the SPARCS consortium, and provide insight into local governance and coordination structure
4. Inform and facilitate the replication of chosen solutions beyond the SPARCS project

1.2 Replication Process

To ensure effective replication based on the Smart Energy Solutions agreed upon in the Implementation Plan, FCs will be supported with a structured process that will result in unlocking into positive energy blocks on local level. Each FC will be supported with this process in different activities in two projects, the process consists of the following stages:

1. Solutions Roadmap (optional): The goal of this phase is to identify potential areas of intervention where projects can be implemented to improve the quality of life in the city and drive sustainable urban transformation.
2. Project Scooping: In this stage, the FCs will receive guidance to build project teams, connect with the right stakeholders, and define the broad scope of the project that fits local needs and the main expected challenges.
3. Market Consultation: In this stage, the focus will be to customise the neutral packaged solution with inputs from citizens, potential service providers, relevant external stakeholders, and the Smart City community.
4. Detailed Assessment: The goal of this phase is to assess the project viability by performing a detailed analysis of policies, regulations, standards, barriers, good practices, and potential risks associated with the implementation of the project.
5. Detailed Planning: In this stage, the scope of the project will be finalised along with the business model will be finalised. Depending on the outcome of the earlier stages, different options may be compared through a feasibility study conducted by a third party.
6. Securing Investment: A part of the budget provided to FCs will be leveraged to attract various private and public sector investments. The investment will be used to secure the first loss and, thus, make the city to be part of a larger public-private investment.
7. Procurement/Implementation: The goal of this phase is to formally announce a tender call to the public, evaluate responses, determine the best

supplier/service provider to deliver the project, formalise the agreement with said supplier through contract signing, and finally, implement the project.

8. Monitoring & Evaluation: Finally for this stage, the goal is to plan the monitoring, evaluation, and reporting of the impacts of the intervention. Following this, a final review and assessment of the project results is performed to determine its contribution to the achievement of the wider city sustainability goals of the city.

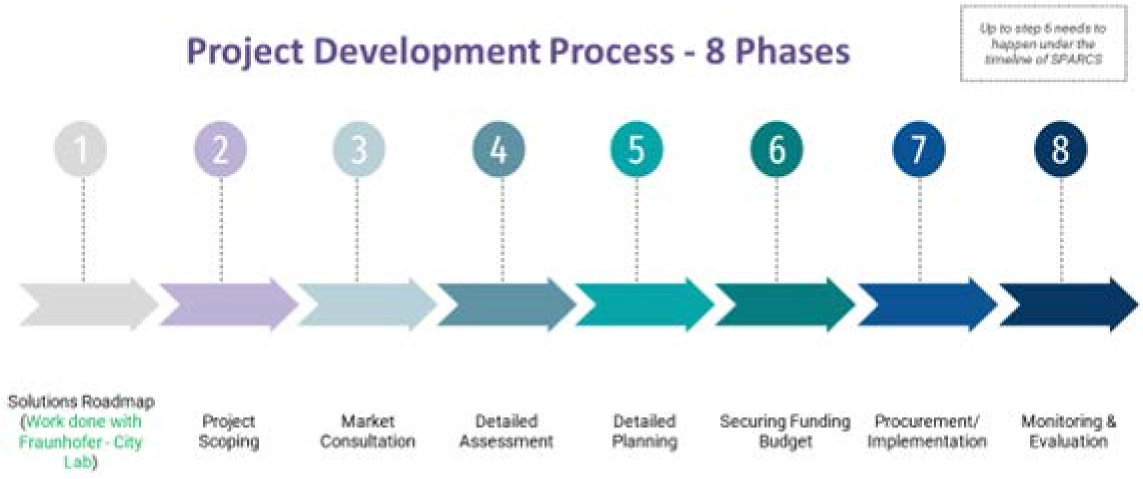

Figure 1 Project Development Process

Figure 1 represents the different stages in the project development process. Following this process, each city evaluates the feasibility of replicating the chosen smart city projects in their local context, thereby increasing the chances of its successful implementation and sustainability.

It's important to note that up to step 6 needs to be completed within the SPARCS timeline. For the FC of Lviv, the two projects to develop are (1) and (2).

2. Solution 1 - Spatial Energy Plan

2.1 Project Scope

2.1.1 Project Scope Definition

A spatial energy plan is a geographical information system that supports the data collection, analysis, and visualisation in a format of maps of energy potential, energy supply and consumption. In Lviv, it will be used as a tool for developers of energy solutions and a beta version of a digital twin of the energy infrastructure, providing opportunities to create algorithms for data analysis and justification of innovative actions, as well as a continuous process of joint creation, justification and implementation of short-, medium- and long-term measures related to the development and implementation of innovative energy solutions.

2.1.2 Project Scope Definition

The project scope definition is presented in Table 1.

Table 1 Project Scope Definition (Spatial energy plan)

Goal	Development and validation of Spatial Energy Plan (SEP) – a geographical information system supporting energy data collection, analysis, and visualisation in a format of georeferenced data layers, regarding Renewable energy Sources (RES) potential, energy supply, energy transportation network, and energy consumption in Lviv Territorial Community.
Tasks involved in the SEP development	1. Development of georeferenced data layers for Lviv Territorial Community's SEP regarding: • Potential of RES • Energy supply • Energy transportation network • Energy consumption 2. Develop the energy sector data-based products based on Geo Informatic Systems (GIS) data to validate SEP 3. Develop the District Heating Scheme 4. Develop the Lvivteploenergo Transformational Plan 5. Develop the Lvivteploenergo Investment Plan 6. Analyse the potential to develop PED technologies based on the RES potential, energy supply, energy transportation network and energy consumption in Lviv Territorial Community. 7. Integrate the SEP into an Open Data Portal and GeoPortal of the Lviv Territorial Community
Output	Data layers regarding the energy potential in Lviv Territorial Community Feasibility study and map of solar energy potential within Lviv Territorial Community

	Feasibility study and map of the energy potential of geothermal source heat pumps within Lviv Territorial Community Feasibility study and a map of the energy potential of air source heat pumps within Lviv Territorial Community Feasibility study and map of waste heat potential within Lviv Territorial Community Data layers of the energy supply in Lviv Territorial Community Data layers about heat energy production in Lviv Territorial Community Data alayers about electricity production in Lviv Territorial Community Data layers regarding energy transportation networks in Lviv Territorial Community Data layers about district heating network in Lviv Territorial Community Data layers about electricity supply network in Lviv Territorial Community Data layers regarding energy consumption in Lviv Territorial Community Data layers about energy consumption by municipal organisations in Lviv Territorial Community Data layers about energy consumption by multifamily houses in Lviv Territorial Community GIS-based District Heating Scheme for Lviv Territorial Community GIS-based Lvivteploenergo Transformation Plan GIS-based Lvivteploenergo Investment Plan SEP integrated in the GeoPortal of Lviv Territorial Community and shared among citizens
Best Practices/ Strategy	Virtual energy advisor by Barcelona municipality. The Virtual Energy Advisor is being developed within the Barcelona Municipality project 'Take charge of your energy' with the aim to reduce household electricity consumption by encouraging behavioural changes amongst tenants.

Development process of Spatial Energy Plan is a long-term process that has a potential for a continuous improvement through integration of new technologies. It will be an agile process with a relevant management and implementation both in a short-term and long-term time horizon. Development process will include three main stages in a next five years (Figure 2):

1. manual energy data collection and analysis;

2. getting proof of concept though development of District Heating Scheme for Lviv; Territorial Community, Lvivteploenergo Transformation Plan, Lvivteploenergo Investment Plan

3. 3.automatisation of energy data collection and analysis.

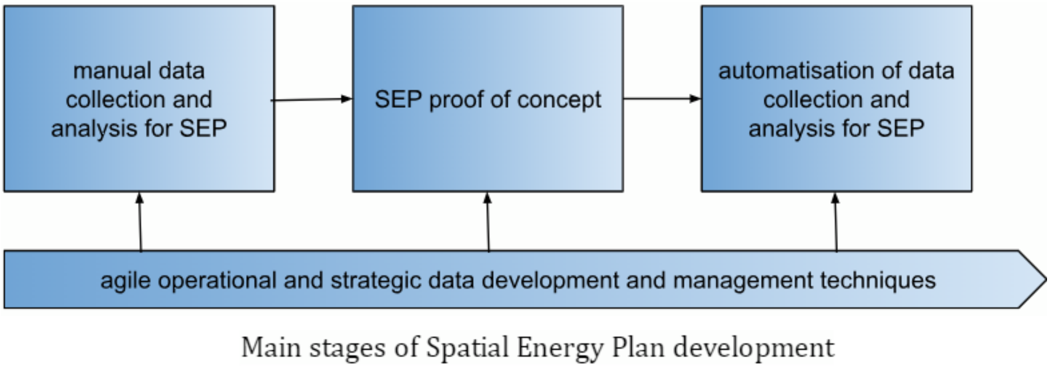

Figure 2 Main stages of Spatial Energy Plan development (Maksym Terletskyi)

2.1.3 Geographical Location

The project will be implemented throughout the Lviv Territorial Community. We will develop data layers starting from specific locations, develop methodology for collecting and analysing raw data and further scale-up the data to the whole community. Geographical area of the project activities will depend on the opportunities to collect data for the development of data layers. Our main case area within Lviv Territorial Community and an area where the concept PED will be developed is Sykhiv neighbourhood - one of the most densely populated area, mainly represented by multifamily buildings as you can see on Figure 3.

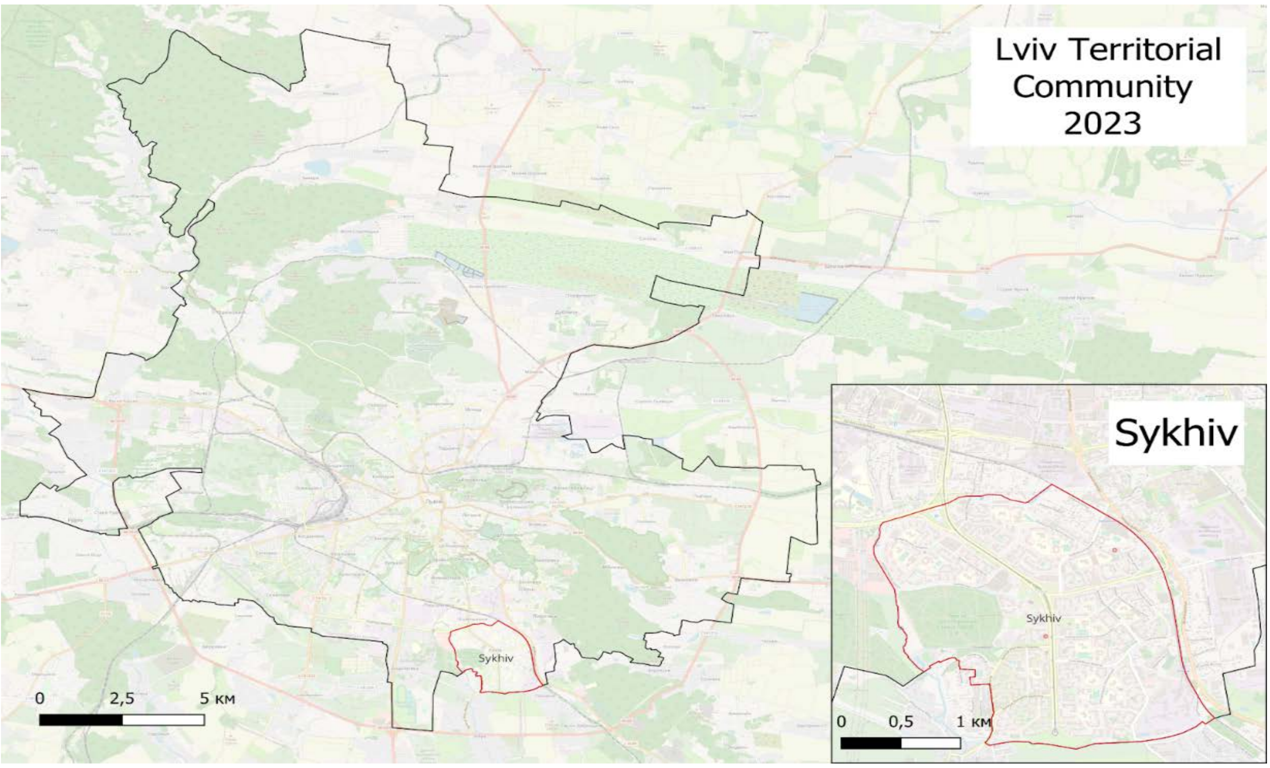

Figure 3 Borders of Lviv Territorial Commnity and Sykhiv neighbourhood (Maksym Terletskyi)

However, we will also develop data layers regarding solar energy potential for Levandivka neighbourhood where single-family buildings are located. Pilot validation of GIS data layers will be carried out for district heating network in Lviv. Thus, it will include the infrastructure of district heating operator - Lvivteploenergo.

2.1.4 Preliminary Technology Assessment

Based on the stages of SEP development mainly data collection and analysis technologies will be needed (Figure 4).

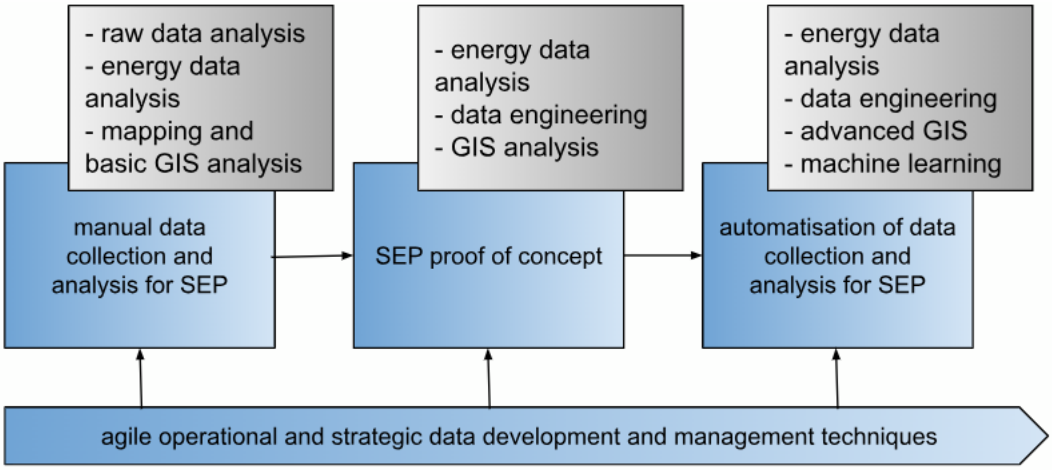

Figure 4 Technologies required for the development of the Spatial Energy Plan (Maksym Terletskyi)

- In the first stage, data collection and analysis need to be provided manually, oftentimes in a paper format such as that of the district heating network (seen in Figure 2).
- Following data collection, all data must be digitised, and further geodesy fieldwork is needed to validate and complement data.
- Consequently, a feasibility study of integrating heat pumps and solar energy into an existing energy supply must be developed.
- Then, the energy data collected and analysed three proofs of concepts must be defined:

  i. District Heating Scheme for Lviv Territorial Community

  ii. Lvivteploenergo Transformation Plan

  iii. Lvivteploenergo Investment Plan.

- Finally, after getting a proof of concept, a third stage of SEP development - the automatisation of data collection and data analysis, will require technologies related to data engineering, GIS development, data analysis and, potentially machine learning.
  A SEP is an instrument and a data-driven ecosystem that could absorb innovations and technologies that already exist and will be developed in the future. Its purpose is to support the development of PEDs in Lviv that could be achieved in a long-term perspective due to the challenges that cities currently face. Thus, SEP development as an agile process with continuous improvements requires relevant management technologies that will combine operational management and strategic management aspects, is key and requires the development of technologies that enable long-term data management development.

2.1.5 Preliminary Assessment of Business Models

SEP is a data management tool that could serve in providing data-driven services. In particular:

1. feasibility studies development regarding the Panels Voltage (PV) installations
2. feasibility studies development regarding the modernization and integration of alternative energy sources in energy supply
3. feasibility studies development regarding the district heating network modernisation;
4. development of the District Heating Schemes
5. development of the Investment Plans and other strategic documents for district heating operators.

Thus, as a tool, it has the potential to reduce municipal budget costs for development feasibility studies and support organisations that provide expertise for municipal and private energy supply, distribution and consumption companies. Specifically, it could increase capacities of Small and medium sized enterprises (SMEs) in participation in the energy consultation market.

Public data about the potential of RES integration in the Lviv Territorial Community could stimulate citizens to integrate RES in their energy balance. Thus, the market of RES technology provides and businesses that provide maintenance will be activated, especially, during the circumstances of war and a high risk of blackout.

So, SEP could provide opportunities both for municipal administration though reducing the budget spendings, stimulate citizens to develop and install RES and improve capacities of SMEs and energy consultancy companies in developing more advanced technologies in the field of PED development.

2.2 Market Consultation

2.2.1 Solution Requirements/Functions

The first stage of Spatial Energy Development with a need to manually collect and analyse energy data to develop first data layers, the energy data collection and analysis expertise for the implementation of such tasks is required.

- Development of georeferenced data layers for SEP:
    - Development of georeferenced data layers regarding the potential of RES in Lviv Territorial Community

    a. Development of georeferenced data layers regarding the energy supply in Lviv Territorial Community
    b. Development of georeferenced data layers regarding the energy transportation network in Lviv Territorial Community
    c. Development of georeferenced data layers regarding the energy consumption in Lviv Territorial Community.

It requires the development of feasibility studies and based on these feasibility studies develop georeferenced data layers.

1. Develop the data-based products in the energy sector in Lviv Territorial Community based on GIS data to validate SEP
    a. District Heating Scheme for Lviv Territorial Community
    b. Lvivteploenergo Transformational Plan
    c. Lvivteploenergo Investment Plan
2. Analyse the potential to develop PED in Lviv Territorial Community based on the RES potential, energy supply, energy transportation network and energy consumption in Lviv Territorial Community

This task requires the development of the analytical tool that will analyse all data layers of the SEP and combine it with the requirements needed to be a PED and requirements needed to develop technologies related to PED concept.

3. Integration of the SEP into an Open Data Portal and GeoPortal of Lviv Territorial Community

This task requires the visualisation solutions and communication tools that will help to integrate the energy data to the Open Data Portal and GeoPortal. Additionally, the successful implementation of this task will require a proper communication campaign among citizens to activate them use the tool and decide to integrate RES in their energy balance. It is important to understand that the software is being developed within the framework of this procurement.

2.2.2 Market Consultation

The Table 2 and Table 3 represent the Services for the development of software packages for automation of planning energy supply and the participants of the tender, respectively.

Table 2 Development of software for automation of planning energy supply. Code DK 021:2015: 72210000-0 Services for the development of software packages. (Prozorro, 2024)

The name of the nomenclatural item position procurement	Code according to Unified procurement dictionary, which is most closely corresponds to the name of the nomenclature item position procurement	Amount of items or volume performance work or provision of services	Place of delivery of goods or place of performance of work or place of provision services	Delivery period of goods, performance works or provision of services
Development of software for	DK 021:2015	1 item	79008, Ukraine,	until September 25

automation of planning energy supply (Code DK 021:2015: 72210000-0 Services for the development of software packages	72210000-0- Services for package development software		Lviv region, Lviv, Rynok square (room 111)	2024

Table 3 Participants of the tender (Prozorro,2024)

Participant's name	Identification code of the participant	Date and time of tender submission
LIMITED LIABILITY COMPANY "DEVPRUV"	44737540	August 24, 2024 15:35
Sole trader CHUMAK RUSLAN YEVGENYEVICH	2918610436	August 24, 2024 14:29
Sole trader DANYLYUK MYKOLA IVANOVYCH	3650803336	August 23, 2024 18:15
LIMITED LIABILITY COMPANY "ED ASTRA"	45175455	August 23, 2024 15:15

2.2.3 Proposed Technologies

As part of the development of the spatial energy plan, a detailed analysis of the possibility of creating tools to improve the functioning of the city's heat supply system was carried out. During the analysis, experts and discussion participants came to the conclusion that the best tool would be software that would combine all the necessary functions for the operation of a smart city heating scheme. This software enables the digitalisation of Lvivteploenergo and private user data for further calculation of data to improve energy efficiency. The final product will be user-friendly and include several features:

- Possibility to process data and convert it to GIS format
- Convenient visualisation for users
- Capability to work with data in various formats

2.3 Detailed Assessment

2.3.1 Legal/Regulatory Framework

In assessing the legislative framework and strategic planning in the energy sector, there are several key laws and policies that influence the future implementation of the spatial energy plan.

Law of Ukraine "On Energy Efficiency" [Закон України "Про енергетичну ефективність"](Law of Ukraine "On Energy Efficiency",2021)

The Law regulates relations arising in the field of energy efficiency and aims to strengthen energy security, reduce energy poverty, sustainable economic development, conservation of primary energy resources and reduction of GHG emissions. Established to fulfill Ukraine's obligations under the Treaty establishing the Energy Community and the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their Member States, on the other hand, this Law aims to implement the acquis communautaire of the European Union in the field of energy efficiency, namely: Directive 2012/27/EU on energy efficiency, Directive 2009/125/EC on a framework for establishing eco-design requirements for energy-related products, Regulation (EU) 2017/1369 establishing a framework for energy labeling.

According to the law, in the context of the SEP, we can identify the following main state policy measures in the field of energy efficiency:

- Eliminating regulatory barriers to energy efficiency measures
- Promotion and implementation of highly efficient technologies, energy management systems, and energy consumption monitoring systems
- Promoting development of the energy service market
- Support for systematic comprehensive research in the field of energy efficiency to develop the scientific basis for the establishment of the most advanced energy-efficient processes and technologies.

Government policy in the field of energy efficiency is aimed at achieving the national energy efficiency target set in the National Energy Efficiency Action Plan. National energy efficiency target shall be calculated in absolute values of primary energy consumption and final energy consumption by the central executive body implementing the state policy in the field of efficient use of fuel and energy resources, energy saving, RES and alternative fuels. The calculation of the national energy efficiency target shall take into account the requirements of the European Union legislation, decisions of the Energy Community, provisions of this Law, other strategic documents defining targets in the field of energy efficiency, and measures to stimulate energy efficiency.

An important factor in the context of the spatial energy plan is the implementation of Article 14, which is based on the implementation of calculations, monitoring, control and information, based on the assessment of the technical feasibility and economic feasibility of installing smart metering systems, heat supply operators take measures to install smart metering systems that provide accurate (reliable) information on actual energy consumption, including by time periods.

Incentives for the installation of smart metering systems can be provided through the following measures:

- Providing state support (assistance) for the installation of smart metering systems

- National Energy and Utilities Regulatory Commission shall take state regulatory measures to stimulate the introduction of smart metering systems

National Energy Efficiency Action Plan until 2030

National Energy Efficiency Action Plan until 2030 was developed in accordance with the EED Directive in cooperation with the Energy Community Secretariat and aims to achieve the national energy efficiency target set in accordance with the approaches and requirements of the Directive and taking into account the approaches of the European Union and Energy Community states. In addition to the 2030 target, interim indicative targets are set for 2021, 2025 and 2030. This will ensure the achievement of energy efficiency targets in the short term (2021), medium term (2025) and long term (2030) and is intended to monitor the sufficiency or insufficiency of the policies implemented to meet Ukraine's international commitments in the field of energy efficiency (interim targets are separately agreed with the Energy Community Secretariat, taking into account the timing of Ukraine's implementation of the EED Directive). This National Plan is guided by the principle declared by the EU in Regulation 2018/1999 of the European Parliament and of the Council of 11 December 2018 - "Energy efficiency first".

This document provides an overview of the expected energy savings from ongoing and planned activities that comply with the requirements of the EU Directive. These activities are divided into relevant sectors. Energy savings were calculated for each measure separately. It is estimated that these measures will result in 26,307 thousand ktoe of primary energy savings and 10,440 thousand ktoe of final energy savings.

The energy efficiency goals for 2030 were estimated based on the following steps:

1. Development of a baseline (BAU, inertial) scenario.
2. Determination of the energy efficiency goal based on the target indicators for energy intensity of the economy, specified in the Energy Strategy of Ukraine for 2035 "Security, Energy Efficiency, Competitiveness".
3. Analysis and consideration of individual measures and policies that may contribute to achievement of energy efficiency targets estimated on the basis of the TIMES Ukraine model

The Table 4 indicates the Key estimates of energy production and consumption in three different period of time.

Table 4 Key estimates of energy production and consumption in 2017 and 2030, ktoe (Law of Ukraine "On Energy Efficiency",2021)

Assessment of energy consumption	2017	2019	2030
Total consumption of primary energy	**86 947**	**86 275**	**91 468**
Fuel consumption (thermal generation)	34 298	33 698	32 784

Electricity production (thermal generation)	12 299	11 606	11 079
Fuel consumption at CHP stations	6 043	5 589	8 474
Heat production at CHP plants	3 419	2 759	3 597
Electricity production at CHP plants	1 032	1 231	1 836
Distribution losses (all types of fuel)	3 150	3 652	2 667
Total final energy consumption	**47 396**	**46 563**	**50 446**
Final energy consumption- Industry	15 098	16 126	19 799
Final energy consumption- Transport	9 624	10 064	10 294
Final energy consumption- Households	16 487	14 004	13 385
Final energy consumption- Services	4 337	4 475	4 801
Final energy consumption Other sectors	1 850	1 894	2 167

Expected reduction in primary and final energy consumption by 2021, 2025 and 2030 are presented in Annex 4. Coefficients used are specific to each measure. The intermediate reporting periods of 2021, 2025 and 2030 were chosen to they correspond to the EU and Energy Community planning horizon, and also aligned with the Nationally Determined Contributions of Ukraine to reduction of GHG emissions under the Paris Agreement under the baseline scenario for the scenario for the United Nations Framework Convention on Climate Change.In other words, in 2030, the energy efficient scenario is expected to reduce energy consumption by 22.3% (primary energy) and 17.1% (final energy).

"Energy Strategy of Ukraine until 2035 "Security,energy efficiency, competitiveness"(Government approved Energy Strategy of Ukraine until 2035, 2017)
"The Energy Strategy (ES) of Ukraine until 2035 "Security, Energy Efficiency, Competitiveness" is a document that outlines the strategic guidelines for the development of the fuel and energy complex of Ukraine until 2035. The forecast indicators contained in the document demonstrate the trajectory of development of the energy sector and related industries. In the future, as part of the development and approval by the Cabinet of Ministers of Ukraine of an action plan for the implementation of the ES, the tasks and indicators of the ES should be detailed and reflected in the relevant programs for the development of sub-sectors. The implementation of the ES will also require the development of new and amendments to existing legislative.
Implementation of the ESU will be carried out in three main stages:
STAGE 1. Energy sector reform (by 2020).
A key emphasis was placed on implementing reforms and creating a competitive and attractive investment environment. The energy companies were reformed in accordance with Ukraine's commitments under the Energy Community Treaty, gas production was increased, energy intensity of GDP was reduced, and RES were further promoted.
STAGE 2. Optimisation and innovative development of energy infrastructure (until 2025)
The second stage of implementing the ES is focused on working in the new market environment and the actual integration of the IES (Integrated energy system) in Ukraine with the European energy system, which will significantly affect the justification for selecting facilities for reconstruction or new construction in the energy sector and for improving energy efficiency.
On this stage, it should take place:

- Integration of the Ukrainian power system with the zone of continental EOTSO-E in the operational mode
- full integration into the European gas transportation system ECTSO-G, further deepening of cooperation with the countries of Central Europe to improve the reliability of energy supplies
- implementation of investment projects under the National Plan Reducing emissions from large combustion plants
- formation of local heat supply systems based on economically based on economically justified consideration of the potential of local fuels, supply logistics, regional and national energy infrastructure energy infrastructure
- improving the efficiency of existing district heating systems district heating systems
- attracting private investment.

STAGE 3. Ensuring of sustainable development (until 2035)
The third stage of the ESU is aimed at innovative development of the energy sector and construction of new generation. Investments in new generation capacities to replace the capacities to be retired. The type of generation will depend on the forecasted fuel price situation and the intensity of development of each type of generation, which will increase the level of competition between them on the introduction of smart technologies to level out consumption peaks. In the area of energy efficiency and environmental protection, it is planned to introduce passive house construction standards, achieve targets for reducing emissions of SO_2, CO_2 and

dust in accordance with the National Plan for Reducing Emissions from Large Combustion Plants, and introduce a GHG emissions trading system in Ukraine.
The gas sector will face the next challenges:

- Increase national gas production, including unconventional gas and production on the continental shelf and within the exclusive (maritime) economic zone of Ukraine
- Adaptation of the gas transportation system capacities to the development of the pan-European natural gas market.

During this period, the Ukrainian coal sector should achieve competitive and transparent operating conditions. RES will develop at the most dynamic pace compared to other types of generation, which will increase their share in the total primary energy supply structure to 25%.

The objective of the ES is to satisfy society's and economy's needs for fuel and energy resources in a technically reliable, safe, cost-effective and environmentally acceptable manner to guarantee the improvement of the living conditions of society.
Main goals and priorities that correspond to the implementation of the spatial energy plan:

- Implementation at the governmental and municipal levels, as well as at enterprises, and continuous improvement of the energy management system, in particular, in accordance with the requirements of standards and international agreements
- Promoting energy efficiency at the consumer level, and developing energy efficiency awareness among citizens
- Promoting development of local energy initiatives, including SMEs in the energy sector
- Transparent formation of tactical decisions that are predictable consistent with the defined long-term goals
- Providing conditions for the formation of technological innovation parks with using modern, scientifically based solutions, technologies and equipment in the energy sector
- Pursuing a sustainable and predictable policy in the field of investment attraction

Integrated programme for energy efficiency, energy saving and renewable energy development in Lviv region for 2021 – 2025 (Integrated programme for energy efficiency in Lviv region ,2018)
Integrated programme for energy efficiency, energy saving and renewable energy development in Lviv region for 2021 - 2025 is directed to the implementation of the Lviv Region Development Strategy for 2021-2027, approved by the Regional Council Resolution No. 948 dated 24 December 2019, in particular, to fulfil the operational objective 1.3. "Energy Self-Sufficiency". Implementation of a set of measures to save energy, improve energy efficiency and increase the use of RES is an important factor in ensuring sustainable development and contributes to the achievement of these goals:

- Creating sustainable infrastructure, promoting inclusive and sustainable industrialisation and innovation
- Ensuring the transition to sustainable consumption and production models;
- Taking urgent measures to combat climate change and related impacts.

The purpose of the Programme is to consolidate the efforts of state authorities, local governments, business entities, public institutions and residents to implement a set of measures aimed at improving energy efficiency, developing renewable energy and saving funds for the maintenance and operation of the housing sector.
The programme's energy monitoring is one of its objectives, which includes collecting and analysing information on energy consumption:

- Comprehensive analysis of information on the level of energy consumption
- Control over energy consumption in comparison with regulatory indicators
- Setting a plan for monthly maximum consumption of the respective type of energy resources (heat, natural gas, electricity, etc)

It is important to note that this programme focuses on a comprehensive analysis of information on the level of energy consumption. In the context of developing a spatial energy plan, a large number of layers and data will be added to the GIS system and software, which will allow for a qualitative analysis and understanding of how the city's energy supply system can be made more efficient.

Sustainable Energy and Climate Action Plan of Lviv community 2030 (SECAP,2023)
SECAP is one of the key documents in the field of energy efficiency in communities, which, based on collected data on the current state of affairs, identifies and provides guidance on the implementation of projects related to energy efficiency and renewable energy use, as well as adaptation to climate change at the local level. The key sections of the Action Plan include an overview of the baseline emissions inventory (BEI) in the base year, a list of mitigation measures for the entire of the plan, risk and vulnerability assessment of climate change climate change risk and vulnerability, adaptation actions and measures for the entire plan period, and a section on financing mechanisms.
The specific objectives of the SECAP are:

- reduce CO_2 emissions emissions by 35% by 2030 in the identified sectors compared to the base year of 2008;
- increase the share of renewable energy sources;
- Increase in the rational use of FER by heat and water supply organisations;
- reduction of heat energy losses during during the transportation of heat carrier
- Promoting investments in energy efficiency projects;
- Raising energy awareness of residents and rational energy use
- Adaptation of the community territory to climate change

Heating supply
The heat supply system of Lviv city includes centralised, moderately centralised and individual heat supply. Approximately 60% of the city's residents are connected to the district heating system, which includes both centralized (multi-apartment and public buildings) and individual heat supply (single-family homes, commercial and industrial buildings). Almost all heat is produced by burning natural gas, although investment projects are being developed to convert gas-fired district heating boilers to biomass. Table 5 represents the different technical characteristics of Lvivteploenergo.

Table 5 Technical characteristics of Lvivteploenergo (SECAP,2023)

Indicator	Measurement units	Value
The scheme of heat supply	-	double-pipe
Networks length	km	420
Total installed capacity of the enterprise	Gcal/h	1 562
Connected capacity	Gcal/h	1 029
Maximum annual gas consumption	m3 per year	200 mln
Maximum annual electricity consumption	kWh/h	70 mln
Annual realization of heat energy	Gcal	up to 1 000 th.
Annual electricity generation	kWh/h	up to 65.1 mln

2.3.2 Technical Assessment

Development of software for automated energy supply planning.

Preconditions for development

- Need to keep automated records of energy generation and consumption by city facilities and territorial communities.
- Necessity of operational analysis of energy generation and consumption by city facilities and territorial communities.
- Lack of capacity to calculate the economic effect of implementing measures aimed at improving energy efficiency in the city and territorial communities.

Purpose and goals of the software package

The main goal of the project is to create software that addresses the city's needs for a unified energy generation and consumption metering system for data analysis to improve energy management and energy efficiency.

Concept of the software system

Software shall be implemented as a web application. Users should be able to log in in a single place and access the functions of the System according to their position. The System shall be designed to be able to quickly integrate with other systems by easily receiving and returning data after authorisation. From the point of view of architecture, the System shall consist of client and server applications, namely:

- Web application for users with a corresponding interface.
- One or more backend applications that implement the logic for the web application.

- A fault-tolerant database.

Module should provide functionality for managing administrative data, users, and their restrictions on access to functionality and data.

Authentication

1. Each user has the ability to log in to the system using a login and password. The user's login must be an e-mail to which the user has access.

2. The system administrator creates users manually through the user interface and assigns them an email (login), position, first name, and last name.

3. After the user's account has been created, the user receives an automatic email with a link to the registration form. There, the user verifies his or her name and surname and sets a personal password.

4. Users who have lost their password can recover it using the password recovery form. To reset a password, the user receives an email with a special link and creates a new password after clicking on the link as you can see on Figure 5.

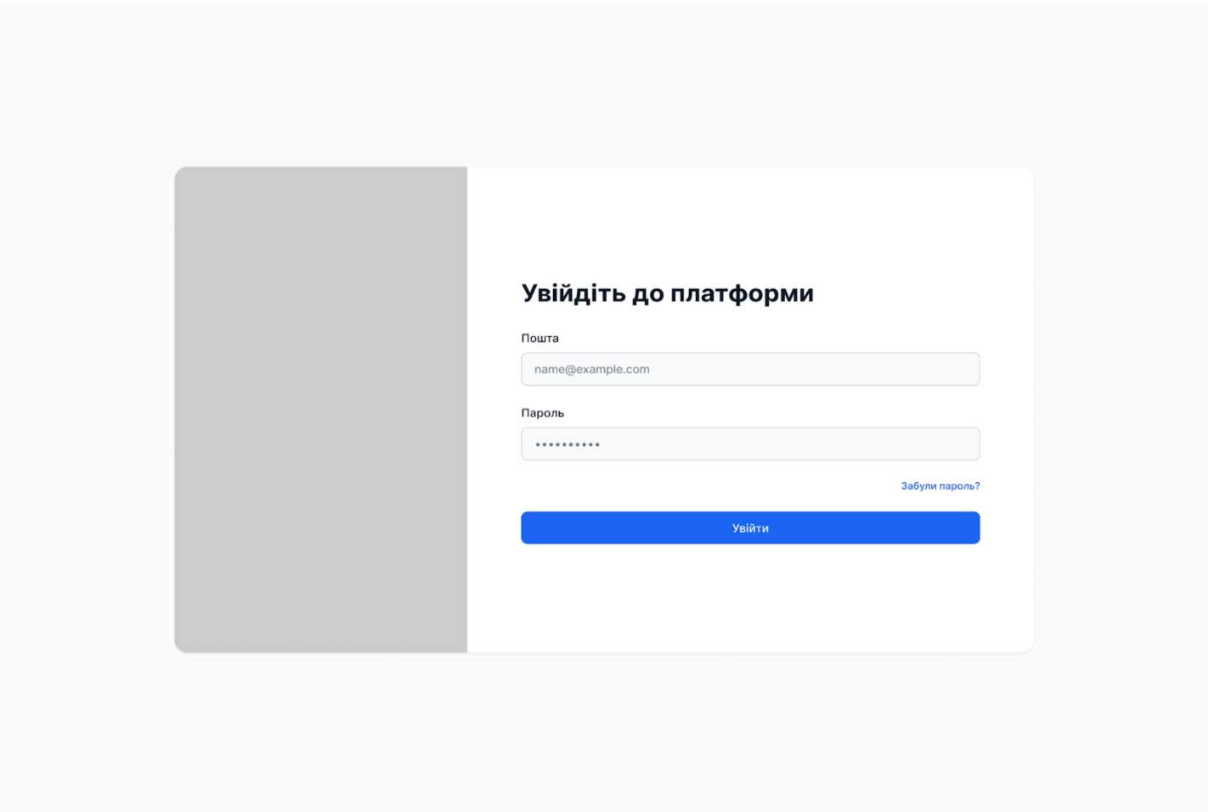

Figure 5 User authorisation (Prozorro,2024)

Form and user list

To manage users, the administrator can create, edit, and deactivate users.

Information to be filled in when creating and editing users:

1. Name*

2. Last name

3. Email address

4. Position*

6. Status (Active or Deactivated)*

On the user form as seen in Figure 6, the objects to which the user has access are recognized if the user has limited access to objects. However, at the position level, you can configure access to all objects in the system.

On the list of users implemented:

1. Search by name
2. Sorting by ID
3. Pagination by page
4. Filters by:
    4.1 Positions
    4.2 Statuses

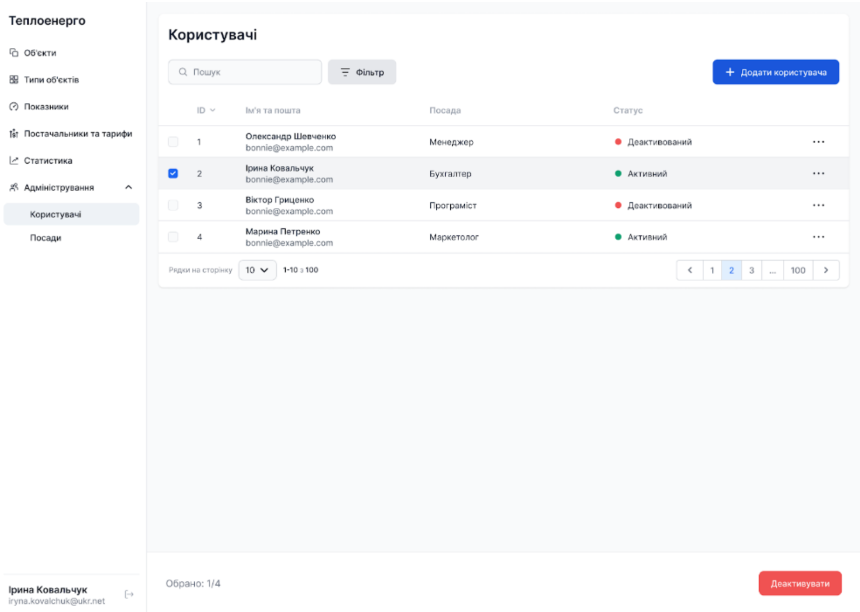

Figure 6 List of users from the SEP software (Prozorro,2024)

During deactivation, the user is not deleted from the database and the user's history is fully saved in the system. If necessary, the administrator can reactivate the deactivated user.

User positions

To manage access rights to the functionality, the Positions module is implemented as on Figure 7. Creating a position, the user specifies what access rights this position has. Fields when creating and editing a position:

1. Name *.
2. List of accesses with the ability to grant and revoke access.

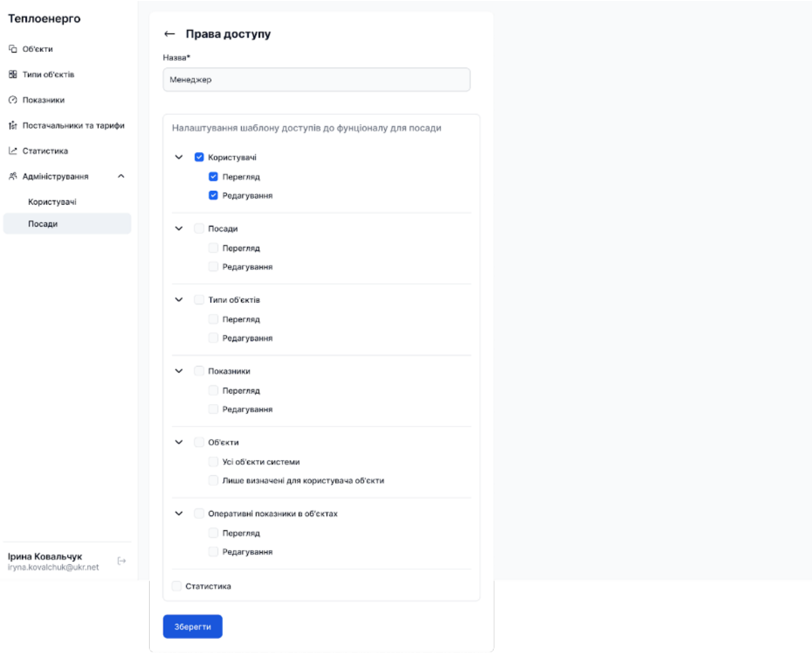

Figure 7 Creating and editing positions (Prozorro,2024)

The positions on the list have been implemented:

1. Search by name
2. Sorting by ID and name
3. Pagination by page

Indicators

To maintain statistics on data, users create indicators by selecting a type and category for each of them. Fields when creating and editing an indicator

1. Name *.
2. Type * (Static indicator or Operational indicator)
3. Category * (user-defined)

On the list of indicators implemented:

1. Search by name
2. Sorting by ID and name
3. Pagination by page

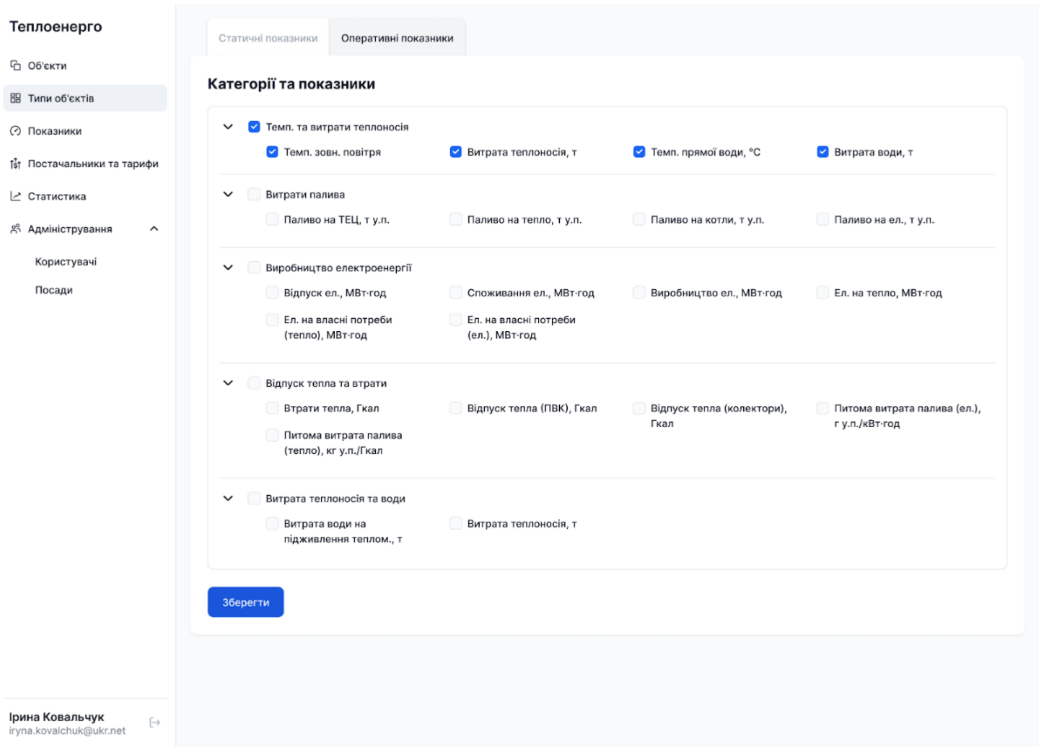

Figure 8 Creation and editing of object types (Prozorro,2024)

Object types

To manage object types in the system, users create object types and select the indicators for them that will correspond to each of the objects of this type (Figure 8).

Fields when creating and editing object types:

1. Name *.

To further enter indicators for each object, the user has the ability to choose which indicators will be entered for each type of object.

On the list of object types implemented:

1. Search by name
2. Sorting by ID and name
3. Pagination by page

Objects

To manage objects in the system, users create objects for which indicators will be entered in the future.

Fields when creating and editing objects as on Figure 9:

1. Name
2. Object type * .
3. Area * (Select from the drop-down list)
4. Settlement * (Select from the drop-down list)
5. Street
6. Building

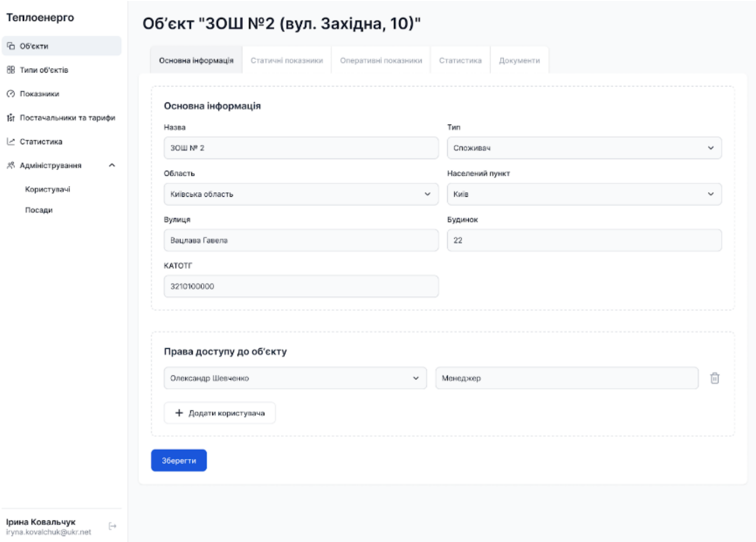

Figure 9 Creating and editing objects (Prozorro,2024)

The list of objects has been implemented:

1. Search by name
2. Sorting by ID, name, type, settlement
3. Pagination by page
4. Filters
   4.1 By object type
   4.2 By settlement

Object documents

User uploads pdf, docx, xlsx, png, jpg files to the object (up to 100MB) and can organize the files into folders for organised storage of the object's files.

Object indicators

To enter data for an object, users switch to the corresponding object and enter static and operational data. Operational indicators are entered with an indication of the metering device (meter).

To create a metering device, the user (Figure 10):

1. Selects the appropriate indicator (for example, Electricity, kWh)*
2. Indicates the number of the metering device
3. Selects the supplier
4. Selects one of the supplier's tariffs
5. Indicates the IP address, ID and password to the metering device (if the metering device and the network support this feature), since the system has the functionality of connecting to meters via IP to collect relevant operational information to automate metering.

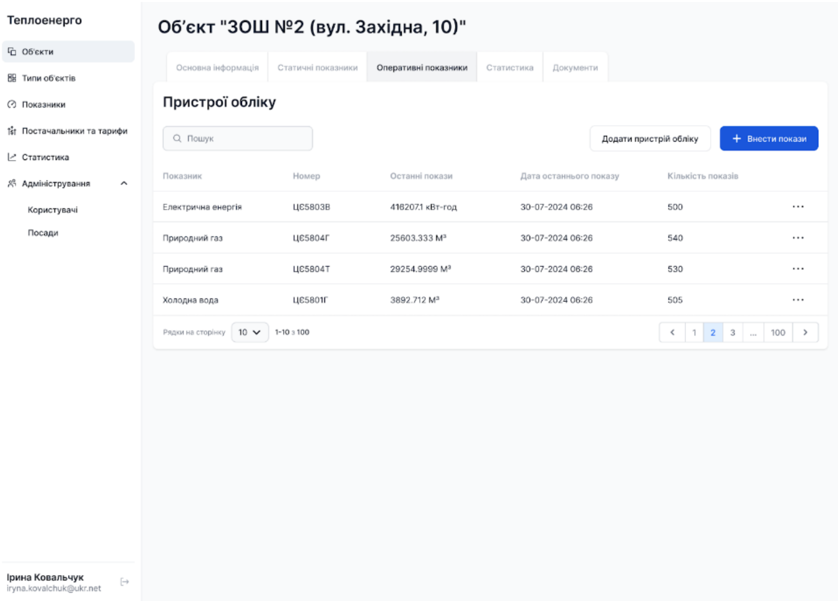

Figure 10 Object metering devices (Prozorro,2024)

In order to create a display, the user fills out the appropriate form, in which he or she indicates:

1. Date and time of measurement*.

2. Reading * (The reading must be greater than or equal to the previous reading. The reading can be entered to the nearest hundredth)

3. Comment.

Loading indicators from file

To load historical data of an object from a file, the user fills in the data in a csv file and imports it into the system. To fill in the file, the user can download a template of the csv file to be filled in and imported into the system. After importing, the user will be able to see a preview of the imported data, as well as errors that were detected by the system in the imported file.

General statistics for the object

The user can view and export to csv the total values of readings for each individual indicator in natural units and in monetary terms for the selected period and the selected type of data grouping: daily, monthly, and by year.

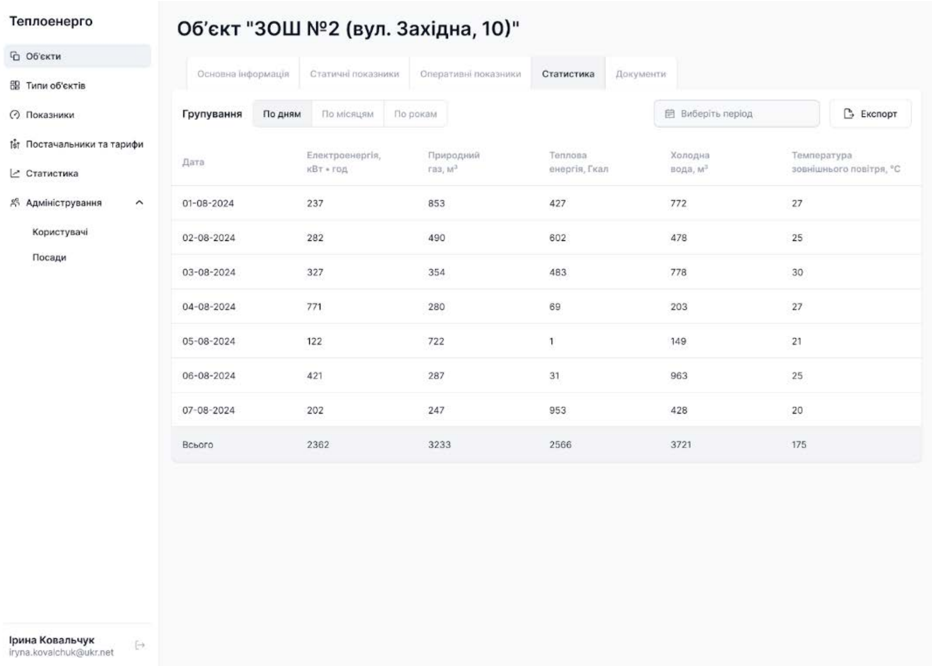

Figure 11 Example of the period from July 01 to July 07, 2024 with grouping by day (Prozorro,2024)

"Outdoor temperature, °C" is automatically stored in the system on a daily basis from a third-party weather service for each settlement as on Figure 11.

Statistics on specific energy consumption by facility

The user can view and export to XLSX the values of specific energy consumption for the facility by energy indicators in general and separately for the selected period and by the selected grouping type: daily, monthly, and by year.

Specific energy consumption is calculated by dividing the sum of the indicators converted into calories (Gcal) by the heated area or heated volume (user selects).

General statistics on objects

The user can view and export to XLSX the total values of readings in physical units and in monetary terms for objects, object types, settlements, and regions for each indicator for the selected period as in Annex 5.

Example of general statistics for a certain period with grouping of data by objects and indicators

General statistics on indicators

The user can view and export to XLSX the total values of readings by object, object type, settlement, and region for each indicator in physical units and monetary terms separately for the selected period and by the selected grouping type: daily, monthly, and yearly in Annex 6.

Sankey diagram of the distribution of consumption and production

On the diagram in Annex 1, the user views the distribution of consumption and production of each indicator in physical units and in monetary terms by various types of groupings, by: objects, object types, settlements, regions, days, months, and years. The user can filter data by period, object type, object, settlement, and region.

Statistics on specific energy consumption

The user can view and export to XLSX the values of specific energy consumption by facility, facility type, settlement, and region by energy indicators in general and separately for the selected period and by the selected grouping type: daily, monthly, and yearly.

Suppliers and tariffs

For each indicator, the user can define suppliers and corresponding rates.

Fields when creating and editing suppliers:

1. Name *.

Fields for creating and editing supplier rates:

1. Name of the rate
2. Indicator * (selects from those created in the system)

Fields when creating and editing supplier rates:

1. Value of the tariff
2. Period of validity of the tariff from and to

Data language and interface requirements

- The main language of the user interface and data shall be Ukrainian.
- The System administrators shall be able to add any number of languages with further translation of information into other languages.
- Users in their personal accounts shall be able to change the language of the user interface and data to one of the languages added by the System administrators.

Requirements for devices and browsers in which the System must work correctly

- The System design shall be correctly displayed on Chrome, Opera, Safari, Firefox browsers of the latest two versions.
- The System design shall be correctly displayed on mobile devices of the latest two versions of the IOS and Android operating systems

Requirements for technologies and development approaches used

- For the development, the Contractor shall use modern and popular approaches and technologies for the possibility of further effective development of the System, taking into account the ease of finding relevant specialists in the labor market. Programming languages and frameworks:
  1. Backend - PHP version 8.2 or higher
  2. Symfony framework
  3. Frontend - Javascript, HTML5, CSS3
  4. VUE 3 framework
  5. Database - PostgreSQL or MySQL
- The architectural approach to the interaction between the client and server side is Rest.
- The Contractor shall use Git or equivalent as a version control system. The software should be divided into versions at the level of product requirements, and each version should correspond to a set of program code states. This will allow tracking the compliance of the software version with the actual code state

at any stage of development. During the software development, the Contractor shall use several states of the program code in parallel, from the implemented but untested to the fully stable tested version, which will be located on the main demonstration stand or the Customer's working server.

Requirements for methodological support

The contractor should use Scrum as a framework for software development management processes. This approach will allow you to demonstrate the developed functionality to stakeholders every 2-3 weeks, which in turn will allow the latter to track the actual status of the project and compare it with the planned schedule and reporting**.**

Requirements for the term of technical and information support

Technical support includes all types of work to eliminate system deficiencies, improvements, customisations, and user training. Technical and informational support shall be available on business days from Monday to Friday within 365 days after the System implementation. The response time of technical and information support shall be up to two hours.

Procedure for control and acceptance of the system

Project management should create a risk register by assessing with the development team the likelihood of a problem occurring and its possible impact on the project. For probable and significant risks, a plan shall be developed to eliminate the risk or its impact, and a contingency plan shall be created separately in case of risk occurrence. The Contractor shall notify the Client of probable and significant risks in a timely manner.

The Contractor shall also develop a document "Test Plan" and test scenarios for each function. The created scenarios should be automated using acceptance and API tests. After the development and integration of the functionality, each individual function must contain a set of test scenarios that must be successfully passed, or else the function must be removed from the release (hereinafter - the release). The development of the alpha version of the system should be divided into releases to allow monitoring of the project stage and compliance with the requirements for the alpha version implementation. The functionality should be included in the release (release) if manual and automatic acceptance tests, APIs and integration tests related to the functionality are successfully completed. Otherwise, the functionality is excluded from this release (issue) and included in the next one. The first iteration of testing the functionality and validating its compliance with the requirements should be performed on separate code branches and demos. The second iteration of testing should take place during the integration of the functionality with other parts of the product and the preparation of the release (release). The contractor should make a decision on the release after receiving a report from his quality control department with successfully passed tests. Next, the final version of the software product shall undergo alpha testing within the Contractor's employees who were and were not involved in the development. The next step is to conduct beta testing on a wider range of stakeholders on the Customer's "working" server. The faults detected during such testing shall be corrected and the testing shall be repeated.

The Customer shall be able to access the demo stand for the purpose of promptly tracking the project development stage and compliance of the implemented functionality with the requirements.

The system will be accepted by the Customer after elimination of the identified malfunctions and non-compliances with the requirements that will be revealed during the acceptance tests. The list of the Customer's remarks shall be formed by the Contractor in the form of a table indicating the date of correction of each remark.

Program code documentation

Taking into account the need for long-term technical support of the system and the Customer's plans for its further development, the Contractor shall take a conscientious approach to the work related to the documentation of the program code. In this regard, the Contractor shall require documentation of each developed function and service: purpose, logic of operation and result. At the request of the Customer, the Contractor shall provide the program code documentation collected in a single document.

Source of the terms of reference development

Terms of reference were developed on the basis of the following documents and information materials:

1. GOST 34.602-89

2. DSTU ISO 9001:2015 Quality management systems

Requirements for protecting servers, code, and databases

1. Contractor shall restrict access to test and production servers to connect only via SSH keys.

2. To encrypt user passwords, the Contractor shall use reliable algorithms, for example, Argon2.

3. During development, access to demo stands shall be limited by the Contractor by IP addresses.

4. Contractor shall restrict access to the database, which shall not be accessible from the Internet and shall have only internal IP to work with the program code.

5. Contractor shall protect working and test servers from DDoS.

6. Before transferring the program code to the Customer, it shall be stored in private servers of the Contractor's local repository and be available only to the project developers.

7. All program code and data shall be backed up to an external remote storage every day.

Description of the research object and methodology

The research object will be provided with the source code of a web application. This source code will be checked for the following flaws:

1. the presence of hard-coded passwords in the code

2. the presence of unsafe database accesses

3. insufficient processing of input parameters

4. use of unsafe and outdated functions

5. application logic errors.

When analysing the source code, statistical analysis tools and manual processing will be used.

These techniques allow us to identify the following classes of attacks and vulnerabilities:

1. errors in the implementation of authentication functions
2. errors in the implementation of authorisation and access control functions
3. attacks on web application clients (including the use of cross-site scripting (XSS) and CSRF HTTP request forgery vulnerabilities)
4. vulnerabilities that lead to code execution (including SQL injection, OS command and XML code execution)
5. disclosure of important information
6. errors in the implementation of system logic
7. errors in the configuration of programs and servers
8. lack of use of the https protocol

Recommended requirements for the equipment on which the System will be installed

1. Multi-core central processing unit
2. RAM - 64GB, DDR4 or higher
3. Network port speed - 1Gbit
4. RAID of NVME disks. The amount of permanent memory - from 2TB

2.3.3 Cost Assessment

The Table 6 indicates the different stages and service provision period associated with the cost assessment process.

Table 6 Cost Assessment (Prozorro,2024)

Stages	Service provision period*	Stage cost UAH
Creation of technical specifications for development for automation of energy supply planning	Until July 31,2024	**99 000 uah**
Software development for automation of energy supply planning	Until September 30, 2024	**1 318 680 uah**
	Total	**1 417 680 uah**

2.3.4 Business Model Identification & Financial Analysis

Our business model is based on the development of a unique software that will eventually cover not only the energy efficiency sector but also all the needs of the Lviv City Council's economic complex. In the future, as this software will be on the balance sheet of the Municipal Institution City Institute, it will be possible to offer a similar model for other cities and communities in Ukraine. The business model outline can be found in the Annex 2 of the document.

2.3.5 Risk Assessment

There are several types of risks that can be identified in this project:

War with the Russian Federation

It is important to note that the most important aspect in this regard should be the security issue in the context of data. Over the past 2 years, Lviv City Council alone has experienced about 50 cyberattacks on citywide systems. Some of these attacks were successful at the initial stage of the war and led to global consequences in terms of data loss and inability to operate. That is why software developers have developed a number of measures that can provide protection against these risks:

- Restricting access to test and production servers with the ability to connect only via SSH keys
- Encryption of user passwords
- Restriction of access to the database, which should not be accessible from the Internet and should have only an internal IP to work with the software code.
- Protection of working and test servers from DDoS.
- Backup of all software code and data to an external remote storage.

In addition, it is worth noting that the possibility of shelling by the Russians is also a major threat to future work, as critical infrastructure is often targeted.

Working with the software

We need to understand that there are a lot of older people working within the city's energy supply systems, who may find it difficult to work in a digitalised environment. Therefore, the interface and functions of the software were reduced as much as possible to ensure that employees do not have any difficulties with this aspect in the future.

2.4 Detailed Planning

2.4.1 Project Implementation Planning

Within the framework of the project, several stages of its implementation were carried out in Table 7.

Table 7 Project Implementation Planning (Prozorro,2024)

Stage	Start date	End date	Activity	Description
1	10.06.2024	30.07.2024	UX design development	Developing a user-friendly design for software users. Include the process of simplifying the interface for users (mainly older people)
2	30.07.2024	10.08.2024	Development of software code in accordance with quality and functionality requirements	General practical work on programming code breakdown
3	10.08.2024	15.08.2024	Development of a testing plan	Develop a plan that will include three

				main stages of testing
4	01.08.2024	30.08.2024	Testing process	The development will be divided into several stages: Alpha testing (conducted over 5 days by a group of experts, including developers and testers) Beta testing (conducted over 15 days with the help of a testing team) Acceptance testing (conducted over 5 days by developers, testers and the contractor)
5	30.08.2024	14.09.2024	Implementation and validation	Final stage of software verification and testing, which includes control analysis of product quality.

2.4.2 Citizen Engagement Strategies for Project Development

In the framework of this project, citizens were not involved in the development, as the work was conducted with classified data due to the war situation.

2.4.3 Risk Management Plan

The Table 8 indicates the various risks and the actions taken to mitigate the associated risks during the project development in the city of LVIV.

Table 8 Risk Management Plan (Prozorro,2024)

Risk number	Risk name	Mitigation action
1	War with Russian Federation	It is important to note that the most important aspect in this regard should be the security issue in the context of data. Over the past 2 years, Lviv City Council alone has experienced about 50 cyberattacks on citywide systems. Some of these attacks were successful at the initial stage of the war and led to global consequences in terms of data loss and inability to operate. That is why

		software developers have developed a number of measures that can provide protection against these risks: • Restricting access to test and production servers with the ability to connect only via SSH keys • Encryption of user passwords • Restriction of access to the database, which should not be accessible from the Internet and should have only an internal IP to work with the software code. • Protection of working and test servers from DDoS. • Backup of all software code and data to an external remote storage. In addition, it is worth noting that the possibility of shelling by the Russians is also a major threat to future work, as critical infrastructure is often targeted.
2	Working with software	We need to understand that there are a lot of older people working within the city's energy supply systems, who may find it difficult to work in a digitalised environment. Therefore, the interface and functions of the software were reduced as much as possible to ensure that employees do not have any difficulties with this aspect in the future.

2.4.4 Quality Management Plan

Currently, the city system does not have software that could facilitate the task of collecting data for the city's energy supply workers. This software will be able to eliminate the problem of general collection of information from all sectors of the economic complex in the future.

To facilitate the quality of use, the following will be developed:

- Web application for users with a corresponding interface.
- One or more server applications that implement the logic for the web application.
- Fault-tolerant database.

2.4.5 Key Performance Indicators (KPIs)

City Institute shall monitor various KPIs to assess the environmental, social, and economic impacts of this initiative, including during the post-commencement stage. This evaluation will help determine if the software is suitable for future energy efficiency measures and development projects. The KPIs are still in development. After the first tests and analysis of the software performance, a number of KPIs will be developed that will allow for more efficient execution of future data collection tasks.

2.5 Securing Investment

2.5.1 Budget Allocation

This project was implemented using only SPARCS funds. Currently, due to the war, the use of budget funds is extremely limited. Detailed budget for the use of the funds can be found in paragraphs 6.3.3 of the Cost Allocation. The total amount used for the software development is UAH 1 417 680.

2.5.2 Additional Sources of Funding

During the project implementation, additional funds were not used except for the SPARCS project fund. Further, the project will continue to be implemented within the framework of the new projects of the European Commission's Horizon Europe (U-CAN) and Life (SupportDHC) programs.

2.6 Procurement/Implementation

2.6.1 Procurement

The process of software procurement took place in several stages. The final result of the tender, the determination of the winner and the final price can be found in Table 9, Table 10, Table 11, Table 12 and Table 13.

Table 9 General information about the tender and procurement (Prozorro,2024)

Name of the customer	Municipal Institution City Institute
Customer category	Legal entity that meets the needs of the state or territorial community
Customer identification code	36417351
Customer location	79008, Ukraine, Lviv region, Lviv, Rynok Sq, 1 (room 111)
Contact person of the customer, authorized to communicate with with the participants	Mytnyk Ulyana Andriivna, +380632580945, ulianamytnyk.city.institute@gmail.com
Type of the procurement item	Services
Name of the procurement item	Development of software for automation of planning energy supply (Code DK 021:2015: 72210000-0 Services for the development of software packages
Code according to the Unified Procurement procurement dictionary	DK 021:2015: 72210000-0: Services for the development of of software packages

Table 10 Terms of payment (Prozorro,2024)

Event	Type of payment	Period, (days)	Payment amount, (%)
Date of invoice	Postpaid	10 working days	100

Table 11 Information about the procurement process (Prozorro,2024)

Date of publication	August 14, 2024 13:38
Request for clarification	until August 22, 2024 00:00
Appeal against the terms of procurement:	until August 22, 2024 00:00
Deadline for submission of bids	August 25, 2024 00:00
Start of the auction	August 26, 2024 12:25
Estimated value	UAH 1 320 000.00 including VAT
Size of the minimum price reduction step	UAH 6 600,00
Size of the minimum price reduction step, %	0,50%
Language(s) in which bids should be prepared:	Language of the tender proposal is Ukrainian

Table 12 Register of proposals (Prozorro,2024)

Participant	Initial offer	Final offer
LIMITED LIABILITY COMPANY “DEVPRUV”	1 188 000,00 UAH	597 000,00 UAH
Sole trader CHUMAK RUSLAN YEVGENYEVICH	1 199 000,00 UAH	598 000,00 UAH
Sole trader DANYLYUK MYKOLA IVANOVYCH	1 319 000,00 UAH	599 000,00 UAH
LIMITED LIABILITY COMPANY “ED ASTRA”	1 320 000,00 UAH	600 000,00 UAH

Table 13 Disclosure protocol (Prozorro,2024)

Participant	Final offer	Published
LIMITED LIABILITY COMPANY “DEVPRUV	597 000,00 UAH	August 26, 2024 13:00

Due to the fact that the company LIMITED LIABILITY COMPANY “DEVPRUV" did not fulfil all the obligations under the pre-tender offer, the tender went to the following participant Sole trader CHUMAK RUSLAN YEVGENYEVICH.

2.6.2 Implementation

After the software execution process is completed, the implementation process will proceed as described below:

- Municipal Institution City Institute together with LCE "Lvivteploenergo", is starting to communicate on obtaining data within the energy supply sector. The list of data for the future calculation will be specified
- Since the software remains on the balance of MI City Institute, the institution provides access to the software to the relevant qualified employees of LCE "Lvivteploenergo"
- After granting access to employees, personal accounts are created within which they will enter data and receive digitalized information on the city's energy sector data
- Based on the results, a detailed analysis will be conducted, and decisions will be made to help the city become more energy efficient and resilient in the face of challenges.

2.7 Next Steps

2.7.1 Monitoring & Evaluation

We should note that the use of this modeling is something new for the city's energy supply system, and the most important thing in this aspect is to show the effectiveness of the digitalised system. In the future, it is planned to expand the use of this modeling functionality not only to energy supply, but also to electricity and water supply, and interaction with the data of the city's district administrations. Based on this modeling, it is planned to develop an entire digitalised system for collecting city data in the household sector.

SPARCS

3. Solution 2 - Data-Driven Sustainable Mobility Plan

3.1 Project Scope

3.1.1 Project Scope Definition

Sustainable urban mobility plays a key role in the context of convenient movement and communication of people in the cities. Naturally, the most important tool in the context of any research or strategy is data, and that is why it was decided to start developing Data-Driven Sustainable Mobility Plan in the context of SPARCS project. This project consists of initiatives implemented through SPARCS and complementary projects of various donors, which provide opportunities for financing and implementing initiatives in the context of sustainable urban mobility. Key initiative within SPARCS was the procurement of PTV VISUM and PTV VISSIM software. Having received the tools in the form of PTV VISUM and PTV VISSIM software based on a digital copy of the Lviv, which includes data on the city's street and road network, socio-demographic statistics, takes into account all traffic participants with the specifics of their interaction, and has the ability to conduct transport modelling at the microscopic level (projects of integrated traffic management schemes), the city has been able to obtain primary data in a digitalised format. In addition, one of the project's objectives is to actively engage in new initiatives that provide an opportunity to implement modern practices in many countries around the world. The Table 14 indicates the project scope definition of the Data-Driven Sustainable Mobility Plan.

Table 14 Project Scope Definition

Goal	Formation of a plan based on the data obtained to ensure sustainable development of the city, improve the quality of urban mobility, and enable the implementation of infrastructure projects in the context of creating a new transport network.
Tasks	Actualise processes in the context of sustainable urban mobility development and Sustainable urban mobility plan (SUMP) realisation Obtaining new investment and grant opportunities for the city in the context of project Acquisition, processing and retrieval of data using PTV VISUM and PTV VISSIM software. Implementation of tasks within the scope of the software. Conducting analysis in the context of attracting the latest potentially relevant technologies in the context of sustainable mobility.
Output	Complete and up-to-date digital transport model, which makes it possible to fully assess the current state, identify problem areas and provide solutions for which the following data were collected: 1. Current traffic routes; 2. Current number of vehicles; 3. Current traffic schedules;

	4. Data through service centres on the number of registered route vehicles in Lviv with reference to engine types, engine sizes, and environmental compatibility. 5. Data on private vehicles registered in Lviv city with reference to engine types, engine sizes, and environmental compatibility. 6. Inclusion of data on street slopes in the transport model. 7. Inclusion of changes to the transport model regarding the organisation of traffic. 8. Participation at the stage of developing draft street reconstruction options to search for the best solution. 9. Attracting new opportunities in the context of implementing sustainable mobility practices in other European cities. 10. SCALE-UP(Horizon 2020). SCALE-UP is an urban-node-driven project that works on demonstrating andevaluating a combination of 28 technical and non-technical innovative, clean, smart and inclusive mobility measures to be implemented within the three urban nodes –Antwerp, Madrid, and Turku – under real-life conditions, focusing on the strategies to achieve their upscaling beyond the urban level and in an interconnected mobility ecosystem. City participates as a FC. 11. REALLOCATE (Horizon Europe). REALLOCATE transforms streets into inclusive, green, safe and future-proof urban spaces, where communities live and thrive. The project enables researchers, mobility experts, urban planners and local citizens to collectively reimagine our cities and redesign how we move from one place to another. During REALLOCATE, 10 cities work in five twinned pairs consisting of a Lead City and a Twin City. Supported by thematic experts, city representatives work on implementing zero-emission, inclusive, active and citizen-centred mobility interventions for their pilot projects.City paricipates as a cascade city.
Best Practices/ Strategy	SUMP

3.1.2 Geographical Location

The project will be implemented throughout the Lviv Territorial Community.Data collection and implementation is community-wide, as well as project implementation. In the future, we are planning to scale the project to other communities and cities.

3.1.3 Preliminary Technology Assessment

In 2022, LCE ”Lvivavtodor”, the implementing enterprise of the project, already had PTV VISSIM and PTV VISUM software. However, these programmes did not have a module that could calculate emissions from transport. In the new versions of the software, these modules have already been included and it is now possible to create a model of CO_2 emissions from both public and private transport. In the new PTV VISUM and PTV VISSIM software, there are many more functions than in the previous versions that Lvivavtodor has. The PTV VISSIM software allows to use a larger area for modelling and to use a larger number of traffic light objects than in the previous version, which directly affects the accuracy of the results. However, for greater accuracy of the results, it is necessary to enter further information about the slopes on the road network. As for the PTV VISUM software, a module for calculating CO_2 emissions from private and public transport, the ability to model intersections with traffic lights, which will directly affect the accuracy of the modelling results, especially traffic volume, congestion and CO_2 emissions, has been added. To determine CO_2 emissions, the programme needs to include vehicle data, such as fuel type, engine type, Euro standard, number of vehicles, etc.

3.1.4 Preliminary Assessment of Business Models

PTV Visum

This software has a high potential for use. We envisage cooperation with logistics centres that are actively interested in construction opportunities, both in Lviv and in other locations across the country. Due to the software's capabilities, it is possible to justify the amount of investment in transport infrastructure projects, streamline freight traffic in the city, and develop a detailed territory plan.

Development of intercepting park and ride car parks is envisaged. Software capabilities make it possible to calculate the projected indicators of such projects and their impact on the mobility of settlements, indicators of the current state and required design solutions for traffic junctions.

Active use of the software is possible for designing the transport network of settlements to use the optimal number of rolling stock, optimal timetables based on passenger flows, and determine the optimal location of transfer hubs.

One of the most promising opportunities may be the creation of transport models of CO_2 emissions and integrated traffic management schemes for other cities and territorial communities in Ukraine. Modelling plays an important role in the context of rebuilding the country's war-torn settlements, as the street and road network of settlements will need to be redesigned and public transport will need to be developed. Modelling will provide a professional approach to reconstruction with the possibility of implementing modern sustainable mobility practices.

An important factor is the calculation of CO_2 emissions from internal combustion engines against the background of the popularisation of electric vehicles. This analysis will provide an opportunity to calculate new areas for catenary lines and electric vehicle charging points.

3.1.5 Supporting Factors & Barriers

In the context of all the project's initiatives, the biggest barrier was the war. Some projects have been stripped of their case study status and participation opportunities. In the context of the simulation, the main obstacle was the number of bidders, since before the war, the office of the PTV Group representatives was located in St. Petersburg, Russia, and this company was a monopolist on the market. After the full-scale invasion, all ties with this country were cut off, and several companies came forward with bids for the procurement. Due to the war, there is a constant high probability of an emergency situation, as just during the period of preparation for the tender and the procurement procedure itself, there was massive shelling of the country's power system in Ukraine, which could have affected the deadline for submitting documentation to the Prozorro system, which in turn could have led to the disruption of the tender and the purchase of the software. Software information gathering, configuration selection, negotiations with the distributor, and determination of the final configuration and price of the software lasted from January to October 2022.

Due to the introduction of martial law in Ukraine, negotiations stopped in February 2022 and resumed in July. The procurement procedure in the Prozoro system was announced on November 16, 2022. As of the end of December 2022, the software has already been purchased and is being used by the Department of Transport Planning, Modeling and Traffic Organization from LCE "Lvivavtodor".

3.2 Market Consultation

3.2.1 Solution Requirements/Functions

A prerequisite for the announcement of the software procurement was the availability of a module used for calculating CO_2 emissions from transport. It was also important to purchase the software by the end of 2022, as a 20% tax on software purchases was introduced on January 1, 2023, which could lead to a significant increase in the purchase amount.

3.2.2 Market Consultation

As part of the tender, a proposal was submitted to the portal Prozzoro (Lokal Ukraininan portal).Three commercial offers were submitted.As a result of the bidding, which lasted 7 days, the company LLC Bezpalov LAB and will supply for LCC Lvivavtodor PTV Visum Modeller +Modeller Plus + Road and PTV Vissim Corridor + Signal Controller Interfaces software. Consultations on the provision of commercial offers and the choice of software configuration were also held with the specialists of Bespalov Lab LLC (Prozorro 2023).

3.2.3 Proposed Technologies

The following software was proposed for the project: PTV VISUM and PTV VISSIM. These products fully assess the state of the transport network, namely the length of queues, delays, travel time between point A and B by different modes of transport, redistribution of transport due to changes in the road network, bottlenecks in the street and road network, the level of air pollution from transport, as well as assess the impact of changes in traffic organisation, number and type of transport on the environmental situation in the community. As a result, it becomes possible to take a more detailed approach to planning decisions in street reconstruction projects in terms of mobility (The world's leading transport planning software, 2022).

3.3 Detailed Assessment

3.3.1 Legal/Regulatory Framework

The main, though not the only, document that outlines the goals and directions of development in the field of mobility and transport in Lviv is the Sustainable Urban Mobility Plan, approved by the Lviv City Council on 13.02.2020. The Lviv SUMP is a strategic sectoral document that defines the city's transport policy for the next ten years and answers the question: how to optimise the city so that the movement of residents in it is efficient in terms of time, comfort, cost, promotes health and causes the least negative impact on the environment.

The objectives of the Sustainable Urban Mobility Plan overlap with those of the SPARCS project:

- Efficient, comfortable and environmentally friendly public transport.
- Optimise traffic flow in the city.
- Make cycling an attractive mode of transport for the vast majority of residents.
- A city of short distances.
- Coordinated mobility management and high level of employee competence

International and Ukrainian documents use a pyramidal illustration called the "Pyramid of Sustainable Urban Mobility" to demonstrate the priority of modes (types) of movement depending on the level of their negative impact on the environment and society. At the top of the pyramid is usually walking (human) mobility, including people with limited mobility, at the bottom are private cars, and between them are bicycles, public and commercial transport.

The Sustainable Urban Mobility Plan directs the City Council to organise urban mobility in a way that is efficient for residents in terms of time, comfort, cost, safety and helps to reduce negative environmental impacts. The Sustainable Urban Mobility Plan identifies pedestrian traffic, public transport and cycling as priorities for sustainable urban mobility. Electric mobility is not an exception or a substitute for the Sustainable Urban Mobility Pyramid, but rather complements it at every level. (Sustainable Urban Mobility Plan for Lviv 2019).

3.3.2 Technical Assessment

PTV VISUM software was purchased with the aim of achieving climate neutrality. Using this software, it is possible to model changes in traffic organisation, and as a result, obtain not only indicators of the redistribution of traffic flows and congestion of the road network, but also changes in the level of CO_2 emissions from transport. Currently, information on vehicles is being collected for further inclusion in the Lviv transport model. The advantage of the updated software is an increase in the number of modules used to calculate and accurately model the results for private transport. The disadvantage of the purchased software is the lack of information on public transport, which to some extent affects the modeling results. (The world’s leading transport planning software, 2022).

3.3.3 Cost Assessment

The total amount of UAH 3,161,000 was spent on the software purchase. The software was purchased through the Prozoro electronic public procurement system. The software supplier was Bespalov Lab LLC, the official distributor of PTV Group software. Currently, the software is used only within the LCE ”Lvivavtodor”, but in the future it can be used for commercial purposes. (Prozorro, 2023).

The team of the Department of Transport Planning, Modeling and Traffic Organisation is currently actively working on such projects:

- Creating a model of CO_2 emissions from public transport;

- Development of a general model of CO_2 emissions from transport;

- Modeling of the Shevchenko Street reconstruction project;

- Modeling for the project of reconstruction of Mykolaychuk Street;

- Creation of a new public transport route network;

- Modeling for the construction of interceptor parking lots at the entrances to the city.

3.3.4 Business Model Identification & Financial Analysis

After analysing possible business models, we understand that there will be a huge demand in our country for specialists who can perform a large number of tasks in this software with high quality and expertise. Nevertheless, we consider it appropriate to focus on participation in the post-war reconstruction of Ukraine and the design of infrastructure projects with the condition of significantly reducing CO_2 emissions and improving mobility in settlements. We expect to receive design orders from both government agencies and private businesses. The list of tasks that can be covered when using this software:

- Analysis, forecasting, management of road network data based on GIS
- Calculation of forecast indicators for transport planning projects before their implementation (interceptor car parks, bridge crossings, cycling concepts, transport interchange hubs, micromobility, night routes, , etc.)
- Indicators for analysing the current state and design solutions of road transport junctions (including roundabouts and interchanges at different levels)
- Justification of the amount of investment in transport infrastructure projects.
- Expediency and efficiency of one-way streets, pedestrian streets and squares, and other traffic reorganisation
- Optimisation of public transport routes, forecasting of passenger traffic, volume of transport work and other indicators
- Assessment and planning of road safety based on road accident statistics
- Projects of car parks and parking lots
- Integrated traffic management schemes
- Feasibility studies of junctions at different levels
- Traffic management projects (schemes)
- Optimisation of traffic lights; Road safety assessments.

The business model outline can be found in the Annex 3 of the document.

3.3.5 Risk Assessment

At the moment, the main risk of not being able to use this software in the future is military operations on the territory of Ukraine, since most of the funds are allocated to meet the needs of the military, there is a risk that other projects will not be funded and there will be no request for their implementation.

An important element of the risk of the lack of further use of the software is the absence of modules for public transport (transit planner and transit operator), which directly affects the completeness and correctness of the information obtained during modelling. This may lead to a lack of customer interest in transport modelling, since one of the important functions that may be in demand in the future is modelling the transport network of cities.

Human resources are also a pressing issue at the moment. Again, due to the mobilization of persons liable for military service, our company may not have qualified personnel who could implement projects of this scale.

University graduates do not have enough knowledge to immediately start implementing projects using this software when they get a job. Additional training is definitely needed by the employees of the Department of Transport Planning, Modelling and Traffic Organization of Lvivavtodor, which in turn leads to a decrease in the volume of projects.

Of course, there is also a threat to the lives of all employees due to frequent shelling.

3.3.6 Project Implementation Planning

PTV VISUM

- In December 2022, the software was purchased
- In the period from January to May 2023, employees of the Department of Transport Planning, Modelling and Traffic Organisation were trained in the new functions of the software
- In July 2023, public transport data was collected to create a model of CO_2 emissions from public transport
- In August 2023, the collected data was entered into the PTV VISUM program
- In September 2023, a model of CO_2 emissions from public transport was created
- Currently, information on private transport is being collected in Lviv city to create a general model of CO_2 emissions from transport

Projects

- In December 2023 Lviv became part of the SCALE-UP project (Horizon 2020) as a fellow city;
- In January 2024 Lviv became part of the REALLOCATE project (Horizon Europe) as a cascade city;
- In May 2024 planning Peer learning visit session in Turku (SCALE-UP);
- In October 2024 planning Study Visit and Project Meeting in Barcelona (REALLOCATE);
- From October to November 2024 planning development of replication roadmaps (SCALE-UP);
- In April 2025 planning Urban Nodes platform event & SCALE-UP closing conference in Brussels (SCALE-UP);
- In June 2025 planning Study Visit and Project Meeting in Gothenburg (REALLOCATE);
- From September to November 2025 planning developing and delivering Replication Plans (REALLOCATE);
- In April 2027 planning final conference and Safer Streets and Climate-Neutral Cities event in Brussels;

3.3.7 Citizen Engagement Strategies for Project Development

PTV VISUM

We consider the following strategies for involving citizens in project development:

- Organisation of workshops
- Organization of public discussions
- Presenting the simulations at a meeting of the city commission on road safety
- Publishing modelling results on social media
- Publication of articles in the media

- Interviews and participation in television programs on transportation modelling
- Processing requests from the city's hotline

An important element of transport modelling is the involvement of Anatomical therapeutic classification (ATC) citizens in discussing their results, as well as the pros and cons of the project, as these projects will directly affect residents' quality of life.

All of these strategies will be used simultaneously because it is necessary to involve as many residents as possible and get feedback from them to understand the needs of citizens and their concerns about modelling projects.

Projects

In the context of the two projects, city activists and all residents who wish to participate in the process will be involved in developing the documents.

3.3.8 Risk Management Plan

To overcome the risks described above, the company reserves employees involved in the project, as they are critical to the functioning of the project and the company as a whole. As for new personnel (university graduates in relevant fields), cooperation has been implemented with Lviv Polytechnic University, Department of Transport Technologies, to update the student training program to provide students with applied knowledge that is currently relevant in the field of transport planning, modelling, and traffic management. We also purchased diesel generators to ensure uninterrupted power supply to the enterprise and to prevent downtime or failure to meet project schedules. To prevent deaths or injuries to employees, bomb shelters have been set up to provide shelter during air raids. Consultations and webinars are also being held on the purchase of new public transport software modules that would cover problem areas in the existing transport modelling.

3.3.9 Quality Management Plan

PTV VISUM

The project, which is being implemented with the purchased software, is innovative and gives a significant impetus to the development of urban mobility. It provides an opportunity to comprehensively assess the impact of traffic management, quantitative indicators of transport intensity with their distribution by type and passenger flows on mobility in the ATC, as well as on the level of air pollution by CO_2 emissions. Based on the results of the modelling, it is possible to identify critical areas of transport concentration and, accordingly, high levels of air pollution and begin to develop plans to eliminate or significantly reduce these areas. A critical element of increasing mobility and reducing emissions is to reduce the intensity of traffic entering the city, develop a high-quality route network, and bicycle connections, and ensure comfortable movement for pedestrians. Also, do not forget about the development of electric transport, which makes it possible to reduce the harmful impact on the environment. By using the purchased software, the city will receive modern and innovative approaches to solving a significant number of actually related problems. It should be noted that a project of this scale and importance for the city's development will give an important impetus to other cities in the country to revise their development concepts.

Projects

New projects won by the city will help to implement modern practices from many cities around the world such as Madrid, Turku, Antwerp, and others. This replication gives an impetus to the future development of modern and innovative projects in the field of sustainable urban mobility in the city.

3.3.10 Key Performance Indicators (KPIs)

PTV VISUM

The project envisages the creation of a significant number of models, for example:

- Creation of a model of CO_2 emissions from public transport
- Creation of a general model of CO_2 emissions from transport
- Modelling of the Shevchenko Street reconstruction project
- Modelling of the Mykolaychuk Street reconstruction project
- Creation of a new city route network

Modelling for the construction of intercepting park-and-ride car parks at the entrances to the city.

1.1 The data on the number of registered route vehicles in Lviv was collected concerning engine types, fuel type and environmental friendliness. These data were entered into the transport model, public transport routes and their schedules were updated, and socio-demographic and attraction point data were updated. The results clearly show which streets or sections of streets have critical levels of emissions and which streets are not covered by the transport network. There is a direct correlation between the level of CO_2 emissions and the number of public transport units travelling along a given street or its section, the type of engine and the level of environmental friendliness of transport, as well as the organisation of traffic.

We think that the KPIs will be the number of public transport vehicles with electric motors, the number of traffic lights where public transport will be prioritised, the number of streets where public transport will be organised in dedicated lanes, and the number of passengers using public transport.

1.2 Information was collected on the number of registered vehicles (excluding public transport) in Lviv, disaggregated by engine type, fuel type, and environmental friendliness. These data were entered into the transportation model, and socio-demographic and pull point data were updated. From the data obtained, it can be concluded that high emissions are directly or indirectly influenced by traffic intensity, engine types and their environmental friendliness, traffic management, and the location and type of pull points. It is also possible to identify significant input intensities into the city along main streets.

We believe that the effective result of this modelling will be a decrease in the incoming intensity into the city, an increase in the percentage of transport, including public transport, with electric motors, the number of traffic lights where public transport will be prioritized, the number of streets where public transport will be organised in dedicated lanes, an increase in the percentage of public transport passengers and, accordingly, a decrease in the number of residents who choose to travel by private cars. Another important element will be an increase in the number of residents who will buy electric cars or choose bicycles, electric scooters, or walking to get around the city. Places of attraction have a significant impact on the amount of CO_2 emissions, so an increase in detailed planning projects will also be an effective result.

1.3 Regarding the Shevchenko Street reconstruction project, macroscopic modelling was carried out, where we obtained the redistribution of traffic on the city's street and road network and intensity with distribution by nodes. Microscopic modelling was also carried out, which allowed us to make effective and justified decisions in the configuration of the street and traffic signal operation modes. The effective result of this modelling will be the acceleration of public transport, reduction of queues and delays, increase in passenger traffic, increase in the number of residents using bicycles, electric scooters, or other alternative modes of transport, as well as reduction of CO_2 emissions into the environment.

1.4 The project for the reconstruction of Mykolaychuk Street included both macroscopic modelling, where we obtained the redistribution of traffic on the city's street and road network and intensity with distribution by nodes. Microscopic modelling was also carried out, which allowed us to make effective and justified decisions in the configuration of the street and traffic signal operation modes. The effective result of this modelling will be the acceleration of public transport, reduction of queues and delays, increase in passenger traffic, increase in the number of residents using bicycles, electric scooters or other alternative modes of transport, as well as reduction of CO_2 emissions into the environment.

1.5 This project is important because most community members use public transportation to get around the city. We collected and updated information on existing public transport routes, the number of vehicles, schedules, as well as updated socio-demographic and data on points of attraction.

We expect from this project an increase in the number of residents who will use public transport, an increase in the number of passengers transported by electric transport, an increase in the number of streets with access to public transport, a decrease in public transport delays, an increase in the number of nodes where traffic lights with priority passage of public transport will be provided, an increase in the number of streets where public transport will be organised in dedicated lanes, as well as a decrease in the level of traffic

1.6 An important element for the development of the city is the construction of interceptor park and ride facilities on all main streets leading into the city. Significant inbound traffic into the city is the main element that affects queues and traffic delays in the morning and evening peak hours. Therefore, through the construction of these car parks and the organisation of public transport prioritisation on the city streets, we aim to make the movement of citizens around the city more comfortable and efficient. The effectiveness of this project will be measured in terms of the number of constructed sites, the percentage of their occupancy, a decrease in the number of incoming flows into the city, an increase in public transport passenger flows, a decrease in public transport delays, an increase in the number of nodes with traffic lights with priority passage of public transport, an increase in the number of streets with dedicated traffic lanes, and a decrease in CO_2 emissions.

3.4 Securing Investment

3.4.1 Budget Allocation

PTV VISUM

Software was purchased for UAH 3,161,000.

According to the terms of the programme:

- 70% of the amount - UAH 2,212,700 - are grant funds
- 30% - 948,300 - are funds to support the statutory activities of the LCE ”Lvivavtodor”. (Prozorro, 2023).

3.4.2 Additional Sources of Funding

PTV VISUM

Additional sources of funding were not envisaged as part of the project.

In the future, the models will be updated at the expense of the enterprise.

3.5 Next Steps

3.5.1 Monitoring & Evaluation

The first stage was to create a model of the city's CO_2 emissions from public transport. This involved collecting data on vehicles operating on the route and entering it into the PTV VISUM software. After that, data on private transport was collected to create a general model of CO_2 emissions from all modes of transport and entered into the model. Based on the resulting transport model, the modeling of the street reconstruction project was carried out and the results on CO_2 emissions from transport were obtained.

3.5.2 Impact Assessment

The enterprise has started a large-scale modernisation of traffic lights to reduce electricity consumption, and each of the 167 traffic lights is being regulated to reduce queues, delays and travel times. These indicators directly affect the level of air pollution from transport. In addition, Swarco representatives conduct training webinars on programming traffic controllers with the latest Smart intersection and Smart corridor control modes. These control modes operate on the basis of data collected from detectors installed at traffic lights, allowing for the most optimal use of the duration of the permissive signals and thus reducing the level of harmful emissions. In addition, when designing street reconstruction, mandatory transport microscopic and macroscopic modelling is carried out, which allows us to choose the best option for traffic management not only in terms of transport performance but also from an environmental point of view.

3.5.3 Post Management & Communication

Ensure safe, affordable, accessible and environmentally sustainable transport systems for all by improving road safety, including the use of public transport, with particular attention to the needs of those in vulnerable situations, women, children, people with disabilities and the elderly. Significantly reduce the number of deaths caused by road accidents and environmental degradation. Reduce the negative impact of transport on cities and start working to assist other cities in their efforts to improve the environmental situation.

4. CONCLUSIONS

During the general analysis, during the creation of these projects in 2019, the task of active digitalisation and improvement of municipal systems in the context of energy efficiency, sustainable urban mobility and achieving the status of a climate-neutral city in 2050 has been set. In conclusion, we can state that the Lviv system has received new tools that will allow for a new analysis of the sectors that have intensified after this project. Lviv's energy system has received a Spatial Energy Plan, which in the form of software will allow for the complete digitalisation of the city's energy circulation system. In the future, the spatial energy plan will be expanded to other sectors (electricity, water supply, general data collection in the city districts, etc.) In addition, we analysed common mistakes during project development. For example, during the war with Russia, it became clear how important it was to develop a geodetic survey system for the city, which would make the city more energy efficient due to the informative use of territories within the city. This task remains for the city even after the project. It is also worth noting that the software will continue to function at the expense of the European Commission project, and after the war is over, at the expense of the city. LCE "Lvivavtodor" has received a unique module that allows enterprise to analyse CO_2 emissions from transport in the city. Many models have been created that allowed for a general analysis of emissions in the city. Thanks to the models, changes in the city's traffic markings were made within the traffic safety commission. We also analysed and implemented the ideas of the so-called “green waves” within the city, which were successfully implemented. These projects provide a wide range of development opportunities in the areas of mobility and energy efficiency for the city and open up new opportunities for the development of digitalised systems.

4.1 Contribution of Partners

Contributions of partners to the two projects are presented in Table 15.

Table 15 Contribution of partners

Spatial Energy Plan	Data-Driven Sustainable Mobility Plan
National ecological centre of Ukraine Association "Energy Efficient cities of Ukraine" Sole trader CHUMAK RUSLAN YEVGENYEVICH	Lviv City Council EGIS Bespalov Lab LLC PTV Group

5. Acronyms and Terms

ATC	Anatomical therapeutic Classification
FC	Fellow Cities
PED	Positive Energy Districts
SEP	Spatial Energy Plan
RES	Renewable Energy Sources
GHG	Greenhouse Gas
ES	Energy Strategy
SMEs	Small And Medium-Sized Enterprises
SECAP	Sustainable Energy and Climate Action Plan
SUMP	Sustainable Urban Mobility Plan
PV	Panels Voltage

6. REFERENCES

Prozorro (2024). Electronic resources. Retrieved from: https://prozorro.gov.ua/tender/UA-2024-08-14-006155-a

Law of Ukraine "On Energy Efficiency" (2021) Electronic resources. Retrieved from: **https://www.rada.gov.ua/en/news/News/215361.html**

Government approved Energy Strategy of Ukraine until 2035 (2017). Electronic resources. Retrieved from: https://www.kmu.gov.ua/en/news/250210653

Integrated programme for energy efficiency in Lviv region (2018). Electronic resources. Retrieved from: https://loda.gov.ua/documents/37390

SECAP (2023). Electronic resources. Retrieved from: https://www.city-institute.org/en/ctrategiyi-1/secap%C2%A0-sustainable-energy-and-climate-action-plan

Prozorro (2023). Electronic resources. Retrieved from: https://prozorro.gov.ua/tender/UA-2024-07-10-003330-a

The world's leading transport planning software (2022). Electronic resources. Retrieved from: https://www.ptvgroup.com/en/products/ptv-visum

Lviv E-Mobility Plan (2023). Electronic resources. Retrieved from: https://transformative-mobility.org/multimedia/lviv-e-mobility-plan

Sustainable Urban Mobility Plan for Lviv (2019). Electronic resources. Retrieved from: https://www.mobiliseyourcity.net/sustainable-urban-mobility-plan-lviv

7. APPENDICES

7.1 Annex 1

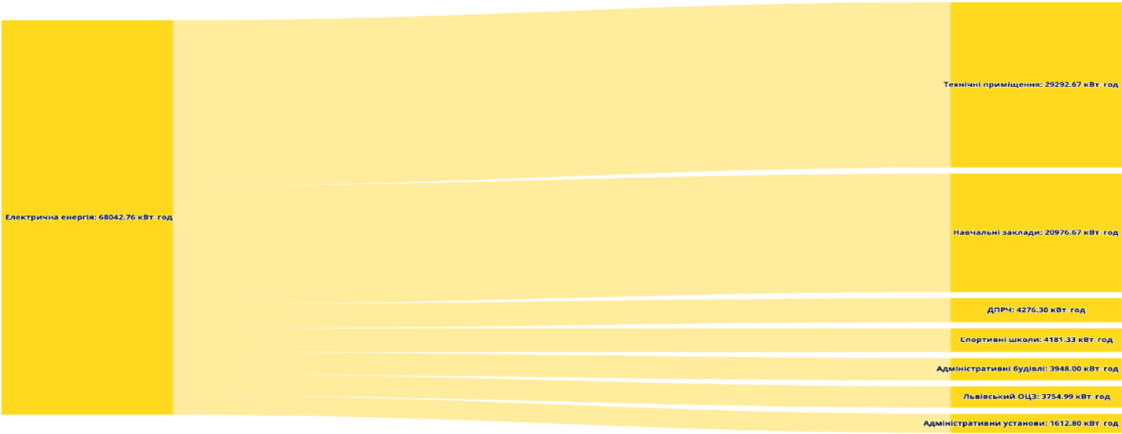

Figure 1a Distribution of consumption of the indicator "Electricity, kWh" with grouping by type of facility (Prozorro ,2024)

7.2 Annex 2

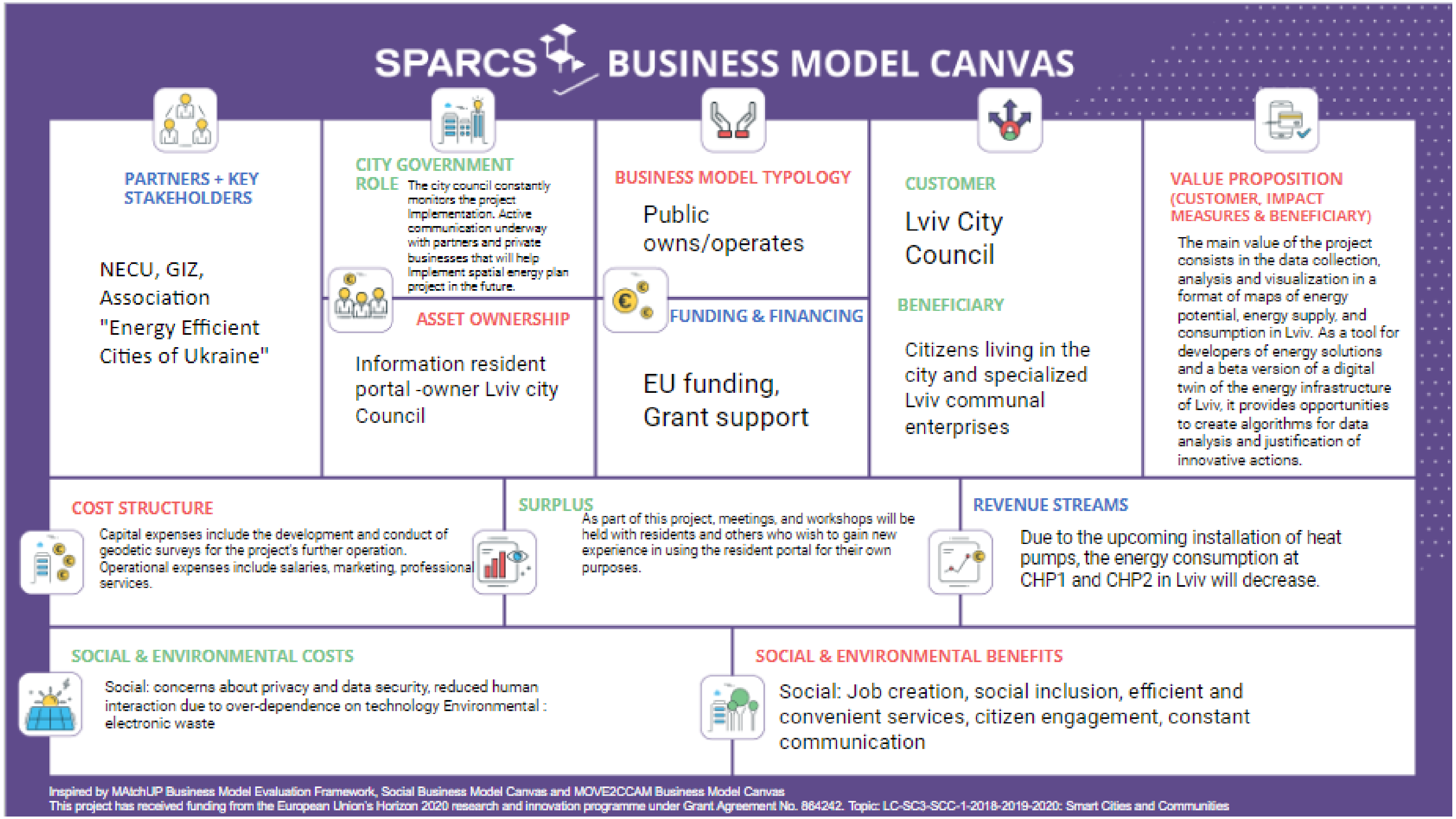

Figure 2a Business model canvas. Spatial energy plan (Yurii Polianskyi)

7.3 Annex 3

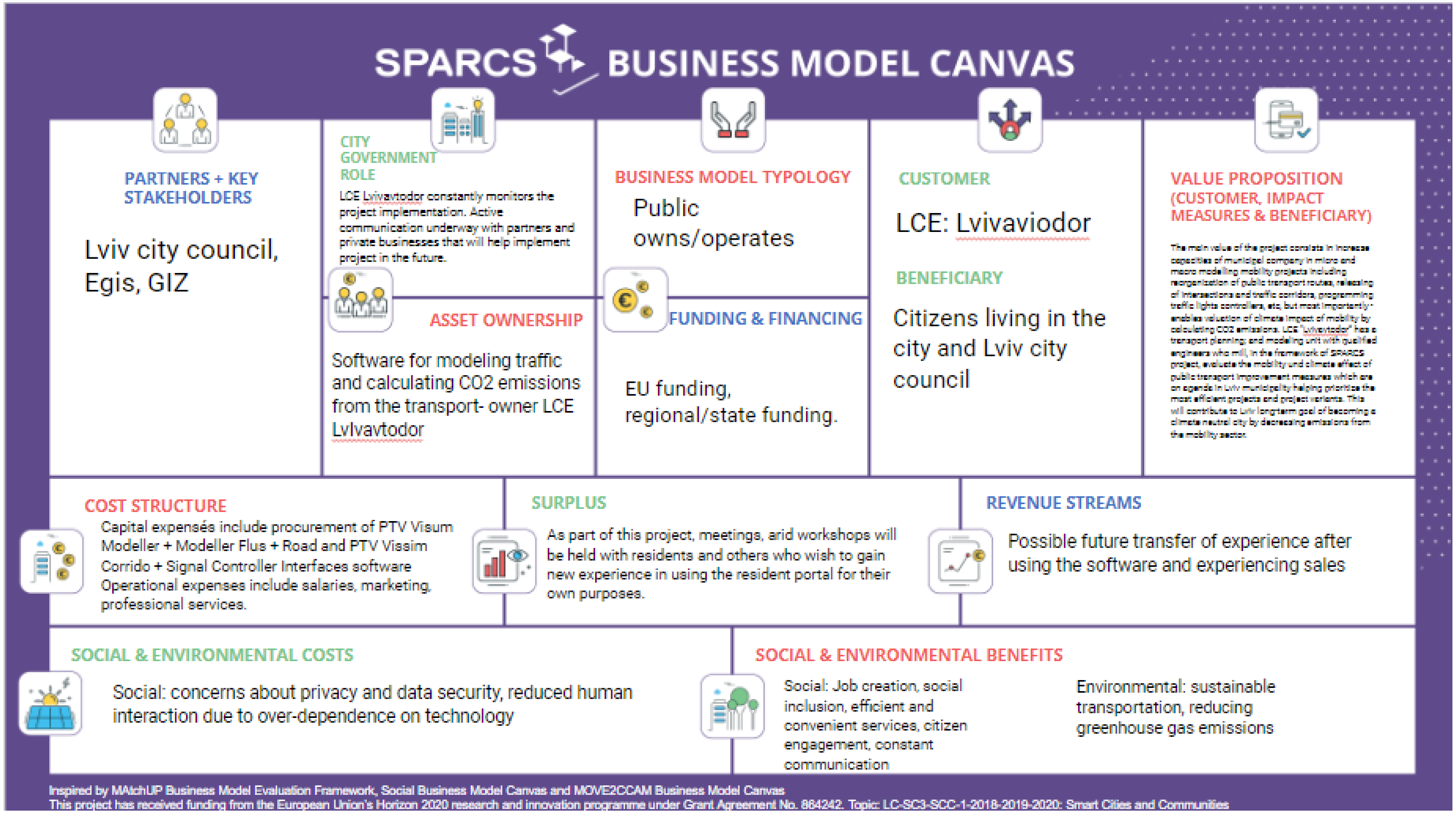

Figure 3a Business model canvas. Data-Driven Sustainable Mobility Plan (Yurii Polianskyi)

7.4 Annex 4

Table 1a Primary and final energy consumption (Law of Ukraine "On Energy efficiency",2021)

Year	2019		2021		2025		2030	
Category	Primary energy (th.toe)	Ultimate energy(th.toe)	Primary energy (th.toe)	Ultimate energy(th.toe)	Primary energy (th.toe)	Ultimate energy(th.toe)	Primary energy (th.toe)	Ultimate energy(th.toe)
Energy consumption under the Baseline Scenario (BAU)	86 275	46 563	102 658	53 411	110 456	57 099	117 775	60 887
Reduction of consumption due to the implementation of measures	-	-	-13 675	-4 158	-19 636	-6 581	-26 307	-10 441
Energy consumption based on implementation of measures	86 275	46 563	88 983	49 253	90 820	50 518	91 468	50 446
% reduction energy consumption relative to BAU	0%	0%	13,3%	7,8%	17,8%	11,5%	22,3%	17,1%

7.5 Annex 5

Table 2a Example of general statistics for a certain period with grouping of data by objects and indicators (Prozorro, 2024)

	Total area, m2	Heated area, m2	Heated capacity, m3	Electricity, kWh (consumption)	Natural gas, m³ (consumption)	Thermal energy, Gcal (consumption)	Cold water, m³ (consumption)	Outside air temperature, °C	Daily electricity production, MWh	Daily heat output from CHP collectors, Gcal	Specific energy consumption per m2, Gcal	Specific energy consumption per m3, Gcal
School № 2	2511	686	816709	603	591	803	774	28	0	0	721	38
School № 22	8432	1022	856841	903	672	811	362	28	0	0	832	87
CHP № 1	6470	713	704550	166	616	448	258	28	150	90	640	29
Boiler house № 40	8427	1054	113187	341	653	720	190	27	0	0	981	18
Total	3306	2023423	2116	2236	19085	1413	2019	22.50	150	90	3174	172

SPARCS

7.6 Annex 6

Table 3a *Example of general statistics for the period from July 01 to July 07, 2024, with data grouping by day and object by the indicator "Electricity, kWh" (Prozorro, 2024)*

Electricity, kWh	Indicators	Total	School 2	School № 22	CHP № 1	Boiler house № 40
1-07-2024	Electricity,kWh	600	25	29	28	30
	Outside air temperature, °C	24.33	29	28	21	24
2-07-2024	Electricity,kWh	595	23	25	30	28
	Outside air temperature, °C	24.67	27	30	25	20
3-07-2024	Electricity,kWh	622	29	30	20	29
	Outside air temperature, °C	25.75	25	24	24	26
4-07-2024	Electricity,kWh	586	27	22	24	26
	Outside air temperature, °C	25.08	26	23	30	30

	Electricity,kWh	605	25	20	22	21
5-07-2024	Outside air temperature, °C	25.17	20	30	29	23
	Electricity,kWh	611	27	20	23	26
6-07-2024	Outside air temperature, °C	25.17	23	28	20	20
	Electricity,kWh	594	22	25	28	22
7-07-2024	Outside air temperature, °C	25.58	24	29	20	21
	Electricity,kWh	595	20	27	25	21
8-07-2024	Outside air temperature, °C	24.79	25	25	25	25
	Electricity,kWh	594	24	27	26	23
9-07-2024	Outside air temperature, °C	25.50	22	29	27	27