D5.7 Implementation Plan Lviv

14/11/2022

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Deliverable administration

No & name	**D5.7 Implementation plan Lviv**				
Status	Released	**Due**	M36	**Date**	14-11-2022
Author(s)	FHG, LVI				
Description of the related task and the deliverable. Extract from DoA	**T5.3 Fellow City Replication Strategy (FHG) M1–24** The objective of this task is to provide an evidence base and in-depth understanding for key systems in the SPARCS Fellow Cities as basis for the development of long-term visions, smart city strategies and the development of locally adapted interventions in the area of positive energy blocks. To this end, Fraunhofer IAO, supported by VTT, will adapt and apply the joint assessment framework as lined out in WP2, T2.1 to each FC within the course of the first 18 months. Subtask 5.3.1 Fellow Cities profile development: A targeted data collection process will take place with different municipal actors from all FCs providing their data inputs into the data repository. The comparison of city-level indicators with corresponding benchmarks and action fields will allow to draft a profile for each city, highlighting the quantifiable sustainability performance in selected sectors (energy, emissions, transportation, buildings) and the current strengths and weaknesses around acting towards a low carbon transformation of the city system. The profile will become the background for an individual smart city strategy and urban transformation plan, as well as the baseline for monitoring progress in the city and for deriving actions and measures in an integrated way (linking governance, strategies and technologies). Subtask 5.3.2 Onsite assessment in Fellow cities: A one-week onsite assessment will be conducted in all FCs consisting of ca. 25 -30 interviews with key local actors and workshops with different urban stakeholders. This will allow the identification and systematization of city specific framework conditions and provide the basis for adapting the packaged solutions to the local conditions. The outcomes of subtask 5.3.2 will consist in ca. 10 – 15 early stage project outlines per city that are based on the packaged solutions and the Lighthouse City interventions. They will then be related back to the results of the assessment (subtask 5.3.1) in order to prioritize activities and design an early-stage roadmap of interconnected projects on the level of technology / infrastructure, strategy and governance. The results of subtask 5.3.2 will be compiled into a local implementation plan and provided as deliverable (one deliverable per FC: D5.4 – D5.8)				
Participants	LVI, FHG				
Comments					

V	Date	Authors	Description
0	01/09/2020	FHG	Draft before assessment of data
0.1	01/09/2021	LVIV	First draft filling sections with information of onsite assessment and replication workshop
0.2	18/01/2022	LVIV	Second draft filling the remaining sections
0.3	28/01/2022	FHG	Second draft review
0.4	28/08/2022	LVIV	Updating of all sections, drafting on missing parts

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0.7	13/09/2022	FHG	Third draft review
0.8	19/10/2022	FHG	Finishing deliverable according to discussions with Lviv due to political situation
0.9	20/10/2022	FHG, LVIV	Last common round of review
0.10	21/10/2022	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.
0.11	14/11/2022	WP leader	Final Version after revising comments from Quality Manager and WP Partner Bable
1	14/11/2022	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)	

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About SPARCS

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

Partners

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EXECUTIVE SUMMARY

SPARCS overall objective is to achieve citizen inclusive, carbon-free urban community by integrating the following key factors: technologies for energy positivity in buildings and districts, citizen engagement, city planning and governance, flexible grid management and energy storage, and e-mobility as an energy system element. SPARCS targets to tackle the multifaceted challenges that cities are called to solve by creating the ecosystems necessary for the urban energy transformation in cities towards a citizen-inclusive **Sustainable energy Positive & zero cARbon CommunitieS.** The cornerstones of SPARCS are two Lighthouse Cities, i.e. LHCs: Espoo in Finland and Leipzig in Germany along with five Follower Cities (FCs) across Europe. These two Lighthouse Cities aim to prove that the urban energy transformation of a city into a carbon neutral urban community is socially and economically viable.

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. Since 2019 SPARCS has been an accelerator for achieving climate neutrality targets and designing innovative solutions for creating energy-positive districts in the city.

Today, at the strategic level, Lviv's transformation to climate neutrality in 2050 has been shaped by the following strategies:

- Integrated concept of development: Lviv 2030;
- Sustainable Energy and Climate Action Plan;
- Green City Action Plan;
- Sustainable Urban Mobility Plan.

In the city there is a constant process of strategic planning and management to fulfil the medium-term goals of the city and ensure climate neutrality as a long-term objective. The role of SPARCS here is to structure and strengthen transformational methods with new approaches in the field of strategic management, to involve and strengthen the role of residents and other stakeholders in the development of policies, designing management and financial models for achieving future goals.

The key task for attaining climate neutrality in Lviv lies in achieving the city's energy independence. The SPARCS project generates and adapts innovative smart solutions for the development of energy-positive districts for Lviv. Thus, ensuring the innovative development of the three pillars of energy positive districts: efficient energy consumption, renewable energy supply and energy efficient mobility.

The present Implementation Plan Lviv reveals the factors affecting the transformation of the city into a climate neutral city. Furthermore, it provides an understanding of key projects that, in the short term should create conditions for the advancement of energy-positive areas and the promotion of the revolution of Lviv into a climate neutral city.

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1. INTRODUCTION

Following the vision to achieve climate neutrality by 2050, Lviv seeks further support in reaching its targets within the context of its key strategic areas: sustainable energy, mobility and spatial development.

Fraunhofer IAO in strategic cooperation with the City of Lviv, studied the areas for improvement in the city and identified its main opportunities for development. This was done as part of the replication activities within SPARCS and using the Morgenstadt assessment framework and more specifically its City Lab Methodology for sustainable urban development. Quantitative analysis of key performance indicators and qualitative analysis of action fields and impact factors provide a holistic view of the sustainable city development of Lviv.

The Implementation Plan Lviv is designed to be used as a roadmap of solutions for the city for tackling energy and mobility challenges. The focus areas are the development of positive energy districts and the transformation of Lviv into a climate neutral city. During the planning and implementation of the City Lab, the invasion of Russia and Belarus to the Ukraine occurred. This led, on the one hand to various difficulties in the process and on the other hand to a change in the approach. The high level of uncertainty and the deficit of resources in Lviv forced the partners involved and specially the local team to opt for a more agile approach for the implementation of the desired smart city solutions. The projects defined in the 'Implementation Plan Lviv' aimed at enabling collaboration and joint development of innovative solutions in the energy and mobility sectors. These solutions aim to bring innovations and transform the city in short-, middle- but also long-term.

1.1 Purpose and target group

The purpose of the Implementation Plan Lviv is to define the framework for communication and cooperation among stakeholders as well as the implementation of innovative smart city solutions in the field of energy and mobility.

The key target group of the Implementation Plan is Lviv City Council with all its departments, offices, municipal companies, and non-profitable institutions related to the energy and mobility sectors. However, other stakeholders are targeted by the Implementation Plan as well, such as:

- Citizens and Civil Society Organisations: The Implementation Plan Lviv enables the participation of citizens and CSOs in policy making and innovation development and empowers them to contribute with their own ideas for actions towards a climate-neutral city.
- Universities and innovation centres: The Implementation Plan Lviv project ideas in the energy and mobility sectors, which encourages further discussions and innovation development. Its openness and flexibility makes the Implementation Plan Lviv an instrument for increasing the participation of academia and innovation institutions in climate neutral and positive energy urban development in Lviv.

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- Businesses: As a policy instrument this plan promote the development of innovative, smart and sustainable energy and mobility solutions. Its openness to citizens, CSOs and the contribution with academia institutions ensure a high potential for its implementation. Thus, it has a great potential for attracting innovative SMEs and support their growth.

The Implementation Plan Lviv uses a quadruple helix approach by involving government institutions, businesses, academic institutions and citizens in the planning and implementation of innovative solutions in the energy and mobility sectors.

1.2 Contributions of partners

The revision of the assessment framework prepared by Fraunhofer, was performed by SPI and Suite5. The data collection of indicators and action fields was carried out by the City of Lviv. Likewise, Lviv has revised this report and contributed with feedback to the assessment carried out by Fraunhofer.

1.3 Relations to other activities

This report is linked with the overall SPARCS City Vision 2050 in Work Package 1, the Monitoring and Impact Assessment in Work Package 2 and the Replication Potential of SPARCS projects and frameworks in Work Package 5. Additionally, the replication in Follower Cities within Work Package 5 is connected to the demo projects in Lighthouse Cities in Work Package 3 and 4.

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2. METHODOLOGY CITY LAB

The basis for the in-depth analysis of Lviv is the Morgenstadt assessment framework and more specifically its City Lab Methodology for sustainable urban development. The model was developed in the course of the "Morgenstadt: City Insights" joint research project in which ten Fraunhofer Research Institutes have pooled their expertise with a further 37 partners from municipal governments and industry to offer cities wide-ranging support for sustainable city development. The project was established in 2011 and is since then the methods are undergoing continuous adaptation and refinement (Fraunhofer IAO, 2022; Radecki, 2019).

In order to achieve an in-depth understanding of the sustainability performance of cities both qualitatively and quantitatively, the Morgenstadt Model is structured into three levels of analysis:

1. Key performance indicators (quantitative analysis)
2. Action fields (qualitative analysis)
3. Impact factors (qualitative analysis)

To create the current report, the relevant indicators and action fields from the Morgenstadt Model, developed in 2011 by the Morgenstadt Initiative led by Fraunhofer IAO together with the University of Stuttgart, were applied. The analysis of this information shows a status quo inventory of Lviv and addresses the following question: "What is the sustainability performance of the city?". Additionally, it assesses the type of data being measured and available at the city level to provide a well-rounded understanding of the city's sustainability within the energy sector and other related sectors. This understanding of the city's challenges, plans and opportunities create a common ground as the foundation for the co-creation and design activities described below.

The third level of analysis utilizes impact factors to identify the city-specific drivers and barriers which are determined by unique historic, cultural, economic, climatic, and morphological characteristics. Impact factors thus extend the general model and adjust it to the needs of each city, providing for an objective performance profile while laying out the basis for an individual sustainability roadmap.

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2.1 City Lab process

The process in the setting of City Lab is divided into four main steps, as illustrated Figure 1.

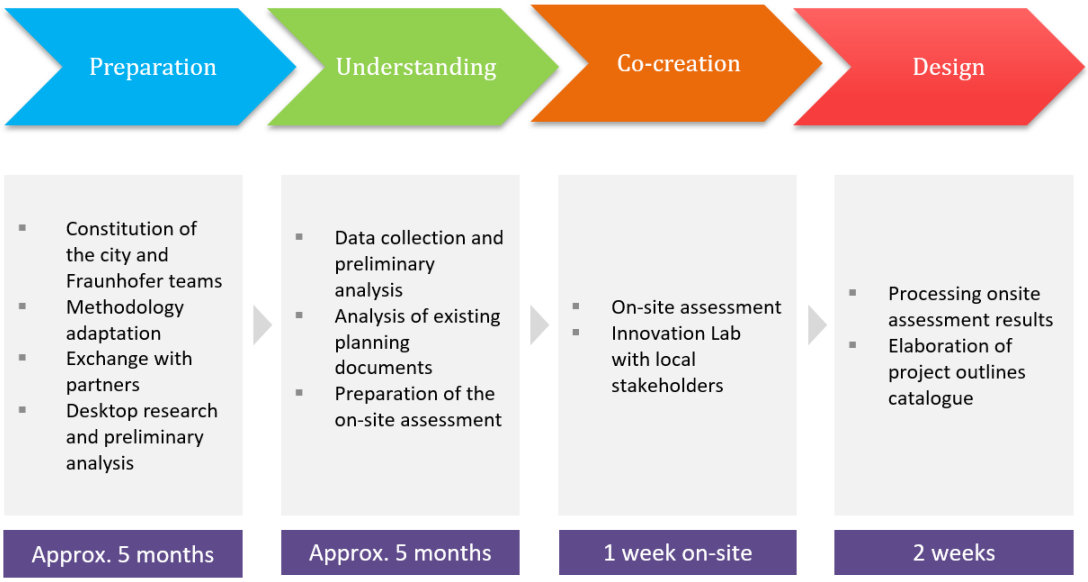

Figure 1: Structure of the City Lab process in Lviv

The first phase of the development of the City Lab comprised the overall **preparation** and with it, the constitution of the local team in Lviv as well as the assessment team from the Fraunhofer side. The city team of Lviv is composed of:

- Maksym Terletskyi –Active Director, Lviv City Institute
- Yurii Polianskyi - Project Manager, Lviv City Institute
- Pavlo Syrvatka – Acting head of street infrastructure office, Lviv City Council

Fraunhofer Team:

- Marielisa Padilla, researcher project manager, Urban Governance Innovation
- Pieter Bult, researcher, Urban Governance Innovation
- Reef Qubailat, research assistant, Urban Governance Innovation

The **understanding phase** consisted of the analysis of strategic documents relevant to the energy sector and the initial data collection. It also included the initiation of data collection through online research and desktop analysis. Existing strategic papers and plans of the city were inquired and studied by the Fraunhofer assessment team. Data collection of the indicators and action fields is described more detailed in Chapters 5, 6 and 7. Gaps in the information and data collected were identified, discussed, and cleared with the local team via several conference calls. Preparations with regard to content (such as the formulation of research questions for the onsite assessment) and organisation for the onsite assessment were also included. This was taken forward in the **co-creation phase** during the onsite assessment, which was dedicated to formulating project ideas together with local experts and the local team in Lviv. As the efforts in these activities are part of the replication work package within the project, the developed measures were inspired, among others, by the projects implemented in the Lighthouse Cities.

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The data collected in the aforementioned phases and onsite results, especially the outputs of the interviews and workshop, was then compiled during the **design phase**. Additionally, design workshops and meetings were organised with local stakeholders during the April-July 2022 to redesign previous projects and create a flexible and agile approach in delivering projects and replication of innovative solutions within the uncertainty and deficit of resources during the full-scale war in Ukraine. This culminated in the final version of the implementation plan; it includes concrete project ideas based on the interventions taking place in the Lighthouse Cities within the SPARCS project.

2.2 The Morgenstadt Framework in the SPARCS project

Since the SPARCS project is focused on energy and related mobility impacts, a carefully considered selection of indicators and action fields from the original framework related to these sectors was carried out. SPARCS partners leading activities related to the replication strategy such as SPI, VERD and CiviESCo gave feedback on the updated/shortened model. A second round of filtering further refined the framework before it was sent to the city for the respective data collection. Alongside this effort, benchmarks were updated, and a scoring system was developed to evaluate the city for international comparison. This framework is divided into the following two levels of analysis.

Assessment of indicators: Measuring the current status quo of urban systems and showing the sustainable performance of the city with a focus on the energy sector (quantitative assessment). They were also tailored to cover the most important aspects of such city categories as mobility, society, economy, ICT, and environment. Out of the initial list of more than 100 Morgenstadt indicators (Radecki, 2019), 62 were selected for this purpose.

Assessment of action fields: Analysis indicates how the city addresses sustainability and which activities it is focused on. It gives an overview of relevant fields of actions and related sub-aspects. In total, 35 action fields consisting of 118 'yes/no'-type questions to understand municipal challenges, select priority areas and identify key activities were defined. The adaptation of the existing framework tailored the action fields and questions to the SPARCS objectives. After that, each question was linked to an evaluation factor, which has been designed such that each action field could receive up to a maximum of 10 points if completely developed or implemented. The grading system has been developed to emphasize important fields including the use of renewable energy and heat sources, intelligent traffic management, promotion of multimodal transport and building stock refurbishment.

- ICT: These action fields address ICT specifically in the areas of data and governance, with applications in traffic management and participatory government. Intelligent traffic management allows for the public transit system as well as individualised transit solutions to respond to evolving conditions and for the city to use historical data to study the cost effectiveness of investments in infrastructure or new mobility solutions.

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- Governance: These action fields include the topics of municipal strategy and planning, organisation and structure, and regulations and incentives. They can be loosely divided into concrete measures and structural action fields, with the first sections providing insight into the city's long-term vision and goals and the political stability necessary to implement them. The structure and networks for sustainability-related policy management, innovation and reporting are assessed as the necessary predecessors for effective policy. Then, a few more specific action fields survey the existence of municipal level policies in place for transportation, air quality, and buildings. These areas provide a concrete starting point for the city in case of a lack of such measures.
- Transport and Mobility: These action fields survey infrastructure for soft mobility such as pedestrian and cycling modes and the corresponding uptake. Studying the linkages between soft mobility and the pricing and infrastructure for public transit, the questions assess the intramodality and vehicle-sharing availability. E-mobility prioritization and visibility through policies and charging infrastructure as well as traditional automotive decreasing measures through policies related to emissions, parking, tolls, and charging, e.g. in congested zones, are addressed. Finally, questions relating to urban freight assess a key component of traffic, the optimisation of which represents a significant environmental impact factor.
- Energy: These action fields assess municipal energy generation and distribution with respect to renewables share, networks for intersectoral resource sharing and the existence of district heating as well as its sources. As citizens are a crucial part of the energy transition, questions also focus on educational outreach to promote efficient consumption, the use of smart grids and meters and distributed energy generation.
- Building transformation: These action fields seek to understand the development of the various fields for building performance in the municipality, beginning with refurbishment of pre-existing stock. Questions regarding regulations for construction, demolition, and materials recycling technologies as well as the recognition of national and international certifications and standards aim to assess impact potential for pre-existing transformative processes. Finally, the level of use of new technologies related to energy and building performance represents the cutting edge of building transformation and indicates a city's ongoing investment into this area.

The sum of all assessment levels allows the research team to obtain an understanding of **the baseline sustainability city profile,** which is the current performance of the city in energy and closely linked key areas, assisting in the development of coherent strategies. The process simultaneously respects the impact factors of the city that are conditioned by external pressures, socio-cultural dynamics, geography, and historical pre-determinations, among others. Moreover, a standardised data assessment throughout the whole evaluation process helps to identify critical challenges and opportunities, which are crucial for the development of project outlines and the roadmap. The assessment process is outlined in Figure 2:

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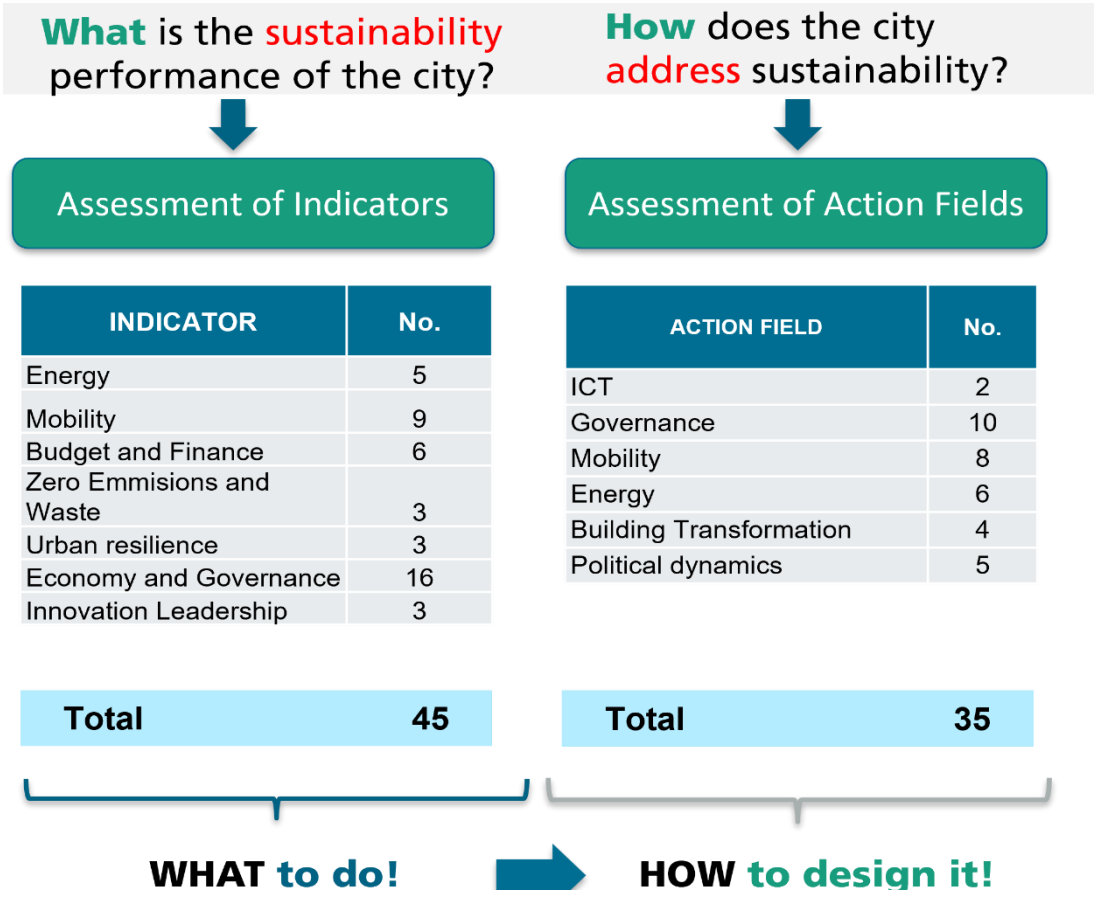

Figure 2: City Lab assessment framework for Lviv

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3. CITY PROFILE LVIV

3.1 Ukraine

Ukraine is the second-largest country in terms of area - after Russia - in Europe. Located in Eastern Europe, bordered by the Black Sea and the Sea of Azov from the south. Its capital, Kyiv, is situated on the Dnipro River in the north-central part of the country. Ukraine is inhabited by around 42 million people over an area of 603.5 thousand km^2 (State Statistics Service of Ukraine, 2020). The country's topography is almost entirely plain at an average elevation of 175 meters above sea level. Mountainous areas are found only on its south-western part and on the south part of Crimean Peninsula and account for almost 5% of the area of Ukraine (Bezberdaya et al., 2022).

The key sectors of Ukraine's economy are the extractive and manufacturing industry, followed by trade and transport (Razumkov Centre, 2017b). The development of extractive industry, i.e. extraction of natural gas, and the manufacturing sector take up a significant percentage of foreign and domestic investments. The manufacturing sector is of high importance to Ukraine's economy from both perspectives of productivity and revenue. Ukraine has a major ferrous metals industry and is among the world's top steel producers (Encyclopædia Britannica, 2022). Other products manufactured in Ukraine are food products, transportation equipment, and a variety of chemicals.

Ukraine's crop production is considered highly developed, partly due to its rich soils and suitable climate (Encyclopædia Britannica, 2022). The country's production of potatoes and grain is among the highest in Europe as well as it is being among the world's largest producers of sugar beets and sunflower oil.

In the country, a high concentration of rich mineral resources can be found (Encyclopædia Britannica, 2022). Ukraine has one of the richest areas in manganese as well as iron ores in many of its regions. Furthermore, the coal mines of Ukraine are among the deepest in Europe. Large reserves of brown coal, which are found in the Dnipro River basin and bituminous coal in the Lviv-Volyn basin, are the main source of fuel for thermal power stations. The country relies on supplementary imported oil and natural gas to satisfy its energy requirements despite the coal production in the country.

Three major areas for Ukraine's natural gas and petroleum productions are the Subcarpathian region, the Dnieper-Donetsk and Crimean regions (Encyclopædia Britannica, 2022). As a result of this, an extensive pipeline transport system was built with the first natural gas pipelines in the region opening in the 1920s, mapped from Dashava to Lviv and then to Kyiv.

Electricity

The primary raw materials for electricity production in Ukraine are mainly uranium and coal; natural gas and oil products (fuel oil) are used as an alternative fuel for thermal generation, and bio-raw materials (solid biofuels, biogas) are used to a lesser extent (NKREKP, 2018).

Uranium serves as a nuclear fuel for nuclear power plants, which produces more than half of electricity in the overall energy balance of Ukraine (NKREKP, 2018). In terms of

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explored uranium reserves and uranium production output, Ukraine is getting closer to the top ten countries of the world, but domestic production output is able to meet the needs of nuclear power by only 30-35%. Today, the only enterprise handling extraction and processing of uranium ores in Ukraine is Eastern Mining and Beneficiation Plant SE. Under the terms of international treaties, Ukraine cannot have a full cycle of nuclear fuel production. In particular, Ukraine cannot enrich uranium, because this process is identical to creating its weapons-grade modifications. Therefore, Ukraine does not enrich uranium or fabricate heat-emitting elements itself, but instead, imports finished nuclear fuel.

Coal is the main raw material for thermal generation, which is the next largest producer of electricity in Ukraine after nuclear power generation (Accounting Chamber of Ukraine, 2020). In terms of geological reserves of coal, Ukraine is ranked first in Europe and eighth in the world (Sushyk, 2022). According to data by Geoinform of Ukraine, the balance reserve of coal in Ukraine was 41.25 billion tons (2020), and the largest coal deposits are concentrated in the Luhansk (35%), Donetsk (32%), Dnipropetrovsk (26%), Kharkiv (5%) and Lviv (2%) regions (Accounting Chamber of Ukraine, 2020).

According to data from the Accounting Chamber of Ukraine (2020) report, Ukraine has 148 coal mines of all forms of ownership, including 95 mines in the temporarily occupied territory. In 2020, only 46 coal mines (including 28 state-owned) are operating under the coal mining regime, and the total coal production is 28.9 million tons. Coal processing (the process of reduction of mineral impurities and waste rocks and reduction of ash content) is carried out in 7 enterprises, which are subordinated to the Ministry of Energy. The largest representative of the private sector is DTEK Energo, which operates four coal beneficiation factories.

The energy potential of biomass which Ukraine has is approximately 23 Mtoe (million tons of oil equivalent); main constituents are plant residues, contributing 44%, and energy crops, at 32%, as of 2018 (Bioenergy Association of Ukraine [UABIO], 2022). Projected calculations illustrate the incorporation of agricultural residues, solid waste, and liquid biofuels will increase in the coming years. Currently, Ukraine underutilises its potential. According to data by the State Statistics Service of Ukraine (2020), Ukraine produced 3.79 million tons in 2019, i.e. 14% of the total estimated potential.

Ukraine is heavily dependent on fossil fuels and nuclear power for its energy needs as the share of electricity produced from hydroelectricity accounts for less than 10%, and the contribution of other renewables being almost negligible (Encyclopædia Britannica, 2022). Thermal power stations can be found all across the country, the largest of which are in the Donetsk Basin and along the Dnipro and in the areas near the Lviv-Volyn coal basin.

Natural gas production

In Ukraine, oil and gas fields are located in three regions: Eastern, Western and Southern. The Eastern Oil and Gas Bearing Region is the youngest in terms of discovery of commercially viable hydrocarbon deposits and the largest in terms of proven reserves and oil and gas production output (International Energy Agency [IEA], 2021). According to data by Geoinform Ukraine SRPE, the balance gas reserves were 778,2 bcm as of the beginning of 2020, and the volumes of 2020 natural gas production were 20,2 bcm (Extractive Industries Transparency Initiative [UAEITI], 2016).

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The majority of reserves and production output are located in the Eastern Region (mostly in the Poltava and Kharkiv Oblasts): 78% of the balance reserve and 93% of the total production output. The rest is located in the Lviv and Ivano-Frankivsk Oblasts and on the Black Sea shelf (IEA, 2021).

Ukrgazvydobuvannia State Enterprise, a subsidiary of Naftogaz of Ukraine NJSC, accounts for the largest share of gas production (70%). The rest of output is produced by almost 60 private enterprises, the key players among which are DTEK Naftogaz, MC Ukrnaftoburinnia PrJSC and Burisma Holdings. According to data by NJSC Naftogaz, gas fields were exhausted by 75% as of 2021. Therefore, in order to increase the production output and not merely maintain the current volume of production, Ukraine should move toward production of gas from unconventional sources and start developing "difficult" deep-drilling boreholes and gas production on the continental shelf and from dense rocks.

Foreign trade

In the past, Ukraine was extremely dependent on gas imports, which accounted to over 50% of its needs. Between 2006 and 2013, the only source of this gas was Russia's Gazprom (Richard, 2008). Russian gas deliveries often went beyond the framework of economic cooperation: they were politicised and became subject of unrelated issues, such as the stationing of Russia's Black Sea Fleet in the Crimea, and others. That, in turn, escalated into the so-called "gas" wars of 2005-2006 and 2008-2009, when Russia halted gas deliveries, thus artificially creating a crisis in Ukraine's energy sector.

With the start of the Russian aggression against Ukraine in 2014, Ukraine began to gradually diversify the sources of gas supply. The import of Russian gas was completely discontinued in 2015, and the 100% of imports are now coming from various suppliers across Europe (Chistney, 2022). In 2020 imported gas accounted for more than 40% of the total consumption of natural gas in Ukraine (Statista Research Department, 2022b).

The Russo-Ukrainian gas dispute of January 2009: a comprehensive assessment In 2014, the Verkhovna Rada abolished the special duty on gas exports to Energy Community member states, and in 2017, the Cabinet of Ministers abolished the licensing of gas exports and the practice of setting export quotas (Pirani et al., 2009).

3.2 Lviv

Lviv is the political, economic, financial, cultural, and educational centre of the Lviv region and in Western Ukraine. In 2016, the city celebrated its 760th anniversary, As part of the decentralization reform, Lviv Territorial Community (hereinafter Lviv TC) was created in 2020, with the city of Lviv becoming its administrative centre. The area has almost doubled mainly in the northern direction, the territorial community now occupies an area of 311.4 km^2, previously 182 km^2 (Main Statistical Office in Lviv Region, 2020). Lviv TC consists of 20 settlements, as part of the community - 3 cities (Lviv, Vynnyky and Dublyany), 2 small towns (Bryukhovychy and Rudno), and 15 rural settlements: Velyki Hrybovychy, Zbiranka, Mali Hrybovychy, Hryada, Volya-Homuletska, with. Zashkiv, Zavadiv, Zarudtsi, Lysynichi, Pidbirtsi, Malekhiv, Sitikhiv, Mali Podlisky, Ryasne-Ruske, Podryasne.

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Figure 3: Map of Lviv Oblast Region showing the city of Lvivterritorial community (Kumar, 2021)

According to the data of the Main Statistical Office in Lviv Region, 2020 , the population of Lviv TC as of 2020 is 780,801 people. The average age is 41 years. The share of population that is male is 47%, and 53% are female. During the years 2015-2020, the population of the city was stable, but had a tendency to decrease. After the formation of Lviv TC, the population rose by 57,000 people, which is an increase of 7%. As shown in Figure 3, The city is part of a bigger agglomeration, the Lviv oblast region, which is inhabited by 2.522 million people (Main Statistical Office in Lviv Region, 2018).

On average, 152,000 people from the surrounding settlements within a radius of 50-70 km around the city commute to Lviv daily (Lviv City Council, 2019). In the context of the development of Lviv, the interaction between the city and the surrounding territories should be mutually beneficial.

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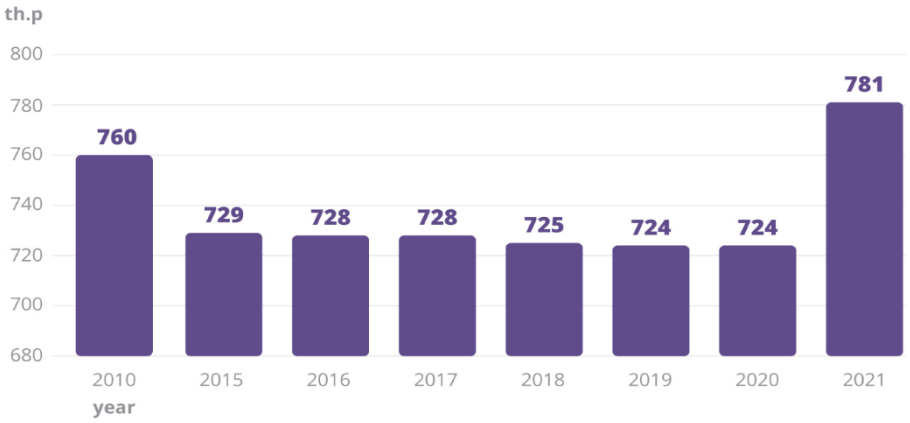

Figure 4: The number of population, th.p (Main Statistical Office in Lviv Region, 2018)

Lviv performs functions as a mini-centre, a mini-capital for the country's West. Local tourism facilities, and elements of the Carpathian tourism infrastructure are concentrated in the city (Lviv airport, concentration of management resources of the tourism industry, etc.) (Texty.org.ua, 2022).

In terms of economic and cultural interaction, the city is a powerful centre in the region of Central-Eastern Europe. The economy of Lviv was reoriented from heavy to light industry and the service sector. The community's economy includes food and beverage manufacturing, information technology, and tourism, while engineering remains an important industry. In addition, many banks and other financial institutions operate in the territory of the city. Lviv is also the most significant transport hub in Western Ukraine. Lviv International Airport named after Danylo Halytskyi, which is located 6 km from the city centre, provides air connections with other cities of Ukraine, as well as with many European and Middle Eastern destinations. International highways connect Lviv with Kyiv, Budapest, Warsaw, and Krakow, while national highways provide connections with other cities of Western Ukraine. Similarly, the railway network provides connections with other parts of Western Ukraine; a significant part of the railways connecting Ukraine and Central Europe passes through the city of Lviv.

The city is an important educational centre in Ukraine, which has 12 universities, 8 academies, and a number of general educational institutions. In addition, Lviv is home to 8 institutes of the Ukrainian National Academy of Sciences and several dozen research institutes.

The main indicators of socio-economic and cultural development of Lviv as of 2020 are presented in

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Table *1* (Lviv City Council, 2018).

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Table 1: Indicators of socio-economic and cultural development of the Lviv (Lviv City Council, 2018)

№	Indicator	Unit	2018	2019	2020
1	Average monthly salary	Ukraine hryvnia (UAH) per month	8 568	10 261	11 300
2	Salary arrears (at the end of the year)	million UAH	20 982.8	9 894.0	8 000.0
3	Amount of sold industrial products at current prices - total	million UAH	45 896.5	41 777.9	44 284.6
4	Number of industrial sales products per person	thousand UAH	61.1	55.2	58.5
5	Small enterprises	pieces	10 457	10 822	11 147
6	Average annual number of employed workers at small enterprises	thousand per	53 004	53 534	54 069
7	Amount of products sold (works, services) by small enterprises	million UAH	53 304.5	64 498.4	78 043.1
8	Amount of completed construction works	million UAH	5 220.25	5 718.3	6 804.8
9	Amount of commissioned housing of the total area	thousand m^2	415.5	416.0	440.9
10	Amount of capital investments	million UAH	13 170.5	15 080.2	17 266.8
11	Amount of capital investments	million USD	39.6	38.9	40.2
12	Amount of goods export	million USD	551.3	473.2	530.0
13	Amount of goods import	million USD	1 482.2	1 442.3	1 831.7

According to the indicator for number of small enterprises per 10,000 people of the available population, Lviv ranks second place among the regional centres of Ukraine (Lviv City Council, 2018). The development of the IT sector has had a positive impact on the city's economy, where the number of employed people has increased from 13,000 to 22,000 in two years. As of 2019, there are 461 IT companies in Lviv, and the growth rate for 2019 is one and a half times greater compared to the previous year. The IT industry makes up 20.3% of the structure of Lviv's economy. Each IT specialist in Lviv creates 2.9 jobs, meaning about 70,000 new jobs were created from IT activities in 2019. However,

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the issue concerning lack of office space and of business infrastructure in the city remains unresolved.

Despite significant development, the community faces a number of challenges, ranging from air quality and traffic congestion to pressure on limited green space, land, and water resources. Environmental problems are one of the priorities Lviv is actively involved in mitigating. The City Council is continuously working to improve the existing situation. Close ties with the EU countries have led to the definition and implementation of relevant regulatory documents and standards in the field of the environment. More specifically, it has contributed to the development of a number of strategies and plans over the past few years, although the implementation of many recommendations has been hampered by a lack of funds and human resources in the city authorities.

After signing the Association Agreement with the European Union (EU) in 2014 and assuming international obligations (including to the IMF), Ukraine began work on reforms to stimulate energy efficiency (Razumkov Centre, 2017a). In 2017, the Energy Strategy of Ukraine until 2035 was approved, which provides for reducing the energy intensity per unit of GDP, increasing the level of energy security and sustainability, as well as measures for integration into the EU network.

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4. SMART CITY INITIATIVES

The development of e-governance, the introduction of various tools of e-democracy, as well as general smart city technologies in various spheres of life are an important component in the development of a modern city.

The digital transformation of Lviv began in 2016, when the first programme of digital transformation (digital policy) was adopted. In recent years, a number of elements of e-governance have been introduced, aimed at simplifying residents' access to various types of information, establishing transparency and accessibility of local self-government bodies, as well as the ability to contact officials via the Internet.

Every year the technological services of the municipality are updated. These updates include:

- The official website of the Lviv City Council, e-services of the “City Hotline” (in form of a website and a mobile application) and other web resources implemented to inform citizens about the work of executive authorities, access to administrative services and other important municipal functions, and the interaction of residents with the authorities;
- An electronic document management system in the municipality, which aims at an increase in the efficiency of the communication with state authorities;
- E-democracy tools such as the public and transparent budgeting, electronic petitions and electronic public consultations. These services shall allow residents to directly influence important decisions regarding the development of the city;
- Different electronic services that aim to simplify and speed up the communication between local authorities and residents and make processes open and transparent. Among them, the "Resident's Personal" portal, which allows residents to order administrative services online;
- The ecosystem of portals and services "Open data of Lviv", which includes the Open Data Portal, the City Dashboard, the Geoportal of Lviv and the chatbot City Helper, which provide citizens with access to public information in various convenient formats;
- A register of the territorial community of the city was introduced and is regularly updated. It comprises all services related to the registration of the place of residence for the cities’ inhabitants;
- Electronic services for tracking traffic have become indispensable tools for public transport. E-payment in form of an e-ticket is being implemented for the city-wide public transport system;
- The municipal video surveillance system was expanded, covering a larger area of the city. It uses face and license plate recognition systems, and shall work as an integral part of ensuring public order in the city.

Lviv's successes in the field of digital transformation, e-government and implementation of "smart city" technologies have been repeatedly recognized in various ratings and awards. In particular, according to the results of the evaluation of the transparency of cities by the international organization Transparency International, every year Lviv

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receives leading positions in this rating. Lviv also received the Open Data City Award 2017 for the highest standards of open data publication (as part of the USAID and UkAID project "Transparency and Accountability in Public Administration and Services"). The city council's electronic document management system was recognized as the best in the "Working Community" (Diyeva Hromada) competition by the Ministry of Digital Transformation of Ukraine (2020). In the implementation of "smart city" technologies, Lviv was repeatedly recognized in various nominations within the framework of the Kyiv Smart City forum: "City of startups" (2018), Mobile city (2019-2020), Architectural city (2020), Ecological city (2020).

The creation of the Ministry of Digital Transformation of Ukraine in 2019 as a specialized central body of the executive power provided a significant boost in the development of the implementation of information technologies in the field of public administration and e-governance. In particular, a number of normative documents were developed and approved, introducing the trends of digital transformation of Ukraine, which must also be met by cities and territorial communities in all corners of the country.

Therefore, after analysing the elements of e-governance that were implemented and functioning in the city of Lviv, the formation of the Lviv city territorial community and the inclusion of other settlements in its composition, as well as new challenges in the field of digital transformation of society, a new Digital Transformation Programme was proposed and approved of the territorial community for 2021-2025 (hereinafter - the Programme) and its new tasks are defined.

The goal of the Programme implementation is to achieve world standards in the provision of administrative and communal services, the openness and accessibility of government, the efficiency of managing the community's economy, with the use of information technologies in all spheres of life.

The main tasks of the Programme development are:

1. Ensuring access to all electronic services and services for residents of all settlements of the Lviv City Territorial Community, in particular by providing unimpeded access to high-speed Internet in all settlements and social infrastructure facilities on the territory of the Lviv City Territorial Community.
2. Updating, consolidation and unification of software and technical resources to ensure the flexibility of their use and reliable operation of the information and communication infrastructure.
3. Support and improvement of the information security system for the functioning of city electronic services.
4. Increasing the level of automation of management processes of the Lviv City Council, as well as subordinate communal enterprises and institutions.
5. Implementation of electronic services to optimize communication between residents and executive authorities.
6. Implementation of informatization projects for the modernization of all spheres of life activity of the Lviv City territorial community.
7. Development of cooperation with IT companies and associations.
8. Implementation of training programmes and improvement of computer literacy of residents.

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To ensure the realization of the goal and the implementation of the tasks, it is planned to implement measures divided into the following directions: IT infrastructure, electronic services, open data, e-democracy, digital literacy, cybersecurity, increasing the efficiency of the organization of the activities of the Lviv City Council, e-education, e-health care, e-culture, smart mobility, smart environment, public safety, promotion of e-government and digital capabilities. Each of these directions contains a number of projects (a total of 55 projects of digital transformation), which are implemented and supported by the information technology office of the Lviv City Council, the Lviv communal enterprise "City Centre of Information Technologies", as well as with the mandatory involvement of various specialized structural units of the Lviv City Council and subordinate communal enterprises that specialize in management in various spheres of city life.

Lviv strives to maximally support national initiatives aimed at the rational use of energy, energy efficiency, adaptation to climate change, and the use of renewable energy sources. For many years, the energy policy has been aimed at sustainable development, environmental protection, energy efficiency, and the use of renewable energy sources. By joining the Agreement of Mayors, developing and implementing the Sustainable Energy Development Action Plan - SEAP (2010-2020), the energy policy of Lviv city was recognised in Europe as well. In order to mitigate climate change, the city of Lviv was one of the first cities in Ukraine to join the Covenant of Mayors, an initiative of the European Commission launched in January 2008. After the implementation of the Sustainable Energy Development Action Plan by 2020, Lviv will join initiative of the Agreement of Mayors. For the 2020-2022 period, the Sustainable Energy Development Action Plan (SEAP) has been updated to the Sustainable Energy Development and Climate Action Plan (SECAP).

An energy-independent city is Lviv's ambition, which includes the advancement of the city's energy sector. This emphasises the transition to 100% renewable energy sources, and the development of energy-efficient and energy-positive districts in the city. The vision of Lviv is a climate-neutral community in 2050, which strives to achieve the goals of sustainable development at the local level.

In 2018, the city signed a memorandum regarding the transition to 100% use of renewable energy sources in the city's energy balance by 2050. In 2020, the Strategic Plan of "Green City" measures for the city of Lviv was approved, as part of its preparation, in which five priority environmental problems were identified:

- Solid waste. Improvements to the waste management system are needed, including the construction of a new waste management facility, improvements in collection systems and reuse rates, and renovation of the old landfill.
- Water resources. It is necessary to reduce leaks in the water supply system and reconstruct the wastewater treatment plant.
- Transport and its impact on air pollution, noise pollution, and overloading of city infrastructure.
- Energy efficiency in buildings. It is necessary to improve energy efficiency in buildings and use urban renewable energy sources.

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- Use of land resources. Improvement of territories and quality of green areas. It is necessary to ensure the sustainable use of land resources in the city.

For the period from 2019 to 2020 in Lviv, an initial assessment of the city was carried out in accordance with the methodology of the European Energy Award, which indicated a score of 52.4%, which allows the city to receive his award (Association Energy Efficient Cities of Ukraine, 2015). At the same time, in 2020, the EEV Action Programme was developed and approved to achieve further improvements in energy efficiency.

The Lviv City Council has systematically worked on solving the above-mentioned tasks for more than ten years and continues its systematic work further. In particular, it is actively working on issues of climate change, energy efficiency, and renewable energy sources with international technical assistance projects in a number of sectors, including projects aimed at improving municipal infrastructure. List of partner organisations includes USAID, GIZ, EIB, EBRD, NEFCO, etc.

Lviv is one of the few Ukrainian communities that was the first to successfully move towards transitioning to 100% renewable energy sources and achieving climate neutrality. Back in 2020, the policy makers declared an ambitious goal - to achieve climate neutrality in Lviv by 2050 (Lviv City Council, 2022), which had already been integrated into city strategies and plans, including the following:

- Integrated development concept of Lviv until 2030
- Sustainable urban mobility plan of Lviv until 2024
- Comprehensive development strategy of Lviv for 2012-2025
- Sustainable energy development plan of Lviv city until 2020 and others.

As can be deduced so far, in recent years, the city has taken significant measures to mitigate the consequences of climate change and reduce greenhouse gas emissions and has also begun to implement measures to adapt to the consequences of climate change.

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4.1 Strategic Plans

Lviv is implementing “Energy Efficient Districts in Lviv” project that aims to reduce the need for housing subsidies and improve indoor comfort. An energy audit was conducted over a few months by experts on energy efficiency for 12 condominiums in Sykhiv where residents received the results of the audit along with recommendations on house upgrades and renovations that will reduce heat consumption and save more than 50% on utilities and save energy costs. These homes are part of the area selected for the pilot project “Energy Efficient District of Lviv”, a project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Government in cooperation with Lviv City Council (Lviv City Council Press Centre, 2020).

Other energy saving programmes are also made available in Lviv, especially for residential buildings and condominiums since 95% of the dwellings in the city are private apartments. Examples include the Lviv city council programmes “Warm House”, “Energy Efficient Residence”, “State energy conservation programme for condominiums and residential buildings”, and “IQ energy programme for condominiums” (Lviv City Council, n.d.).

Lviv has participated in the project "Municipal Heating Reform in Ukraine" (MHR), implemented by International Resources Group (IRG) and funded by the US Agency for International Development (USAID) as part of the international projects in which the city actively participates. Through this project, the city installed tools for thermal energy consumption metering and an automatic weather adjustment system in two schools and three residential buildings in the city (Lviv City Council, 2020).

The Lviv City Council approved the Sustainable Energy Programme 2020 (SEAP) along with a General Strategy of Development for 2012 – 2025. The main goals of both plans are reducing the energy consumption by 22.4%, improving the ecological condition of the city including reduction of carbon dioxide emissions by 20%, increasing the share of renewables to 20% by 2020, reducing energy consumption by 20% (SPARCS Proposal, 2019), and increasing the city’s energy security and its economic independence (Lviv City Council, 2020)

4.2 Indicators and Action Fields Analysis

Innovation fostered in the local economy

Lviv’s indicators show the city’s emphasis on innovation through its high scores in both areas of education and innovation leadership. The city allocates 36.5% of its overall expenditure towards the education sector which is well above the “green” benchmark at 15%. Furthermore the city’s university and college students make up 15.1% of its total population exceeding the “green” zone benchmark of 10% and indicating high educational opportunities and values.

The support for business innovation in the local economy is reflected through the positive difference between the number of business registrations and de-registrations. In Lviv it is 50 per 100,000 residents.

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Table 2: Sample economy and governance indicators for Lviv

Indicator Description	City Value	Green	Yellow	Red
Unemployment rate (%)	0.4	< 7	7 - 12	> 12
Spending on rent of net household income (%)	25	< 20	20 – 40	> 40
Doctors per 100,000 residents	387	> 200	75 - 200	< 75
Life expectancy at birth (years)	77.27	> 75	65 - 75	< 65
Number of burglaries per 100,000 residents per annum	950	< 300	300 – 1,000	> 1000
Green area (ha/100,000 residents)	37.6	> 50	20 – 50	< 20

Political accountability and high institutional resilience

Lviv's political dynamics related action fields show both a high scoring performance in some areas as well as an opportunity for improvement in others. The city scores high in the realm of path dependency in which it shows that there have been recent regular debates, during the last two electoral cycles, on long term decarbonization and energy solutions as well as existing political public debates on future urban transformation strategies. This shows the commitment towards the city's sustainability goals through integrating these debates and strategies in the political mandate. In addition, the fact that the regional and metropolitan structures as well as the local political representatives are all directly elected by the citizens, shows a high level of political accountability. However, for these efforts to be as effective as possible, further focus must be placed on sustainability matters within the political mandate and the different political parties. For instance, the formation of coalitions and partnerships regarding the sustainability issues as well as having political parties that are directly defined with urban sustainability. This highly increases the willingness for further opportunities to be seized in this regard

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5. ENERGY PROFILE LVIV

Lviv has been working towards sustainability in the energy sector since 1994 where the city began to actively promote the establishment of tools for implementing energy consumption metering in buildings (Lviv City Council, 2022). Since then, the city has participated in a number of projects concerning the management of energy resources such as the MUNEE project. The project aimed at exploring possibilities of using low-cost methods for more energy efficient buildings. This was possible through the implementation of a pilot project as a tool for the exploration in materials and tools to create a database for energy consumption in buildings. Another project in this context is the EMULATE project "Energy City" within the European program TACIS which focused on providing an opportunity for cities to learn from the experience of a number of European cities to be able to build modern energy management systems for city buildings.

The city carried out several organisational and restructuring activities within its administrative body to focus on achieving its energy policy. Lviv introduced monthly energy consumption monitoring in over 500 public buildings as well as developing approved limits for energy consumption where a considerable amount of energy was saved by the year 2010 (Lviv City Council, 2022).

Lviv focuses on engaging the community and people in its plan for energy saving, especially among the youth in schools. Many activities, campaigns, and measures are constantly taking place to raise awareness and popularise the concepts and potential of energy efficiency. These activities include supporting the "Earth Hour" organised by WWF, the initiation of "Energy Efficient Schools" where elective courses concerning the matter were held in some schools in the city and a number of public campaigns take place regularly in the city such as the "Energy Days" (Lviv City Council, 2022).

5.1 Strategic Plans and Goals

Electricity

In 2018, the reform of the energy sector at the state level began in Ukraine. One of the points of this reform is that Oblenergo of Ukraine was divided into a distributor and a supplier in order to fulfil the requirements of the Law of Ukraine "About Electric Energy Market" (Lviv City Council, 2022). Today, they are legally two different companies. Therefore, the electricity supplier Lvivenergozbut LLC separated from Lvivoblenergo. Now Lvivoblenergo Private Joint Stock Company provides electricity distribution services to consumers in the Lviv region, provides electricity to about a million consumers and issues bills to consumers, while Lvivenergozbut LLC is a company that supplies electricity and accepts meter readings. Characteristics of the Lvivoblenergo PrJSC network are presented in Table 3.

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Table 3: Network information about PrJSC “Lvivoblenergo” (Lviv City Council, 2022)

Indicator	Unit	Value
Electricity supply area	thousand km	21.8
Total number of substations	pieces	9561
35-110 kW	pieces	214
6-10-35/0,4 kW	pieces	9347
Total power of transformers	MVA	5 758.1
35-110 кW	pieces	3 299.5
6-10-35/0,4 кW	pieces	2 458.6
Length of overhead power lines	km	37 738.9
Length of power transmission cable lines	km	4 291.1
Total number of employees	persons	4 140

Subsidiaries of Lvivoblenergo PJSC: Lviv City Electric Networks (LCEN); 6 subdivisions of district electrical networks and 4 structural units: "Lvivenergoaladka", "Lvivenergoavtotrans", Guard Squad, "LvivenergoCommunication". As of today, LCEN serves 2,700 km of cable and 700 overhead power lines with a voltage of 0.4-10 kV, 79 distribution points of 6 kV, and more than 1,100 transformer substations. LCEN supplies electricity to almost 300,000 private and legal consumers (Lviv City Council, 2022).

In recent years, significant development of alternative sources of electricity has been observed in the Lviv region. The share that occurs in regional networks is growing significantly. For instance, generation in 2017 was 3.1 million kWh, in 2018 it was 21.3 million kWh, then in 2019 it rose to 110.3 million kWh (Lviv City Council, 2022). The issued technical conditions for the connection of alternative energy sources make it possible to make a forecast of the electricity amount supply of electricity producers connected to the distribution system.

Figure 5 shows the percentage distribution of electricity consumption in Lviv between the main consumers in the base and current years. In general, electricity consumption decreased by 18% compared to the base year (Lviv City Council, 2022).

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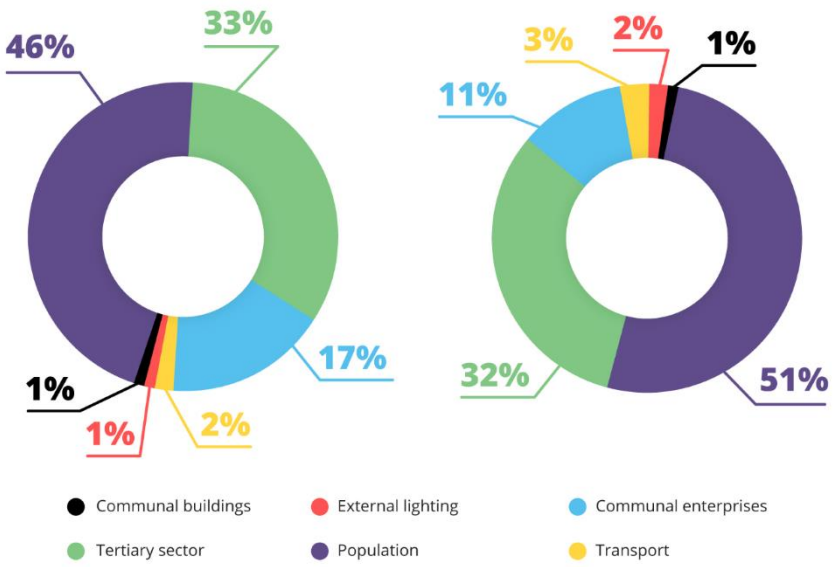

Figure 5: Distribution of electricity consumption by the main consumers of the community in base and current years, % (Lviv City Council, 2022)

Transport

Transport is considered one of the biggest problems in Lviv, as about 90% of air pollution in Lviv is caused by motor vehicle emissions (Lviv City Council, 2022). The amount of CO_2 emissions generated by motor vehicles depends on numerous parameters, the main ones being the type of fuel, engine design, age and type of vehicle, average annual mileage, average fuel consumption per 100 km, seasonal and weather conditions, etc. Calculation of CO_2 emissions from vehicles is based on data on total fuel consumption. For each type of fuel, the appropriate characteristics are used in the calculations - fuel conversion coefficients from natural units to energy units and greenhouse gas emission coefficients. For the analysis of emissions from transport, the following types of fuel are taken into account:

- petrol,
- diesel,
- liquefied gas,
- compressed natural gas,
- electricity.

As a percentage of the collected data on fuel consumption, compressed natural gas is less than 1%, so it is not taken into account in the calculation. Public transport is the main mode of transportation in Lviv (Lviv City Council, 2022). More than 50% of residents use it every day. The community has a developed network of public transport, one of the best electric transport networks in Ukraine, but the quality and quantity of vehicles is not sufficient. Even though a number of measures have been implemented to improve the

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fleet of vehicles, the city still plans to invest in modernisation and promote the development of public transport in the community.

The public transport system in Lviv includes trams, trolleybuses, buses, and minibuses ("routes"). LCE Lvivelectrotrans is responsible for electric transport in Lviv, while routes and buses are managed by one municipal LCE ATE No. 1 and four private companies: LTD Mira and K, PJSC LATP 14630, LTD Fiakr Lviv, LLC Uspih BM".

General information on the number of vehicles as of December 2020. and fuel consumed by public transport in 2020. presented in Table 4: Number of vehicles in Lviv (Lviv City Council, 2022) (Lviv City Council, 2022).

Table 4: Number of vehicles in Lviv (Lviv City Council, 2022)

Transport	Units	Amount
Trolleybus	pieces	121
Tram	pieces	135
Electrobus	pieces	1
Bus	pieces	510

City public transport

In order to analyse and calculate CO_2 emissions from municipal transport, data were obtained from the structural units and communal enterprises of the Lviv City Council on the fleet of rolling stock in terms of cars, trucks and other special vehicles, as well as on the amount of fuel consumed in natural units (Table 5) (Lviv City Council, 2022).

Table 5: The amount of fuel consumed by public transport (Lviv City Council, 2022)

Type of Fuel	Units	Amount
Diesel	thousand l	6411.7
Natural Gas	thousand l	11.3
Electricity	th.kW*h	22 701.5

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From the aggregated data, utility transport consumes the most diesel fuel both in the base year and in the current year. Gas and electricity consumption also increased. However, gasoline consumption has decreased significantly (Table 6).

Table 6: Amount of fuel consumed by public transport (Lviv City Council, 2022)

Type of Fuel	Units	2008	2022
Diesel	thousand l	903.31	839.95
Petrol	thousand l	825.26	437.11
Propane	thousand l	2.3	10.8
Natural Gas	m^3	233.7	288
Electricity	th.kW*h	154.6	251.65

Private and commercial transport

As of 2020, approximately 200,000 cars are registered in Lviv, which at least 50% are over 13 years old (Lviv City Council, 2022). Also, every day more and more private cars enter the city during the morning rush hour, park near their place of work and leave. This creates a heavy traffic load and negatively impacts air quality. An important problem is the very low average, speed of 11-14 km/h (traffic jams, multiple "stops, and starts") and this causes an increase in greenhouse gas emissions.

Because the level of motorisation increases, this problem will worsen if measures are not taken to at least partially reduce the use of cars. The calculation of fuel consumption and CO_2 emissions in the base year was calculated in accordance with the applied methodology for calculating private and commercial fuel for 2020. The calculation results are presented in Table 7 (Lviv City Council, 2022).

Table 7: Fuel consumption by private and commercial vehicles (Lviv City Council, 2022)

Type of Fuel	Units	2008	2022
Patrol	th.l	43156.86	72916.12
Diesel	th.l	44946.96	93439.26
Liquefied gas	th.l	6885.00	24641.61
Electricity	th.kW*h	245.28	4531.95

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The general distribution of CO_2 emissions by type of fuel from all types of transport in comparison with the base year is presented in Figure 6.

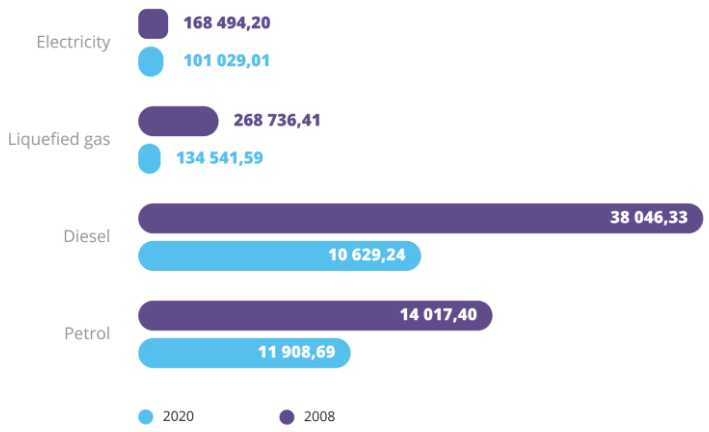

Figure 6: Distribution of CO_2 emissions by fuel type compared to the base year (Lviv City Council, 2022)

Gas Supply

Delivery of natural gas to Lviv is provided by JSC "Operator of the gas distribution system Lvivgaz". This company is engaged in the distribution of natural gas through gas distribution pipelines throughout the territory of the Lviv region.

The main activities of the company are:

- Transportation of natural gas through distribution pipelines;
- Maintenance and repair of gas networks and structures;
- Design and construction of gas supply systems using steel and polyethylene gas pipelines;
- Installation, verification, and repair of gas meters, etc.

JSC "Lvivgaz" has an extensive system of gas regulation points (GRP), underground and aboveground networks, which are connected to the population, communal households, and industrial gas consumers of Lviv. The total length of distribution gas pipelines in the region is 24,712.284 km, of which 16,638.736 km are distribution, and 8,073.548 km of gas pipelines (Lviv City Council, 2022). Regulation of gas production pressure with the help of 4,267 gas regulation points and 72,781 hose regulators.

The main consumers of gas in Lviv are heat supply enterprises, the tertiary sector, the population and public buildings. Dynamics of gas consumption for the period from 2012 to 2020 presented in Figure 7. During this period, a significant reduction in the volume of gas consumption by household consumers/population of Lviv is observed. A decrease in natural gas consumption is also observed among other categories of consumers (Lviv City Council, 2022).

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Figure 7: Dynamics of gas consumption by main consumers from 2012 to 2021, th. m^3 (Lviv City Council, 2022)

If we consider the distribution of natural gas consumption by the main consumers of the community for the current year, then almost half the amount of natural gas, 48%, is used by heat supply enterprises, 38% - by the population. 14% - the tertiary sector, and budget buildings - less than 1% (refer to Figure 8).

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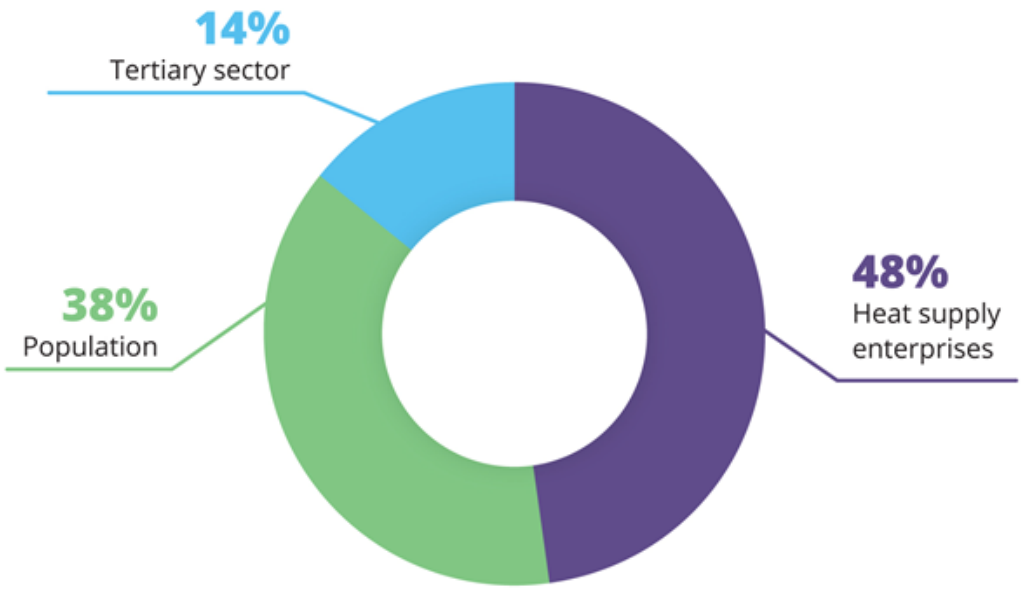

Figure 8: Distribution of natural gas consumption by the main consumers of the community in 2020, % (Lviv City Council, 2022)

From 1 August 2020, a free natural gas market for the population began to operate in Ukraine (Lviv City Council, 2022). Therefore, residents can choose a gas supply company. They have different prices and package offers, but they may differ in the quality of service. However, gas delivery (that is, maintenance of networks) is a natural monopoly, and gas delivery tariffs are regulated by the state. Precisely in order to give consumers the opportunity to freely choose their supplier, the government separated the payment for the delivery of gas and gas itself as a commodity.

From 1 July 2015, PJSC "Lvivgaz" divided its powers and is engaged only in the maintenance of gas networks and fuel accounting, while "Lvivgazzbud" LCE has become a supplier of natural gas. Now every resident can change the provider, choosing more favourable conditions for themselves.

Heat

The heat supply system of Lviv includes centralised, moderately centralised, and individual heat supplies (Lviv City Council, 2020). Approximately 60% of the city's residents are connected to the centralised heat supply system (hereinafter referred to as DH), which includes both centralised (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 central heating gas boilers to biomass. In addition, the city has a very small share of renewable energy supply due to the small number of solar PV installations installed on buildings.

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Centralised supply of thermal energy and hot water supply (hereinafter referred to as hot water supply) is carried out by two main municipal enterprises (Lviv City Council, 2020):

- LCCE "Lvivteploenergo";
- LCE "Zaliznychneteploenergo".

The main activities of LCCE "Lvivteploenergo" are the production of thermal energy, the combined production of thermal and electric energy (TPP-1), transportation and supply of thermal energy, provision of heat supply services, and hot water supply. LCCE "Lvivteploenergo" includes (Lviv City Council, 2020):

- CHP-1, HC"Northern", HC"Pivdenna";
- 154 boiler rooms;
- 136 CHP (central heating points);
- 113 IHP (individual heat points)

Technical characteristics of LCCE "Lvivteploenergo" are presented in Table 8.

Table 8: Technical characteristics of LCCE "Lvivteploenergo" (Lviv City Council, 2022)

Indicator	Unit	Value
Scheme of heat supply	-	two-pipe
Length of networks	Km	420
Total installed capacity of the enterprise	Gcal/h	1 562
Connected power	Gcal/h	1 029
Maximum annual gas demand	m3 per year	200 mln.
Maximum annual electricity demand	kWt. h	70 mln.
Annual realisation of thermal energy	Gcal	to 1 mln.
Annual production of electrical energy	kWt. h	to 65.1 mln.

As a result of the cooperation of the city council with the EBRD and the Eastern European Partnership for Energy Efficiency and Ecology (E5R), LCCE “Lvivteploenergo” received funds in 2018 for the implementation of the project "Modernisation of the Central Heat Supply System in the City of Lviv" (Lviv City Council, 2022).

During the heating season, LCCE "Lvivteploenergo" provides thermal energy (for heating needs) to 53 medical institutions, 73 preschool educational institutions, 117 secondary schools, 12 higher and professional educational institutions, as well as 1,643 residential buildings (Lviv City Council, 2022). As for hot water supply, the enterprise provides 1,100

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houses (data as of 2020). The dynamics of the implementation of thermal energy from 2012 to 2020 LCCE "Lvivteploenergo" is presented in Figure 9.

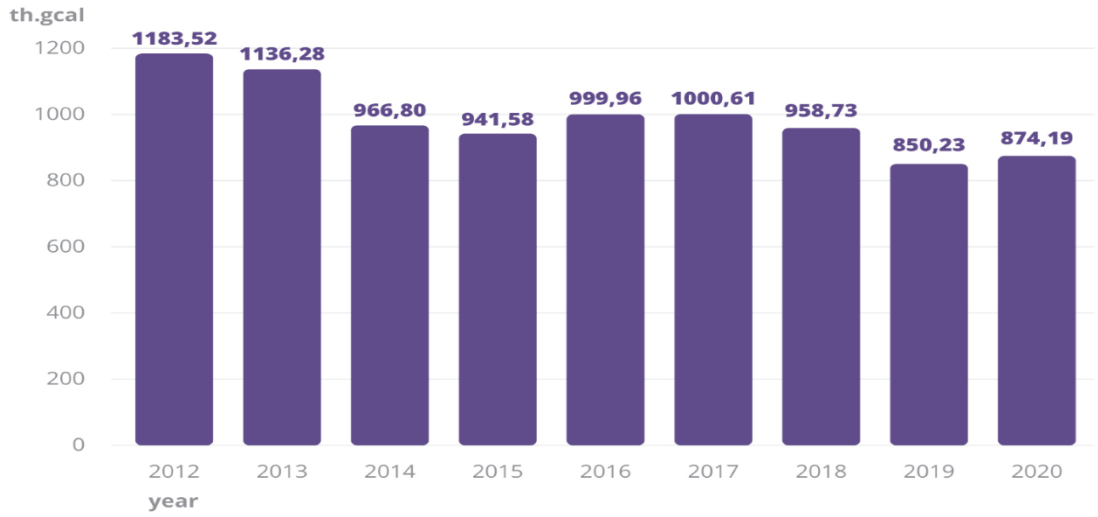

Figure 9: Implementation of thermal energy from LCCE "Lvivteploenergo", th. Gcal (Lviv City Council, 2022)

The main activities of LCE "Zaliznychneteploenergo" are the production and supply of thermal energy for centralised heating and hot water supply of housing stock, public sector facilities, and other consumers, as well as increasing the pressure of cold water to ensure cold water supply.

LCE "Zaliznychneteploenergo" operates

- 19 boiler houses;
- 33 CHP (central heating points);
- 267.6 km. heat networks (in one-pipe dimension) (Lviv City Council, 2022).

The enterprise serves Zaliznychny, part of the Shevchenkivskyi and Frankivskyi districts of the city (Lviv City Council, 2022). Centralised heating services are provided in 523 residential buildings, of which 374 have hot water supply, in 19 schools, 19 children's institutions, and 8 medical institutions (data as of 2020).

The Dynamics of the implementation of thermal energy from 2012 to 2020 LCE "Zaliznychneteploenergo" is presented in Figure 10.

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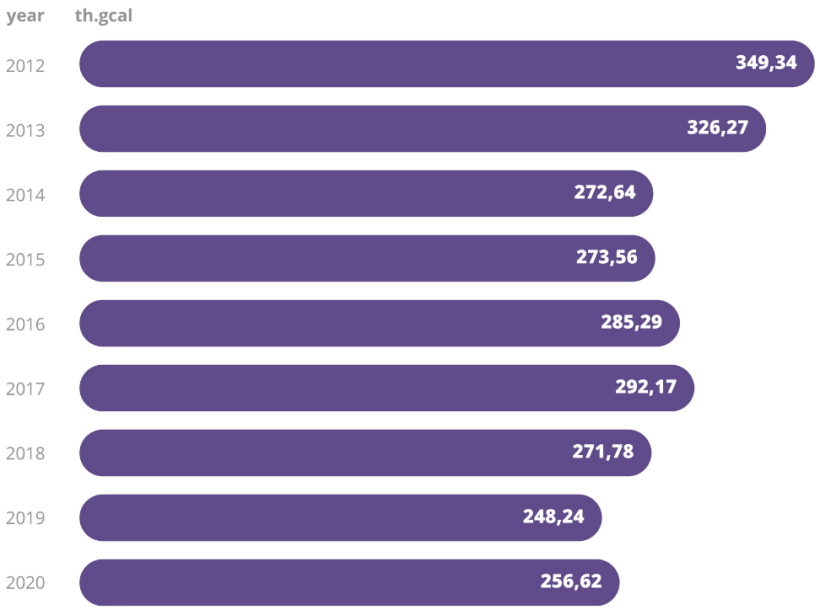

Figure 10: Realisation of thermal energy from CE "Zaliznychneteploenergo", th.Gcal (Lviv City Council, 2022)

The main consumers of thermal energy are the population with more than 60%. 10% are used by the budget sector; 23% of thermal energy is lost in networks (see Figure 11), which is much higher than the specified norm - 13% in accordance with point 3.1.8. KTM 204 of Ukraine 244-94 "Norms and instructions on the regulation of fuel and thermal energy consumption for heating residential and public buildings, as well as for economic and household needs in Ukraine." (Design and Research Institute for Gas Supply, Heat Supply and Integrated Improvement of Cities and Towns of Ukraine, 1993). Therefore, it is obvious that it is necessary to plan and implement measures for the modernisation of heating networks.

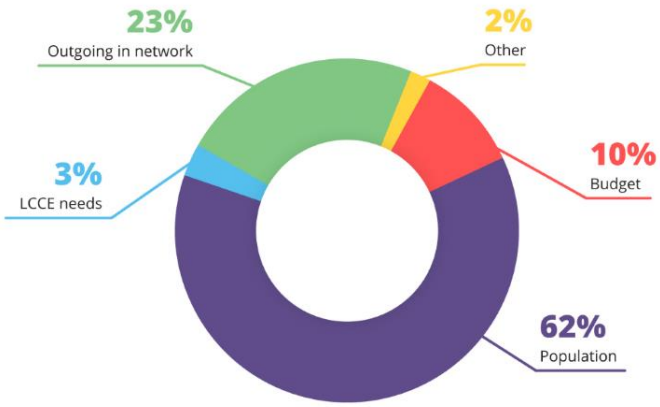

Figure 11: General distribution of thermal energy by the main consumers of the community in 2020, % (Lviv City Council, 2022)

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5.2 Indicators and Action Fields Analysis

Affordable energy prices

Reviewing Lviv's indicators that are related to the energy sector, it shows that the city faces a number of challenges in this area (refer to Table 9). The city of Lviv showed a high amount of electrical energy use of 14600 kWh/a/cap, exceeding the "red" threshold set at 7000 kWh/a/cap while it appears that electrical consumption of households specifically falls into the "yellow" range with a total of 1125.29 kWh/household/year. On the other hand, it is shown that the average electricity price for private users in Lviv is as low as 0.05 euro/kWh which certainly explains (at least partially) the high consumption values above.

As for the annual refurbishment of buildings, the city has also scored low with only 86 buildings/year, which makes up less than 2% of the existing building stock. It should be mentioned here that these building refurbishments are of large multifamily houses as there is a city and state support for the residents of such houses.

Table 9: Sample energy indicators for Lviv

Indicator Description	City Value	Green	Yellow	Red
Annual rate of refurbishment as a percentage of existing building stock (%)	86 (<2)	> 5	5 - 2	< 2
Total energy use of the city per cap (MWh/a/cap)	7.05	< 15	15 - 20	> 20
Electricity consumption per household (kWh/household/year)	1125.29	1,500–3,500	900–1,500; 3,500–5,000	< 900 or > 5,000
Total electrical energy use per cap (MWh/a/cap)	14600	< 3000	3000 - 7000	> 7000
Average electricity price for private consumers (€/kWh)	0.05	< 0.21	0.21 – 0.35	> 0.35

Centralised energy supply and smart grid in testing

Opportunities and windows for improvement are noted when reviewing Lviv's performance in the action fields. The city shows certain readiness and aptitude towards improving its performance in this area. For instance, Lviv has already carried out pilot projects with smart grid components as well as hybrid grids transforming electricity in heat/cold and the other way around. However, it shows that more focus should be placed on the promotion of the use of renewable energy such. The development of standards and obligations for investors to install or use renewable energies is needed. The city nevertheless supports and invites the installation of solar panels, wind-energy, and biomass plants through incentives and subsidies.

A noticeable room for improvement is seen in the area of thermal heat. Although there is an efficient centralised district heating and cooling system, which is covering more than

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25% of all buildings demand, it is still not running on any kind of renewable energy. Furthermore, the geothermal heat is a potential source of energy that is still not in use and can be efficiently exploited by companies and public buildings for an improved sustainable energy performance.

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6. MOBILITY PROFILE LVIV

The project "Integrated Urban Development in Ukraine" was launched in Lviv in April 2018. The project aims at helping the local authorities, in six cities in Ukraine, to plan long-term developments in their cities. As part of this project, Lviv worked on preparing and adopting a Sustainable Urban Mobility Plan (SUMP), which was approved by Lviv City Council in early 2020 (Lviv City Council, 2019).

Some of the main challenges addressed in Lviv's SUMP are the attractivity of the urban spaces and active mobility such as walking, cycling, etc. (Figure 12), street safety, the quality of public transport in terms of efficiency, ecological viability, and comfortability.

Lviv has a well-developed public transport network system in relation to other Ukrainian cities, having one of the best electric public transport networks in Ukraine. Public transport is the main mode of transportation and is used by over half of its population on a daily basis (Lviv City Council, 2019). Compared with most European cities, the number of inhabitants using the public transport in the city is high; however, this might be a repercussion of the low purchasing power of the residents rather than a conscious choice. The growth of welfare and people's relocation to the affluent suburban areas have contributed to the increase of private cars, as seen in Figure 13. This has affected the resident's mobility and quality of life, especially at the city entrances where carload tends to be high whereas at the same time the available suburban public transport is reducing and degrading.

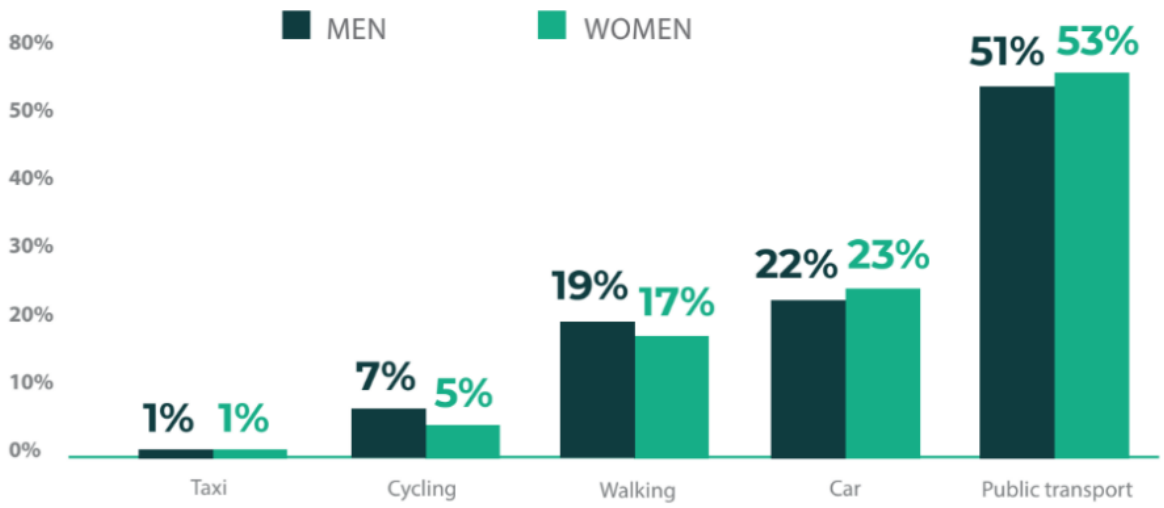

Figure 12: Lviv modal split 2019 (Mobility Lviv, 2020)

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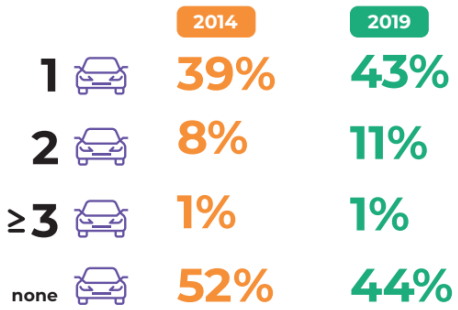

Figure 13: Growth of the ownership of personal cars per household 2014 – 2019 (Mobility Lviv, 2020)

6.1 Strategic Plans and Goals

Public transportation network

Lviv railway station serves 24,000 long-distance passengers a day; it comes second after Kyiv central station in number of passengers served per day (Lviv City Council, 2019). This numbers reached over 50 thousand daily during arrival of evacuation trains in February-March 2022 after start of full-scale invasion of Russian federation into Ukraine (Statista Research Department, 2022a). There have been ideas about including Lviv on the rail network of the European railway “Euro Collection” as part of the reconstruction of the railway line from the existing border stations "Mostiska-2" or "Rava-Ruska", which would increase the importance of Lviv as a transit point between Ukraine and the EU (Lviv City Council, 2019).

Lviv also serves around 15,000 round-trip passengers from locations around the city. These passengers mainly use the suburban and interurban bus routes. However, the passenger comfort is critically low on these routes’ stations, as most of them do not provide the necessary level of facilities. For example, most of these stations do not have adequate waiting space for passengers. There are 96.5 km of main railway tracks and 76.8 km of access railway tracks in the community as well as nine railway stations, of which two serve long-distance connections. There are 9 railway platforms in the community, with the other 10 platforms deserted and not in use. This is because many railway lines are underused. Passenger traffic is concentrated mainly at the central station (Lviv City Council, 2019).

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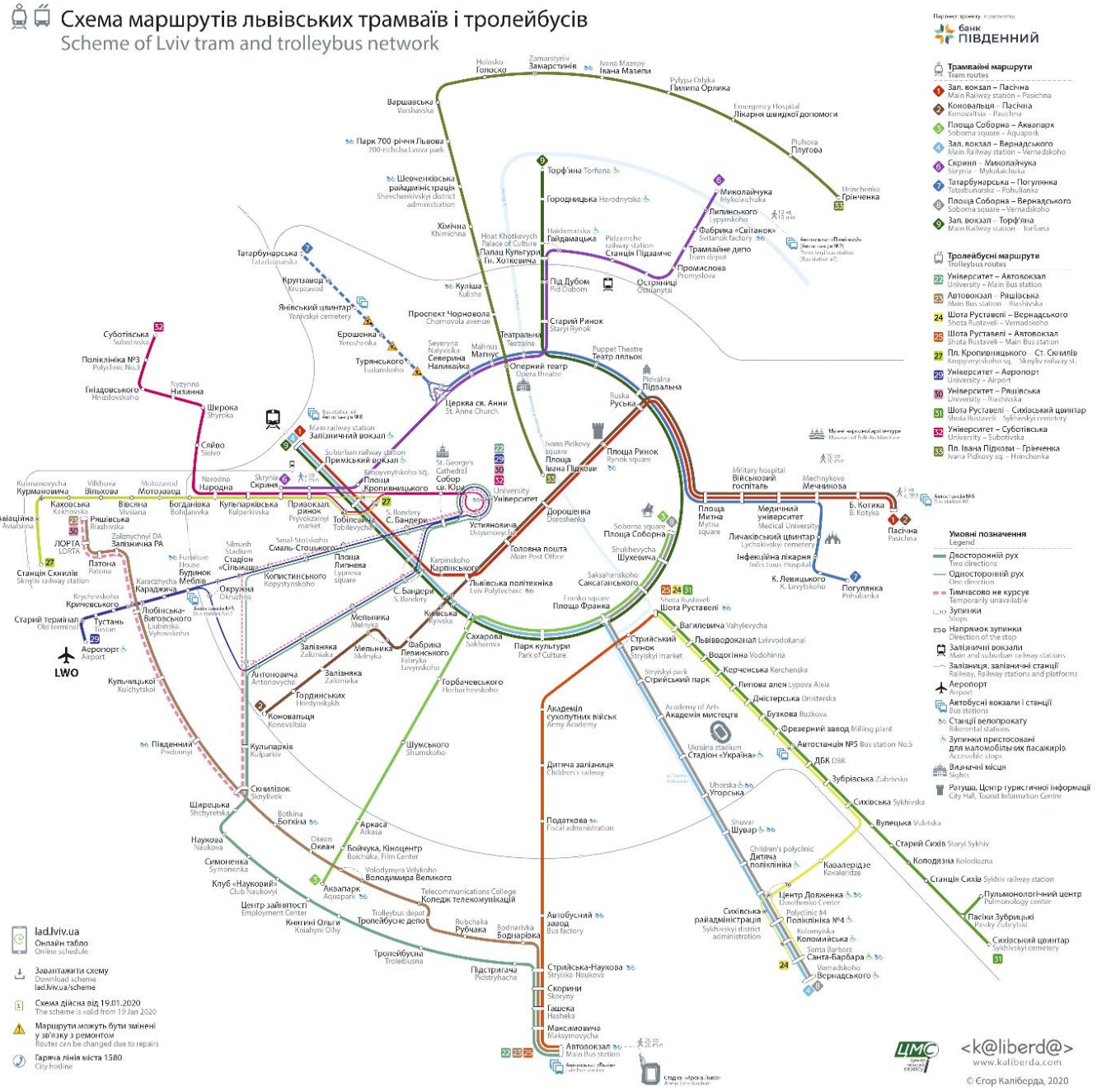

Figure 14: Lviv tram and trolleybus network (Mobility Lviv, 2020)

The urban transport system in the city consists of trams, trolleybuses, and busses (Figure 14). The electric system of public transport consists of nine tram and nine trolleybus routes. Most of the city residents use the bus routes frequently, with bus routes network consisting of 56 routes in the city. These are operated by four private operators and one municipal operator, i.e. ATP-1. At night, seven municipal bus routes connect the city with the urban outskirts and the Main railway station (Lviv City Council, 2019).

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In 2011, an urgent need for a more adequate public transport arose and in order to reduce traffic jams especially in the city centre, the city had signed a contract with EBRD to start a reconstruction along the tram routs N2 and N6. In 2012, more than 100 buses were added and put in use and the number of bus routes were reduced to 52 while the capacity of the buses was almost doubled. However, these routes number were later increased to include areas newly added to Lviv territorial community. Real Time Traffic control centre was installed in the city as part of reorganisation as well as electronic payments for electric public transport were made available in the city in 2017 (Lviv City Council, 2019).

Since 2017 Lviv has already been working together with different actors to develop a mobility card system to encourage citizens to use public transport more often. The project, "Lviv Automated Fare Collection system" was kicked off as an open call tender to develop, supply, implement and maintain automated fare collection system for Lviv. . The project is planned to be finalised in 2022 (Lviv City Council, 2019).

Active mobility

The city council in Lviv approved the development programme of the first stage of the cycle network in 2011 up to the year 2020, illustrated in Figure 15 (Lviv City Council, 2019). This involves the construction of 268 km of cycle tracks until the end of 2020. Due to various reasons, only some 100 kilometres of bicycle paths were implemented until end of 2022 which is 45% of the planned amount to be constructed. The second stage of cycling network development was initiated in 2021 and is waiting for City Council approval in the year 2022 (Lviv City Council, 2022).

Until 2015, the city did not initiate construction of individual bicycle infrastructure projects unless it was part of existing street reconstruction or maintenance projects (Lviv City Council, 2019). The lack of experience in designing bicycle infrastructures and the priority of a city planning for the car movement, led to some problems in the implementation. The implementation of the first lanes provoked for instance movement conflicts with pedestrians as well as fragmentation of the bicycle network in the city.

The first full cycling route connected the northern district of the Halytske Perekhrestia area with the central part of the city. The emergence of this route as well as its flat terrain had contributed to the fact that the northern regions showed the most cycling activity. In 2018, the percentage of city trips by bicycle during the warm season was about 1.5% (Lviv City Council, 2019). The share of bicycle use in the city is growing each year as the city has been working on promoting the cycling culture in many ways such as by producing a series of videos under the name "bike to work" (Mobility Lviv, 2020).

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Figure 15: Planned Lviv cycling infrastructure development 2011-2022 (Mobility Lviv, 2020)

In Lviv the pedestrian and cycling comfort shows still some room for improvement. New Spaces for pedestrians are made available for example when construction and rehabilitation of streets happens. Also since 2014, the city has been actively implementing pedestrian and child-friendly sidewalks and public spaces (Sustainable Urban Mobility Plan, 2020) as well as fully pedestrianizing the old medieval centre of the city.

As part of the city's plan to enhance its accessibility and motivate the citizens to a more active lifestyle, "The Green Line Project" is being developed by the German Society for International Cooperation GIZ with support from the Department of Architecture and Urban Studies of the Lviv City Council (Lviv City Council, 2019). The project develops an approximately 8 km cycling and walking route that will connect the Sykhiv residential district with the centre of the city of Lviv, passing through and providing access to a range of public facilities, institutions, and public spaces along the way. The first stage of this project is due in 2022.

The Green Line Project is part of the city's green network and aims to create more options for the different users and its different levels of accessibility (see Figure 16). The project will meet their day-to-day mobility and leisure needs as well as create more access to the green spaces. In general, it is aimed to achieve three main goals: city connectivity, city walkability, and leisure. For this playgrounds, sports grounds, cultural areas, and suburban pedestrian areas will be created to encourage the development of a suburban cycling route (Mobility Lviv, 2020).

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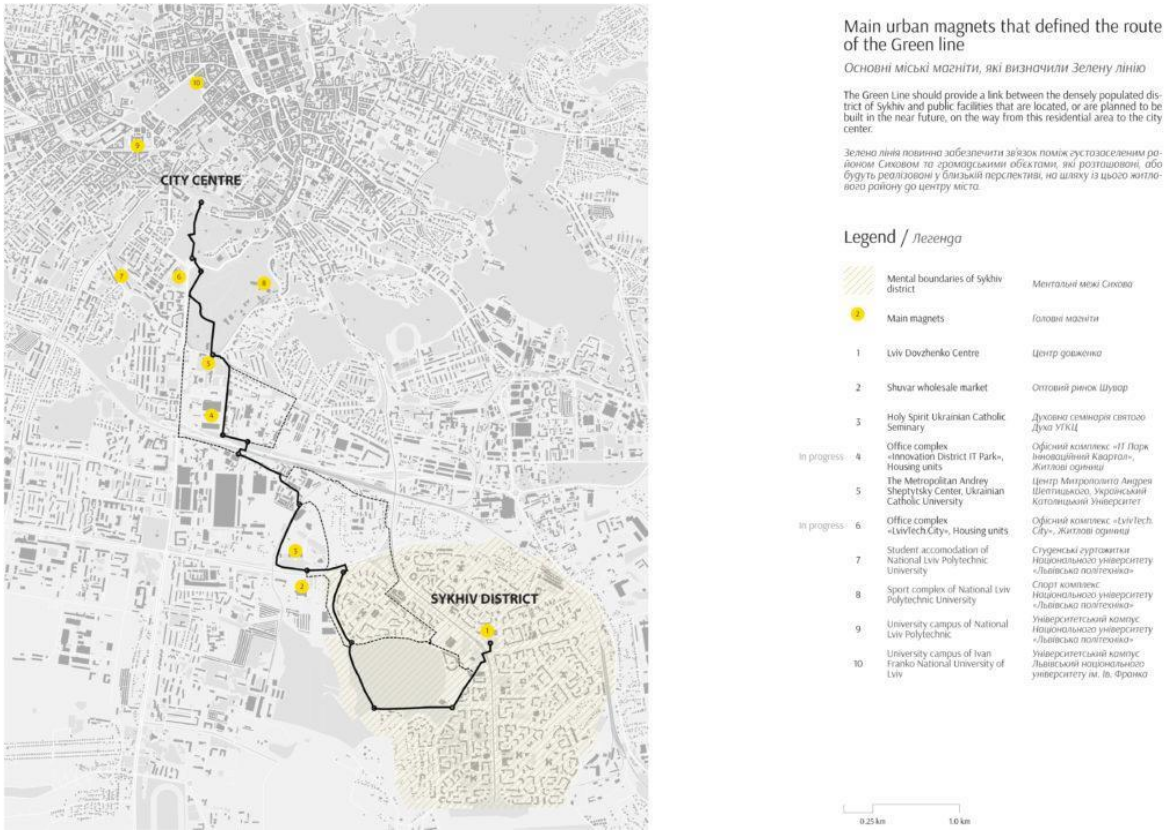

Figure 16: Main and alternative ways of laying Green Line and the city magnets, forming the route (Mobility Lviv, 2020)

6.2 Indicators and Action Fields Analysis

Local readiness for inter-modality

With the high value of 54% share of the public transport in the city´s modal split, Lviv performs very well relative to other European cities and is exceeding the "green" benchmark at 40%. The share of private vehicles is low (23%). This is placed well below the "green" zone benchmark and would translate into not only less local air pollution and CO_2 emissions but also to greater opportunity for the development of alternative transportation modes. The city's share of bicycle and pedestrian modes are marked at 6% and 24% sequentially with both values falling in the "yellow" range. The indicator kilometres of bicycle path per 100,000 inhabitants marks 15.1 km which falls well below the "red" benchmark at 35 km/100,000 inhabitants. This suggests that the bicycle infrastructure is not developed enough to accommodate the potential increase of bike use as a mode of transport. This value is surprisingly not coherent with the above-mentioned good performance in the indicator share of bicycle use in the city which might indicate a less safe environment for bikes on the streets and therefore validate the aforementioned planned project "Green Line". The sample mobility indicators are tabulated in the table below.

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Table 10: Sample mobility indicators for Lviv

Indicator Description	City Value	Green	Yellow	Red
Share of traffic by public transport of total traffic (%)	59	> 40	25 - 40	< 25
Share of traffic by bicycle mode of total traffic (%)	8	> 25	5 - 25	< 5
Share of traffic by pedestrian mode to total traffic (%)	24	> 40	20 - 40	< 20
Personal Vehicles (including private vans, excluding motorcycles and trucks) to total traffic volume (%)	10	< 15	15 - 40	> 40
Share of economic traffic on overall road trips (%)	32.1	> 20	20 - 30	> 30

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7. PROJECT IDEAS FOR THE TRANSFORMATION OF LVIV

7.1 Virtual Onsite Assessment

Due to the COVID restrictions on-site assessment week in Lviv was organised during a period of two months and several online and hybrid co-creating sessions were organised as part of the workshop. A total of 9 project ideas were developed together with the interviewees and during the internal co-creating sessions with the local team. These project ideas were inspired by the implementations in the Lighthouse Cities in SPARCS. As an introduction, the City Lab methodology was presented followed by the presentation of the preliminary results and the 9 developed ideas. After that the participants were divided into 3 groups according to their expertise and/or area of interest for a detailed discussion on a specific project package and developed a list of projects, as illustrated in the following figure.

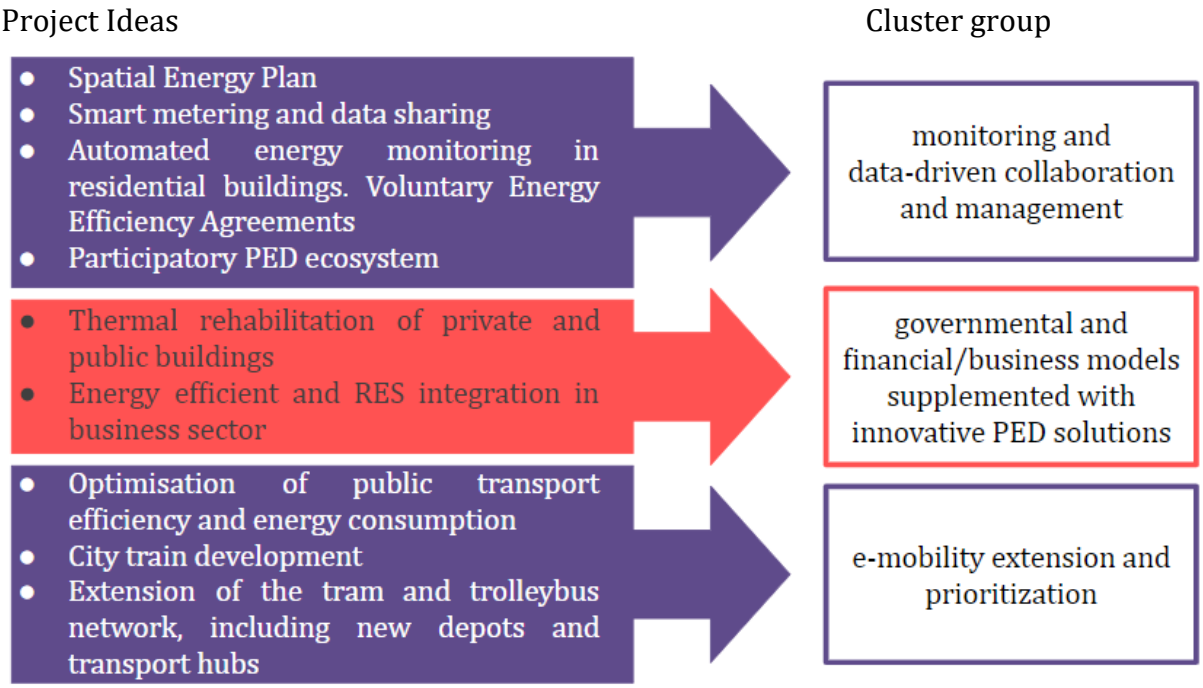

Figure 17: Projects developed in 3 groups for replicating PED solutions in Lviv

7.2 Innovation process

Following the project idea creation process, a new session for discussion was organised to validate and further develop the projects regarding their needed components, the strategic stakeholders, next steps, possible financing options, and others. Specific templates were designed, distributed and explained to the moderators in advance. The groups had two weeks to fill in the templates (see the first project descriptions below). Finally, the results of the discussion and the filled templates were presented to the plenum in the form of a marketplace with a short 3-minute pitch.

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However, due to the Russian full-scale invasion to Ukraine a number of project ideas had to be changed due to the new financial situation and other challenges connected to the war. An internal workshop was organised to adapt the project descriptions. Further frameworks were defined that would enable implementation and replication of innovative solutions under the state of war in Ukraine and the very unpredictable environment. As a result, three final framework projects were defined to continue the development of PED solutions in Lviv, which are described in the following section.

7.3 Project Ideas for Lviv

Project 1. Spatial Energy Plan

Figure 18: Spatial Energy Plan

Components

№	Component
1	Creating a district heating GIS for data collection, analysis and visualisation.
1.1	Geodesy works for georeferenced data collection regarding district heating infrastructure
1.2	Creating district heating infrastructure layer for GIS
1.3	Creating a building layer for GIS
1.4	Developing an interface on city land cadastre portal for visualisation of data
1.5	Developing an interface on city open data portal for visualisation of data
2	Development of the district heating scheme with feasibility studies for district heating development actions

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council	Lviv City Council	LCE Lvivteploenergo LCE Zaliznychteploenergo Office of Architecture and Urban Planning Department of Housing and Infrastructure	Citizens and businesses in Lviv

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Applying a district approach in energy efficiency planning and management. - Increase the energy efficiency of the building sector and heating infrastructure. - Reduce the costs for heating services and increase the comfort of living. - Stimulate the energy efficiency measures implementation in Lviv. - Increase the safety in the field of using gas infrastructure.	- Reduce the use of gas for heating and CO_2 pollution.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- District heating provides services for 2400 multifamily buildings of Lviv. - District heating in Lviv needs to be modernised because more than 800 km of pipelines are more than 20 years old and are in a bad condition. - District heating in Lviv uses natural gas as a primary source for heating. - Heating supply is 643.3 Gcal*hour. Losses in the system are more than 50 %.	- Gas supply to Ukraine is not stable in the long term, due to a military conflict and economic war with Russian Federation, thus, to mitigate risks related to gas supply or price changes, district heating in Lviv should be efficient and flexible. - Municipality cannot finance the modernization of district heating, only by using local budget resources and need to engage private stakeholders in joint investments into the infrastructure. - Last update of the heating scheme was in 2008.	NA

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Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Lack of proper inventory of data. - Unstable price for energy resources. - Lack of legal framework for district heating development. - Lack of the one data sharing protocol. between counters in buildings and counters in DH companies.	- Grants - Local budget

Next Steps

Next Steps / Obstacles
- Exchange of knowledge with Mariupol city on the methodology of heating scheme development. - Tender for a geodesy of district heating infrastructure for LCE Zaliznychteploenergo and implementation of works. - Tender for geodesy of district heating infrastructure for LCE Lvivteploenergo.

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Project 2. Smart metering and data sharing

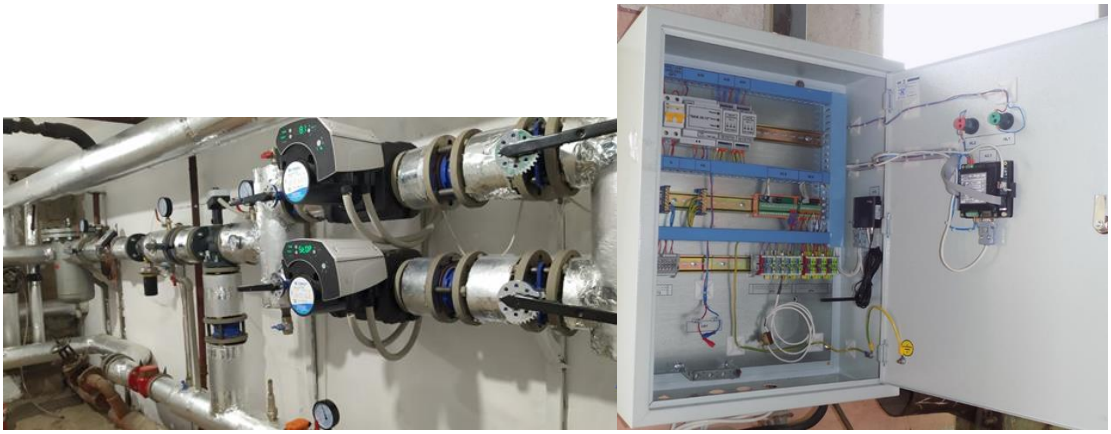

Figure 19: Smart meters

Components

№	Component
1	Gathering data about the existing system of sensors and other smart meters in Lviv.
2	Feasibility study about existing market opportunities regarding smart energy and water data monitoring systems.
3	Choosing one the most efficient data monitoring systems and testing it on several buildings in Lviv to justify the optimisation characteristics of energy operations.
4	Replicating data monitoring system in Lviv for development of an optimised system for data gathering regarding heat and water consumption in Lviv.

Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
LCE Lvivvodokanal LCE Lvivteploenergo LCE Zaliznychteploenergo	Building owners Municipal IT Centre	LCE Lvivvodokanal LCE Lvivteploenergo LCE Zaliznychteploenergo Municipal IT Centre	Department of Housing and Infrastructure

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Monitoring of energy and water consumption and more efficient use of heating energy and water. - Implementation of sustainable development programmes (Spatial Energy Plan, IUDC: Lviv 2030, GCAP, SECAP, Municipal Energy Plan). - Improvement of citizens quality of life and economic well-being (reduction of expenditures for heating).	- Reduction of energy resource consumption - Reduction of CO_2 emission via energy efficiency measures implementation based on monitoring.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- Different non-interoperable systems of data collection and no automated process of data synchronisation.	- Law that regulates the need for installing meters in each building. - Programme that supports the installation of meters	

Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Lack of opportunities to install smart meters in some buildings. - Low signal for data transfer from meters to central database. - Unequal distribution of costs among citizens for heating and water supply services.	- Local budget and programmes for implementing energy efficient measures.

Next Steps

Next Steps / Obstacles
- Gathering data about existing systems of data gathering and smart meters in Lviv. - Feasibility study about existing systems and smart meters in the market. - Testing the most suitable monitoring system in minimum 2 buildings. - Replicating and providing the autonomous system of heating and water consumption in Lviv.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Project 3. Automated energy monitoring in residential buildings. Voluntary Energy Efficiency Agreements

Components

№	Component
1	The Voluntary Energy Efficiency Agreements (VEEA). Drafting and concluding the VEEA between energy consumption data managers and housing cooperatives regarding voluntary commitment to energy efficiency measures implementation and municipality access to energy consumption data.
2	Creation of Information-Analytical Solution (IAS) for gathering, analysis and presenting the data of average indicators for energy consumption and energy efficiency. As well as the dynamics of energy efficiency change (fluctuation).
2.1	Integration of data from energy consumption data managers.
2.2	Data collection and gathering (preservation).
2.3	Data processing and analysis.
2.4	Data presentation in the form of a convenient and intuitive web-platform interface.
3	Energy consumption data integration with existing systems of data collection, processing, and presentation in Lviv city (Open Data Portal, City Dashboard, Geoportal Lviv, Spatial Energy Plan).

Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council NECU	NECU	Heads of housing cooperatives Management companies Lviv citizens Energy consumption data managing companies Service providers LCE Municipal IT Center LCE Teploenergo LCE Zaliznychteploenergo	Department of Housing and Infrastructure

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Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Implementation of sustainable development programs (IUDC: Lviv 2030, Spatial Energy Plan, GCAP, SECAP, Municipal Energy Plan). - Improvement of citizens' quality of life (in accordance with the results of an index study of the quality of life of residents) and economic well-being (reduction of expenditures for heating and electricity).	- Reduction of energy resources consumption. - Reduction of CO_2 emissions after energy efficiency measures implementation.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
As for today, Lviv City Council does not possess the full data on energy consumption in the residential sector.	Consolidated data on gas and electricity consumption are in the possession of energy consumption data management companies (monopolists), who are not interested in the transfer of data to the municipality. This creates obstacles for free analysis and inclusion in the web platform.	Energy consumption data is partially personal and considered to be 'sensitive' data. Residents have little motivation to transfer their own energy consumption data to the municipality.

Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- The absence of a system for analysing data on energy consumption does not allow us to clearly articulate the goals and targets for achieving energy efficiency.	- Reduction of heating and electricity costs. - Potential reduction of energy losses through decision-making on energy efficiency measures implementation, planning and problem-solving. Incentivizing of companies, which deal with the implementation of energy-efficient solutions (including banks, construction businesses, and consulting). - Such data will allow the city to attract external funding for energy efficiency projects and implement larger-scale schemes, which will help to benefit from economies of scale.

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Next Steps

Next Steps / Obstacles
- Creating a concept for a data collection solution. Establishment of an automated mechanism for transfer/open access provision to energy consumption data, its collection, and later - a cartographic web platform for visualisation of processed data - NECU. - Organisation of meetings of residents of housing cooperatives to provide permission for the transfer/open access provision to energy consumption data to the municipality or third parties (data processing companies) – LCC. - Survey of Lviv housing cooperatives regarding the transfer of data on energy consumption and energy efficiency and find out the motivation for the transfer of these data. - Organisation of dialogue between service providers (energy consumption data management companies) and Lviv City Council on data transfer decisions. - Creation of mechanisms for involving housing cooperatives and energy consumption data management companies in concluding the VEEA; submission of this issue for consideration and discussion with the SPARCS consortium - LCC+NECU. - Drafting of the Voluntary Energy Efficiency Agreements.

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Project 4. Participatory PED ecosystem

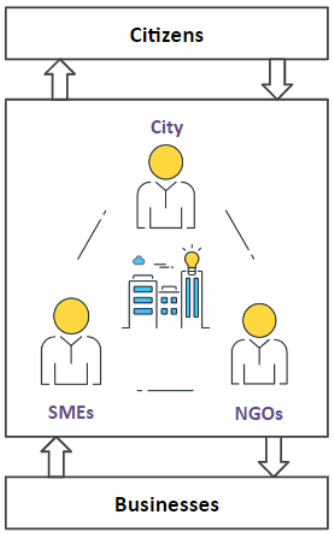

Figure 20: Governance Model

Components

№	Component
1	Develop an ecosystem for data collection and transferability among key stakeholders in the energy sector.
1.1	Define stakeholders in the energy sector in Lviv.
1.2	Define a list of data and needs of each stakeholder.
1.3	Create a model for information flow among stakeholders and
2	Create a formal platform (cluster, association, working group etc.) to define rights and responsibilities of all stakeholders regarding the provided data and data use for developing PED solutions.
3	Organise minimum one meeting per quarter for planning and strategic management of initiatives regarding PED solutions development in Lviv.

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council Ivan Franko University Technical University Lviv Ukrainian Catholic University Association of Energy Efficient Cities		LCE Lvivteploenergo LCE Zaliznychteploenergo Lvivoblenergo	House Condominiums

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Implementation of sustainable development programs (IUDC: Lviv 2030, Spatial Energy Plan, GCAP, SECAP, Municipal Energy Plan). - Improvement citizens quality of life and economic well-being (reduction of expenditures for heating and electricity).	- Reduction of energy resources consumption. - Reduction of CO_2 emissions.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
		Energy data is divided among different stakeholders who are not communicating with each other. Developers of solutions are facing a lack of proper and in-time energy data.

Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Absence of a system for data flow among key stakeholders in Lviv does not allow us to develop joint solutions in the energy sector.	- Commercialisation of data for private stakeholders.

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Project 5. Thermal rehabilitation of private and public buildings

Figure 21: Photo of thermal rehabilitation

(Photo source: Google Street View; Municipality of Lviv)

Components

№	Component
1	Thermal modernisation of residential and public buildings.
1.1	Choosing the list of pilot buildings and conducting an energy audit.
1.2	Implementation of complex energy efficient measures in buildings according to the recommendations from the Energy Efficiency Fund.
2	Developing the catalogue of solutions for thermal modernisation of residential and public buildings.
3	Feasibility study and a replication strategy for scaling up complex energy efficient measures in other buildings in Lviv.

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council citizens and their formal groups	Lviv City Council citizens and their formal groups	LCE Lvivteploenergo LCE Zaliznychteploenergo Department of Housing and Infrastructure Department of Economics citizens and their formal groups	

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Economy on heating energy bills. - Monitoring of heating in buildings and regulation of heating consumption. - Equal distribution of heat in buildings. - Opportunity to provide a heating monitoring through installation of smart meters and bypasses. - Decreasing the energy losses on 30% and improving the maintenance of district heating.	- Decreasing water losses on 10-15%. - Reducing the energy resources on 30%.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- Low energy efficient buildings.	- Proper regulatory framework provided by Energy Efficiency Fund. - Municipal programme for supporting thermal. modernisation of buildings - Increasing the cost of building materials, works and services.	- Reduction of solvency after the COVID-19. - Start of the Nord Stream 2.

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Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Low level of solvency among citizens - Economic instability for businesses.	- Local budget will provide 20 mln EUR in 2021 for thermal modernisation of buildings within the programme that will be annually financed until 2025. - Programme "Energodim" from a state Energy Efficiency Fund. - Regional programme for compensating parts of loans. - Compensations for businesses through providing vouchers for energy efficient measures.

Q&A and Next Steps

Next Steps / Obstacles
- Choosing of buildings for conducting an energy audit and further participation in the programme. - Organising meetings of residents for participation in the programme. - Knowledge and experience exchange regarding the best practices of conducting programmes related to thermal modernisation of housing stock.

Project 6. Energy efficiency and RES integration in the business sector

Components

№	Component
1	Thermal modernisation and RES integration in business offices and other business buildings using energy-efficient vouchers.
1.1	Pilot implementation of soft measures (smart energy monitoring and regulation, energy management) regarding energy efficiency and RES integration in the business sector by using vouchers.
1.2	Pilot implementation of infrastructure measures regarding thermal modernisation and RES integration in the business sector by using vouchers.
2	Develop a catalogue of energy-efficient solutions and RES integration solutions.
3	Feasibility study for policy recommendations and further replicating of solutions for energy efficiency and RES development in the business sector in Lviv.

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council local businesses	Lviv City Council local businesses	Local businesses	Department of Economic Development

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Economy on heating energy and electricity bills. - Monitoring of heating and electricity in buildings and regulation of energy consumption. - Decreasing the energy losses and improving the maintenance of business buildings.	- Decreasing CO_2 emissions and energy resources use (fossil fuels).

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- Low energy efficient buildings.	- Proper regulatory framework provided by Lviv City Council. - Increasing the cost of building materials, works and services.	- Reduction of solvency after the COVID-19.

Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Low level of solvency among businesses. - Economic instability for businesses.	- Local budget will provide 100 thousand UAH for energy efficiency and RES integration measures per voucher.

Q&A and Next Steps

Next Steps / Obstacles
- Organising a competition among businesses to provide vouchers - Knowledge exchange about how to motivate businesses to participate in getting vouchers and implementing energy efficient activities.

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Project 7. Optimisation of public transport efficiency and energy consumption

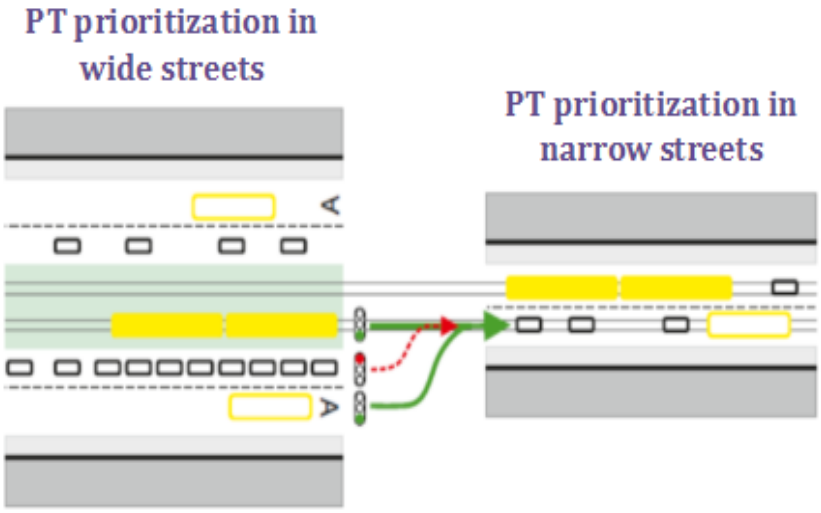

Figure 22: Public Transport prioritisation scheme

Components

№	Component
1	Development of an IT system for gathering, analysing and presenting the data of average indicators for electricity consumption, energy efficiency and the dynamics of energy efficiency change (fluctuation).
1.1	Data collection and data storage facilities.
1.2	Data processing and analysis.
1.3	Data presentation in the form of a convenient and intuitive web-based resource.
2	Smart meters installation in e-Public Transport fleet and connection to the IT system.
3	Feasibility study to justify and implementation of traffic reorganisation measures (based on preliminary tests of different solutions and selection of the most efficient interventions).
4	Develop a catalogue of solutions for energy-efficient public transport in the city.
5	Energy consumption data integration with existing systems of data collection, processing, and presentation in Lviv city (Open Data Portal, City Dashboard, Geoportal Lviv, Spatial Energy Plan).

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council	Lviv City Council	LCE Lvivelectrotrans LCE Lvivavtodor LCE Municipal IT Center	

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts

- Increase the efficiency, including the energy efficiency, of public transport.
- Improve the quality of public transport services (frequency, higher speed).
- Increase citizen's quality of life (Quality of Life Index) measured by the level of satisfaction about public transport services.
- Support the decision making and implementation of Lviv development strategies:
  - Sustainable Urban Mobility Plan,
  - Integrated Urban development Concept: Lviv 2030,
  - Green City Action Plan,
  - Sustainable energy and Climate Action Plan,
  - Municipal Energy Plan,
  - Spatial Energy Plan.
	- Reduction of electricity consumption.
	- Reduction of CO_2 emission after the implementation of energy efficiency measures to traffic reorganisation.
	- Better quality of electrically powered public transports will motivate citizens not to use cars for mobility needs in the city, thus there will be a decrease of CO_2 emissions from vehicle engines.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
LCE "Lvivelectrotrans" does not possess the real time data on electricity consumption of electric public transport vehicles when they are on the way, only aggregated data on energy supply stations. Thus, there is little understanding about how traffic reorganisation influences the energy efficiency of PT.	Decision making regarding the policies and implementation of actions in the field of mobility planning, public transport development and traffic management is not data driven. Thus, there isn't enough evidence to prioritize public transport among other mobility modes in the city.	No traffic regulations aimed at prioritization of public transport makes electric public transport less attractive and the use of public transport among citizens decreases. COVID-19 restrictions decreased the use of public transport among citizens.

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Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- The lack of a system for analysing data on electricity consumption does not allow us to clearly articulate the goals and targets for achieving energy efficiency of electric public transport. - The lack of data on energy consumption per unit on a specific public transport route does not allow us to analyse how changes in traffic organisation influence the electricity consumption and thus to justify the implementation of the most efficient solutions.	- Reduction of electricity costs. - Potential reduction of inefficient electricity usage through decision-making on traffic reorganisation and energy efficiency measures implementation, planning and problem solving. - More efficient public transport will attract a certain share of the car-users and bring more revenue to the public transport services provider. - The data on electricity usage will allow the city to further attract external funding for energy efficiency projects in electric public transport and implement larger-scale projects.

Q&A and Next Steps

Next Steps / Obstacles
- Meeting with a chief engineer of LCE. Lvivelectrotrans and discuss the technical aspects of the project implementation. - Developing ToR for smart meters – LET. - Developing ToR for an IT system - Lviv, MCIT. - Tendering and developing IT system - Lviv, MCIT. - Tendering, procurement, and installation of smart meters and connecting them to the IT system - Lviv, LET, MCIT. - Testing different temporary traffic reorganisation solutions on the selected public transport routes - LAD, LET, MCIT. - Analysing the test results - LAD, LET, MCIT. - Introducing the most energy efficient traffic reorganisation solutions on a permanent basis - LAD

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Project 8. City train development

Figure 23: City Train Development

Components

№	Component
1	Development of the Concept for the Railway Transport Development within Lviv territorial community.
1.1	Development of the Lviv city's vision about the use of railway as transport mode for passengers within Lviv territorial community
1.2	Presenting the city vision to the Ukrainian railway company and getting an approval for the joint detail work on the Concept
1.3	Jointly with a state-owned company 'Ukrainian Railway' develop a detailed Concept for the Railway Transport Development within the Lviv territorial community and justifying the need for concrete projects in this field.
2	Integration of the Concept for the Railway Transport Development within the Lviv territorial community to the Complex Plan of Lviv Territorial Community Development.
3	Development of the Detailed Territory Plans for the areas where railway and other relevant infrastructure will be extended within the Lviv territorial community.

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council Ukrzaliznytsia	Lviv City Council Ukrzaliznytsia	Ukrzaliznytsia LCE Lvivavtodor Office of Transport Office of Architecture and Urban Studies	

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Implementation of sustainable development programs (SUMP, IUDC: Lviv 2030, Spatial Energy Plan, GCAP, SECAP, Municipal Energy Plan). - Improvement of the quality of electric public transport services. - Potential improvement of citizens' life quality (in accordance with the results of the Quality of Life Index), in particular, in newly amalgamated communities.	- Shift to more environmentally friendly means of transport (from motorised to electric), resulting in reduction of CO_2 emission. - Higher efficiency of public transport will also attract more users, including those moving by cars and potentially decrease the CO_2 emissions from car-usage.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- Railways are connecting newly amalgamated communities with Lviv.	- Prioritisation of freight transport in Ukrzaliznytsia. - SUMP is planning to use intersections of roads and railways as transport hubs.	

Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Efficient cooperation between the municipality and state railway company for joint development of railway electric transport	- Grants - More efficient public transport that connects more points of attraction will draw a certain share of the car-users and bring more revenue to the public transport services provider. - The preliminary study can assist further external funding for implementing the extension of the railway fleet.

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Q&A and Next Steps

Next Steps / Obstacles
- Development of the Lviv city's vision about the use of railway as transport mode for passengers within Lviv territorial community - Knowledge exchange between Lviv and other cities about good cooperation practices on integrating railways into public transport in cities.

Project 9. Extension of the tram and trolleybus network, including new depots and transport hubs

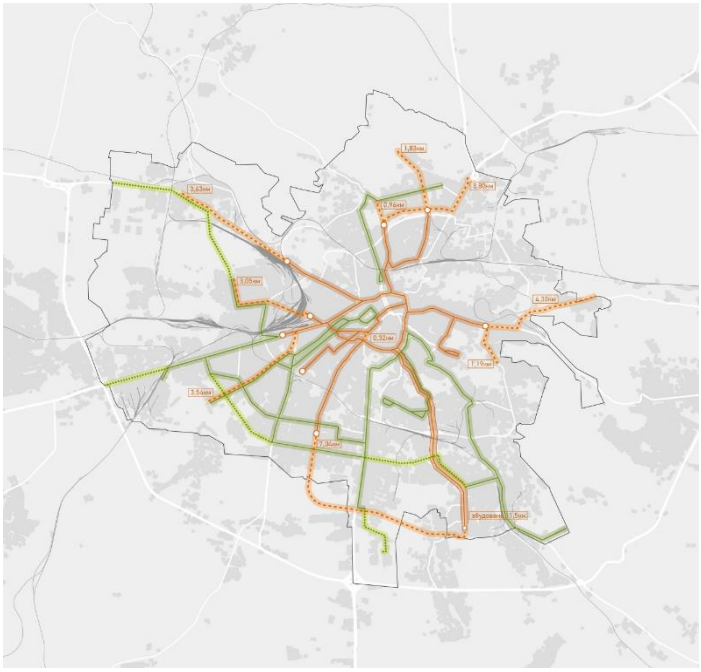

Figure 24: Tram and Trolleybus network

Components

№	Component
1	Development of Detailed Territory Plans (DTP) for areas that are not developed yet within the Lviv territorial community and where the tram and trolleybus networks are planning to be extended, including new depots and transport hubs.
1.1	Data collection and gathering stakeholders' interests, including the public consultation procedures.
1.2	Data processing and analysis.
1.3	Development of alternative scenarios (concepts) and stakeholder engagement for discussing the best-case scenarios.

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1.4	Transport modelling for the best-case scenarios.
1.5	Environmental effect evaluation.
1.6	Suggesting optimal solutions for the city planning and construction board for its approval.
1.7	Organisation of public hearings to present and collect final suggestions for the DTP.
1.8	Presenting the DTP to the Lviv City Council for its approval.
2	Development of the City Planning Conditions and Limitations for the areas that are already constructed and where the tram and trolleybus networks are planning to be extended through reconstruction of existing street infrastructure.
2.1	Data collection and gathering stakeholders' interests, including the public consultation procedures.
2.2	Data processing and analysis.
2.3	Development of alternative scenarios (concepts) and stakeholder engagement for discussing the best-case scenarios.
2.4	Transport modelling for the best-case scenarios.
2.5	Providing the optimal solutions to the Architecture and Urban Studies Office of Lviv City Council.
2.6	Development of the City Planning Conditions and Limitations by Architecture and Urban Studies Office of Lviv City Council, based on the optimal solutions for tram and trolleybus networks extensions, including transport hubs, provided to them.
2.7	Presenting the optimal solutions about reconstruction measures in existing streets to the City executive Committee for approval.
3	Further implementation (including design and construction works) of the most efficient proposals of the tram and trolleybus network extension.

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Relevant Stakeholders

Owners	Investors	Infrastructure providers	Other relevant stakeholders
Lviv City Council	Lviv City Council	LCE Lvivelectrotrans LCE Lvivavtodor Office of Architecture and Urban Studies Office of Transport	

Impacts

Expected Socioeconomic impacts	Expected Environmental impacts
- Implementation of sustainable development programmes (SUMP, IUDC: Lviv 2030, Spatial Energy Plan, GCAP, SECAP, Municipal Energy Plan). - Increase in efficiency of public transport. - Potential improvement in the quality of electric public transport services. - Potential improvement of citizens' life quality (in accordance with the results of the Quality of Life Index).	- Optimisation of energy consumption. - Shift to more environmentally friendly means of transport (from motorised to electric), resulting in reduction of CO_2 emission. - Higher efficiency of public transport will also attract more users, including those moving by cars and potentially decrease the CO_2 emissions from car-usage.

Local Preconditions

Geographic, physical & technical preconditions	Governance aspects	Other preconditions
- Electric transport routes do not connect all the most crucial points of attraction. - Lack of logical transport hubs for a convenient interchange, which results in the need for bus routes duplication. - Localization of depots far from the end-stops leads to a high rate of empty runs. - Paralysation of electric public transport in case of accidents on the route.	- Draft of the Public Transport Concept already identifies 18 potential plans for trams and trolleybuses extensions, including transport hubs and new depots.	

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Challenges and Financial Options

Challenges addressed	Financing Options & Business Model
- Lack of data and analytics for selecting the optimal scenario of extension of the tram and trolleybus network. - Engagement of stakeholders for mobility planning processes. - Developing public transport routes and increasing attractivity of public transport for encouraging new passengers, in parallel. - Integrating dynamic charging technology into the public transport network.	- Reduction of energy costs in the transport sector. - Potential reduction of inefficient energy usage through eliminating route duplication and decreasing empty runs. - More efficient public transport that connects more points of attraction will draw a certain share of the car-users and bring more revenue to the public transport services provider. - The preliminary study can assist the city to further attract external funding for further implementing the extension of the tram and trolleybus network.

Q&A and Next Steps

Next Steps / Obstacles
- Define the most appropriate tram and trolleybus networks extension plans for a feasibility study among 18 already defined in the public transport development concept. - Developing ToR for feasibility study - Office of Architecture and Urban Studies, Office of Transport, Lvivavtodor. - Learning from other cities on implementation of new technologies - Office of Architecture and Urban Studies, Office of Transport, Lvivavtodor. - Developing the feasibility study - Office of Architecture and Urban Studies, Office of Transport, Lvivavtodor.

7.4 The way forward in Lviv under the political circumstances in 2022

The city of Lviv has been facing huge challenges since the 24th of February 2022 after the beginning of the full-scale invasion of Russia to Ukraine. Hundreds of thousands of internally displaced people, business relocations, economic crisis, rehabilitation of injured civilians, support of the army of Ukraine. All these challenges changed previous approaches of positive energy district technologies. The current approach is to try to implement small scale innovative smart city actions without proper and stable financial models instead of integrating innovative and smart city solutions into large scale projects, mainly financed by loans from the EBRD, the European Investment Bank, and long-term municipal programmes. To be able to do this and at the same time reach the city strategic goal of becoming climate neutral by 2050 despite the present circumstances, the deployment of innovative PED solutions using a more agile approach and governance model is needed. For this, the city promotes the joint co-creation of solutions by municipal institutions, together with businesses, academia, NGOs, and citizens. Key for this, is data

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collection, visualization, analysis and sharing it among stakeholders as fast as possible.

SPARCS project will set up such an accelerator in Lviv - a governance model supported with data-driven tools that will provide a fast justification, decision making and deployment of smart energy and mobility solutions.

Key component of the governance model will be a SPARCS ICT Ecosystem, based on the SPARCS ICT Reference Architecture. The SPARCS ICT Ecosystem is a replicable model for data securing, data communication between different stakeholders and co-creation of innovative smart city solutions. It consists of the following eight layers that facilitate the data interaction and digital communication between relevant stakeholders:

- data storage facilities
- services/interfaces to access data from the different data storages / legacy systems
- access control to the data
- data transfer protocols for communication data outside
- data collection service with relevant API (application programming interface), adapters, (model) converters, to securely collect (extract) the required data
- data mapping service for mapping data into a common information model
- data visualisation framework (service) to access data from the common information model to allow for development of specific applications
- user specific interaction layers with dashboards containing different visualisations, comparative analysis, feasibility studies and recommendations on energy optimisation, etc for decision making

This ICT Ecosystem will enable digital interaction and data flow among three main stakeholder groups: (1) the Lviv City Council, including city officials, district administrations and relevant departments; (2) the co-creators of PED solutions, such as: utility companies, mobility operators, city service companies, private businesses, universities, expert NGOs; (3) building owners, home-owner associations and citizens as both co-creators and PED end-users.

Delivering specific data-driven tools together with a framework for co-creating and implementing relevant solutions in Lviv are key projects to support the implementation of innovations in the energy and mobility sectors. The Spatial Energy Plan is for instance a key project for the energy sector that combines the GIS of energy infrastructure with short, middle and long-term actions. Additionally, there is the Data-Driven Sustainable Mobility Plan that combines Vissum software for traffic modelling and calculates CO_2 emissions from transport with co-creation and implementation of sustainable mobility solutions (see Table 11).

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Table 11: Key projects in energy and mobility sectors

Project 1. Spatial Energy Plan	**Project 2. Data-Driven Sustainable Mobility Plan**
Components	
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. As a tool for developers of energy solutions and a beta version of a digital twin of the energy infrastructure of Lviv, it provides opportunities to create algorithms for data analysis and justification of innovative actions.	Software for modelling traffic and calculating CO2 emissions from the transport that will be used for justification of mobility solutions in Lviv.
A continuous process for co-creating, justifying and implementing short-term, middle-term and long-term actions related to the energy and mobility sectors in Lviv. Based on the agile approaches in the project management process will begin from co-creating the actions and forming a backlog - **"bank of actions"**. **Monthly planning meetings** will be organised for development teams and decision makers to discuss and define ideas from the "bank of ideas" to begin their deployment in the next month. Both GIS in Spatial Energy Plan and Vissum software in Data-Driven Sustainable Mobility Plan will provide justification of ideas before each meeting to support decision makers. **Monthly review meetings** for presenting deliverables and outputs by development teams to decision makers and (if relevant) to end-users.	
Expected socioeconomic and environmental impacts	
- Reduction of energy resources consumption in Lviv. - Reduction of greenhouse gas emissions from the housing sector.	- Shift to more environmentally-friendly means of transport resulted in a more sustainable modal split. - Reduction of greenhouse gas emissions from transport in Lviv.

It is expected that the described SPARCS ICT governance model (as a general governance model for developing and implementation of smart city and innovative solutions) and the two projects presented above, will provide an agile process for co-creation and implementation of smart and innovative PED solutions in Lviv. This taking into account the unpredictable environment and lack of financial resources.

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8. CONCLUSIONS

This report provides a diagnosis of the city and allows for understanding the status quo of Lviv in the specific sectors of analysis. It gives a picture of the sustainability realm in the city and where the city is progressive and where it needs to improve on its mission toward carbon neutrality. The analysis has narrowed down what sustainability actions could be relevant as possible SPARCS projects that can draw learnings and replicate actions done in the Lighthouse Cities. This report provides the opportunity for the city to review possible fields of intervention based on the provided assessment of the various indicators and action fields as well as the points of action identified.

The current Implementation Plan of the city of Lviv has been the outcome of a well-designed process, based on the City Lab methodology and the Morgenstadt Framework. The data collection provided key input, as well as the interviews and the overall onsite assessment. This process has promoted the development of key strategies and project planning within the city administration.

The whole city lab process was done in cooperation with various municipal departments, SPARCS project partners and key city stakeholders. It provided a valuable opportunity to better understand the city, its vision and select several projects for the future.

1.4 Summary of achievements

Within the framework of the current deliverable, considerable effort has been put towards the goal of sustainability within the city of Lviv. The expression of the city's Smart Vision has been among the main achievements since it will serve as a strategic plan for success. It can act as a guide when involved parties encounter challenges and it can motivate them to work towards the achievement of the set sustainability goals.

Despite all events and commotion that took place in the city, we were able to communicate with many strategic partners and stakeholders and reach joint solutions in the context of climate neutrality.

In parallel of the implementation plan preparation the city has achieved several important successes, examples are these:

- Introduction of a system of automated monitoring of energy and water consumption in public buildings
- Communication with city residents about energy efficiency
- Stakeholder analysis – mostly focused on the PED realization.
- Implementation of a spatial energy plan in the city for reduction of energy resources and greenhouse gas emissions from the housing sector.
- Purchased Heat pumps in the biggest boiler rooms in the city.
- Successful in other international calls –, United Nations Development Programme, CIVITAS, Horizon 2020, Horizon Europe (project DISTENDER, project CRAFT, project Civitas FastTrack, project ShareP).
- The SECAP, SUMP, vision report – preparation, communication, and implementation.
- Other project applications in international calls are awaiting (e.g. SCALE)

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- Active role in the international, national, regional, and local initiatives, and platforms.

1.5 Impacts

The implementation plan, aligned with the key strategic areas, is an important instrument and holds the opportunity of aligning the city on a common mission to achieve carbon neutrality and energy positivity in the shortest possible time.

The development process, the virtual on-site assessment and the innovation process, worked towards getting the attention and support of the relevant key stakeholders for the achievement of the project's goals and the determination of smart city project ideas, including three mobility solutions, two energy solutions and a circular economy solution. The following table is a summary of some important findings of this whole process.

Table 12: SWOT Analysis Lviv

Strengths	Weaknesses
Existing strategic documents (SECAP, SUMP, Integrated development concept, Green city action plan)	Existing building stock is energy demanding and CO_2 emitting
Ambition to become more sustainable	Lack of personnel experience
Openness for innovation	Technical implementation expertise
Support of the Municipal Administration	Legacy systems
Openness for innovation	Russian aggression
Opportunities	**Threats**
Networking and knowledge exchange	Bureaucracy
Funding opportunities from EU and UN	Financial issues
Cooperation with cities	Limitations of current legislation
Stakeholder engagement	War
Enhance local resources	Energy crisis

1.6 Other conclusions and lessons learnt

Within the framework of the Implementation plan, Lviv realized how important it is to achieve the goals set out in the strategies developed for the city. In connection with the beginning of Russia's military action against Ukraine, vector of the city's work was changed and the number of projects decreased. Despite all challenges, the city is actively engaged in the development and implementation of two current projects: Spatial energy plan and Data-Driven Sustainable Mobility Plan. There are constant active discussions and debates with other cities and partners to get acquainted about their projects and experiences

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facilitated in SPARCS and another projects. The current energy crisis pushes the government to implement energy-efficient solutions. In this concept SPARCS project, as an accelerator of solutions in the field of energy efficiency and climate neutrality, is of particular importance for city of Lviv.

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9. ACRONYMS AND TERMS

CHP - Central heating points
CSO – Civil society organisations
DH - district heating
DHS - district heating systems
DTEK - largest private Ukrainian investor in the energy industry
EBRD - European Bank for Reconstruction and Development
EIB - European Investment Bank
FHG - Fraunhofer
GIZ - German International Cooperation Society
GRP - Gas regulation points
IHP - individual heat points
IMF - International Monetary Fund
JSC - Joint Stock Company
LCCE - Lviv city communal enterprise
LCE - Lviv communal enterprise
LCEN - Lviv City Electric Networks
LLC - Limited liability company
LVl - City Institute, Lviv
MC - Mining company
NEFCO - Northern Environmental Finance Corporation
NJSC - National Joint Stock Company
PrJSC - Private Joint Stock Company
PT – Public transportation
RES - regional electrical station
SEAP - Sustainable Energy Development Action Plan
SECAP - Sustainable Energy Development and Climate Action Plan
SUMP - Sustainable Urban Mobility Plan
TC - territorial community
UAH - Ukrainian hryvnya
USAID – United States Agency for International Development

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10. LIST OF FIGURES

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11. LIST OF TABLES

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