D5.6 Implementation Plan Kladno

30/09/2022

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Deliverable administration

No & name	**D5.6 Implementation plan Kladno**				
Status	Released	**Due**	M36	**Date**	30-09-2022
Author(s)	See cover page				
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	FHG, VTT, SPI*, CVUT*, VERD				
Comments					

V	Date	Authors	Description
0.1	01/09/2020	FHG	Draft before assessment of data
0.2	30/09/2021	KLD	Draft inputs into the new version
0.3	01/05/2022	KLD	Working Document
0.4	16/05/2022	FHG	Review & Input
0.5	31/08/2022	KLD	Final draft made by Kladno
0.6	06/09/2022	CVUT	Review by CVUT
0.7	16/09/2022	FHG	Review by FHG
0.8	29/09/2022	WP	Deliverable checked by WP leader and released to the

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		leader	Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1	30/09/2022	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 organizations, city planning and decision making entities, transforming cities to carbon-free inclusive communities. Lighthouse cities Espoo (FI) and Leipzig (DE) implement large demonstrations. Fellow cities Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) prepare replication with hands-on feasibility studies. SPARCS identifies bankable actions to accelerate market uptake, pioneers innovative, exploitable governance and business models boosting the transformation processes, joint procurement procedures and citizen engaging mechanisms in an overarching city planning instrument towards 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

Sustainable energy Positive & zero cARbon CommunitieS (SPARCS) supports European cities in transforming into Sustainable energy Positive & zero cARbon CommunitieS by creating citizen-centric ecosystems that are equipped to bring about meaningful change.

The current deliverable is part of task 5.3 (Fellow City Replication Strategy), aimed at providing an evidence-based and in-depth understanding for key systems in the SPARCS Fellow Cities – the City of Kladno specifically, as basis for the development of long-term visions, smart city strategies and of locally adapted interventions regarding positive energy blocks.

The Implementation plan provides a baseline profile of the City of Kladno and several project which are partially already implemented or project outlines, that are based on interventions in Lighthouse Cities and the packaged solutions. The baseline profile highlights quantifiable sustainability performance of the city, its strengths and weaknesses around carbon transformation.

The methodology followed is the Fraunhofer Morgenstadt (FHG) assessment framework and more specifically its City Lab Methodology for sustainable urban development, based on the qualitative and quantitative analysis of the city of Kladno.

The profile of the city is outlined. The vision of Kladno is expressed. All accompanied by key strategic documents of the city (SECAP – Sustainable Energy and Climate Action Plan; SUMP – Sustainable Urban Mobility Plan, SDS – Sustainable Development Strategy) which were designed in early stage of the SPARCS - thus an overall strategic framework and projects pipeline is in the place.

Last, but not least, the on-site assessment was implemented, during which, a total of 30 project ideas were discussed, inspired by the implementations in the Lighthouse cities in SPARCS. Most of them were the result of interviews with representatives from several city departments including political representatives. Following debate had pointed to the couple of projects for further detailed elaboration under the FHG methodological framework – (1) Renewables exploitation within the public infrastructure; (2) Supporting and promoting of the clean individual mobility in the city; (3) Positive Energy District (PED) in the area of Sletiště (sports area). The rest of the projects are developed in parallel, some of them are - also thanks to the SPARCS - already under realization (energy management; smart city platform Invipo, eBikes system), or are at the final stage of the preparation (energy savings within the winter stadium, ISO management implementation, EPC energy savings in 23 buildings etc.).

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1. INTRODUCTION

Kladno, the largest city in the Central Bohemian Region of the Czech Republic, has a population together with its adjacent suburban areas of more than 125,000 with nearly 70,000 in Kladno proper. The City of Kladno is building on the goals of the Covenant of Mayors and has voluntarily committed to reduce CO_2 emissions in its territory by at least 40% by 2030 compared to 2019 and to increase resilience to the impacts of climate change. The city has committed to several other goals, e.g., through the key strategic document, the SECAP which provides a roadmap for achieving these goals and includes a 2050 outlook, by which time the city has set a goal of achieving carbon neutrality, or net zero carbon emissions.

Thus, the city transformation by the year 2050 is foreseen, and to tackle the industrial, social and energy change, the overall city strategy and vision is focusing on the modernization of the infrastructure and energy sources; innovation and technology exploitation; and citizen´s needs. The city of Kladno focuses on energy transformation, the economic opportunities to be revealed and detected, and the social impact of energy transformation.

Achieving decarbonization targets by 2050 would require far-reaching technological changes in all sectors. It must go together with reducing the use of coal (and gas) for electricity and heat production, changing the transport behaviour and the composition of the other sectors (incl. construction) should be transformed. Furthermore, it is necessary to reduce the energy consumption of buildings and bring innovative and modern technology.

The implementation plan contains a guidance how to reach such goals. Data collection, city profile and data timelines serve as important tools showing the various pathways. The action fields allow to highlight the quantifiable sustainability performance in selected sectors, and the current strengths and weaknesses concerning the low carbon transformation of the city's system. All can lead to drawing attention to the dozens of project outlines.

A City Lab Methodology for sustainable urban development was applied, consisting of a virtual onsite assessment, interviews, and a City Lab Innovation Workshop, which generated project ideas for further development after local and internal discussions.

Essential interconnection with the vision roadmapping process, Positive Energy District design, KPIs preparation and business model testing were executed, all parts are thus creating overall and comprehensive development picture.

1.1 Purpose and target group

Kladno seeks further support in achieving its goals within this context. Within SPARCS and as part of the replication activities in the project, Fraunhofer IAO, with its Morgenstadt Initiative, and in strategic cooperation with the City of Kladno, studied the areas for improvement and success, which became the basis for the Implementation Plan.

The aim was to develop a roadmap of solutions for the city to tackle key focus areas such as: Smart Governance, Energy and Buildings, Mobility and Urban Environment and Digital Services.

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The report was undertaken by FHG and the City of Kladno. The results presented here constitute an integrated set of innovative projects, which shall support the municipal goal of carbon neutrality by the year 2050.

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 Municipality of Kladno. Kladno provided feedback to the assessment carried out by Fraunhofer. Kladno together with its technical partner CVUT has revised the initial version of this report and expanded texts with details on newly developed strategies and plans (SECAP, SUMP, SDS) as well as specific project outlines (e.g. PED).

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 Kladno 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 Kladno 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 4 main steps, as illustrated in following figure.

Figure 1: Structure of the City Lab process in Kladno

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

- David Škorňa, City of Kladno (overall coordination of the SPARCS)
- Zdeněk Nedvěd, City of Kladno (energy expert)
- Matěj Steigauf, City of Kladno (IT expert)
- Jan Pospíchal, City of Kladno (urban and spatial planning)
- Eva Havelková, City of Kladno (PR, communication)

And Indirectly:

- Daniela Cimrmanová, City of Kladno (Head of the EU grants and projects Dept.)
- Jakub Hříbal, City of Kladno (EU grants expert)

with support from CVUT UCEEB

- Michal Kuzmic, Czech Technical University
- Nikola Pokorný, Czech Technical University
- Nicol Staňková, Czech Technical University
- Wojciech Belch, Czech Technical University
- Tomáš Vácha, Czech Technical University
- Petr Wolf, Czech Technical University

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

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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 organization 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 Kladno. 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.
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**. 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.
Also, continuous activities were incorporated into the work, i.e. the new energy strategy – Sustainable Energy and Climate Action Plan (SECAP), new policy on the mobility – Sustainable Urban Mobility Plan (SUMP) and also overall strategic framework – Sustainable development strategy (SDS).

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,

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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.
- 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 intermodality 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

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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 the following graph:

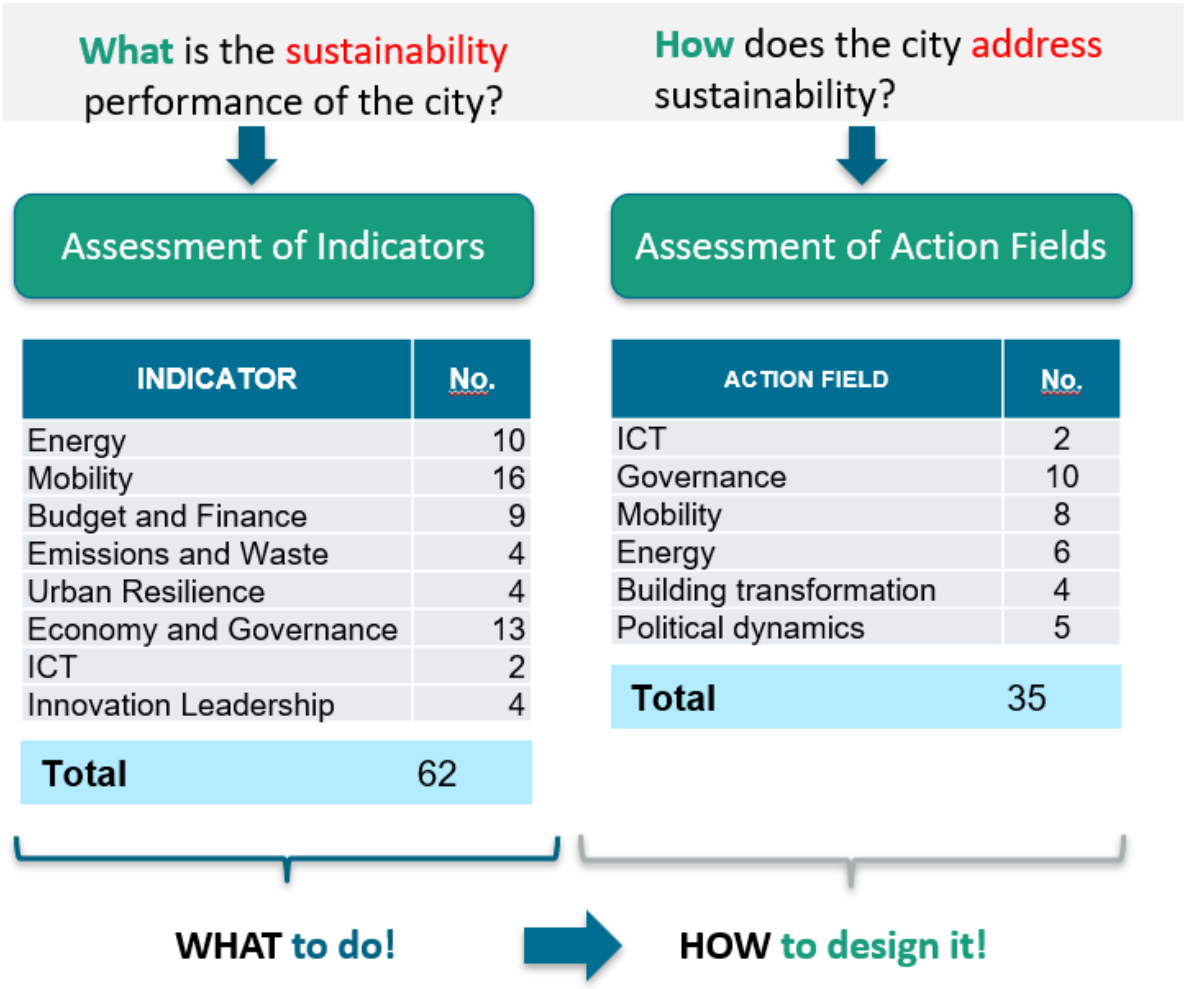

Figure 2: City Lab assessment framework for Kladno

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3. CITY PROFILE KLADNO

3.1 Czech Republic

The landlocked country located in Central Europe, southeast of Germany, has been a member of the European Union since May 2004. The Czech Republic was formed in 1993 after Czechoslovakia was split into Czechia and Slovakia. The Czech Republic has a population of 10.7 million inhabitants on an area of 78,865 km^2 and a density of 136 inhabitants per km^2 divided into 14 regions with around 1.3 million residents inhabiting the capital city Prague alone. The most inhabited region following Prague is the Central Bohemian Region (see Figure 3) which has Prague as its administrative centre, nevertheless, the city itself is not part of the region but a region of its own, with over a 1.3 million inhabitants (Czech Statistical Office, 2018).

The republic's main and largest industry is the automotive sector. However, other key sectors include iron and steel production, chemical production, electronics, transport equipment, and pharmaceuticals. The country has been focusing on more high-tech, services-based and knowledge economy as the demand in the automobile industry is decreasing (Emerging Europe, n.d). Agriculture is one of the traditional industries of The Czech Republic and 54% of the total area of the country is used for agricultural purposes. Around 70% of this land is arable and individual crops are rotated. Next to crops, livestock, high quality hops cultivated in Bohemia and vineyards in southern Moravia are important segments of the agricultural sector (The Ministry of Agriculture of the Czech Republic, 2019).

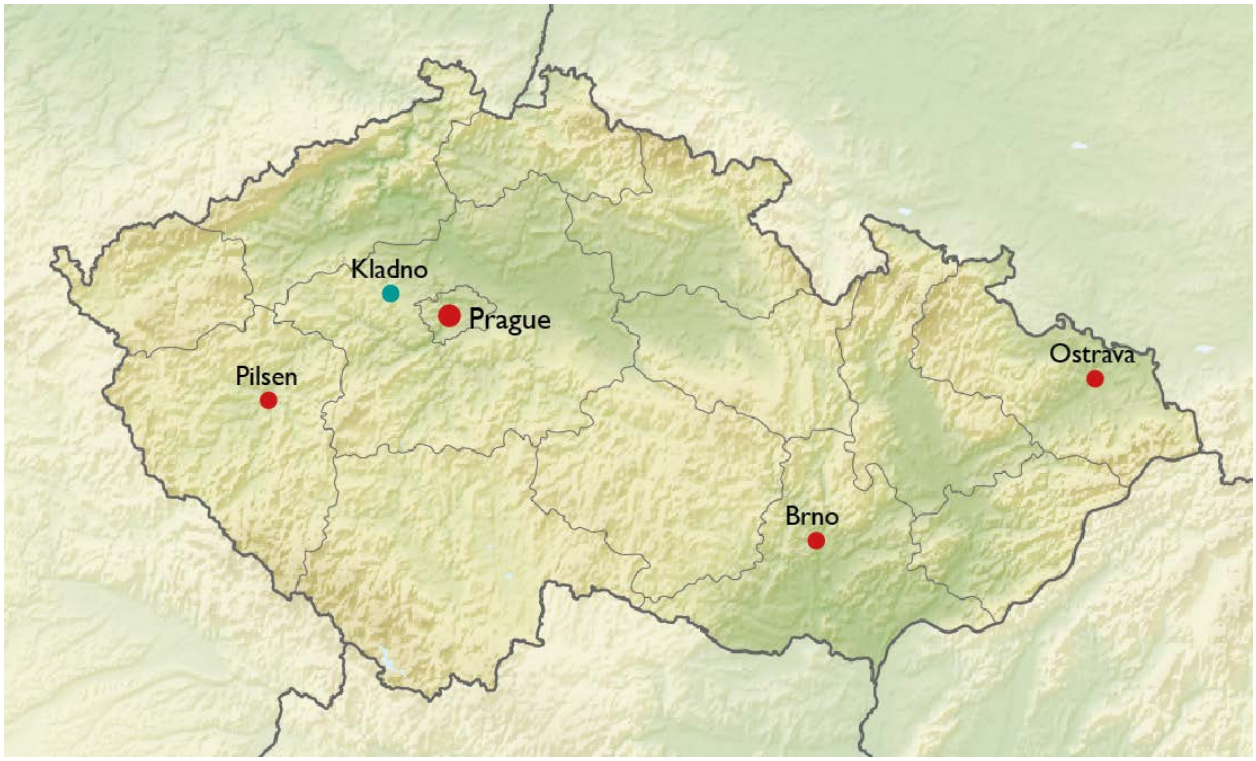

Figure 3: Map of The Czech Republic pointing out Kladno

The Czech Republic has become a popular tourism destination. Its capital Prague is one of the most visited cities in Europe and a UNESCO World Heritage Site. Nonetheless, efforts

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are being made to diversify the tourism offers in the country and attract visitors to the attractions outside the capital city. Tourists are predominantly from European countries, however visitors from Middle East and the Asian Pacific are helping to grow the tourism industry (FitchSolutions, 2020).

The unemployment rate in The Czech Republic was 1.9% in June 2019 and 3.4 % in 2021. This is the lowest unemployment rate in the European Union, which has an average unemployment rate of 6.3% (Emerging Europe, 2019). The Czech Republic is behind Germany, France, Sweden and Norway as the the fifth-largest energy exporter in the EU (2017). The energy is mainly generated from domestic coal 51% and from nuclear energy with 33%, 4% of the total electricity was generated through natural gas and the rest through renewable sources. The country has substantial coal resources in the Moravian-Silesian region. Nonetheless, the government announced the goal to gradually phase out mining by 2030 at the latest (OECD, 2020). This goal has been discussed and re-evaluated in the light of energy crisis linked to Russian invasion of Ukraine in early 2022. However, the general ambition to cease coal mining in the 2030-2040 decade has not been officially contested. The CO_2 emissions per year have been decreasing since 1980 and are at an equivalent of 10.53 tons per person (2016). 54.4% of the CO_2 emissions stem from energy production, 15.1% from the industry sector, 13.8% from transport and 9.8% from buildings. The rest is attributed to non-combustion (Worldometer, 2020).

In order to combat emissions, the Czech Republic created the "National Energy and Climate Plan". It aims to follow suit with EU targets and announced to reduce its total greenhouse gas emissions by 30% by 2030 compared to 2005 (see Figure 4). This decarbonisation goal also includes the shift to renewable energy sources. In The Czech Republic's previous "Energy Action Plan" it set renewable energy targets for 2020. It aims to meet 14% of the heating and cooling demand by renewable energy sources by 2020 and 22% by 2030. Additionally, 14% of the electricity demand shall be produced by renewable energy sources and 11% of the energy demand in the transport sector stem from renewable sources by 2020 (Ministry of Industry and Trade of the Czech Republic, 2019; Smrz, 2020).

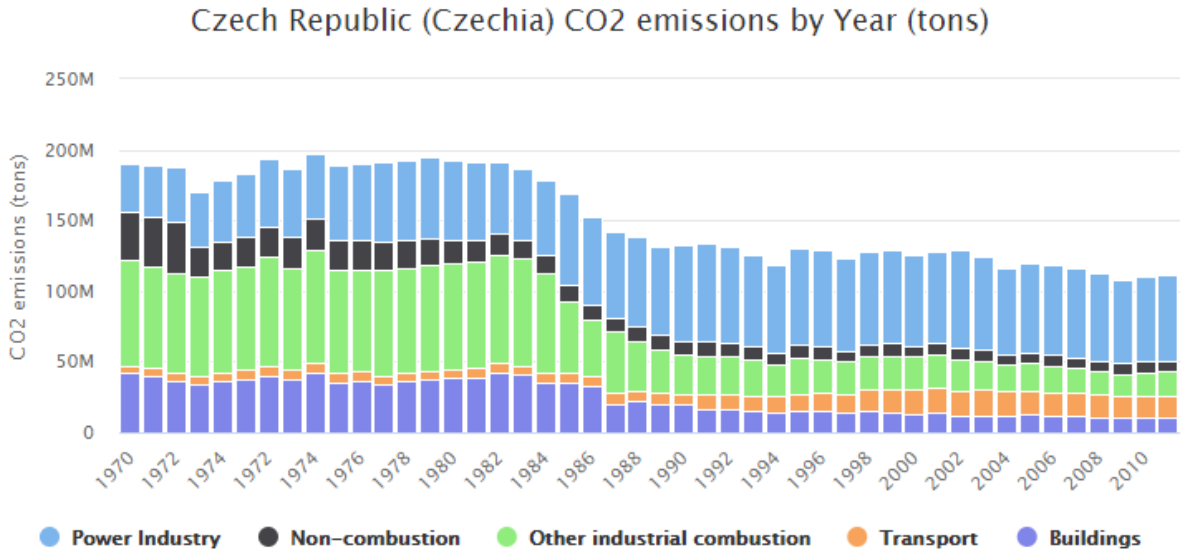

Figure 4: Czech Republic CO_2 emissions by year (Smrz, 2020)

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3.2 Kladno – creating its own set of niche-strengths

Kladno is a city in the Central Bohemian Region (Středočeský kraj) of the Czech Republic. It is located 25 kilometres northwest of the capital city Prague. Kladno is the largest city in the region and has a population together with its adjacent suburban areas of more than 125,000 (nearly 70,000 in Kladno proper).

Figure 5: Kladno (Bělohradská, 2019)

Kladno is part of the Prague metropolitan area. The city encompasses a space of 36.97km^2 with a density of 1900 residents per km^2 and is thus the highest populated city in the Bohemian Region (see Table 1).

Table 1: Basic information of Kladno (in 2020)

Population	69,337
Area	36.97 km^2
Density	1.900/km^2
GDP/Capita (PPP)	$42,492
Main Economic Pillars	Manufacturing Industry
Main Emissions Sources	Tertiary/housing sector & Road Transport

Kladno was the historical birthplace of heavy industry in Bohemia. When the largest factory of Kladno and most important player in Czechia's steel production, Poldi Kladno, announced bankruptcy in 1993 and the coal mines of Kladno closed down, Kladno and its vicinity found itself in a difficult situation (Malvenuti, 2014). Nonetheless, due to efforts, predominantly from the city authority, Kladno managed to recover, modernise and create better living conditions for its inhabitants (Pecinovský, 2017). Today several companies have settled in Kladno, including LEGO (children plastic toys), Barco (visualization products manufacturing), Transito Properties (electronic appliances), Showa Aluminium, (specialized in air conditioning units for automotive), Quickstep, (Laminate, wood and vinyl floors) and Dr. Oetker (food production) (Pecinovský, 2018). The old industrial zone,

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where Poldi was located is not at the production level as it used to be, but it is industrialised again. Companies like TZ rolling mills, which produces rail steel, NKT Cables, which manufactures cables for high and low voltage applications, or Beznoska Company, which specializes in producing implants and tools for bone surgery, have settled here (Pecinovský, 2018).

The production industry is well integrated and attracted through the transportation system of Kladno. The city offers good connections to two motorways into the direction Karlovy Vary and Chomutov and Prague. However, the positive economic impacts of this transport network, the intensive freight transport has a downside as it goes right through Kladno. Therefore, investments are made to lead traffic around the city and establish road links between both enterprise zones and the motorways. Furthermore, the proximity to Prague and the Ruzyne Airport are important for Kladno's connectivity especially for the employment (Pecinovský, 2018).

Population changes in the city of Kladno reflect the general demographic trends of the Czech Republic - demographic ageing of the population and partly also the process of suburbanisation, both in the sense of moving people from Kladno to its hinterland and from Prague to its wider hinterland (see Figure 6 and Figure 7). In terms of the future development of the population, growth is expected until 2026, followed by stagnation or a slight decrease. Population trends may vary slightly in relation to planned developments. In terms of age structure, a significant increase in the number of people over 75 years of age is expected (City of Kladno, 2021a).

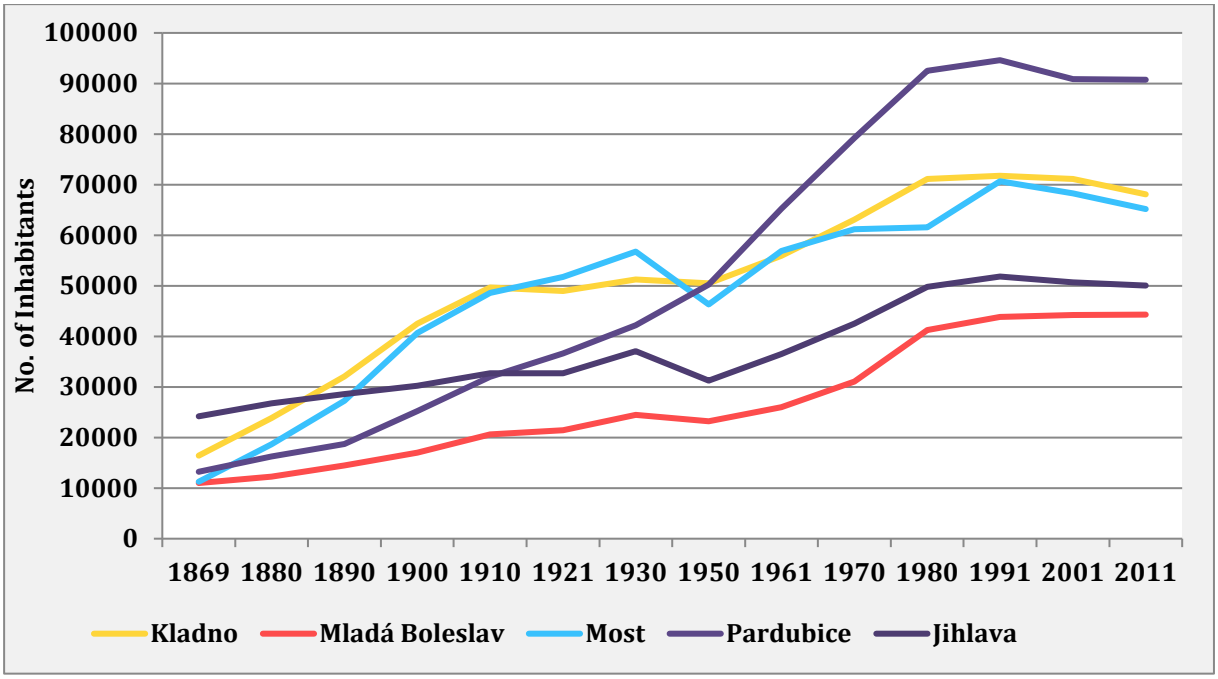

Figure 6: Long-term population trends in reference areas (Czech Statistical Office, 2020)

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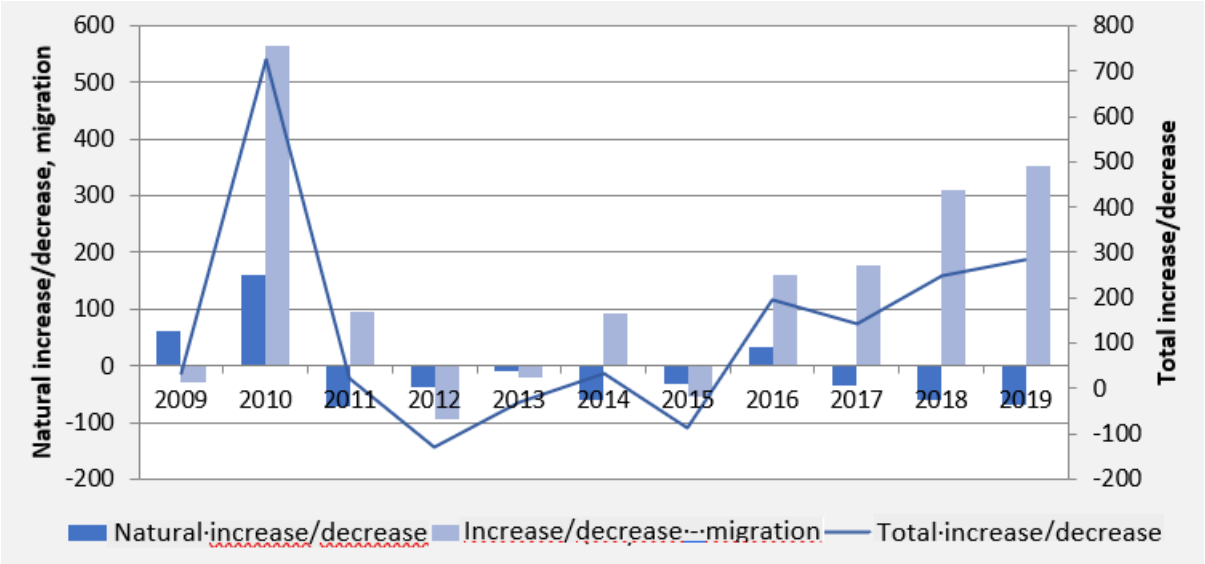

Figure 7: Long-term population trends in reference areas (Czech Statistical Office, 2020)

The Understanding and Co-creation phase was based on these key valid strategies:

- Sustainable development Strategy for Kladno (2013)
- Sustainable development Strategy for Kladno (2014)
- Strategy of territorial administrative district of ORP Kladno (2014)
- Data actualization (2020)
- Bilateral and multilateral interviews during the data collection (2020)

Since these documents were published, new strategies had been designed and during 2021 also approved by city itself. Now the city builds its development targets inc. energy, climate, clean mobility etc. towards 2030 with the outlook to 2050. Also the analytical and strategic documents were created for instance in the area of sport, social services and waste. The current key strategic documents are:

- Sustainable Energy and Climate Action Plan Kladno (SECAP Kladno) (2021)
- Sustainable Urban Mobility Plan of Kladno (SUMP Kladno) (2022)
- Sustainable Development Strategy (SDS) (2021)

Sustainable Energy and Climate Action Plan Kladno (SECAP Kladno)

The city, in collaboration with partners had developed a new energy policy in 2020/2021. It sets out proposals for how the city should develop in the field of energy and what targets to meet. It contains specific tasks to make the city's energy sector not only smart and sustainable, but also beneficial to its citizens. The Action Plan addresses energy in the transport, housing, waste and water management and public lighting sectors.

The document is based on logical steps - Baseline Emissions Inventory (BEI) including a comprehensive energy review; the Action Plan for Sustainable Energy and Climate of the Statutory City of Kladno; Consultation and final report.

The Action Plan captures emissions from all fuel and energy consumption in the study area; electricity transmission and distribution in the city; heat from CHP sources, etc.

For each measure, the Action Plan defines a description; the person or entity responsible for implementing the measure; timing (start - end, major milestones); cost estimate;

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estimated energy savings / increase in renewable energy production; estimated CO_2 emission reductions (City of Kladno, 2021b).

Sustainable Urban Mobility Plan of Kladno

It is a strategic document designed to meet the mobility needs of people in the city in order to improve the quality of life. It is a proposal for the city's transport policy, resulting in a list of measures that fulfil the vision and strategic objectives of the plan. The strength of the strategic document lies in its systematic approach, careful analysis of the situation, objective target setting, and the preparation of coherent measures based on a common vision (City of Kladno, 2021c). Designed measures should lead to improved transport safety, reduced air pollution, noise, energy consumption, improved efficiency of transport of people and goods, contribute to enhancing the attractiveness and quality of the urban environment and territory, primarily for the benefit of citizens. In 2022, the actualization was carried out.

The Sustainable Development Strategy of the City of Kladno

It is a basic conceptual document defining the future development of the city. At the level of strategic vision and priorities, it aims to the long-term time horizon of 30 years (2050). At the level of designing specific activities and measures, it is then designed in the medium-term perspective of 10 years towards 2030 (City of Kladno, 2021a).

City vision

Among others, the city of Kladno has developed its vision (see also the work under WP1 in SPARCS). The city vision should be framed by overall city strategy since in the same period of time the Sustainable Development Strategy and Sustainable Energy and Climate Action Plan were designed.

The vision consists of five strategic areas of Energy; Digital networks and e-services; the Mobility and public space; Good governance and Positive Energy District, which were selected by the city working group before the vision workshop in order to narrow the future discussion. The importance of the strategic areas was confirmed by the experts working on the Sustainable Development Strategy and verified by the Task Force of the city. Although the current set up is based on five strategic areas their thematic focus is not isolated and self-standing, on the contrary, these strategic areas are cross-cutting and they are influencing several other priorities or particular projects, directly or indirectly examples are entrepreneurship support, social inclusion, innovation exploitation).

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4. SMART CITY VISION

The smart city concept does not have its own strategic documents. Smart city approach is incorporated in the current and valid strategies and implementation. Basic framework is already Kladno´s vision which is constructed as a live mechanism, and it is a dynamic vehicle showing continuous progress in the city.

The process then helps, speeds up, facilitates, but in the negative case it can also slow down or even limit the achievement of the targets and vision itself. To see the vision picture from a complex perspective the integration of the four horizontal principles must be in place:

- being inclusive (in complex way incl. stakeholder engagement as a core approach).
- ensuring resilience approach.
- designing priorities and measures in a smart (city) way.
- planning in a sustainable way.

The key element of the smart city approach is smart city governance model which had been already introduced within the vision design process (see Figure 8).

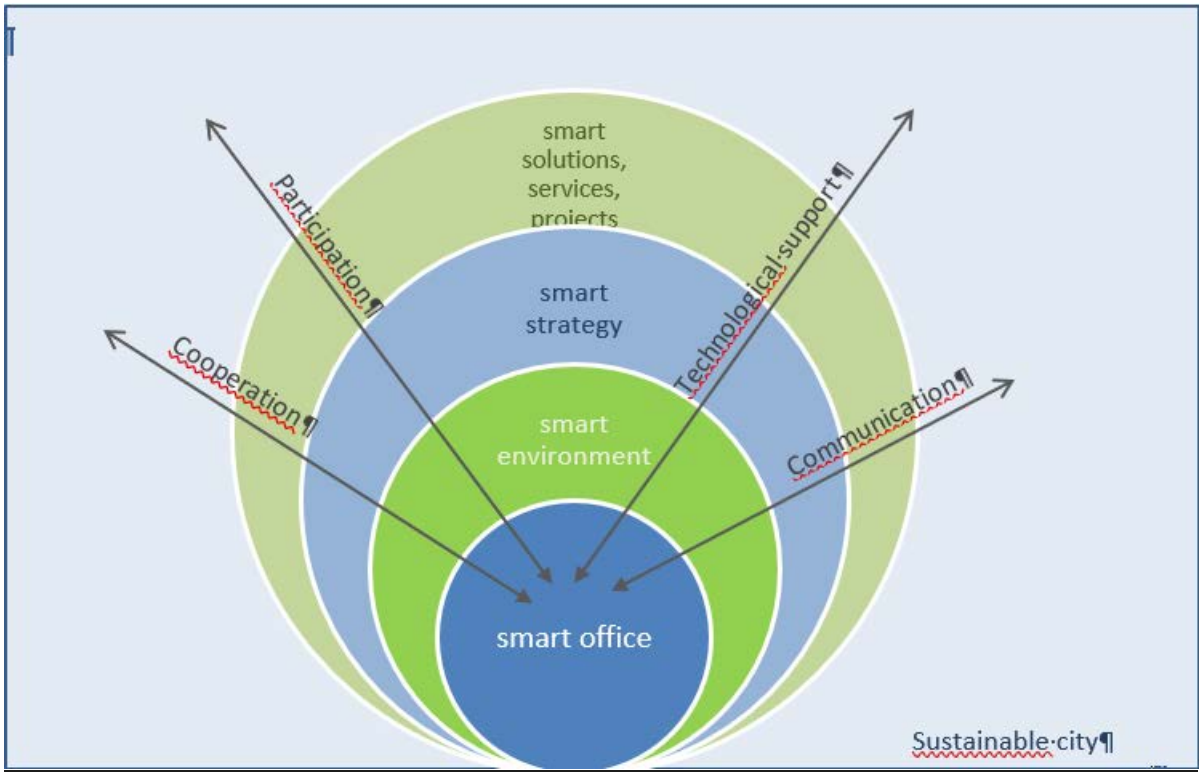

Figure 8: Kladno Smart City governance model (author´s own)

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5. SMART CITY INITIATIVES

There is no solid/self-standing strategy for the smart city. The city is applying the smart city as a horizontal principle within all measures which should be introduced. Smart city impact assessment should be implemented before the projects proposals are approved. In this term several tools are still under preparation.

For the SECAP, key strategy for the energy, mobility, and related areas, the Smart City Compass tool is used. It is a national initiative aiming on the implementation, monitoring and reporting of the key measures for the municipality leaders. Kladno has used this opportunity and tests there a set of the SECAP indicators. It intends to connect its set of indicators also with the databases of the Czech Statistical Office. See Figure 9.

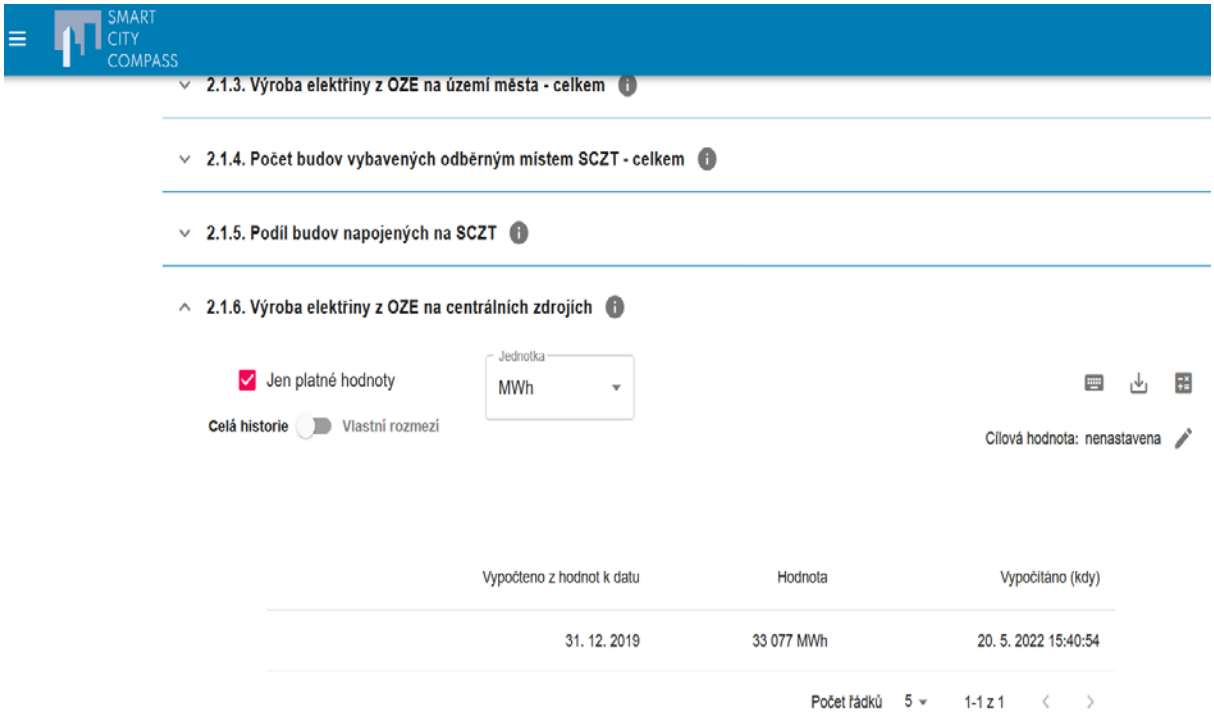

Figure 9: The Smart City Compass, tool for smart cities ("Smart City Compass," 2022)

Some of the smart projects are interconnected through the city platform Invipo. These include modules for public transport, parking, public lighting, waste management and bike sharing, and prospectively also water management and environmental sensors in schools. Also, the smart SW tool for the energy management was established.

The following overview is showing the examples of the activities and systematic projects implemented (mostly in the area) of digitization and data.

- City Integration Platform and Dashboard Invipo
- IoT LoRaWAN to accommodate the environmental monitoring and evaluation; network of NBIOT is used as well (Sigfox was tested)
- eBikes sharing system
- Underground waste containers (incl. sensor system)
- Traffic telematics and traffic markers
- Thermal heat mapping

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- Public lighting sensors
- GPS in buses with delay monitoring
- Schools with indoor air quality monitoring
- Parking spaces pilot monitoring system
- Energy management ICT system

Next to the investment projects the city executes several "soft" activities such a learning programmes, procedural schemes, strategic management, integrated urban planning etc.

5.1 Strategic Plans

Following Table shows the examples of the goals and results defined by the SDS.

Table 2: Examples of the goals and results (City of Kladno, 2021a)

Goals	
• **to improve the quality of life of residents** • **to optimise the traffic situation in the city** • **to improve safety in the city** • **to improve city management** • **to ensure consistency between the ICT development strategy and the needs of the Smart City project development concept**	
Results	**Monitoring indicators**
• **Optimising the traffic situation in the city** • **Improving the quality of life of the inhabitants** • **More efficient city management** • **Citizens can and want to use digital technologies**	• Cleverly controlled intersections • Smart containers with sensors • Newly installed camera system • Offer of training courses for citizens in the use of digital technologies and services • Publication of SC data according to the SC concept/strategy
Prioritisation and sequencing of key steps	
1. **Smart Cities project development concept according to the communicated need including priorities** 2. **Acquisition and operation of software for evaluation of transport indicators (passenger/freight, density...)** 3. **Acquisition and operation of sensors for air quality monitoring or integration of existing SC sensors** 4. **Provision of parking lot monitoring** 5. **Provision of traffic density data** 6. **Ensuring publication of existing data**	
Sub-steps and type activities	
Actions, activities and interventions of the Statutory City of Kladno: • **Extension of the optical network (smart stops, security, information boards for citizens, hotspots, etc.)**	

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- **development of Smart City projects (smart intersections, smart container system with sensors, etc.; see other thematic areas and the cross-cutting priority Kladno Smart)**

Actions, activities and interventions of other actors:

- **Implementation of training courses for citizens in the use of digital technologies and services**

There are several project outlines to be implemented in the future. The work on its design us underway. These are the examples:

- Using the EPC model for the preparation and implementation of the energy savings measures in the public buildings.
- The energy flexibility testbed.
- Electromobility in the public transport / city support in the individual eMobility (charging systems, smart regulation).
- Smart retrofit of the public lightning.
- New business model in the RES (solar energy, thermal energy etc.), including energy communities.
- Smart parking system incl. navigation equipment.
- Use of the waste heat in the winter stadium.
- Using the minewater for the energy purposes.
- Building of the waste-to-energy facilities.
- Pilot smart-metering in the several buildings.
- Water consumption metering.

5.2 Indicators and Action Fields Analysis

Summary from the data collection (see also Table *3*)

In analysing the economy and governance indicators for Kladno, its economic strength is medium, with a nominal GDP per capita of EUR 25,400, it is far below the European average.

The labour market situation in the city is very favourable, although it still reflects structural changes in the economy causing slightly favourable characteristics. An unemployment rate of 2.4 (2019; and 3.6% in 2020) is much better than the "green" benchmark threshold. In terms of the structure of major employers in the local economy, the importance of large industrial employers remains. It is also driven by the employment in services which is significantly higher compared to the other Czech cities, and this a result of commuting to Prague for work.

The high quality of life is reflected in a life expectancy of 75.26 and 80.5 years for males and females, respectively.

While the percentage of buildings owned by the city as part of the total building stock is rather low (3.4%), individual homeownership is not. Homeownership reflects decision-making autonomy, and the fact that 83% of residents over 25 are homeowners, only 12.8% rent, and 4.2% live with the parents indicates relative independence. On average, 22% of the income is spent on rent. Furthermore, Kladno performs not well in the urban

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resilience category as it possesses no plan for natural disasters, has not allocated a portion of the budget to disaster risk management and does not have a climate change adaptation strategy (though this has been partially rectified by the adoption of SECAP, containing set of recommended adaptation measures). This represents some crucial groundwork on which to build initiatives preserving the prosperity in the city as well as the livelihoods of future residents.

Table 3: Sample economy and governance indicators for Kladno, 2019

Indicator Description	City Value	Green	Yellow	Red
Buildings owned by the city as percentage of total building stock (%)	3,4	> 35	15 - 35	< 15
Percentage of homes owned by residents (%)	83,00%	> 79.3	59.3 - 79.3	< 59.3
Unemployment rate (%)	2,40%	< 7	7 – 12	> 12
Spendings on rent of net household income (%)	22%	< 20	20 – 40	> 40
Life expectancy at birth (years)	75.26/80.5	> 75	65 – 75	< 65

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6. ENERGY PROFILE KLADNO

Historical background

Since 2000, there has been a general reduction in fuel and energy consumption due to the shutting down of intensive plants and industrial production. Also, the structure of energy inputs has changed as there is an increasing share of biomass combustion in electricity and heat production. Higher share of natural gas combustion in connection with the development of gasification in the city was needed in the past decades. We can observe a reduction in the consumption of light fuel oils linked to the conversion to the heat supply system (City of Kladno, 2021b).

Development and optimisation of heating central system, new housing estate and reconstruction and introduction of combined heat and power (cogeneration, etc.) improved the condition of the energy policy in the city. Several technical changes to the network through investments occurred in past decades, like new sources, co-firing of coal and biomass, etc. Since past years we can see a gradual construction of small-scale PV sources for electricity generation in the city (City of Kladno, 2021b).

The impacts of the energy system on the environment were significantly affected by the existence of the ECKG power plant in the city. Although it was by far the biggest polluter of the environment, if only the emissions from the production of heat in this source were evaluated in comparison with individual heating with brown and black coal, the specific emissions are SO 2 eq [kg / 1GJ] approx. 10x resp. 7.5x smaller. Compared to heating with natural gas, the specific emissions generated during heat production in ECKG were approximately 2 times higher (City of Kladno, 2021b).

New strategic approach

The Territorial Energy Concept of Kladno was first introduced in 2002 and evaluated the State Energy Policy of 2015. Since the strategy was not relevant anymore, because of the changes over the time, pressure on the clean energy measures and due to new trends, the city developed the new strategy, the Sustainable Energy and Climate Action Plan Kladno, SECAP which was approved by the City Council in June 2021.

The SECAP sets out proposals for how the city should develop in the field of energy and what targets should be designed and by an accurate system of the implementation also to be met. The SECAP captures emissions from all fuel and energy consumption in the study area; electricity transmission and distribution in the city; heat from CHP sources, etc. For each measure, the SECAP defines a description, the person or entity responsible for implementing the measure, timing, cost estimate, estimated energy savings / increase in renewable energy production and estimated CO_2 emission reductions.

The SECAP sets a headline binding target of a 40% reduction in CO_2 emissions by 2030, using a combination of energy saving measures, energy efficiency improvements and the use of renewable energy. The key non-binding targets set within the transport sector are a 50% reduction in emissions from road transport, to be achieved by switching to less or zero-emission transport modes. The plan of the city is to become carbon neutral and resilient/adapted to climate change by 2050.

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6.1 Indicators and Action Fields Analysis

Summary from the data collection (see also table 5)

In general terms, Kladno did not perform well in the energy sector based on the data collection in 2019, at least in two key parameters (see the Table *4* below). Importantly, only 4.75% of energy and electricity demand is covered by renewable sources, which is far below the general standards.[1] At the same time 71% of heating demand is served by district heating systems which is well above the "green" benchmark threshold. The average price for electricity is 7.7 cents, approximately 28 cents below average. Based on indicator city should focus on expanding the share of renewable energy sources on energy consumption.

Table 4: Sample energy indicators for Kladno

Indicator Description	City Value	Green	Yellow	Red
Electricity consumption per household (kWh/household/year)	1006	1,500–3,500	900–1,500; 3,500–5,000	< 900 or > 5,000
Share of end energy demand covered with renewable energies (% of end energy demand)	5%	> 23	23 - 13	< 13
Share of electricity demand generated by renewable energies (% of electricity demand)	4.75%	> 40	30 - 40	< 30
Average electricity price for private consumers (€/kWh)	0,077	< 0.21	0.21 - 0.35	> 0.35
Share of heat demand delivered by disctrict heating systems (%)	71%	> 50	15 - 50	< 15

In reviewing Kladno's performance in action fields, its high score in the promotion of renewable energies row stands out. While the city scores particularly well, it has only just begun the work related to these subjects. In addition, while energy and resource flows were optimized on a district basis, measures for linking energy and resource flows of local businesses have not been developed, which presents another path for innovation. Kladno also has good performance in Highly efficient centralized energy supply, most of infrastructure covered with district heating but still there is scope to find out thermal sources through heat pumps based on geothermal energy, mine water or waste heat and other renewable sources of energy both on the local level and as an input source for the central heating.

Basic energy and climate profile[2]

The operation of all sectors in the territory of Kladno in 2019 produced 491,599 tons of CO_2, which represents an equivalent annual production of 7.1 tons of CO_2 per inhabitant of Kladno as shown by Figure 10 (City of Kladno, 2021b).

[1] To acknowledge, historically this number was higher, even around 20 %. The fact was linked to a higher share of biomass burnt at the main power & heating plant. After 2017 this trend reverted as the plant switched back to brown coal as a main input.

[2] Data mentioned in the chapter are based on the SECAP, 2022 and related technical and analytical works.

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The largest share of energy consumption or CO_2 production in 2019 was accounted for by the tertiary sector buildings with 50%, followed by residential buildings with almost 29%, and individual road transport with 9%.

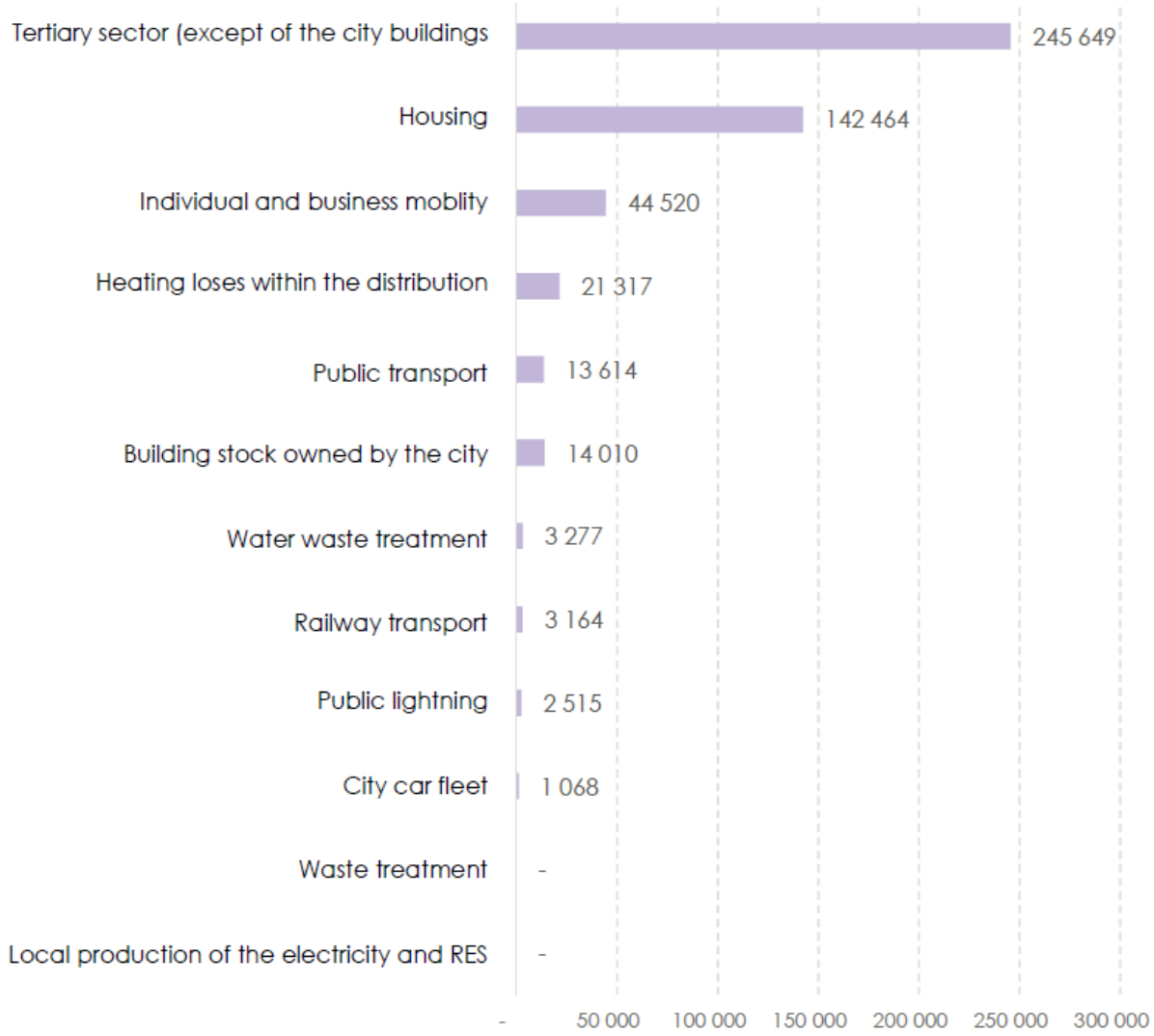

Figure 10: CO_2 Emission balance, 2019, equivalent tons (City of Kladno, 2021b)

The total sum of all the energies is 1,825,082 MWh for 2019. However, this figure also includes the energy in the form of heat and electricity produced by the heating plant, which is also reflected in the building consumption. This total should therefore be reduced by these values. **The resulting total energy consumption in the city after this correction is 1,340,955 MWh.** In terms of total energy consumption, energy from renewable sources accounted for just under 2%, with non-renewable fossil fuels accounting for the remaining 98% (see Figure 11).

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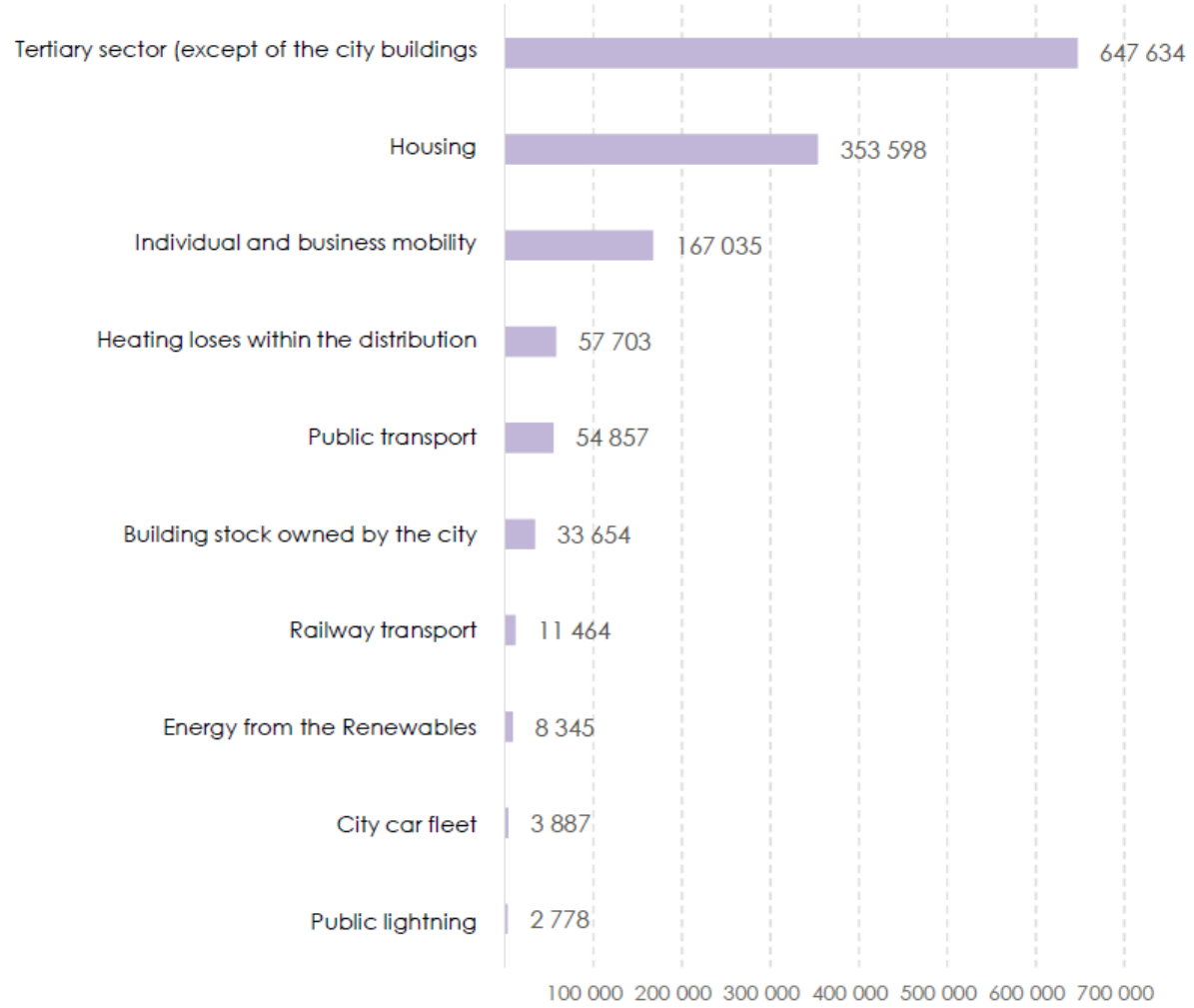

Figure 11: Breakdown of the energy consumption, 2019, MWh/an (City of Kladno, 2021b)

In 2019, 2,018,499 MWh of electricity was produced in the private power and heating plant in Kladno[3], of which only 230,593 MWh were consumed in Kladno. Along with electricity, the plant also produces heat in cogeneration mode. In 2019, 253,534 MWh of heat was delivered to the distribution network. The main energy input of the heating plant has long been brown coal. See Figure 12.

[3] Primary product is electricity from coal, secondary product is „waste heat" that is partially utilized for central heating network.

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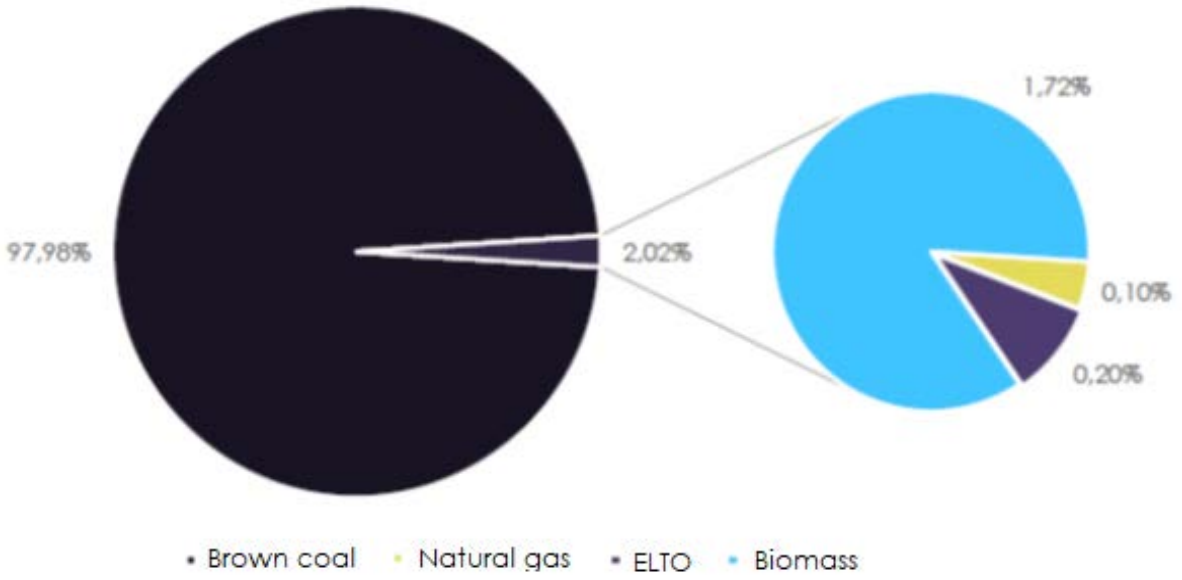

Figure 12: Distribution of heat plant feedstock, 2019, MWh (City of Kladno, 2021b)

6.2 Strategic Plans and Goals

Even after the 2030 emission savings targets are met, the energy intensity of individual sectors of the city should continue to be reduced in combination with an increase in the share of energy consumption from local zero- or low-emission sources. The vision for 2050 is an energy-efficient and largely self-sufficient city, full of innovative, smart solutions. See the plans towards 2030 under Figure 13.

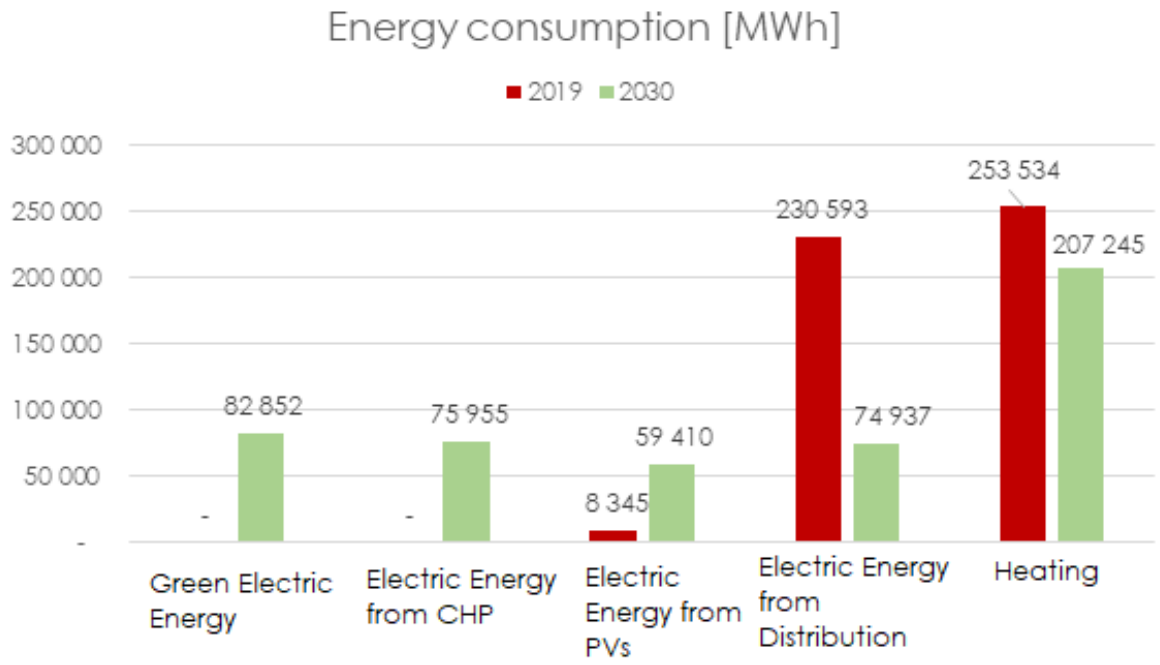

Figure 13: Consumption outlook in 2030 (City of Kladno, 2021b)

The proposed measures target up to 11% savings in total energy consumption by 2030, while saving 40% of CO_2 emissions. After the implementation of the energy saving

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measures, the annual energy consumption in the territory of the city of Kladno is expected to decrease to 1,199,549 MWh by 2030 (see Table 5) and the current equivalent CO_2 emissions to 297,189 tons of CO_2 (see Figure 14). Without the implementation of the above measures, a decrease in equivalent CO_2 emissions to only 469,032 tons of CO_2 can be expected by 2030.

Table 5: Energy savings 2030 outlook (City of Kladno, 2021b)

MWh/year	2019	2030	Change
Own heat consumption from the heating plant	195 832	166 853	-15 %
Heat losses during distribution	57 703	40 392	-30 %
Electricity consumption from the distribution network	230 593	74 937	-68 %
Green electricity consumption	0	82 852	-+ 100 %
Electricity consumption from CHP	0	75 955	-+ 100 %
Electricity consumption from PV power plants	8 345	59 410	+ 612 %

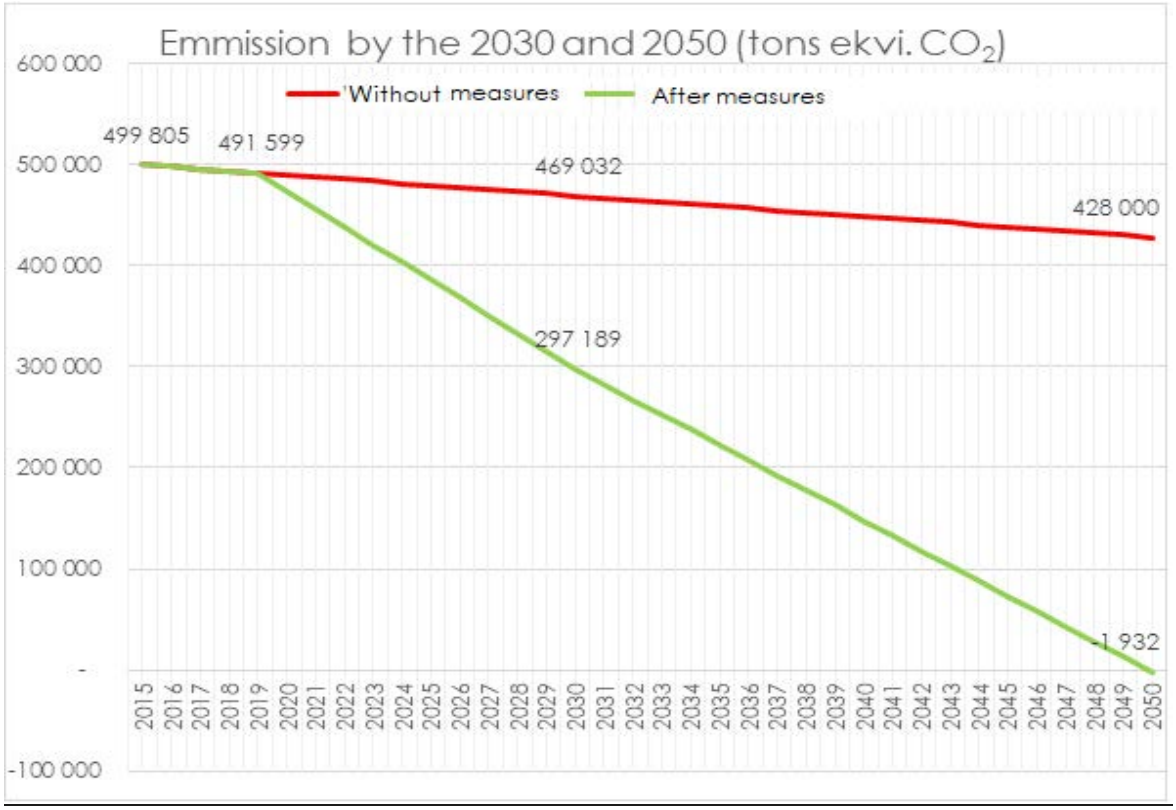

Figure 14: Emission outlook until 2030/2050 (City of Kladno, 2021b)

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At the level of actions/measures the future proposals are stated in the following Table.

Table 6: Key measures until 2030/2050 (City of Kladno, 2021b)

Municipal buildings	Housing
Installation of PV panels in the framework of the already planned projects Comprehensive energy retrofitting of non-insulated buildings Energy saving measures in already insulated buildings Energy saving measures in historic buildings Energy saving measures in other buildings Implementation of Combined Heat and Power Purchase of green energy Use of smart management, metering and smart buildings	Citizen observatory space for energy data Grant and consultation room New construction support for sustainable construction Energy Saving in Family Home Buildings Energy Saving in Residential Buildings Installing photovoltaics on single-family and apartment buildings Supporting the creation of CHP energy communities Awareness campaign for more efficient lighting and green energy Boiler inspections Installation of heat pumps Building plan assessment tool
Municipal fleet	**Public lightning**
Replacement of part of the fleet with emission-free vehicles Adjustment of contractual conditions for transport services Possible optimisation of the use of urban vehicles and routes	Comprehensive reconstruction of the public lighting system Specification of the public lighting system Activities related to the reconstruction of the public lighting system
Tertiary sector	**Energy production**
Stakeholder engagement Grant and consultancy advice Comprehensive building envelope insulation PV installation CHP implementation Awareness campaign for more efficient lighting and green energy Boiler inspections Building plan assessment tool	Energy saving measures on buildings and public lighting Energy saving on heat distribution Promoting electromobility Installation of PV power plants Local combined heat and power production Purchase and use of green energy TEPO service development
Other	
Use of hydrogen and green hydrogen Use of geothermal energy from mine water Utilisation of bio-waste	

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Comprehensive energy management incl. ISO 5001:2019 implementation
Design, implementation and construction of 1-2 Positive Energy Districts
Design and implementation of the energy communities

By 2050, carbon neutrality can be achieved through the abovementioned energy saving measures combined with changes in the city's energy concept. Energy consumption is expected to fall to 402,741 MWh with a significant reduction in equivalent CO_2 tons of the emissions to 1,932 tons of CO_2. Without significant intervention, equivalent CO_2 emissions of 428,000 tons can be expected in 2050.

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7. MOBILITY PROFILE KLADNO

Key managing document in the area of the transport is the **Sustainable Urban Mobility Plan of Kladno (SUMP)** which was created in 2019 and updated in 2022. SUMP covers all modes and forms of transport throughout the territory, including public and private, passenger and freight, motorised and non-motorised, movement and parking.

The city vision is "transport for quality of life". It also consists of the innovations and the use of innovative transport technologies like electric vehicles, plug in hybrids, carbonless fuels etc. shall be focused on.

Crucial inputs while creating the new city strategy were carried out such as

- The household questionnaire survey
- Measurement and assessment of the road traffic
- Traffic modelling
- Intersection capacity assessment
- Traffic accident modelling
- Environmental impact assessment
- Analysis of the city´s transport expenditure
- Forecasting the level of motorisation

7.1 Indicators and Action Fields Analysis

Summary from the data collection (see also table 8)

The importance and quality of the public transportation network in Kladno is reflected in the modal split: only 34.9% of the modal split is occupied by public transport. Environmentally friendly ways of commuting are underrepresented in Kladno relative to average European cities.

Table 7: Sample mobility indicators for Kladno

Indicator Description	City Value	Green	Yellow	Red
Share of traffic by public transport of total traffic (%)	34.9	> 40	25 - 40	< 25
Share of traffic by bicycle mode of total traffic volume (%)	4.4	> 25	25 - 40	< 5
Share of traffic by pedestrian mode to total traffic (%)	20,7	> 40	5-25´	< 20
Annual no. of public transport trips (per cap.)	4	> 400 (ISO 37120)	200 - 400 (ISO 37120)	< 200 (ISO 37120)
Personal Vehicles (including private vans, excluding motorcycles and trucks) to total traffic volume (%)	39	< 15	15 - 40	> 40

The mobility system is the dependence on personal vehicles, supported by the passenger vehicles per city inhabitant indicator, where the value is 10 which is well below the

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"green" benchmark threshold. It's an important factor because not only do personal vehicles contribute a disproportionately higher amount to local air pollution, CO_2 emissions, congestion and space occupied for transport, but their use also undermines the development of alternative forms of transportation. According to 2016 statistics, The city has, a very low number of annual public transport trips (4) compared to the global average of 200-400 trips. As such, the public transport system needs to become more attractive to local residents, involving increased funding to make upgrades and increase demand. The bicycle infrastructure should be extended with more bike lanes while a simultaneous decrease in the number of cars in the city would make these softer forms more appealing. The city has the goal of significantly increasing the portion of soft modes, with pedestrian and cycling plans currently in implementation.

The high portion of personal vehicles in the modal split (163%) also undermines the success of business models for mobility alternatives. A car sharing system, for example, has little chance to be successful partly because the majority of city dwellers possess a car, which may hinder expansion and electrification of the municipal fleet. These are all examples of potential for reinforcing feedback loops if the necessary interventions in the system are made. At this stage, the high-share of personal vehicles is holding back solutions and thus, active intervention also needs to be made to deter personal vehicle use in conjunction with promoting the alternatives.

Motorization[4]

As of 2021, the motorization rate in Kladno is 1.75 inhabitants/vehicle (573 passenger cars per 1,000 inhabitants) (see Table 8).

Table 8: Automobilization in Kladno, the Czech Rep. and Prague (Czech Statistical Office et al., 2022)

Year	Kladno	Czech Republic	Prague
2016	**1.97**	2.05	1.62
2017	**1.95**	2.02	1.58
2018	**1.88**	1.94	1.51
2019	**1.81**	1.88	1.48
2020	**1.76**	1.83	1.45
2021	**1.75**	1.79	1.44

In 2030, according to the Central Automobile Club of the Czech Republic´s car transport forecast, there will be about 7 million passenger cars in the Czech Republic (compared to 5,993,042 in 2021), i.e., an increase of about 2 million. For the city of Kladno, with the same development trend of motorization (including the consideration of population development - discussed below), this development means that in 2030 there will be approximately 669 passenger cars per 1,000 inhabitants in Kladno (i.e., motorization of 1.49 inhabitants per passenger car, which is still better than for Prague as of 2021). This is approximately 54 thousand passenger cars for Kladno.

[4] Data mentioned in the chapter are based on the Sustainable Urban Mobility Plan of the Kladno, 2022.

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Road transport[5]

The city of Kladno is connected to the superior infrastructure by the I/61 road, which serves as a feeder to the D6 motorway (south of the town) and the D7 motorway west of the town. However, the connection to the D6 motorway is unsatisfactory because it passes through the built-up area of the road settlements for almost its entire length, has insufficient capacity and throughput and does not create conditions for safe and smooth traffic. Moreover, the importance of the I/61 road in the section between the D6 motorway and Kladno lies in the connection to the Kladno-South PZ. Therefore, the relocation of the road in the section D6 - Pražská including the connection to the Kladno-South PZ is planned in the long term. Currently, Directorate of Roads and Motorways (ŘSD, 2020) expects the EIA opinion on this construction to be issued in 2020, the planning permission in 2021, the construction to start in 2024 and the commissioning in 2027.

The city is in the metropolitan area of the capital city of Prague and thus, among other things, belongs to its catchment area. The proximity to Prague causes high population movement between the two cities, primarily due to the supply of employment opportunities in Prague and the lower price of real estate in Kladno compared to Prague (see Figure 15). However, this creates a high demand for road infrastructure capacity, parking and public transport. The commuting volume between Prague and Kladno is up to 12,000 inhabitants which is approximately 17-18% of Kladno's population.

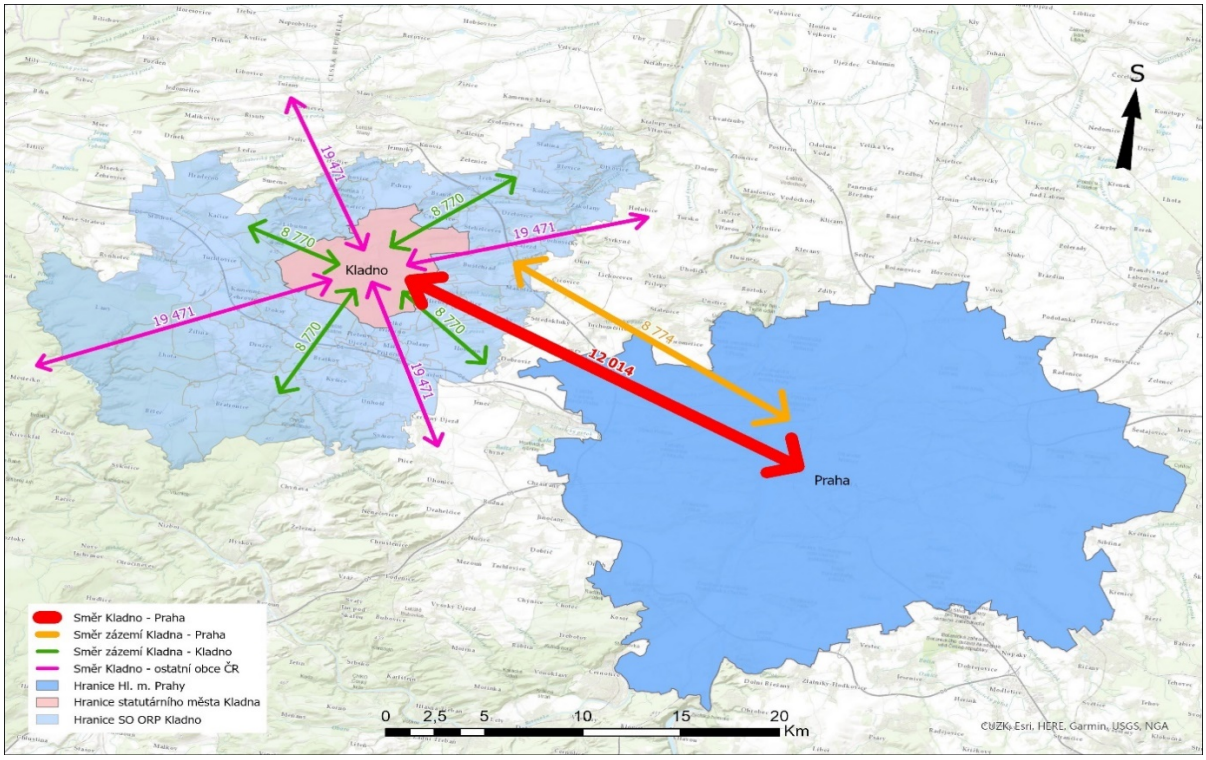

Figure 15*:* Geomorphology of the area, journey from Kladno to Prague of an average resident of Kladno (Czech Statistical Office & City Traffic, 2020)

[5] Data mentioned in the chapter are based on the Sustainable Urban Mobility Plan of the Kladno, 2022.

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Railway transport[6]

The national railway line 120 Prague - Rakovník passes through Kladno. Line 093 Kladno - Kralupy nad Vltavou branches off at Kladno station. All lines are single track without electrification and have low line speeds. On the line Prague - Kladno 80 km/h, from Kladno to Kralupy 60 km/h. The operation on the line 093 Kladno - Kralupy is ensured by passenger trains at an interval of 120 minutes, at peak weekday times at an interval of 60 minutes. On the line Kladno - Rakovník, an approximate interval of one hour is ensured by interchanging a fast train and a passenger train.

The location of stations and stops within the city is a fundamental limit for the use of rail transport (see Figure 16). Only one fifth of the population of the city of 70,000 inhabitants is within walking distance to the railway boarding point. Therefore, a significant part of the population uses bus connections, which serve the territory of the city evenly, when travelling to the vicinity of Kladno or Prague.

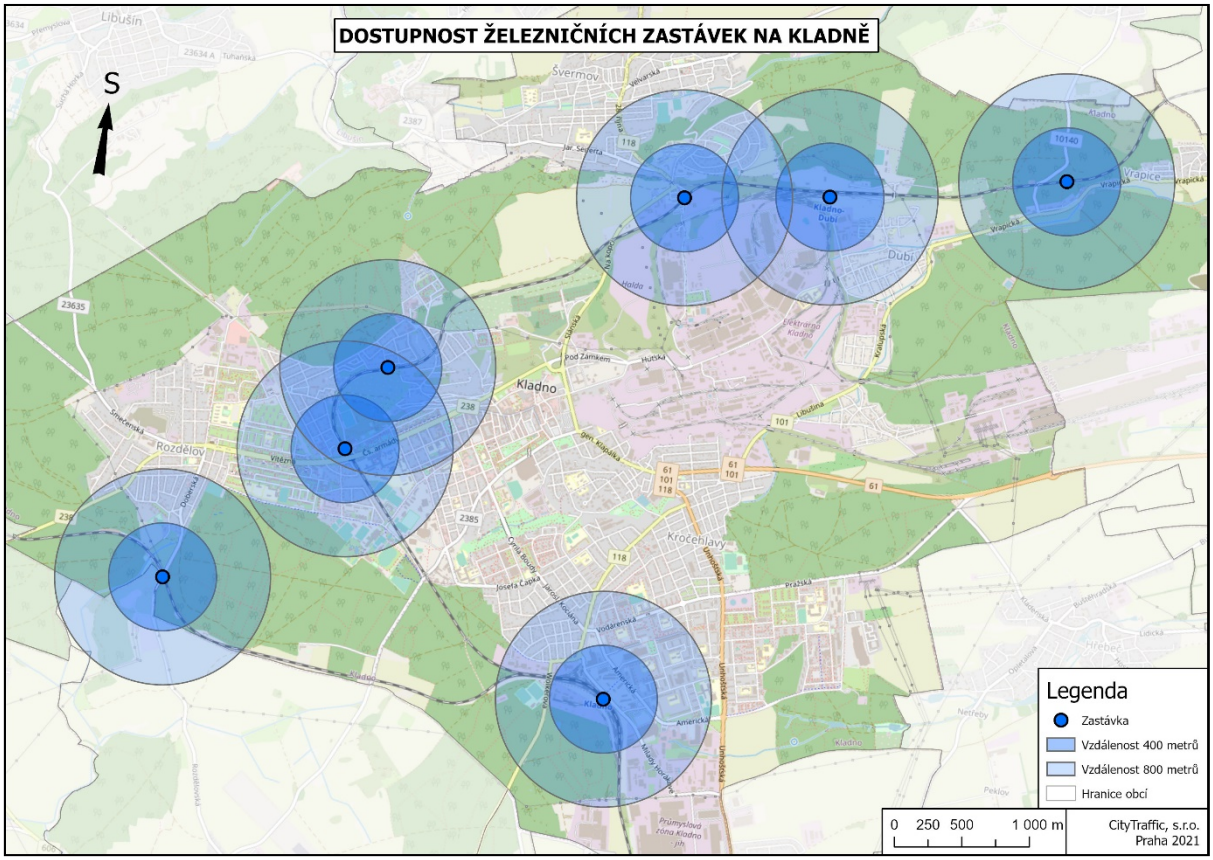

Figure 16: Availability of the Train station in Kladno (Czech Statistical Office & City Traffic, 2020)

Thus, the individual car transport remains the fastest connection. However, this only exacerbates the parking shortage problem, which is directly linked to the future development of electromobility.

The planned upgrading of the railway line to allow higher travel speeds could be a significant benefit for the link between the two cities. However, this is still linked to the service of the city of Kladno or the coverage of the area. People must get to the railway

[6] Data mentioned in the chapter are based on the Sustainable Urban Mobility Plan of the Kladno, 2022.

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stations somehow. They can choose either walking (which is the most suitable option from the point of view of sustainable development) or a combination with cycling (which, however, creates a demand for bicycle boxes and other bicycle storage options), public transport (in this case there is a high demand for frequency and continuity of connections) or driving (high demand for parking capacity near the railway stations).

However, many users will continue to use the private car to travel to Prague. This puts a strong emphasis on capacity parking on the outskirts of Prague, where the user can switch to highly efficient public transport in Prague. When comparing the traffic volume data, it can be determined that on the D6 motorway the difference between the number of vehicles for the whole day before Kladno and after Kladno totals approximately 9,300 vehicles. On the D7 motorway, on the other hand, there are approximately 12 800 vehicles from Kladno. This means a total of about 22,000 vehicles per day. However, it is necessary to take into account that one commuter is counted on the way there and back. We can therefore talk about approximately 10 thousand vehicles per day.

Other modes of transport[7]

The bicycle network in the territory of the Statutory City of Kladno comes from the original routing that connects the parts of Kladno Rozdělov, Sletiště, the city centre, Kročehlavy and industrial zones with each other. In general, the cycling network of Kladno can be considered fragmented and in its current state as non-conceptual with isolated sections. The current cycle network does not cover the main axes of cycling in the city and its organisation is in some places unsatisfactory from the point of view of road safety (see below for more details). The regional link of cycling transport is currently implemented largely thanks to the infrastructure of the so-called cycle route around Kladno (routes 0017 and 0018), which provides a satisfactory connection for some municipalities in the hinterland of Kladno, but for other municipalities the connection is unsatisfactory or almost impossible. In 2015, the document Cyklogenerel (General Cycling Plan) of the entire territory of the Statutory City of Kladno (hereinafter referred to as the Cyklogenerel) was prepared. Based on the spatial concept of the city itself, it determined the concept of cycling, in which it defined the missing routes in the city.

Regarding the sharing system, in 2019, the city has started to use shared bikes for transport around Kladno. An analysis of the routes taken by the users of the shared bikes shows the use of mostly urban road infrastructure. The main bicycle thoroughfares are Americká, Jaroslava Kociána and Cyrila Bouda Streets, and the Kročehlavy housing estate (Italská Street, Wenceslas Square). Furthermore, the streets most heavily used by bicycle traffic were Pod Zámkem, Čs. Armády and Vítězná. However, the highest incidence of Rekola movements (rental bikes) was recorded in the vicinity of the Sletiště sports complex.

The city's pedestrian network is largely adequate. Locations that have had a sidewalk in the past that has been taken away in favour of parking or where the sidewalk is completely absent are unsatisfactory. Pedestrians are therefore forced to use the roadway for walking.

[7] Data mentioned in the chapter are based on the Sustainable Urban Mobility Plan of the Kladno, 2022.

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e-mobility

To improve the environment and reduce emissions from public transport, it is proposed to continue to promote alternative fuels in public transport and regional transport. On regional routes, the introduction of electric buses is supported according to the requirements of ROPID (regional transport authority), which coincides with the measure proposed in the SECAP concept. The latter foresees a 28% reduction in CO_2 emissions, with a more rapid replacement of CNG vehicles and the use of electricity from green sources, even greater reductions can be achieved. The operation of CNG vehicles proved to be very price sensitive during the 2022 energy shock.

The carrier ČSAD Kladno has already been operating two electric buses since 2021, and more will be added through gradual fleet renewal. In cooperation between the City of Kladno and ČSAD Kladno, a project is being prepared for the purchase of 16 electric buses and the construction of the related transport infrastructure (fast charging station, overnight parking for electric buses or even service charging stations), which should be deployed in 2023 on the main lines 603 and 606.

Energy balance[8]

Individual (personal and business) transport accounts for 9.1% of the total emissions of the city of Kladno. In total, fuel was consumed in 2019 with an energy volume of 167,035 MWh, which is 44,520 tons of CO_2 equivalent emissions. The largest share of energy consumption and emissions production is attributable to diesel and gasoline, with a minority share attributable to LPG (see figure 17 and 18).

In the proposed target point, 16 % of the original energy will be saved to 140,211 MWh. The equivalent CO_2 emissions will thus be reduced by 43 % to 25,462 tons CO_2/year.

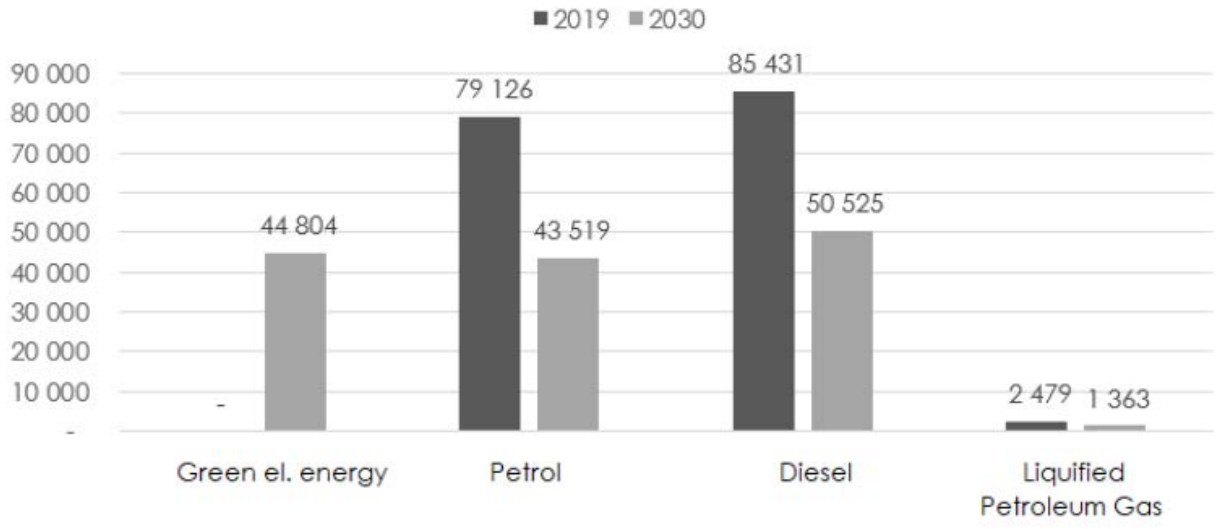

Figure 17: Individual mobility – energy consumption targets in 2030, MWh (City of Kladno, 2021b)

[8] Data mentioned in the chapter are based on Kladno SECAP, 2022 and related technical and analytical works.

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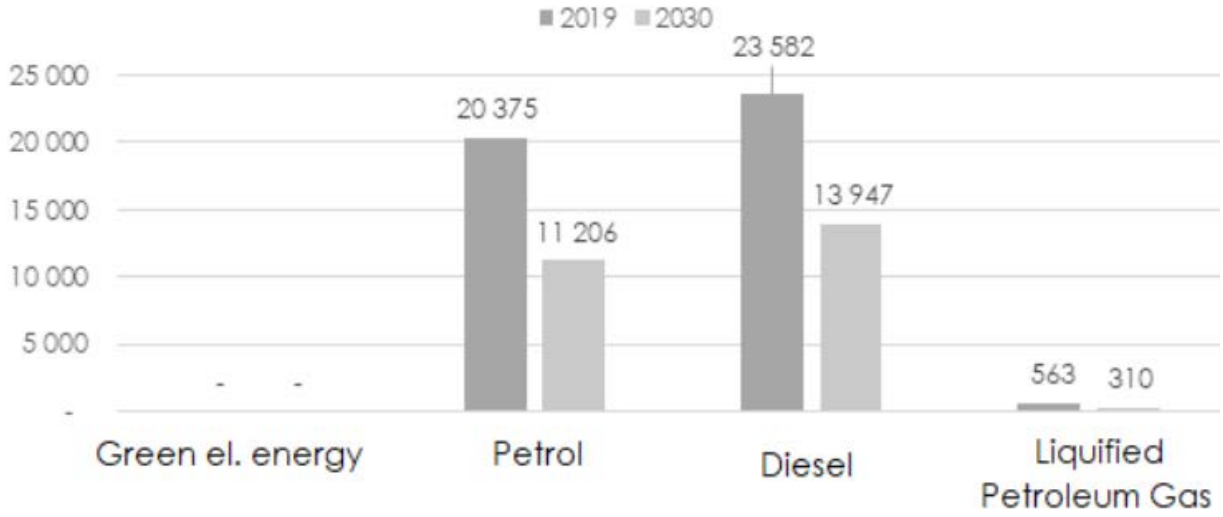

Figure 18: Individual mobility – emissions balance targets in 2030, eq. tons CO_2 (City of Kladno, 2021b)

Public transport contributes 2.8% of the total emissions of Kladno. The public transport fleet consists of 70 diesel buses and 120 CNG buses. For the purpose of this analysis, fuel consumption for 2019 was provided. In the case of non-city buses, fuel consumption was calculated from available information according to route lengths and frequencies from timetables. Non-city buses are considered as diesel buses. Total fuel energy consumed in 2019 was 54,857 MWh and in CO_2 equivalent emissions 13,614 tons CO_2/year. CNG accounts for the largest share of energy consumption and emissions production, with a smaller share of diesel.

No energy savings are considered in the proposed situation. However, there will be a 28% reduction in equivalent CO_2 emissions to 9 788 tons CO_2/year (see Figure 19 and Figure 20).

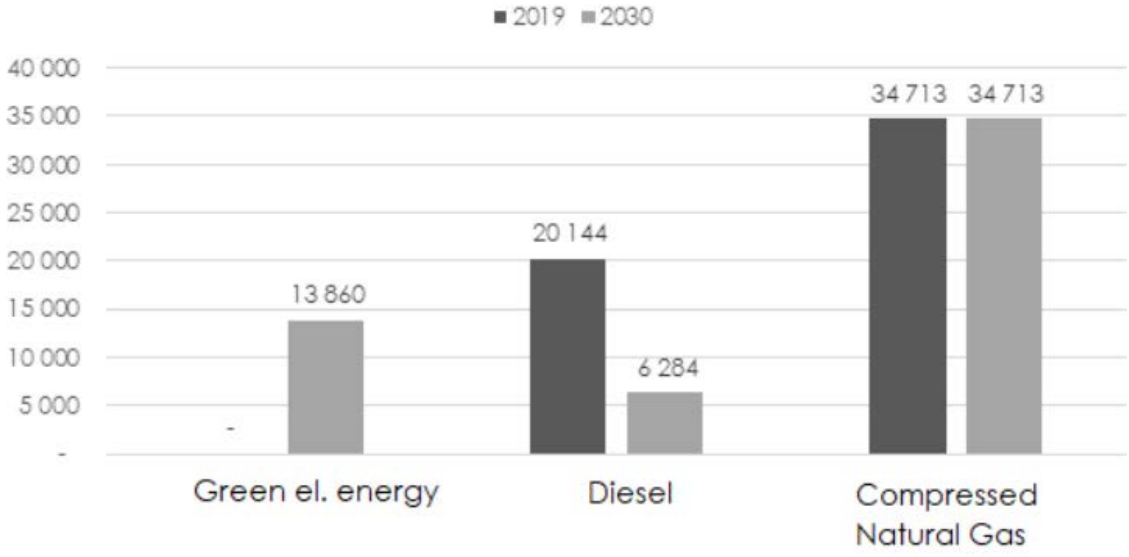

Figure 19: Public mobility – energy consumption targets in 2030, MWh (City of Kladno, 2021b)

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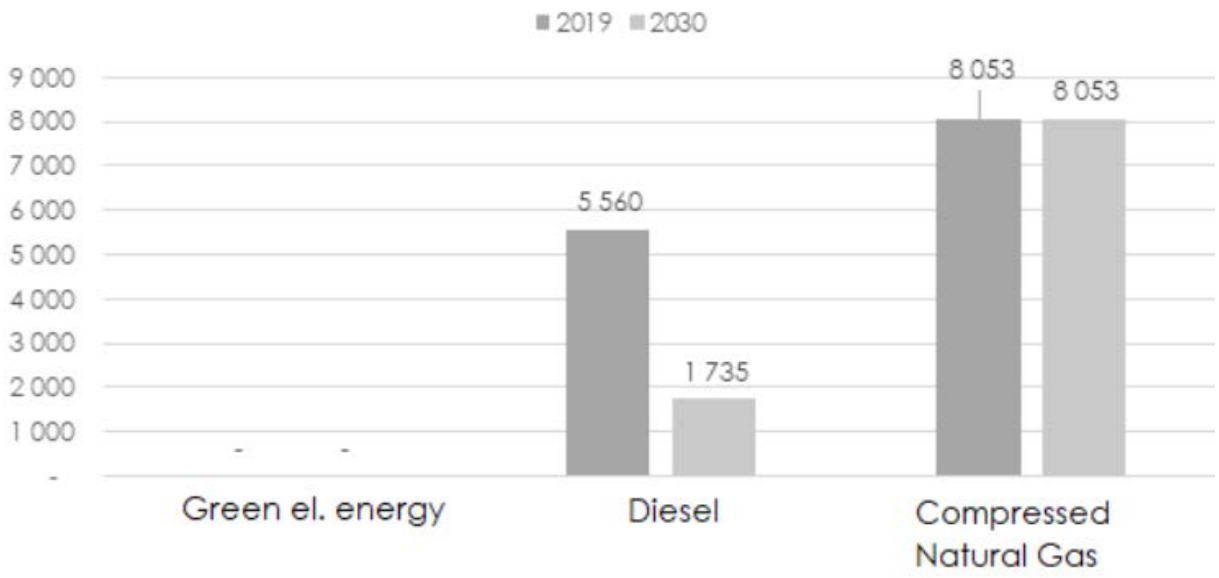

Figure 20: Individual mobility – emissions balance targets in 2030, eq. tons CO2 (City of Kladno, 2021b)

Another category is city fleet. Municipal vehicles contribute only 0.2% of the total emissions of Kladno. It is thus the least polluting sector. In total, 3,887 MWh of fuel in energy equivalent and 1,068 tons CO_2/year in CO_2 equivalent were consumed in 2019. The largest share of energy consumption and emissions production is attributable to diesel, with a smaller share attributable to gasoline. No energy savings are envisaged in the proposed situation. However, there will be a 50% reduction in CO_2 equivalent emissions to 534 tons CO_2/year.

Rail transport contributes 0.6% of the total emissions of Kladno. At present, all train traffic in the city consists of diesel trains, the consumption of which was calculated from data on the utilisation of individual railway sections. Total diesel energy consumption for 2019 was 11,464 MWh and 3,164 tons CO_2/year in CO_2 equivalent emissions.

In the proposed targets, the electrification of the railway section and the use of green energy is considered. In the section of the station "Kladno", the share of electric trains is only 50%, as both railways 093 and 120 run in parallel here and line 120 remains in its original mode without electrification. An increase in energy consumption on the main electrified section can be expected due to the increase in capacity of the suburban transport to Prague. However, the exact increase in consumption cannot yet be determined. However, the equivalent CO_2 emissions will be reduced by 56% to 1,391 tons CO_2/year. See Figure 21 and Figure 22.

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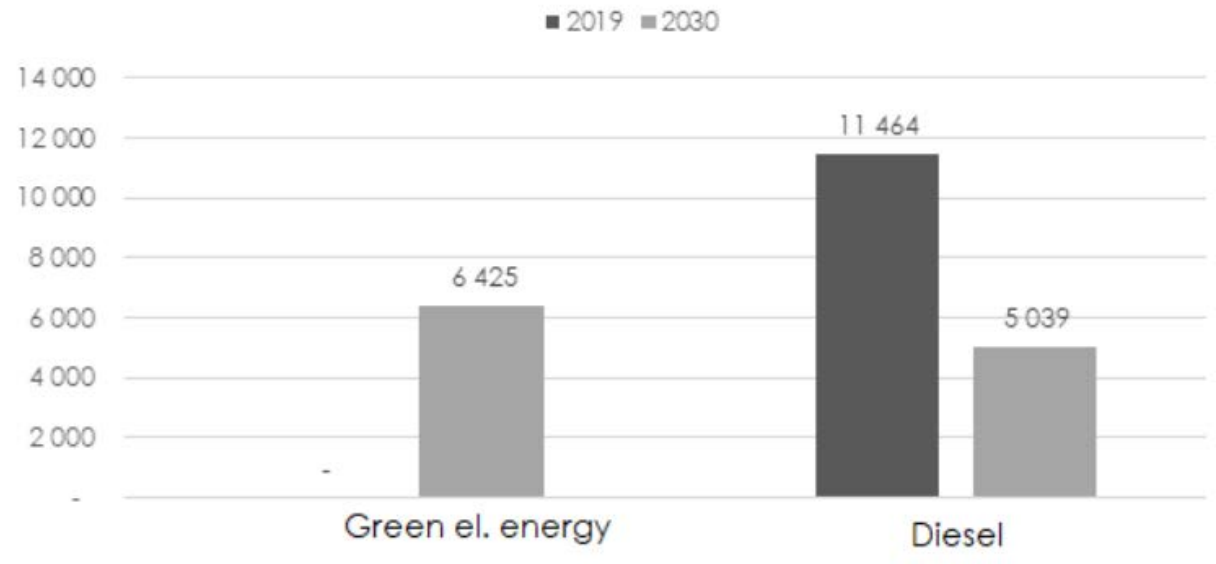

Figure 21: Railway mobility – energy consumption targets in 2030, MWh (City of Kladno, 2021b)

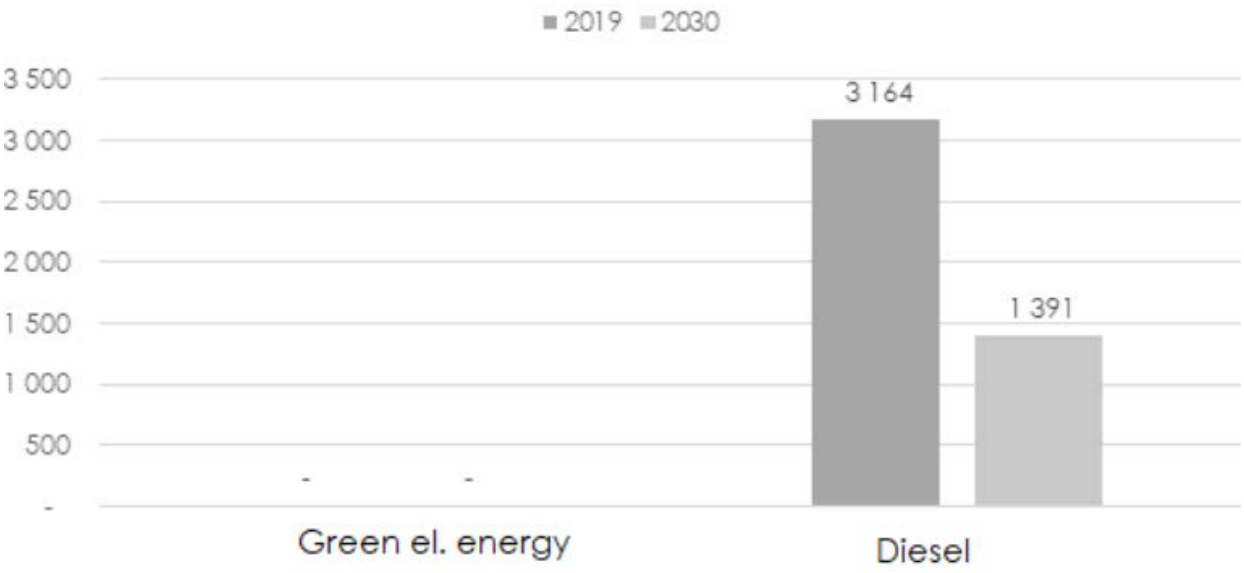

Figure 22: Railway mobility – emissions balance targets in 2030, eq. tons CO_2 (City of Kladno, 2021b)

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7.2 Strategic Plans and Goals

Based on the mapping and modelling made between 207-2019 which was also updated in 2022 the SWOT analysis for the mobility area was done (see Table 9).

Table 9: SWOT analysis (City of Kladno, 2021a, 2021b, 2021c)

STRENGHT	WEAKNESSES
67% of journeys made by sustainable transport High quality public link transport and Intelligent transport systems Expanding safe cycling network Existence of a pedestrian zone in the city centre Majority of public transport fleet on alternative fuels Capacity skeleton for car transport Short commuting time to the capital city of Prague Large number of calmed areas of zone 30 and residential streets Extensive network of adequate sidewalks Development intensities of up to 20 thousand vehicles/24 hours Low level of motorisation in residential development Diversion of long-distance traffic on D6 and D7 High mobility of inhabitants	High number of fatal accidents involving pedestrians Low share of pedestrians in the modal split Lack of a ring road around the city Large number of inappropriate intersections Four-lane alignment of Cyrila Bouda and Americká streets Lack of modernisation of the railway line to Prague Poor rail accessibility for residents Lack of coordination between public transport lines Large number of residents commuting to Prague Lack of P+R capacity at railway stations and stops Absence of cycle routes Unfinished network of cycle paths Lack of barrier-free accessibility of bus stops Lack of cycle path connection between Rozdělov area and the centre Lack of cycling solutions between the centre and Sletiště area Inadequate cycling solutions in the plans for the redevelopment of the Kladno city interchange and the redevelopment of the bus station
OPPORTUNITIES	**THREATS**
Construction of a bypass and diversion of freight traffic Reducing pedestrian accidents by reducing the number of lanes at crosswalks Increasing the share of cyclists and pedestrians in the modal split Construction of a bike path along the cancelled line to Vinařice Active transport and land-use planning policies to reduce negative transport impacts	Great potential for growth in the level of motorisation Increasing number of traffic accidents Increasing traffic intensity High hopes for parking solutions using IT systems Increasing demands on public transport and public line transport to cover demonstrable losses Increasing pressure to change the division of transport labour towards greater use of individual car transport Over-reliance on CNG

The SUMP is also defining the potential scenario for the transport division (see table 10).

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Table 10: Proposed scenarios for the development of the modal split (SUMP Kladno)

Scenario	Status	Trends	Non-motorized	Public transport	Combined
Individual car transport	43 %	52 %	36 %	42 %	32 %
Public transport	29 %	25 %	25 %	35 %	32 %
Cycling	7 %	8 %	14 %	8 %	12 %
Walking	21 %	15 %	25 %	15 %	24 %
Total	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

While the trend scenario assumes an increase in the share of car transport, especially at the expense of walking and public transport, the so-called active scenarios assume the implementation of policies promoting sustainable transport. In the long term, the City has chosen a combined scenario for implementation. Pedestrian, bicycle and public transportation activities will be encouraged. This will achieve synergies to reduce the share of individual car transport. See also in Figure 23

Expected targets of the city are (SUMP, SECAP, 2021):

- City fleet = a 50% reduction in CO_2 emissions:
- Public transport support =16% decrease in energy consumption; 43% decrease in CO_2 emissions:
- Public transport = 28% decrease in CO_2 emissions:
- Rail transport = 56% decrease in CO_2 emissions:
- Non-motorised transport = projected 5% decrease in car traffic:

Figure 23: Scenario - 2030 trucks left, right vehicles for a total of 24 hours (City of Kladno, 2021c)

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Summary of measures is captured in Table 11.

Table 11: Summary of the mobility measures (City of Kladno, 2021c)

Measure	Descriptions of the measure
Safe cycling	Improve cyclist safety by building separated and widened shared paths for pedestrians and cyclists where cycling with vehicles is unsafe. Crossings for cyclists will be constructed and signage on trails will be revised.
Safe on the roads	Modification of dangerous intersections on the basic road network by converting them into contact, roundabout or traffic light-controlled intersections. Pedestrian crossings will be designed on all arms of the intersection. Sections in poor technical condition will be reconstructed.
Safe crossing	Funds will be provided for the annual adjustment of a part of the crossings in order to ensure the conditions of the ČSN and Decree 398/2009 Coll.
Video surveillance	Camera surveillance at the bus station, selected bus stops and public transport vehicles to increase passenger safety.
Safe to Schools	Ensure safe routes to schools by building safe pedestrian crossings between primary schools and catchment areas. Crossings over capacity roads will be equipped with traffic lights or crossing guards between 07:30 and 08:00.
Electromobility	Ensure that more than 1,000 electric vehicles can be charged in the city by expanding charging stations by 2030. Allow for the construction of private sector charging stations.
Alternative mobility in the public transport	Introduction of 100% CNG-powered public transport buses or electric buses. After 2030, increasing the share of clean vehicles (hydrogen or electric) following the milestones set out in Directive (EU) 2019/1161 of the European Parliament and of the Council on the promotion of clean and energy efficient road vehicles.
Preferences of the buses	Preference for buses at traffic lights or dedicated lanes.
Carpooling and carsharing	Ensure support for multi-family car sharing and multi-user car sharing.
Smart Bus Stops	Expand the number of electronic signs and information boards displaying current delays and transmitting them to search engines and apps.
Smart junctions and preferences	Gradual reconstruction of signalized intersections with the establishment of dynamic or coordinated control. Establish camera surveillance with recording at traffic lights.
New parking houses in the housing estate	Preparation of a parking development plan in order to complete the necessary parking capacities in residential developments. Establishment of collective garage owners' associations in housing estates is envisaged. The garages will also offer the possibility of charging electric cars.
Promoting pedestrian zones and footpaths	Revitalization of the pedestrian areas and walkways to enhance aesthetics, safety and pedestrian comfort.
Creation of zones 30 (2 dB noise reduction)	Continue to establish 30 zones with a 30 km/h speed limit everywhere in residential areas outside of the primary roadway network. Residential streets will be implemented in areas without sidewalks.

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Measure	Descriptions of the measure
Transit diversion	Divert through traffic by constructing a bypass of the city and routing it to the parent transportation network. A new bypass between III/23631 and III/2384 will be investigated by a reconnaissance study in the subdivision.
Electromobility	The renewal of the municipal car fleet and the construction of public charging stations will increase the attractiveness of electric mobility and reduce energy and fuel consumption.
Provision of residents' parking capacities	Improving conditions and reducing illegal parking in residential areas. Ensure sufficient parking and carsharing capacities, improve the standard of transfer nodes (Kladno station, bus station, transfer between train, public transport, PAD, P+R, B+R and K+R).
Modification of non-conforming and addition of new sidewalks	Construction of new sidewalks at locations of increased demand or locations of major traffic accidents and widening or repair of substandard sidewalks. Selected sidewalks will be designed as shared use paths for pedestrians and cyclists.
Bidirectional movement of cyclists in one-way streets	Allow two-way bicycle movements in a one-lane, two-way traffic pattern.
Support of public transport, including provision of new routing	Development of the existing public transportation system and introduction of service to new locations, such as area Na Pláních or area Korea and other routes as needed and as the city develops.
Improving bus stops	Reconstruction and modification of bus stops to ensure passenger comfort and accessibility for people with reduced mobility or orientation.
Reconstruction and reduction of the bus station	Develop a proposal for a new bus station, reducing the footprint of the station and establishing a multi-storey P+GR car park on the vacated area (with partial use in P+G mode).
Construction of shared cycling paths	Provide connections for cyclists on the defined core network through the construction of shared cycle paths. Continue to mark them out and connect with new paths surrounding villages that are not well connected.
Reconstruction of lines 093 A 120	Support for the preparation and implementation of the modernisation of the railway line Prague - Kladno-Ostrovec and an increase in the number of trains on the given line. It also includes connecting the railway and other transport at Kladno station and Kladno city stop.
Restrictions on freight transport	Restriction of the passage of freight traffic in residential areas wherever it is possible to use an alternative route on the superior transport network.
Adequate crossing lighting	At all current pedestrian crossings it is proposed to examine the intensity of lighting and visibility of pedestrians to drivers and to ensure sufficient lighting at these locations.
Bikesharing	Ensuring the promotion of a cycle share service to support sustainable and non-motorised transport.
Placement of bike stands	Making cycling more accessible by placing cycle stands at interchanges to other transport modes and at essential amenity services.
Building a positive image of	Using promotional campaigns and activities to show people the benefits and opportunities of sustainable transport in order to induce behavioural

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Measure	Descriptions of the measure
sustainable transport	changes and contribute to improving the health and quality of life of the city's residents.
Traffic education and awareness	Through education and awareness-raising actions, increase knowledge of road rules, awareness of traffic safety, sustainable mobility and considerate movement of people on the roads.
Communication and information on transport	Actively communicate with citizens, organisations, institutions and increase public awareness of the traffic situation in the city, sustainable transport options and upcoming transport projects/activities.
Quality of the documentation	Ensure the preparation of quality design documents for transport projects/buildings, including capacity assessments and provision of 15m bus passage at locations of current bus routes.
Integrated transport system	Support deeper integration of public transport, regional lines and rail transport to ensure coordination of timetables, fare recognition and improved passenger services while maintaining the transport needs of Kladno.

In area of the clean mobility the SUMP is supporting especially electromobility and with long-term perspective after 2030 also a hydrogen transport. In the public transport there are already most of the buses based on the CNG and partially on the electricity.

The charging stations and electric cars in the individual mobility are not developed too much. There are currently 2,703 electric vehicles (BEV+PHEV) registered in the Central Bohemian Region. The ratio between the total number of registered passenger cars in the Central Bohemian Region and in the city of Kladno has been used to derive that there may be approximately 132 EVs in Kladno by 2021 (City of Kladno, 2022).

Based on the comprehensive feasibility study carried out in 2022 (City of Kladno, 2022). The city tries to determine the relevant and feasible scenarios in the area of electromobility. High scenario is the closest option to the national framework/strategy, but the real data over the past years are showing slower pace of the charging stations constructions and electromobiles sales. Low scenario is based on the pessimistic outlook due to energy crisis and geopolitical situation in the EU. Kladno city would choose the medium scenario, enough ambitious and enough realistic. In the parallel, many of factors are influencing the final status, the city should act as an active stakeholder in this field, especially when comes to its regulative role, supporting role etc. See following table.

Table 122: Development of electromobility in Kladno - emission-free and hybrid vehicles (Czech Statistical Office et al., 2022)

	2021	2030 - low	2030 - medium	2030 - high
Population	68 896	80 846	80 846	80 846
Number of registered cars	39 465	54 000	54 000	54 000
Number of eCars	132	657	1 953	4 440
Share of eCars/1000 inhabitants	2	8	24	55
From total	0.34%	1.21%	3.61%	8.21%

The analysis done in 2022 built on the solid socio-economic, environmental, participatory data. The information and data were also connected to the map documentation.

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Elementary “blueprint” for the establishing the future proposal is an expected demand of residents/users in 2030 (see Figure 24). The proposal of the charging stations (in 2030) incl. specific features is shown in Figure 25.

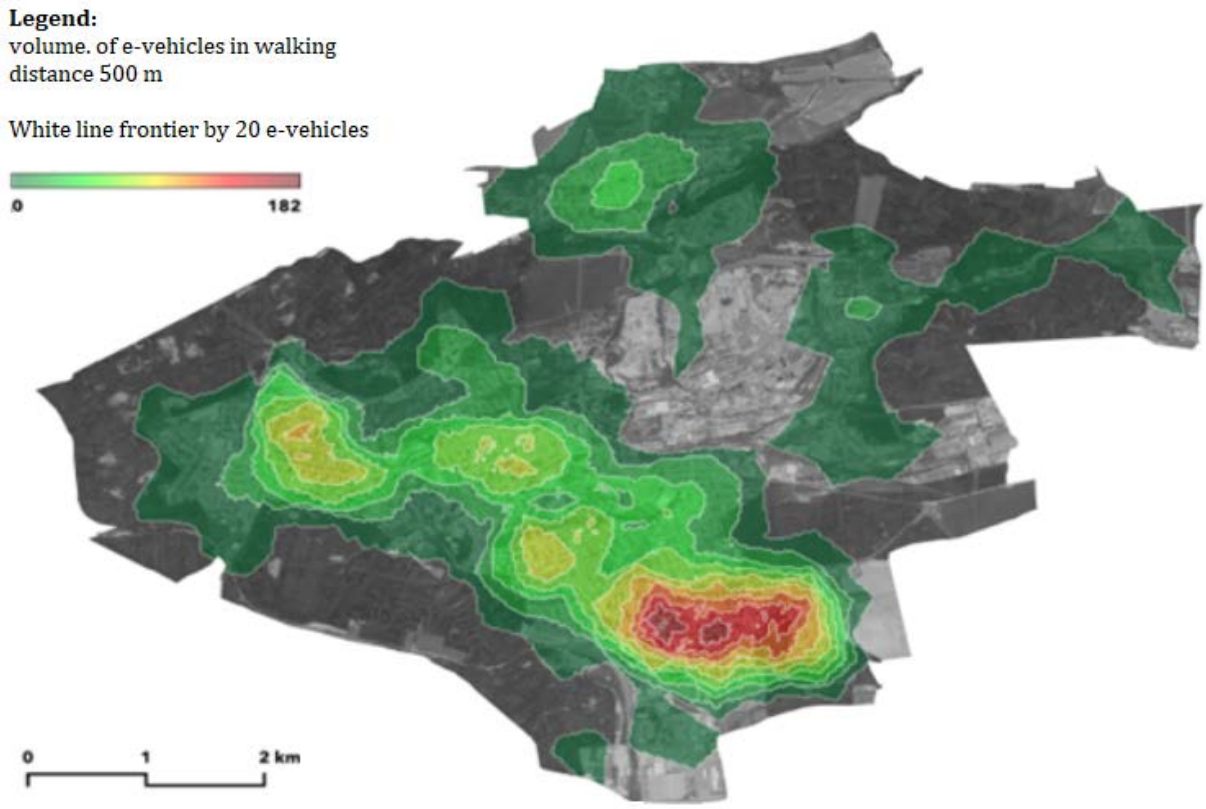

Figure 24: Expected charging demand - medium scenario = 1953 e-vehicles (SmartPlan, 2022)

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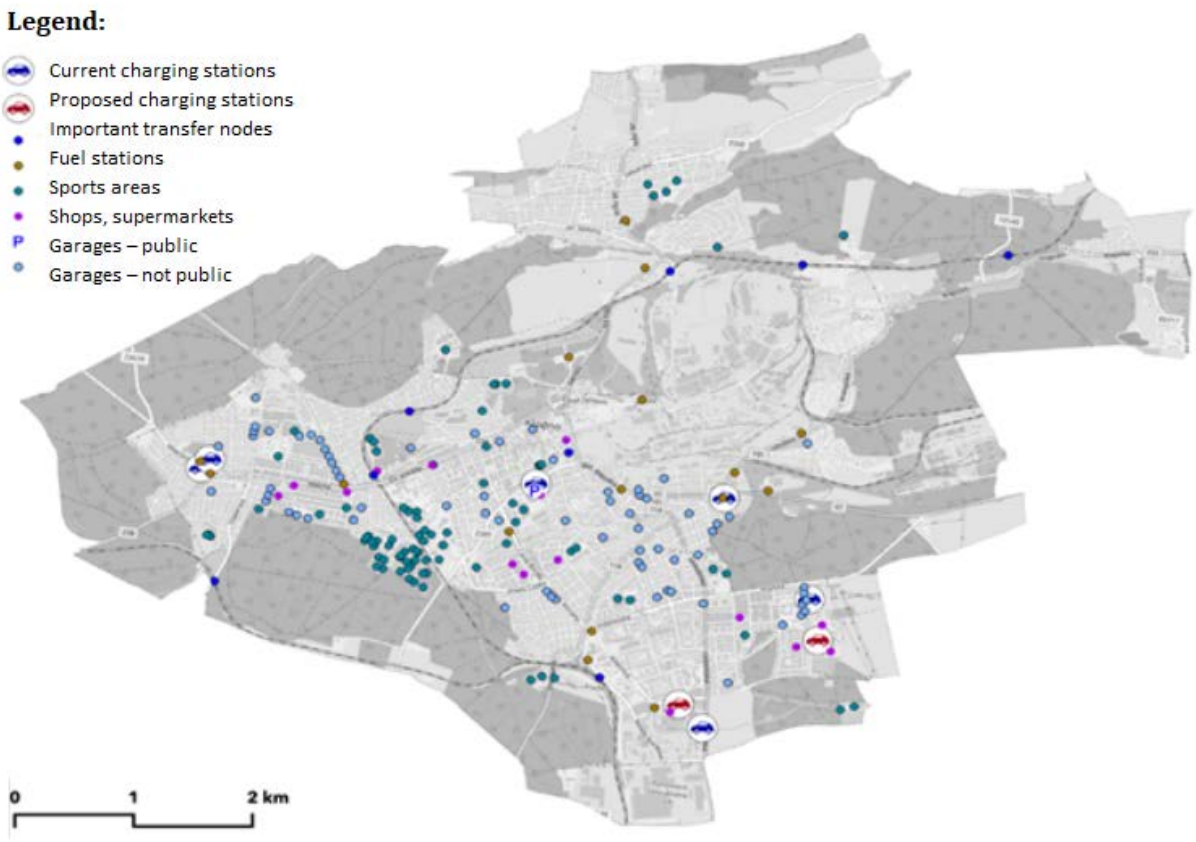

Figure 25: Identified existing and planned charging stations (SmartPlan, 2022)

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8. WASTE MANAGEMENT PROFILE KLADNO

Sustainable Development Strategy of the City of Kladno until 2030 consists of the one priority on the waste management incl. some proposals and measures.

Kladno has its Waste management plan (City of Kladno, 2017). The obligation to prepare a Waste Management Plan is imposed on the municipality by Section 44 of Act No. 185/2001 Coll., on Waste and on Amendments to Other Acts, as amended. Municipalities that generate more than 10 tons of hazardous waste or more than 1,000 tons of other waste per year are required to prepare a municipal waste management plan. The plan must be in accordance with the binding part of the Regional Waste Management Plan and its amendments. The municipality's waste management plan is a binding basis for the municipality's waste management activities and a basis for the preparation of the municipality's spatial planning documentation.

8.1 Indicators and Action Fields Analysis

Summary from the data collection (see also Table 13)

With a recycling rate of over 21%, the waste management system of the city is not well-equipped to handle material flows. This value falls in the red range of the indicator benchmarks. This sector needs a lot of improvement in terms of recycling, reduce or reuse initiatives.

Table 13: Sample waste indicators for Kladno

Indicator Description	City Value	Green	Yellow	Red
CO2 Gas Emissions (t/cap)	6,5-7,5	< 2,5 t/per cap	2,5–7,5 t per cap	> 7,5 t per cap
Water consumption (l/cap/day)	85 - 88	70 - 150	40 -70 or 150 - 250	< 40 or > 250
Recycling rate (%) percentage of total municipal solid waste generated that is recycled (includes materials recycling and organics valorisation, for ex. composting, animal feed etc.)	21	> 65	65 – 25	< 25

Waste-related action fields present areas of achievement as well as for improvement in Kladno. Closely tied to mobility and industry, air pollution presents one such area for improvement. In addition, while water consumption is in the “green” area of the benchmark analysis, action fields indicate that treated or rainwater techniques have not yet been explored. This, too, could be an area of improvement in minimizing environmental impact.

Since action field assessment indicates a relative deficit, development of building process regulations with regard to waste and pollution is the most important avenue for innovation in the waste sector. Lower scores in the building section of action fields, for example in construction management, presents Kladno with opportunities. Life cycle analysis and dismantling concepts could be integrated into building requirements to establish circular resource flows, for example the utilization of old building materials in

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new construction. This effectively targets building construction waste, especially given that household recycling is quite advanced. Kladno can benefit from guidance provided here by CVUT (e.g., catalogue of construction products containing recycled materials).

System of the waste collection[9]

In Kladno, municipal waste is sorted into paper, plastics, white and coloured glass, beverage cartons, biodegradable component of municipal waste, metals. Used textiles are also collected in special containers on the territory of the city.

The following waste management facilities are located on the territory of the town (all facilities are operated by AVE Kladno): collection yard Kladno-Rozdělov, Kladno-Vrapice collection yard, Composting plant Libušín, Waste collection, purchase and storage Libušín.

Mixed municipal waste is disposed of by landfilling. Due to the planned ban on landfilling by 2030, the disposal of mixed municipal waste will have to be addressed. In accordance with the objectives of the Central Bohemian Region Waste Management Plan for the period 2016 to 2025, it can be assumed that mixed municipal waste from Kladno will be disposed of in the planned energy recovery facility to be built on the premises of the Mělník Power Plant.

In 2016, the Kladno has 178 collection points for recycling, where paper, glass, plastic and beverage cartons are sorted into special containers. Collection of waste is operated by different private companies. Total annual waste production at Kladno is relatively stable, as per 2016 data generation rate were 3.58 kg per capita per day. In 2016, around 78% waste went for landfilling and 21% were recovered whereas around 0.1% went for incineration. See also Figure 26, Figure 27 and Figure 28.

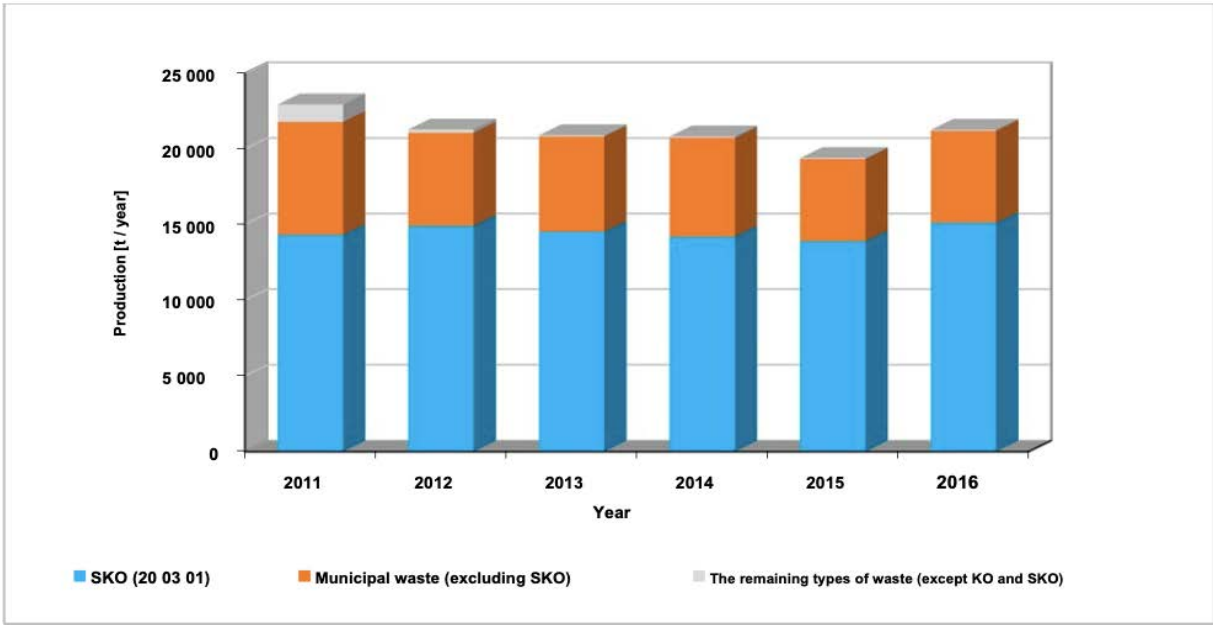

Figure 26: Amount of waste generated from Kladno (City of Kladno, 2017)

[9] [9] Data mentioned in the chapter are based on Kladno Waste management plan (2018) and Sustainable Development Strategy (2021).

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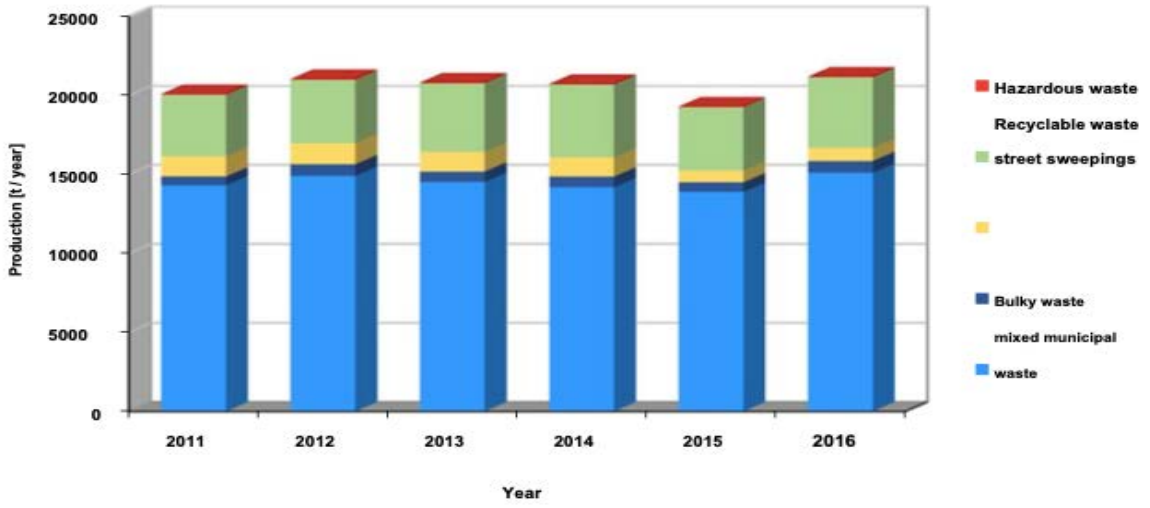

Figure 27: Composition of waste generated from Kladno (City of Kladno, 2017)

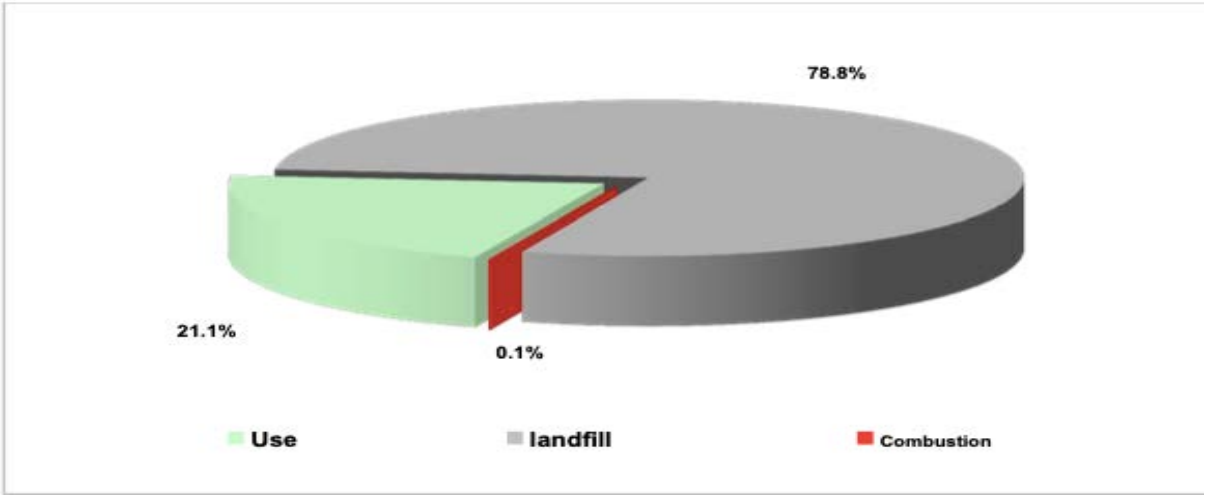

Figure 28: Method of waste treatment at Kladno (City of Kladno, 2017)

Looking at some new data a total of 3,146.4 tons of sorted waste recycled by the residents of Kladno in 2021 in the EKO-KOM's system. Thanks to the functional operation and development of the sorted collection and recycling system of municipal waste, they have reduced Kladno's carbon footprint. Kladno saved more than 73.5 million MJ energy. It was around reduction of 2,737.6 tons of CO_2.

Kladno has a taking back policy for hazardous substances such as lamps, electric appliances which ensure the return of used products offered for recollection are bound to legal entities. It started in 2005 and gradually increasing the amount collected by every year. There is a need improve the preparation for reuse and recycling in particular for paper, plastics, glass and metals, with its focus on waste prevention over recycling, the initiative additionally plans for consumer education to minimize waste production while educating about new opportunities for waste to be sorted and collected as the city develops them.

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8.2 Strategic Plans and Goals

The following table shows the examples of the future proposals defined by the SDS.

Table 14: measures in the area of the waste management (City of Kladno, 2021a)

Goals
• To reduce the overall production/weight of municipal waste in the city. • Increase the proportion of separately collected recyclable components of municipal waste. • Maximise material and energy recovery of waste. • **Minimise the proportion of municipal waste going** to **landfill.**
Results
• Waste management in line with future national and European legislative requirements. • A functioning system of circular management including collection, sorting and recovery of waste, integration into the circular management system at a higher (regional and national) level. • Social viability and economic acceptability of the waste management system for the citizens of Kladno.
Prioritisation and sequencing of key steps
• Analysis of the city's current waste management needs. • Creation of new waste disposal sites.
Monitoring indicators
• Total municipal waste production per 1 citizen (kg). • Share of sorted or actually (material, energy) recovered municipal waste components per 1 citizen (%).
Sub-steps and typical activities
Actions, activities and interventions of the Statutory City of Kladno: • Analysis of the city's waste management needs in the context of legislative amendments (EU, Czech Republic) until 2030 • More detailed analyses and investigations on the origin of individual waste components in order to improve waste management planning. • Improving the availability of separate waste disposal (denser network of disposal sites for individual waste components by individuals and legal entities). • Consideration of the construction of a municipal composting plant (location, financial balance sheet, etc.). Evaluation of the regional solution for composting. • Feasibility study of waste to energy solution potential on city and regional scale. Continuous assessment of Melnik scenario (export of waste to the planned Melnik power & heating plant). • Establishing a voluntary association of municipalities in Kladno to coordinate waste management in the region. • Cultivation of the areas around containers for sorted waste. • Extension of the optical network (smart stops, security, information boards for citizens, hotspots, etc.). • Development of Smart City projects (smart intersections, smart container system with sensors, etc.; see other thematic areas and the cross-cutting priority Kladno Smart).

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Actions, activities and interventions of other actors:

- Municipal support for the existence of consumer goods repair shops, sharing of second-hand goods, rental of household tools, etc.

Details, targets, scenarios and dozens of the measures are defined by the Waste Management Plan. Below, examples of the strategic projects from the energy point of view are mentioned.

There is no municipal waste landfill or composting plant in Kladno. According to the information from AVE Kladno company, 26.89 thousand tons of municipal waste was produced in 2019, which is taken to landfills out of the city. It is not situated in the city thus according to the SECAP methodology the total emissions production in the city for the sector is 0 tons CO_2. Despite this fact there are several project ideas for the future.

The Kladno heating power plant will change its fuel base, or expand it by burning municipal waste, including already landfilled waste, green hydrogen, biogas, natural gas, minority biomass. By 2038, a complete shift away from coal is planned.

It is recommended to map the potential of waste heat use in the city for the purpose of supplying buildings with thermal energy for heating and hot water, or for using waste heat to increase the efficiency of heat pumps. A suitable opportunity could be the use of waste heat from the compressor cooling of the ice rink or from other operations in the SAMK area (esp. in the ice-hockey stadium which is part of the main PED alternative). However, it is recommended to analyse the efficiency of the operation and the potential for waste heat recovery, sludge or biogas production.

In addition, (see also Kladno SECAP (City of Kladno, 2021b)) the city produces 2,219.30 tons of bio-waste, which is sent to composting plants in the vicinity of Rakovník and Beroun. Another possible measure is the comprehensive use of bio-waste. Bio-waste is not yet systematically used in Kladno and is taken to distant composting plants. These include foodstuffs and raw materials unsuitable for further consumption, edible fats and oils, catering waste (school, canteen, restaurant, kitchen waste), Category 2 and 3 animal by-products, waste from bakeries, confectioneries, dairies and similar operations, expired cans, fats, oils and their mixtures, biodegradable municipal waste and sludge. The theoretical annual production of biodegradable waste of the city of Kladno can be determined at 12,297 tons. Using the available technologies, up to 2,049,550 m3 of biomethane can be produced from this amount of bio-waste, which represents an energy equivalent of 12,525 MWh. The calorific value of biogas depends on many factors and can realistically be as high as 9.3 kWh/m3. Biomethane also has a variety of uses - after desulphurisation it can be burned for heat production or used as fuel for CHP units for simultaneous production of electricity and heat. After upgrading and deodorisation, biomethane can be supplied to the regular natural gas network or bottled. Another possible use is its application in the energy mix of transport.

Wastewater treatment plant is also one of the strategic project areas where high emissions are observed (3,277 tons CO_2), esp. when comes to use of the sludge and energy recovery from incineration.

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9. PROJECT IDEAS FOR THE TRANSFORMATION OF KLADNO

During the on-site assessment, a total of 30 project ideas were introduced and some of them also developed together with the interviewees and during the internal co-creating sessions with the local team. These project ideas were also inspired by the implementations in the Lighthouse cities in SPARCS.

Since the city decided to run extended volume of meetings and interviews the onsite assessment took more than 3 weeks of the time. It was also caused by the Covid restrictions and lower availability of the experts and interviewees.

On April 7, 2021 an introductory opening session was organized for presenting, and discussing and proposing the existing ideas. The overall city platform for energy was used for these purposes. The aim was to introduce preliminary project ideas such Smart Regulation, Public Retrofitting & PV integration, the Urban Data Platform & Smart Applications, and Smart Parking management, Mobility Hubs & Kladno Stations, Energy from Waste, Smart Metering in Public Facilities, and Charging & Shared eVehicles.

Intensive multilateral thematic meetings (from April 8 to 21, 2021) were carried out since Kladno aimed to have a specific input regarding their particular priorities. For this reason, interviews with partners with great impact in Kladno such as TEPO (heat distributor), Sev.en Energy (power plant operator, heat producer), Arriva (transport operator), Veolia (water management operator) or AVE (waste management operator) helped to address different needs and project proposals in Kladno.

Also, the round table for the implementation of the Positive Energy District was held on April 20, 2021. The round table focused on the PED status quo in Kladno, PED in Leipzig (examples and approaches; good and bad practices; overall role of the heating system), PED paradigm for Kladno and pre-conditions (incl. role of urban planning; virtual power plant), PED Sletiště locality (boundaries; locality characteristics; energy schemes; energy and economic opportunities; discussion) and on the question “How to succeed with PED in Kladno, who needs to do what; how to exploit the replication etc.”

On Friday April 23rd, the City of Kladno, together with CVUT & Fraunhofer IAO concluded the three-week very intensive virtual on-sites (after 18 meetings).

On June 15 2021, because of the funding importance the round table called “Energy: role of business and investment” took place. The project proposal goes hand in hand with funding opportunities, thus the city invited dozens of experts from the research, other cities, banks, financial institution etc. Agenda consisted of the introduction of Kladno goals and needs, project introduction, involvement of the of partners, business, developers, banking (why, for what, how…) incl. FHG inspiration part. Key topics which were discussed: business models for energy solutions, financial strategy, innovation and technology gathering, collaboration models; tools (strategy towards investors; construction standards; etc.). Also, other Czech cities (Prague, Brno, Písek) came with inspiration.

9.1 Virtual Onsite Assessment

Before on-site assessment, a total of 30 project ideas were designed by the city and experts. See following table.

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Table 15: original proposal of the project outlines (author´s own)

Project outlines	Strategic priority/area
P1 Public retrofit	Energy
P2 Clean energy from photovoltaic system incl. business model	Energy
P3 Heating system	Energy
P4 Public lightning	Energy
P5 Energy use from the waste treatment	Energy
P6 Mine water usage for heat supply and storage	Energy
P7 Public clean mobility	Mobility
P8 Supporting the clean individual mobility	Mobility
P9 Promotion of the eMoblity	Mobility
P10 Parking management	Mobility
P11 Mobility HUBs	Mobility
P12 Cycling HUBS and “super blocks” in the city	Mobility
P13 Public space - more green in city	Mobility
P14 Digital Infrastructure	Digital services
P15 Invipo – smart platform	Digital services
P16 Urban Platform	Digital services
P17 Smart Metering	Digital services
P18 Intelligent energy management	Digital services
P19 Smart strategic planning	Good governance
P20 Learning and knowledge based organization	Good governance
P21 Innovation and energy (city) HUB	Good governance
P22 Participation model	Good governance
P23 Smart regulation	Good governance
P24 Financial strategy	Good governance
P25 Positive Energy District: Research and Analysis	Positive energy district
P26 Positive Energy District: area I, Sletiště	Positive energy district
P27 Positive Energy District: area II (e.g. brownfield)	Positive energy district
P28 PED: virtual power plant/energy community	Positive energy district
P29 Waste heat from winter stadium	Energy
P30 Energy production from sewage sludge	Energy

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9.2 Project filtering

The city team has designed around 30 project outlines, some of them were already partially implemented, some of them were in the preparatory phase and some of them were proposed newly, e.g. based on the inspiration from the innovative approaches in other cities or are part of the replication task in the SPARCS. But most of the project outlines are part of the compulsory implementation of the SECAP.

The project filtering was done by local SPARCS team under the advice and suggestion of representatives of the municipality. Eight project ideas were selected for the discussion during the workshop, based on the need to hear stakeholders' opinion, political support, availability of resources needed to be implemented and limitations of current laws and regulations.

9.3 Innovation workshop

Around 35 people attended the online workshop (see also Figure 29). The workshop participants were a broad group representing the city, distribution companies, public bus operators, representatives from the energy, waste, water companies, the Czech Technical University, etc.

The aim was to validate and further develop the projects regarding the needed components, the strategic stakeholders, next steps, possible financing options, and others.

At the beginning of the workshop an introduction and the City Lab methodology was presented followed by the presentation of the preliminary results and the developed ideas.

For the discussion 8 project outlines were filtered:

- Public Retrofit & photovoltaic systems (Energy)
- Energy from Waste (Energy)
- Smart Parking Management (Mobility)
- Mobility Hubs & Kladno Stations (Mobility)
- Charging & Sharing eVehicles (Mobility)
- Smart Regulation (Governance)
- Smart Metering Public facilities (ICT)
- Urban Data Platform & Smart Applications (ICT)

For practical work the templates were designed, distributed and explained to the moderators in advance – since the city wanted to use the momentum and gain even more insight from the partners the extended template was used for the interviews.

Discussion was held in two blocks, each on was divided in the four groups – energy, mobility, good governance, and ICT. Team members from city and CVUT UCEEB as a main partner of the city acted as a moderator, assigning a work group and two project ideas per topic. A pre workshop rehearsal had been organized, between members of local team, in order to decide final agenda, resolve organizational and technical issues and assign participants and project ideas.

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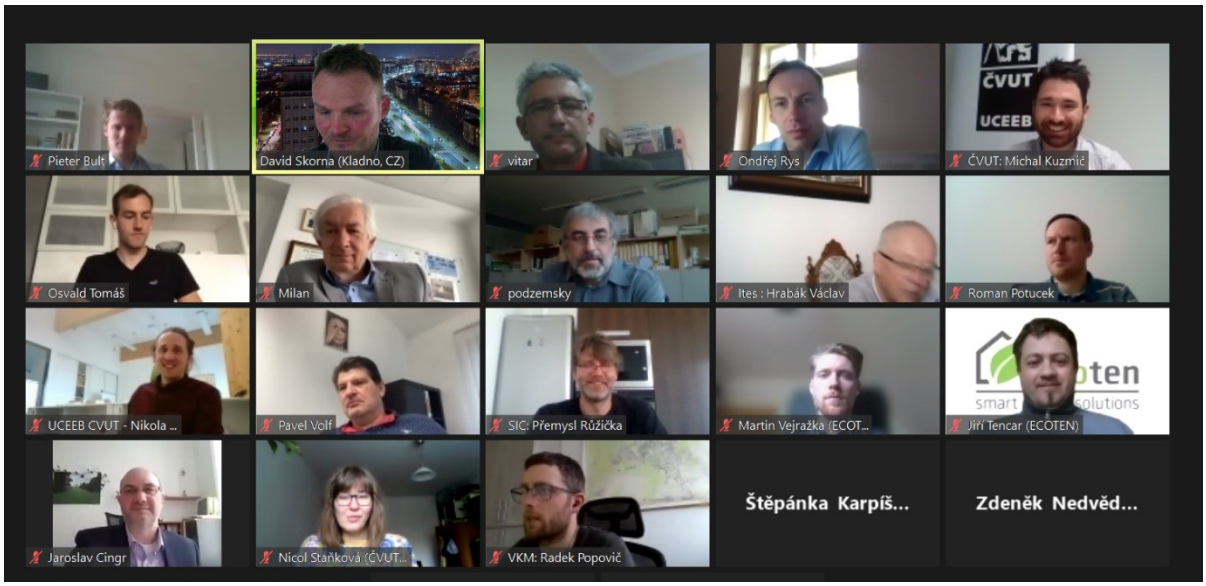

Figure 29: Snapshot from the workshop (made by author)

Finally, the results of the discussion (se also snapshots of the project outlines under Figure 30 and 31) and the filled templates were presented in the plenum in the form of a marketplace with a short pitch. Given the limited time available on the innovation workshop, the summary was introduced briefly at the end of the meeting. Key outcomes were discussed between the City Lab team, CVUT UCEEB and Fraunhofer during the internal coordination meeting between the meetings with the stakeholders and after the innovation workshop.

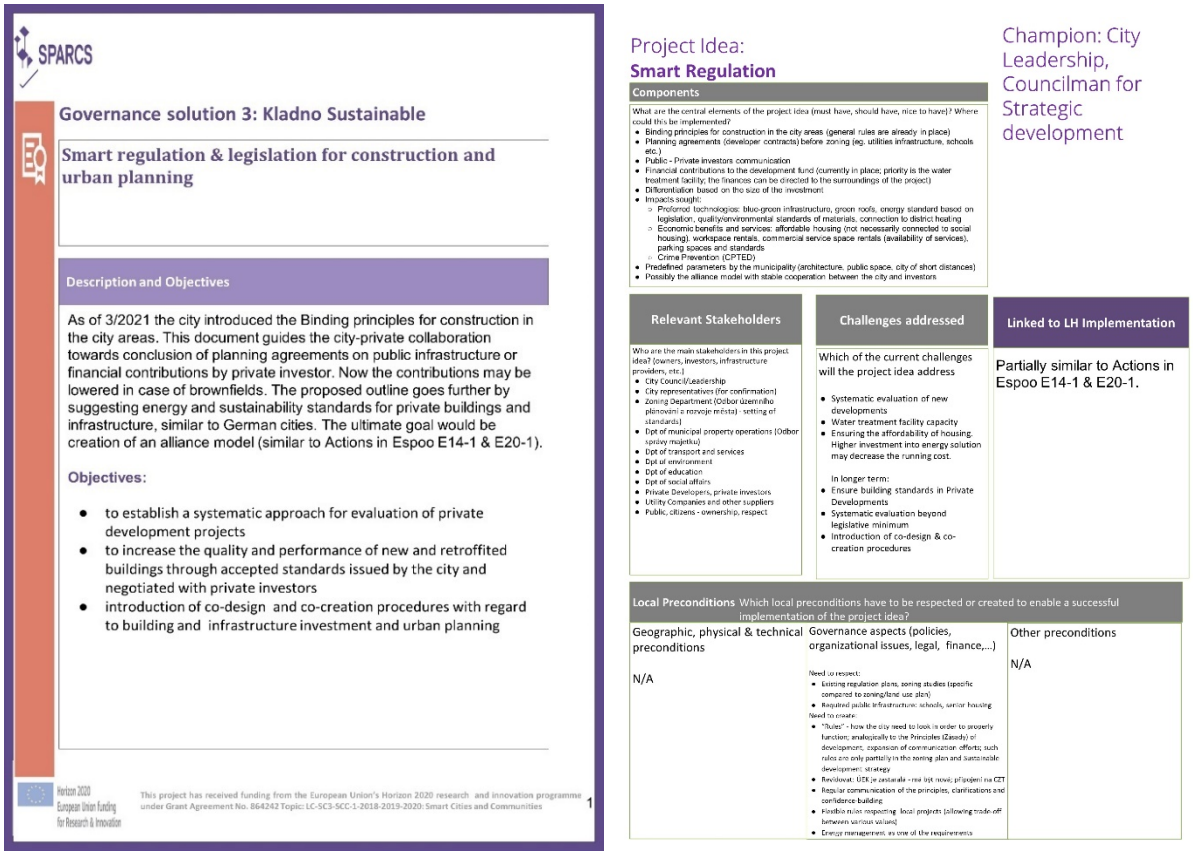

Figure 30: Snapshot of the project posters (Example: smart regulation)

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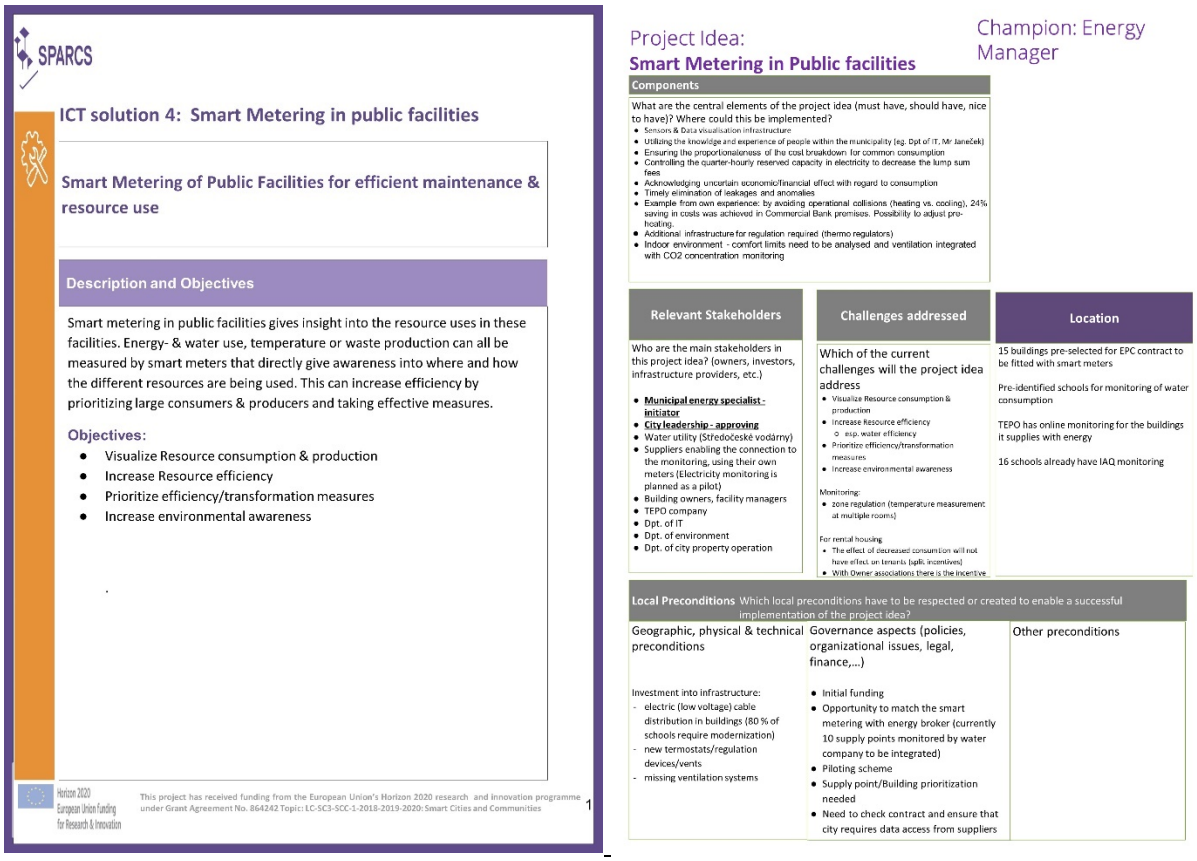

Figure 31: Snapshot of the project posters (Example: smart metering)

9.4 Project Ideas for Kladno

As mentioned above, eight project ideas included three mobility solutions, two energy solutions, two from the ICT area and one from the good governance were discussed during the innovative workshop, other projects ideas were touched as well.

For the purpose of detailed elaboration under the SPARCS co-creation process incl. intensive support from the Fraunhofer and under potential Lighthouse´s inspiration the city Kladno has chosen 3 project outlines:

1. Clean energy produced by the photovoltaic system incl. business model (P2)
2. Supporting clean individual mobility (P8)
3. Positive Energy District: area I, Sletiště (P26)

The city has created extended templates for the project outlines. Templates consist of the required information from the FHG IAO methodology and there is more information the city needs for the development of projects.

Details are mentioned in the following tables.

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Table 16: Clean energy produced by the photovoltaic system incl. business model (city property)

Project outline no. 2	**Clean energy produced by the photovoltaic system incl. business model (city property)**
Increasing of the self-sufficiency of the public buildings incl. pilot and innovation actions	
Description	
By 2030, it is planned to install new PV power plants on the roofs of buildings with a total annual production of 59 410 MWh/year. An alternative to PV panels is hybrid photovoltaic-thermal collectors. The prerequisite is primary coverage of the electricity consumption within the building and sufficient size of the battery storage. Surplus electricity can be exported to the distribution grid, resold to other consumption points in the city or used for heating by heat pumps. By installing PV panels on flat roofs or on suitably oriented pitched roofs of these buildings, part of the electricity consumed can be replaced by locally generated electricity without emission burden. The assumption is a 40% reduction in electricity consumption for buildings with flat roofs and a 20% reduction for buildings with pitched roofs. A more precise evaluation of the potential of installing PV plants needs to be assessed individually.	
Problem analysis / objectives / results / impacts	
Challenges addressed / problem analysis ● Low production of the energy from the renewables. ● High consumptions of the energy. ● High costs. ● High dependency on the distribution grid.	**Objectives** ● Increasing production of the clean energy for its own consumption (partially for the grid). ● Increasing self-sufficiency of the buildings and resilience. ● Setting up new business products for the city company. ● Preparation for future energy communities.
Expected outputs/results ● Analysis of the relevancy of the city buildings. ● Project plan for the installation of the solar panels and/or other technology such as heat pump, geothermal solutions. ● New business model for the city (incl. business plan for new production, distribution and sales) ● Installations themselves. Battery storage placement. ● Technical inputs for energy flexibility testing.	**Planned impacts** ● Higher self-sufficiency of the city property regarding the energy use. ● Savings (energy and finance) for future use and other investment (multiplicator) ● City as an active player in the exploitation of the renewable energy. ● City as a key component in the energy communities. ● Pilots: combination of the PVs, electromobility (perhaps also with the carports), storages, involvement of the housing sector or some communities.

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Vision and city strategies fulfilling	
Contribution to vision fulfilment	**Contribution to city energy policy (SECAP)**
Strategic area: Energy (statement: stable heat and electricity distribution system that significantly integrates emission-free, renewable and decentralised sources; battery storages; resilience and security of the supply)	SECAP area: 4.1.1 city buildings EE, 4.1.2 tertiary sector EE, 4.1.3 housing EE, RES production; 4.5.1 multi-sectoral, 4.6.4 monitoring; 4.6.5 Mitigation SECAP measures: SECAP01-05; SECAP14, SECAP16, SECAP22, SECAP25, SECAP29, SECAP59-60, SECAP62, SECAP65, SECAP74, SECAP76, SECAP81
Components	**Potential (particular) projects**
● Thermal mapping (done) ● Analysis of the roofs potential (ongoing) ● EPC in buildings – retrofit (as a complementary project within 23 buildings) (ongoing) ● Creation of the new business model for the city company. ● Procurement and realization of the installation ● Smart energy management in the buildings ● Operation and service in production part ● Energy community pilot	● See the bullets in the Component part

Partnership and roles		
Main responsibility	City– grant and project unit	Main coordinator incl. SPARCS management
Co-guarantee role	City – asset management dpt.	Main responsible body for the city properties; analytical, technical support
Partner 1	City – investment dept.	Funding and investment planning
Partner 2	TEPO	City company, so far with the heat licence; future aim is to place also the licence for the electricity incl. new team for the business
Partner 3	Schools, other buildings managers	Landlords of the buildings; with deep knowledge on how the building operates; also final users.
Partner 4	Distribution companies	Partner needed already for the design phase; capacity check; connection to the grid
Partner 5	Housing association	For the pilots.
Partner 6	External experts	Depends on the scale of the project

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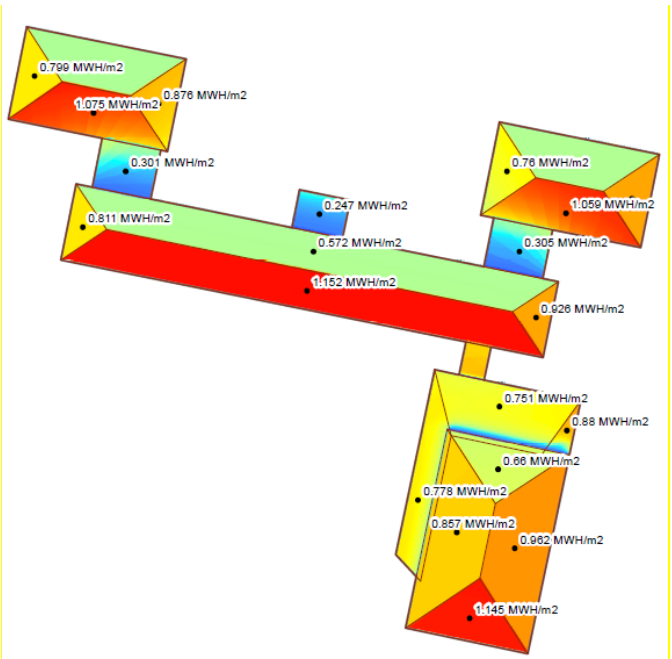
Localization		
Analysis is run in the whole city; according to the background documents, thermal mapping and technical reports there is a selection of the potential city building for the installation of the PV systems. It is across the city; there are buildings such as schools, retirement facility, administration buildings, sports facilities, etc. PED locality Some localities for the pilots need to be selected. Particular buildings are selected for the energy flexibility testing		
Local preconditions (readiness)		
Geographic, physical & technical	Feasibility of the installation in particular localities in the city. Construction readiness. Distribution network and free capacity for the connection.	
Governance aspects (policies, organizational issues, legal, finance,…)	Connection to the grid (rules, procedures, deadlines etc) New business model setup Budget possibilities for starting the installations EU funds calls open	
Availability of necessary input data (analyses, studies, input data)	Analysis of the city´s building potential Roof´s screening. Preliminary business model	
Potential Barriers to the project		
Limited connection to the grid Too long procedures and bureaucracy Missing human resources Limited funding Overheated marked Unavailability of materials and technology		

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Financing Options & Business Model	
Estimated budget • EUCF – 60 mio. EUR • Other documentation - 50 mio. EUR (I. Phase) • Realization – depends on the project scale and internal/external provision of the realization. • New city company setup – not available at the moment.	
Sources ● EUCF – partial budget for the analysis ● City budget – technical documentation ● Realization – EU funds; city budget; private capital	Business models: ● City-EU funds-national grants ● Private capital in case of the external provision of installations and/or operation.
Schedule and milestones	**Procurement / Construction aspects**
Analytical part (I. phase) - 10/2022 Documentation (I. phase) - 03/2023 Pre-realization (I. phase) - 06/2023 Realization part (I. phase) - 09/2023	Market consultation Procurement in case of the lending the property

Why it is smart and innovative
The city intends to retrofit the buildings in a comprehensive and smart way. It means it is designed as a complex approach consists of the renovation of the building, smart metering (sensors, smart meters, etc.), installation of the technologies producing the clean energy (such as a photovoltaics, heat pumps, integration into the district heating network and potential connection with the energy communities. It has one denominator = increasing the self-efficiency of the public buildings. The idea is a comprehensive and there are dozens of new technologies incl. digital layer. The producing the renewable energy is a core of this part (in parallel the city is running other components from the overall idea).

Link to the implementation in other cities		
Lighthouses in SPARCS	Other cities abroad	Other cities in Czech Rep.
Leipzig (solar thermal plant)	Tbc.	Prague (energy community)
Espoo, Lippulaiva (shopping centre PVs)	Tbc.	Brno (city installations)

Next Steps
Finalization of the complex analysis of the installations´ potential
Selection of the buildings/property
Preparation of the technical documentation
Preparation of the business model, human resources hiring etc.

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Pilot installation
Licencing of the city company if needed
Installations of the PVs system incl. battery storage (internal or external incl. Procurement)
Operation phase incl. maintenance

Table 17: Support of the infrastructure for the clean mobility, mostly electromobility

Project outline no. 8	**Supporting clean individual mobility**
Support of the infrastructure for the clean mobility, mostly electromobility	
Description	
Mobility in Kladno is characterized mainly by the use of private and company vehicles and at the same time sustainable and ecological modes of individual transport are not widely used. The city's intention is to support low and zero emission mobility. Kladno does not have a developed car sharing system, partially a bike system has been tested. There is not a sufficiently dense network in the city (there are about 5 charging points) of public car charging stations, neither construction nor model / elements in construction management are supported. Strategic locations should be selected at bus stations, in the shopping centre and transport hubs. And according to the location and connection options in the locality, also select the type of charging station (AC, DC) and the number of charging points.	
Problem analysis / objectives / results / impacts	
Challenges addressed / problem analysis • High emissions and pollution from transport • Lack of eInfrastructure in the city • Non-existent support for electromobility in Kladno • Lack of a unified approach to the reconstruction of roads, parking spaces, etc., with regard to the construction of the charging network • Lack of cooperation with business partners • Low willingness to change the fleet • High investment/expenses of new solutions in eMobility.	**Objectives** • Promoting the active mobility • Reducing the emissions • Reducing the use of personal vehicles • Reducing the noise levels • Promoting the modern lifestyle • Increasing the density of charging infrastructure in the city • Increasing the share of energy production from RES • Creation of a city fleet of electric vehicles
Expected outputs/results • Map of the charging infrastructure • Map of the connectivity of the charging with the distribution network • Construction standards and procedures in the city administration • New city eFleet	**Planned impacts** • Gradual replacement of the combustion engines by low/zero emission vehicles • A denser network of charging stations • Increasing self-sufficiency by connecting the green solutions (PVs, charging, storage, parking, etc.)

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• Proposals of the innovative pilots (eHubs, Plaza Hub, hydrogen stations …) • More charging stations in the city	• Better mobility brings less burden in the city (budget, noise, pollution) – multiplication effects

Vision and city strategies fulfilling		
Contribution to vision fulfilment		**Contribution to city energy policy (SECAP)**
Strategic area: Mobility and Public space (statement: Kladno has a high share of the low/zero emission transport; sub-statements: individual eMobility; public eMobility, eBikes etc.)		Area 4.2 of SECAP SECAP measures: SECAP35, 39-41, 49-50, 52
Components		**Potential (particular) projects**
• Building charging stations (AC, DC) according to relevant locality • Design of the construction norms / standards when building stations, incl. building integrated stations. • Car sharing system / traffic and management • System of contacting the third parties • Internet connection • City (incl. mobile) applications – information, reservation system, etc. • Incorporation of data into the city system - into Invipo		• Feasibility study carried out by city • Construction standards incl. city internal manuals and directives • Agreements and contracts design • Pilot construction of the charging stations • Other
Partnership and roles		
Main responsibility	City – dpt. of transport	Main guarantor of the agenda; overall control of the mobility and transport
Co-guarantee role	City – grants and projects unit	Guarantor for the SECAP and SPARCS (= main strategic basis)
Partner 1	Building and Construction Authority	Conditions, permissions, administration for the construction
Partner 2	ČEZ distribution	Cooperation with the distribution companies due to capacity of electricity and conditions for the connection
Partner 3	Private operating companies	Investors and operators of the charging infrastructure (for the eCar, eBikes, eScooters)
Partner 4	Private sector - shopping centres, sports area etc.	Final spots for some charging points
Partner 5	ŠKODA, Hyundai and other producers of electric cars/bicycles/scooters	Partnership regarding new technology, systems, promotion, contractors

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Partner 6	National partners and association for clean mobility	Expert support as far as setup of the overall scheme in the city, lobbying for the city, bringing new experiences

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Localization	
• Mobility Hubs, shopping centre, hospital, sports area and facilities, etc. • High population density vs. supply and demand satisfaction • Housing estate (increase of parking capacity) - combination with retrofit of the buildings • Proximity to new development projects • Capacity of electricity and parking lots in relevant localities (e.g. shopping centre). • Sharing the availability of charging stations in this case. • Initial investment - places, economy.	
Local preconditions (readiness)	
Geographic, physical & technical	• Construction of transformer stations / increase of power input • Connecting charging stations (bicycles and cars) • Permitting processes • Selection of suitable localities with the greatest potential (e.g. on the basis of transport heatmap) • Good and connected (with the city, for example) cycling network • Internet network availability
Governance aspects (policies, organizational issues, legal, finance,…)	• National and Czech national e-mobility strategies (links) • Clear picture of the charging system in the city - results of the analysis / feasibility study • Model of the construction and operations/service • Subsidy to a certain critical extent • Ownership relationships of places to connect / build • Agreements with partners - shops, owners of recharging points • In November 2021, an amendment to Decree No. 268/2009 Coll., On technical requirements for constructions, will enter into force: However, if it is a change of construction or a completely new construction of an apartment building with more than 10 parking spaces, the obligation to install cables for later installation of the charging station for each fifth parking space will apply to this construction. This obligation applies to both underground and above - ground collective garages in the building, as well as to parking spaces physically adjacent to the building
Availability of necessary input data (analysis, studies, input data)	• 1st mapping took place in 2020 - there are about 10 places where the location of charging stations was considered relevant • Bike sharing system is already in operation (NextBike) • Feasibility study incl. proposals, business model for city etc = September 2022
Potential Barriers to the project	
• High infrastructure construction and maintenance costs • Technological development in the given area (obsolescence of infrastructure) • Lack of parking and charging spaces • Reluctance to distribute network connection / low capacity and low power consumption • Lack of interest of providers (other business ideas)	

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- Low demand from citizens / entrepreneurs
- Long administration and complexity of preparation

Financing Options & Business Model

Estimated budget

- Feasibility study = approx. 30k EUR
- Other analytical/technical preparation work = btw 20-50k EUR
- City eFleet = btw. 120-300k EUR
- Charging stations = depends on the overall design
- Apps for the users = tbc.
- Pilot = depends on the design

Sources

- Necessary financial participation of the city, especially in the first years of operation
- EU funds (OP Transport, National Recovery fund, National Environment Program or others).
- Private funds

Business models:

- Preparation – study (city).
- Financing the construction of charging stations - private sector (according to agreement and scope of infrastructure)
- Charging infrastructure management/operations (private sector)
- Application creation (the city in cooperation with research and the current Invipo system)
- Building Energy Management System integration where needed (e.g. for flexibility purposes)
- Internet network (private, city budget)
- City fleet (purchase – city; charging points – city or private)

Schedule and milestones	**Procurement / Construction aspects**
Feasibility study = 2022 Construction standards = 2023 City Fleet = 2023 Contracts with the private operators = 2023 Charging stations (city property) = 2023-2024	Depends on the model the city will choose

Why it is smart and innovative

Good governance = city does not influence all the aspects of the life in the city incl. private business decisions about future investment. But the city could do it partially by smart regulation, support (financial incentives, land lease etc.). At the same time the electromobility is making pressure on the distribution network and if there is no good regulation, proper communication and at the end of the day also specific formal cooperation with the investors the constructions of the charging network would be uncontrolled, not functioning and even it can cause problem with other investment steps. The city wants to actively play role also in this term and based on the deep analytical and participation approach the city intends to design one of the scenarios how the infrastructure and services in this filed might look like.

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Link to the implementation in other cities		
Lighthouses in SPARCS	Other cities abroad	Other cities in Czech Rep.
Leipzig, Baumwollspinnerei bi-directional charging pilot	Tbc.	Moravskoslezský Region – hydrogen public station Brno: construction of the AC charging stations by city company
Next Steps		
Preparation of analysis / feasibility study of individual e-mobility.		
Analysis of the possibility (and feasibility study) of the involvement of the city and city companies, or consortia of other partners (AVE, etc.)		
Negotiations with ČEZ Distribution (network capacity and connection options) and ČEZ electromobility (public charging infrastructure) ČEZ ESCO (private charging infrastructure - construction and operation) or other experts.		
Screening of the possibilities of creating a car and bicycle rental system; possible application design.		
Negotiations with e-car, e-bike providers, owners of places where charging will take place. Setting up cooperation, financial strategy, etc.		
Assessment of the operation of the Fleximodo system (bicycle sharing) in Kladno + data incorporation into the Invipo system and communication with citizens.		
Creation of building regulations and standards for electromobility.		
Campaign towards citizens; enlightenment and questionnaire survey.		

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Table 18: Project outline template – PED Sletiště

Project outline no. 8	**Positive Energy District Sletiště**
Design and implementation of the positive energy district in the sports area Sletiště	
Description	
The City of Kladno aims to assess the feasibility of a Positive Energy District and to build PED in one of the selected districts: Kladno Sletiště around municipal Sports area (SAMK). In the future, the goal is to upscale and replicate to other city districts. PED is part of the city that employs different technology and organizational innovations to achieve energy-positive balance. It is expected to offer a high standard of living. On annual balance the PED produces more energy from renewable energy sources that what it consumes (in total).	
Problem analysis / objectives / results / impacts	
Challenges addressed / problem analysis ● Unfinished retrofitting projects in the Sletiste locality ● Untapped potential of the locality for the RES Production ● Untapped potential for energy integration of buildings ● Stabilizing and growth of municipal district heating (DH) network ● Missing element of integrated development planning in the locality (buildings are dealt with separately) ● Low cooperation level with private investors	**Objectives** ● Decreasing energy consumption of buildings in Sletiste ● Maximizing local RES production, achieving positive balance… ● Creating synergetic local energy network ● Connecting the locality to the district heating distribution network with economy-efficient use of local resources ● Creation of long-term development plan for the locality towards PED, where individual projects contribute to general vision of PED ● Creation of working partnership of public and private sector
Expected outputs/results ● Retrofitted and newly built buildings containing RES and innovative elements ● Creating of local microgrid (local distribution network/energy community) or long-term contract for using private distribution network ● Area connected to the district heating, local loop on low temperatures ● Clear vision pf PED, including alternatives and individual investment ● Defined operation models and identified sources for financing	**Planned impacts** ● Increased energy efficiency of buildings (towards attainable energy standard) ● Increased local production from RES (over 100 % of the annual consumption in the locality) ● Exploited synergies between buildings (and infrastructure) (~100 % re-used waste heat from the winter stadium, ~100 % use of available areas for RES/PVs, ~100 buildings integrated with regard to power, maximized share of heat integration ● Maximum of buildings connected to DH
Vision and city strategies fulfilling	
Contribution to vision fulfilment	**Contribution to city energy policy (SECAP)**

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Positive Energy District: „Kladno has several functional PEDs“	It will be defined in the pre-feasibility study and later detailed in the preparatory process. Potential production from PV: 1740 MWh/an; from waste heat: 1694 MWh/an. PED balance max = 130 %.
Components	**Potential (particular) projects**
<u>Strategy</u> ● SECAP, Sustainable development strategy (SUR) <u>Design</u> ● Finished implementation of Energy Management Software (Energy Broker), processes according to ISO50001 ● Pre-feasibility study ● Decision on the Investment alternative (selection of buildings to be newly constructed and retrofitted) ● Construction-energy concepts for individual buildings ● Study of heating supply ● Study of DH development ● Co-design of PED: phase I (municipality + TEPO), phase II (private partners) ● Investment outline/Feasibility study <u>Implementation</u> ● Smart/Net metering installation on existing buildings ● Reconstruction and new construction of buildings: sauna world, parking house (if confirmed), new swimming facility, new ball game hall, new tennis hall, finished retrofit of the winter stadium, others ● Installation of new decentralized resources: cogeneration/heat pumps/photovoltaics ● Local heating loop ● MaR and predictive control ● Local IoT network ● Re-Contracting with suppliers <u>Operation</u> ● Operation monitoring ● Optimization ● Dissemination	See components, more specifically according to buildings and infrastructure: <u>Non-investment</u> ● „Generel“ (master plan) of the Sletiste sports area development (negotiated with neighboring entities around) ● Architecture study and project documentation for SAMK buildings ● Project documentation for new DH infrastructure ● Project documentation of private residential projects (ÚS28, ÚS33) and potential other private investments <u>Investment projects</u> ● Winter stadium Retrofit, incl. Infrastructure for waste heat utilization ● Sauna worlds, incl. PVs ● New swimming facility and parking house ● Tennis hall ● Partial extensions/retrofits (eg. summer pools) ● PVs on available roofs and areas <u>Additional required infrastructure (eg. power Distribution)</u>

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Partnership and roles		
Main responsibility	City of Kladno	Management and coordination
Co-guarantee role	CVUT UCEEB	Expert support
Partner 1	SAMK	Collaboration, management of individual Retrofit projects
Partner 2	TEPO	Collaboration, updating strategy, Investment into infrastructure, cooperation on pilot operation of DH and new resources
Partner 3	Albrecht Architekt	Adjustment of project documentation to co-opt new technologies
Partner 4	CVUT Faculty of Biomedical Engineering (FBMI)	Collaboration in design, Investment into new technologies
Partner 5	Elderly housing (Domov s pecovatelskou sluzbou)	Collaboration in design, Investment into new technologies
Partner 6	Skupina ČEZ (Distribuce, ESCO)	Data provision, renting distribution grid, energy services (Retrofit and resources), eventually operation of source//other technologies
Partner 7	Rezidenční areál U STADIONU - Kladno a.s.	Private partner, potential customer to waste heat produced in winter stadium and partner in PV and other technologies installation.

Localization

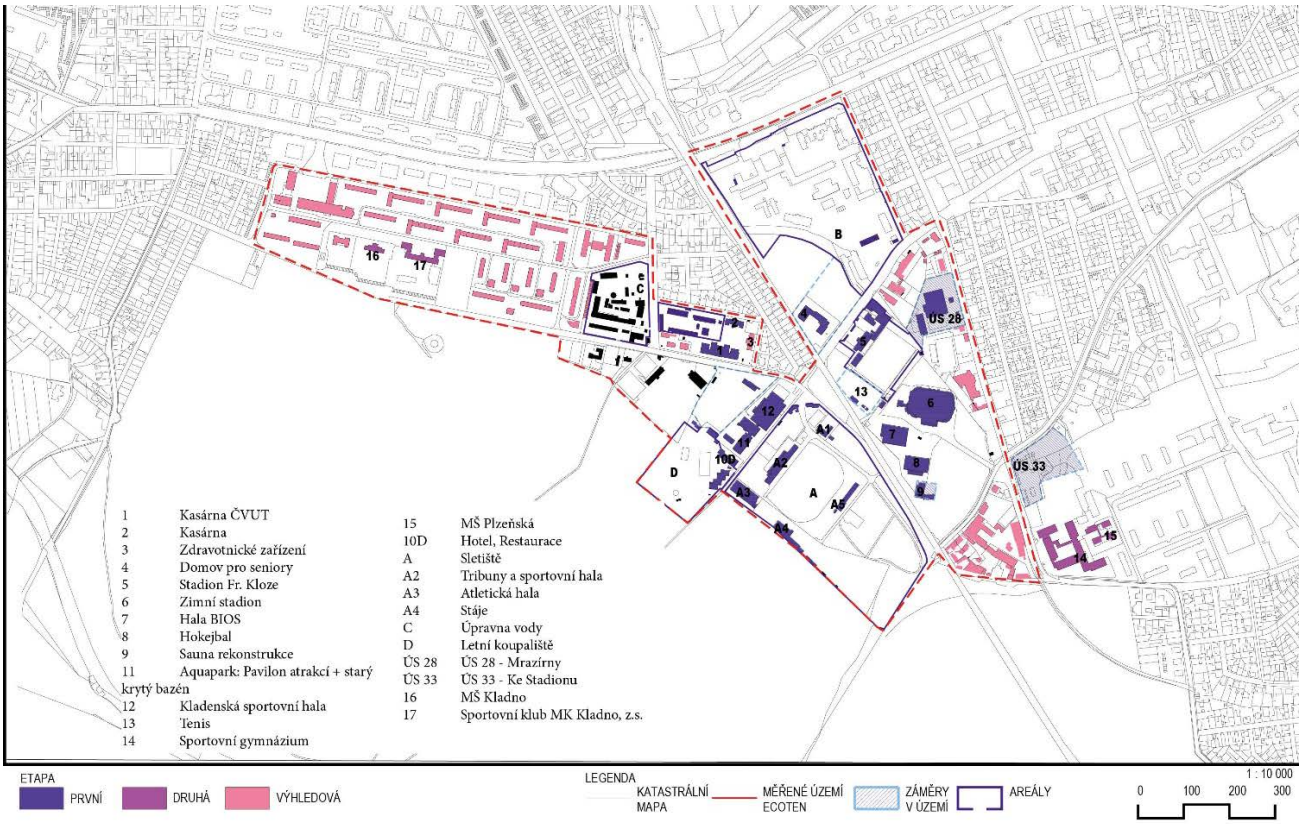

Figure 32: Localisation of PED Sletiště (Map source: City of Kladno)

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Phase 1 (dark violet): municipal buildings, SAMK buildings, Faculty of Biomedical Engineering (FBMI), elderly housing Phase 2 (violet): Private developments ÚS28, ÚS33, Moskevská Elementary School, sport and residential buildings – private Outlook (pink): mostly residential housing in the surroundings	
Local preconditions (readiness)	
Geographic, physical & technical	Existing: ● 90% of buildings are already existing ones, ● 2 electrical substations – public ones Required: ● New heating Distribution loop ● New (to be assessed) power Distribution microgrid and infrastructure
Governance aspects (policies, organizational issues, legal, finance,…)	Financing: continuous screening required Politics: political support needed Legal: Legal advisory for negotiations with DSO needed, energy community set-up
Availability of necessary input data (analysis, studies, input data)	● SECAP/Baseline Emission Inventory as required by tender documentation ● Energy Broker 2019-2021 ● Provided studies (EPC, PV analysis) ● Project Documentation (architecture inputs) ● Continuous monitoring from own metering devices ● Own metering not yet available (as of 2021) ● Required collaboration of architect/project planners
Potential Barriers to the project	
Low political commitment Insufficient coordination of individual investment	
Financing Options & Business Model	
Estimated budget ● Including investment into construction/retrofit works: 100 M CZK+ ● Only technologies and non-investment activities: 50 M CZK (to be detailed)	
Sources ● EUCF, ELENA (design phase) ● Modfond (ETS-based funding) ● Recovery and Resilience Facility ● OP TAK (Structural funds - Operation programme Technologies and applications for competitiveness) ● PPP (Public-private partnerships)	Business models: ● Retrofits and large energy sources: direct investment (municipality), joint venture, EPC/D&B&O (ESCO) ● DH infrastructure and heating supply: operated by municipal energy company ● PVs: own power production and sales (licence for TEPO/SAMK) vs. EaaS ● Flexibility services: market aggregator partner

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Schedule and milestones	Procurement / Construction aspects
9/2022 – Fine-tuned pre-feasibility based on further inputs (study by Ostrava university) 12/2022 – Finalization of studies for District Heating development; decision on investment alternative 12/2023 – Creation of Investment outline for PED (SPARCS deliverable) 12/2023 – Retrofit implementation 6/2024 – New construction implementation 9/2024 – Investment and operation partners contracted (DH and other PED services)	PD new construction of buildings in SAMK area PD modernization of DH Construction works (retrofitting and new) Infrastructure development (power, heating, communication. other) Flexibility services

Why it is smart and innovative
Unique integration of city buildings and infrastructure, public-private collaboration, complexity, innovative technologies, operation model, positive balance.

Link to the implementation in other cities		
Lighthouses in SPARCS	Other cities abroad	Other cities in Czech Rep.
Leipzig: Duncker Viertel, Baumvollspinnerei Espoo: Lippulaiva	Carquefou/Nantes Trondheim	Písek (PEB) Děčín (RES in district heating) Karviná (PED general concept)

Next Steps
Fine-tuning Pre-feasibility PED balance and study
Decision on the Investment alternative (selection of buildings to be newly constructed and retrofitted)
Detailed design of electric microgrid, heat supply
Adjustment of project documentation

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10. CONCLUSIONS

The first draft of the implementation plan was written in autumn 2020. The data collection was done some time ago. The new version prepared during summer 2022 is a combination of the older data/indicators and new findings coming from the strategic documents (SUMP, SECAP and SDS), the vision roadmapping process, the PED pre-feasibility design phase, other projects' realization, an analytical work and from other activities. New research of all action fields (see data collection in 2020) was not carried out in 2022.

The current Implementation Plan of the city of Kladno has been the outcome of a well-designed process, based on the City Lab methodology and the Morgenstadt Framework. The data collection was a key input, interviews together with the overall onsite assessment as well, in the parallel key strategies and project planning within the city administration is taking place.

The activities are undertaken, including the on-site assessment and the data collection process, the cooperation among the various municipal departments, the SPARCS partners, and the stakeholders, provided an invaluable opportunity to better understand the city, express its vision and select several projects for the future.

10.1 Summary of achievements

Within the framework of the current deliverable, considerable effort has been put towards the goal of sustainability within the city of Kladno. The expression of the city's vision has been among the main achievements since it will serve as a strategic framework for success. Together with the key mechanism, the SECAP, it serves as a strategic framework for any project´s design.

Of course, the participation of key partners is important. The city experts, different companies, and stakeholders outside of the city administration and citizens can together create a functioning ecosystem which might generate projects with value added.

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

- Investment done or just before starting the realization– the winter stadium energy management; NextBike sharing system.
- The SECAP, SUMP, vision report – preparation, communication and implementation.
- Thermal mapping of the city – overall heating map of the city; also, particular buildings.
- Stakeholder analysis – mostly focused on the PED realization.
- Pre-feasibility study for PED Sletiště area.
- Projects preparation – EPC 23 buildings (project application just before submission); retrofit of the public lightning (application submitted); public clean mobility (application in the design phase)
- Technical studies are run – relevancy of the photovoltaic systems in the system incl. new business model for the city company; e-mobility feasibility study regarding the support of the individual e-mobility.

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- Successful in other international calls – EUCF, Horizon 2020 (project GlocalFlex).
- Other project applications in international calls are awaiting (e.g. Interreg CE).
- Systematic tools – energy management within the city administration and infrastructure incl. intelligent software and ISO 50001:2019 implementation (all under continuous elaboration); smart city system Invipo.
- Smart city training in the SPARCS and the Czech educational programme.
- Pro-active role in the international, national, regional and local initiatives, and platforms.

10.2 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 2030 with outlook in 2050 as the SECAP is stating.

10.3 Other conclusions and lessons learnt

Now that several projects are running, the implementation of the key strategies as well, the implementation plan may serve as a proper medium for a vehicle for fundamental development ideas and at the same time as a starting point for the realization of the strategic projects.

However, there are several challenges that need to be tackled during future work:

- it is the "people"; they are the core of the execution of the ideas, strategies, and projects; the process of creating a city diagnosis and a city profile required active involvement of different departments within the city and stakeholders out of the city; execution of the ideas and also a collection of the data, e.g. for this report, was challenging as the data used in the report were updated throughout its preparation and new strategies, figures, indicators, etc. have been developed in different contexts, with the different motivation of the stakeholders and also sometimes problematic availability of the information.
- the replication; project proposals and relevant solutions need to be tested as far as their relevancy for the replication in Kladno; local conditions sometimes do not allow replication of the solutions designed somewhere else (even from Lighthouse cities to the Fellow cities); also the national framework (legislation mostly) or regional context (economical and societal dependencies), etc.
- the funds´ availability; the strategy is first, data and decision making come very soon, but mostly it is the funding which decides about the design and realization of the solutions planned in the implementation plan or the SECAP; the city needs to check continuously the variety of possible options from where and how to finance the projects.

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11. ACRONYMS AND TERMS

BEV	Battery Electric Vehicle
B+R	Bike and Ride
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CVUT	České vysoké učení technické (Czech Technical University)
ČSAD	Česká státní automobilová doprava (Czech State Automobile Transport)
EIA	Environmental Impact Assessment
EPC	Energy Performance Contracting
ESCI	Indicators of the Emerging and Sustainable Cities Initiative
FHG	Fraunhofer Morgenstadt
GDP	Gross Domestic Product
GPS	Global Positioning System
HEV	Hybrid Electric Vehicle
IoT	Internet of Things
ISO	International Organization for Standardization
kWh	kilowatt hour
K+R	Kiss and Ride
MPO	Ministry of Industry and Trade
MWh	Megawatt hour
NBIOT	Narrow Band Internet of Things
OECD	Organization for Economic Co-operation and Development
PED	Positive Energy District
PHEV	Plug-in Hybrid Electric Vehicle
P+R	Park and Ride
ROPID	Regionální organizátor Pražské integrované dopravy (Regional organiser of Prague Integrated Transport)
ŘSD	Ředitelství silnic a dálnic (Directorate of Roads and Motorways)
SDS	Sustainable Development Strategy
SECAP	Sustainable Energy and Climate Action Plan
SPARCS	Sustainable energy Positive & zero cARbon CommunitieS
SUMP	Sustainable Urban Mobility Plan
UCEEB	Univerzitní centrum energeticky efektivních budov (University centre for energy efficient buildings)
UNESCO	United Nations Educational, Scientific and Cultural Organisation

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12. LIST OF FIGURES

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13. LIST OF TABLES

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