D5.11 Project Development Report Kladno

30/09/2024

Michal Koníček[1], David Škorňa[1], Michal Kuzmič[2]

[1] Statutory City of Kladno, nám. Starosty Pavla 44, Kladno 272 01
[2] Czech Technical University, University Centre for Energy Efficient Buildings, Třinecká 1024, Buštěhrad 273 43

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

Deliverable administration

No & name	**D5.11 Project Development Report Kladno**				
Status	Released	**Due**	M60	**Date**	2024-09-30
Author(s)	City of Kladno, UCEEB				
Description of the related task and the deliverable. Extract from DoA	**T5.4 Project Development in Fellow City (BABLE) M1 – M60** The goal of this task is to support the Fellow Cities to bridge the gap between writing the Implementation Plan and starting with implementations. 2 out of the 10 projects from the Implementation Plan will be taken through a structured project development process consisting of initial scoping, market consultation, detailed planning, and securing investment, all of which will result in unlocking investments into positive energy blocks on a local level. This report gives detailed plans for up to 2 projects from the Implementation Plan including: list of functionalities suited to local needs, technologies to be implemented, costs of planned implementation measures, suitable funding and business models, key timescales, lead partners, risks & risk mitigation measures, Local governance & coordination structure.				
Participants	**BABLE**, VTT, Fraunhofer				
Comments					

V	Date	Authors	Description
0	27/06/2024	Kladno	Draft version sent for review to BABLE
1	05/07/2024	BABLE	Feedback from BABLE
2	23/07/2024	Kladno	Draft version n. 2 sent for review to WP leader
3	05/08/2024	WP leader	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
4	30/09/2024	VTT	Coordinator submits the deliverable to the EC

Dissemination level

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

About SPARCS

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

Partners

SPARCS

Table of Contents

List of figures:

SPARCS

List of tables:

EXECUTIVE SUMMARY

By joining the SPARCS project, the Statutory City of Kladno has transitioned from a situation where energy issues and the transition to carbon neutrality were not on the agenda for the city to a situation where the city is able to transfer its newly gained experience to other cities at national and international level in this regard. In some areas Kladno is now considered a pioneer within the Czech Republic, thanks to its involvement in this international initiative. A key step in achieving carbon neutrality was the development of the Sustainable Energy and Climate Action Plan (SECAP, 2021) and its subsequent implementation. The document provided the city with a solid framework that set a standard for others to follow. The project also initiated a snowball effect, leading to additional sub-projects and the essential funding needed to transform Kladno from a post-industrial city.

The energy issue has been and is being addressed in several ways. These included reviewing the condition of city-owned buildings, acquiring of building energy performance certificates of the building. Among others, the project included the implementation of tangible outputs in the form of pilot projects, which are detailed in this document.

The pilot projects are as follows:

1) Self-sufficiency of the public buildings – less consumption, higher production, 1a) Positive energy district Sletiště. The topic of energy also has overlap into urban mobility and is reflected in the pilot project on energy.

2) E-Mobility Public/Private & Charging System.

Throughout the beginning of the SPARCS project Kladno acquired important strategic documents, besides the previously mentioned SECAP the city also has a Sustainable Urban Mobility Plan (SUMP), eMobility feasibility study, Positive Energy District (PED) feasibility study etc. Together with other project deliverables such as City Vision and Roadmap the city is well prepared for the future. Now it is the time to take these plans from paper to reality.

1. INTRODUCTION

1.1 Purpose and target group

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

The objectives of this Project Development Report include:

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

1.2 Relations to other activities

Kladno set up an Ecosystem Energy Platform consisting of approximately 40 partners from local, regional and national levels. Regular 1- to 1-day meetings and working groups had been held. A stakeholder analysis was performed.

The City Lab process took place in Kladno in a virtual format due to the restrictions of COVID-19. An online panel with around 30 participants was held as an introductory meeting before an on-site week. Around 30 experts were interviewed in March 2021, from different fields including (energy, mobility, environment, administration, etc.). These interviews resulted in a total of 20 project ideas and outlines in the areas of ICT, waste management, energy, mobility, and more. Later on, around 10 outlines were added. An internal project filtering took place through discussions and using the ranking tool developed for this purpose, resulting in the selection of eight projects to be discussed during the innovation workshop as the second part of the on-site assessment phase organised by Fraunhofer.

The innovation workshop was also held virtually again with more than 30 participants from public administration, universities, private sector (heating power plant, distributor, mobility operator, etc.). During the workshop, the previously selected project ideas were discussed and elaborated on different aspects such as feasibility, stakeholder participation, and political preconditions. Followed by another round of internal discussions within the city team and partners, the city chose two projects to further detail and develop within the next phases of WP5. As an integral part of the onsite tour Kladno organised a PED round table and Business and Investment forum. Several experts, investors, and the banking sector attended the meeting and are in contact with the city regarding the potential for business development of some projects.
The chosen projects were (1) E-mobility public/private and charging system and (2) Renewables (Photovoltaic Panels) on public buildings.

1.3 Local Governance & Coordination Structure

The responsible unit within the city structure is the Grants and Project Preparation Department (GPPD). There is one position dedicated specifically to this project, the coordinator. Since the project aims at various themes cooperation with other departments is necessary. Given the topic the coordinator reaches out the Transport Dep., Environment Dep., but also the city-owned ICT company for technical support. There are also other roles within the GPPD, some members of the unit focus solely on the administrative part, collecting invoices, overseeing the budget for the use of subsidies, archive documents, etc.

Some GPPD actions must be approved by the City Council, usually those that involve finances. The Head of the Department consults with the Deputy Mayor of Kladno on GPPD proposals prior to submitting material to the City Council, primarily to fine-tune the proposal so that it is more likely to be approved and consistent with City direction. If the proposal is approved, the formal confirmation is the subsequent signature of the mayor of the city.

Another part of the coordination structure is the cooperation with one of the SPARCS partners, namely local university CVUT namely UCEEB (University Centre for Energy Efficient Buildings), which is located nearby and helps the GPPD on multiple levels, e.g. strategic documents such as PED feasibility study or organising thematic workshops. Therefore, regular joint meetings are therefore a necessity.

1.4 Replication Process

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

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

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

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

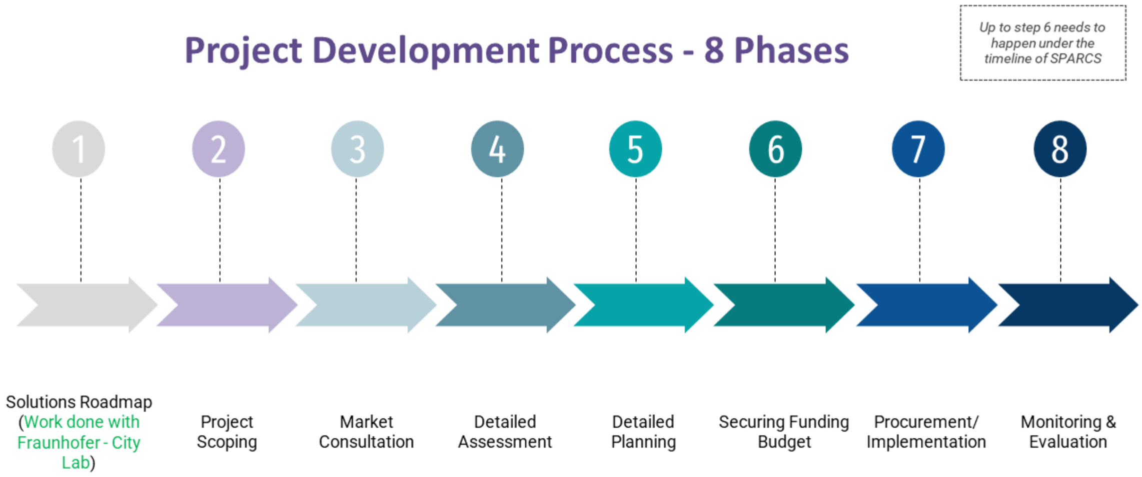


Figure 1: Project Development Process

Following this process (see Figure 1), each city evaluates the feasibility of replicating the chosen smart city projects in their local context, thereby increasing the chances of its successful implementation and sustainability.

It's important to note that up to step 6 needs to be completed within the SPARCS timeline.

For the FC of Kladno, the two projects to develop are (1) E-mobility public/private and charging system and (2) Renewables (Photovoltaic Panels) on public buildings.

2. E-MOBILITY public/private & charging system

2.1 Project Scope

2.1.1 Project Scope Definition

One of the biggest problems of the city of Kladno (also based on a questionnaire survey among local residents for the document Sustainable Development Strategy of the City of Kladno until 2030 (Miškovský, 2021, p. 110)) is the traffic load of the city. This is logically linked to noise pollution and air pollution, as well as parking issues. This is caused by a combination of several elements, including commuting to and from Kladno, the age of some housing areas that were not built for such a large number of cars, insufficient infrastructure for other alternative modes of transport, the absence of important transport structures, the location of the city between two motorways, etc. Because of these and other reasons, Kladno commissioned a Sustainable Urban Mobility Plan (SUMP) in 2023 (CityTraffic, 2023), which provided the city with a more detailed view of the issue, concrete actions and a plan for the way forward, thus partly avoiding further speculation and delays. This allows easier linking with other strategic documents and strategic planning of the city.

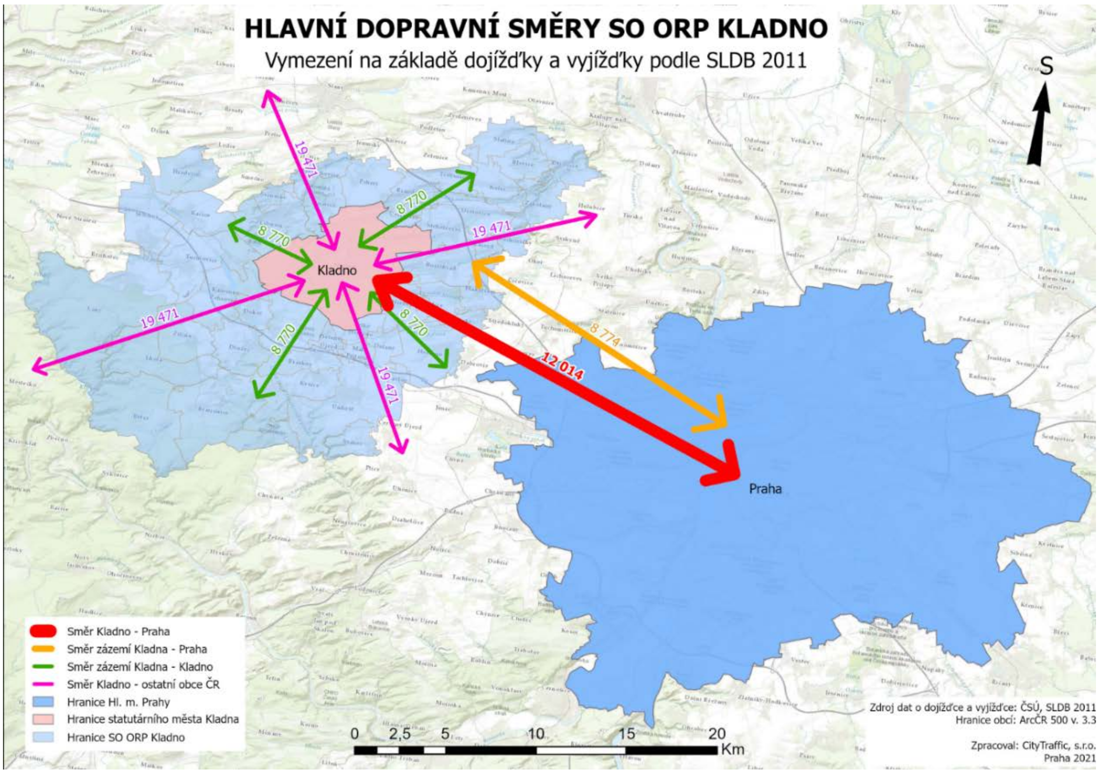


Figure 2: Main traffic directions of the Kladno municipality

The red arrow displays the number of people (12 014) commuting to Prague from Kladno according to the 2011 census, the orange arrow displays the number of people (8 774) commuting to Prague from other parts of the administrative district of the municipality).

The city of Kladno has a strong link to the capital city of Prague. The proximity to Prague causes high population movement between the two cities (see Figure 2), primarily related to the supply of job opportunities in Prague and the lower price of real estate in Kladno compared to Prague. In general, this is an issue for all larger settlements, or catchment areas, where people commute to work to a larger settlement and live in smaller and more distant ones. However, this fact creates high demand for road infrastructure capacity, parking and public transport. Commuting between them is up to 12 000 inhabitants (approx. 18 % of Kladno's population). In terms of public transport, people use bus transport more often than train transport. The location of stations and stops within the city is a crucial limit for the use of rail transport. Only one-fifth of the city's population is within walking distance of a train station. For about 55,000 inhabitants the train is inaccessible on foot or less attractive, therefore a significant part of the population travels to the surroundings of Kladno or Prague by bus connections, which serve the territory of the city evenly. However, individual car transport remains the fastest connection and therefore Kladno suffers from a large number of cars -> heavy traffic -> parking problems -> unattractive public spaces.

The shift to more sustainable modes of transport should help eliminate the negative elements mentioned above, and the city should benefit from these changes for years to come. In addition to the long-planned transport infrastructure works, such as the double-tracking of the railway to Prague to ensure regular and more frequent connections, the construction of infrastructure for electric vehicles (EVs) and cyclists should also help the transition. The transition to electromobility should be done in line with another strategic document and that is the E-Mobility Study (Feasibility Study of Individual Electromobility Connection Points (SmartPlan, 2022)) and other alternative sources which are following the SECAP, which aims to reduce emissions so that the city becomes carbon neutral by 2050.

As far as cycling is concerned, there is a huge potential in Kladno, as most of the city is located on a relatively flat area. Providing quality and safe cycle paths with connections to other transport links can reduce the need for car transport in the city and for transport to nearby Prague.

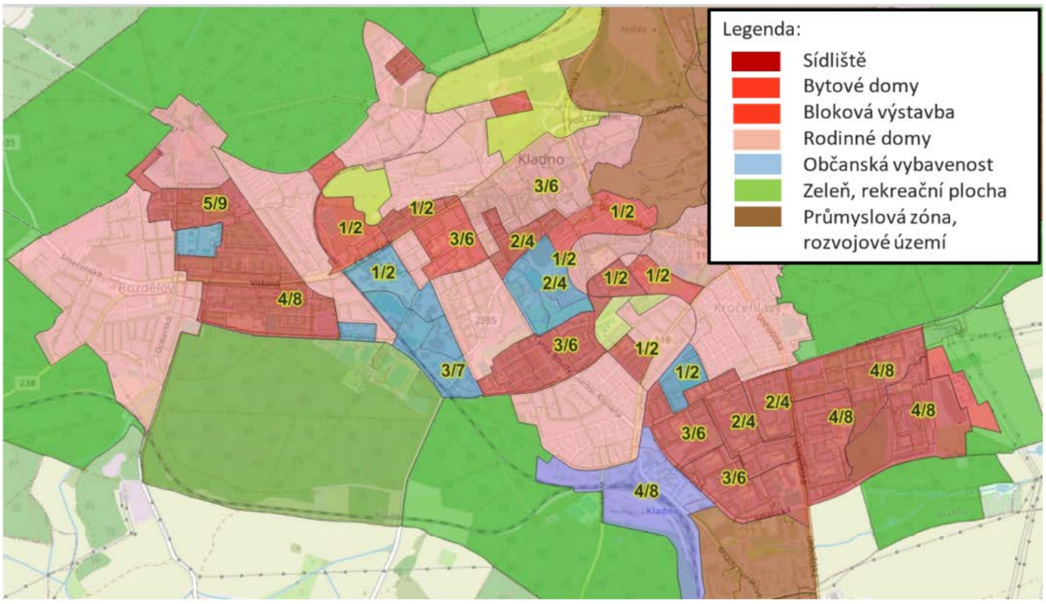


Figure 3: Proposal of charging stations/points for the first and second phase

The red colour shows the areas of housing estates and apartment buildings; the light shade of red shows the family housing areas; blue shows the civic amenities, the brown shows the industrial zone and development areas, the green shows the greenery and recreation area.

The numbers in yellow are not fractions but two numbers. First number stands for number of charging stations and the second one for the number of charging points.

2.1.2 Geographical Location

Kladno is located about 25 km northwest of Prague. As a result of the proximity of the capital city of Prague in the so-called metropolitan area, Kladno is strongly influenced by the transport, population development, regional development, etc. As of 1 January 2024, the population of Kladno was 69 078 inhabitants (ČSÚ, 2024). It is the largest city in the central Bohemian Region in terms of population and, together with the adjacent suburban areas, has more than 110 000 inhabitants. Kladno is divided into 7 subareas, of these the Kročehlavy district has the highest population density, where there is a large housing estate. There are also parts of Kladno like Dubí where family houses predominate.

The proposed solution for the placement of charging stations is based on the previous data and map analysis are detailed in the E-Mobility study (SmartPlan, 2022), see Figure 3. It is also based on the recommendation of the European Commission to cities on efforts to minimize the costs of public budgets in the case of direct involvement of the municipality in the process building (i.e. building on city land, near the substation, with sufficient demand, with a low load on the distribution network).

The distribution of charging stations - in areas with single-family houses we can assume that charging will be from 'own sockets'. Conversely, in residential developments/estates there will be a high demand for public charging infrastructure. In 2030, a predominance of slow AC charging (90%, family houses) over high-speed DC charging (10%, e.g., shopping centres is expected). The city of Kladno has very well-defined boundaries of Basic Settlement Units (BSU) since it very closely describes the imaginary boundaries of different types of territory or development. The city has at its disposal a more detailed description and characteristics of the area to each BSU - this will be one of the basic input documents for the definition of the proposed sites for the charging stations in the design section. Specific locations for more charging stations are related to the construction of new parking lots. The rest of the distribution network is also related to frequently visited places within the city, such as shopping centres, city offices, hospital and other points of interest.

As already mentioned, the town is located in a relatively flat area with a few exceptions. There is an elevation change of tens of metres in the case of inner-city traffic. However, in the context of individual electromobility, this is a relatively insignificant issue owing to the expected low number of journeys within one day (in contrast to public transport, where a high frequency of journeys and a large number of trips over a small area are expected).

On the way to Prague, the absolute elevation is approximately 200 metres lower. From the point of view of recuperation, the driver will not gain much when driving the electric car from Kladno towards Prague to work, and the vehicle will be discharged more on the way from Prague to Kladno. However, the expected impact on drivers' decisions on where to charge is very small.

2.1.3 Preliminary Technology Assessment

It can be suggested that fast DC stations will naturally arise as part of commercial services (shopping centres, gas stations) or as a follow-up to the national commitment of the Czech Republic in the construction of the TEN-T transport network (urgent charging at important transport nodes at intervals of 60 km). Slow AC charging is to serve residents for charging vehicles overnight or employees during the day (see Figure 4). This approach to building the charging infrastructure takes into account the real capabilities of the distribution network and at the same time saves battery life. This proportional distribution of AC and DC stations is a worldwide trend (Amsterdam, Oslo, Berlin and others) (SmartPlan, 2022 p. 120). Recommendations for station locations were consulted with the distribution company, so that the technical possibilities of the network and the connectivity of individual stations are fully taken into account. Some sites for example recommend 11 kW charging points to take advantage of the existing low voltage lines. It is advisable to prepare the cabling for a larger number of charging points in the first phase to reduce the cost of expanding the charging infrastructure at a later date. Particularly in the PED area, it can be expected that the growth of battery-electric vehicles will continue beyond 2030.

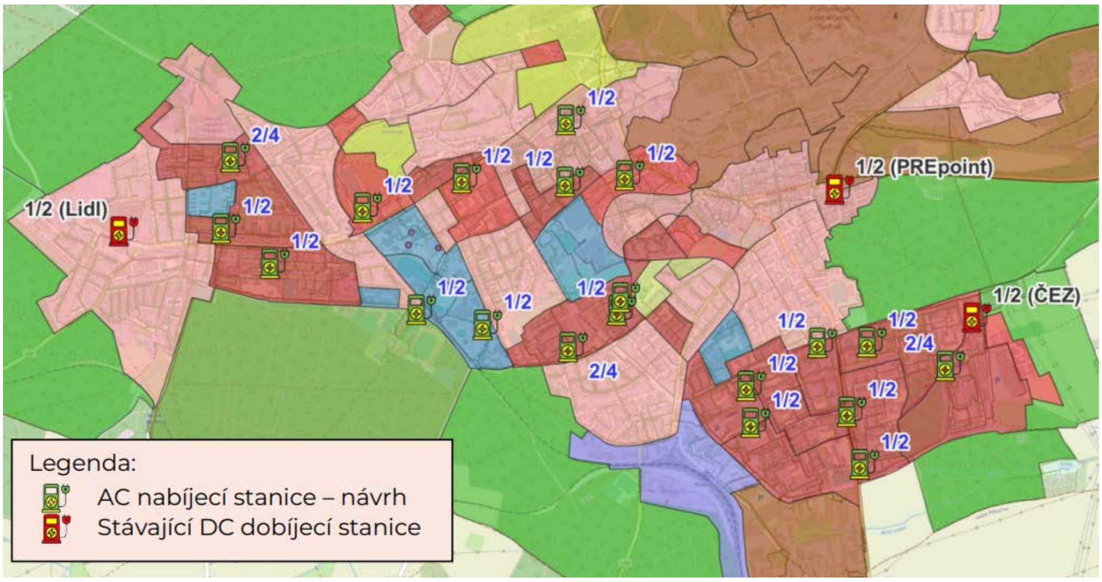


Figure 4: Charging stations selected for the first phase

Green = AC, Red = DC.

2.1.4 Preliminary Assessment of Business Models

Cities aim to identify financing methods that avoid prioritising large-business goals over social goals, as the former approach ultimately leads to inequality (Grossi & Pianezzi, 2017). Therefore, it is critical to find a balance between generating economic benefits and addressing social needs when developing sustainable/smart city solutions. By establishing effective business models, cities can overcome these obstacles and ensure the financial viability and long-term success of their initiatives.

City council managers face several challenges during the implementation of smart city projects:

1) Unclear local system: there's a need for a transparent and well-defined local framework that allows for improved planning and mapping of various activities throughout the project's stages.

2) Non-financial impacts: emphasis on non-financial aspects requires city council managers to weigh the costs against the benefits of smart services meticulously which ensures that the broader implications of such projects are considered.

3) Stakeholder identification: understanding and aligning with key partners, customers, and beneficiaries and recognizing their unique views on the project's risks and rewards could be complex (Krista Timeus, Jordi Vinaixa & Francesc Pardo-Bosch 2020).

When it comes to Assessment and Business Models the role of the city is primarily communication with stakeholders and managing negotiations with potential operators of these facilities. Kladno's main role in charging infrastructure should not be to build it alone (however, even filling stations were not built by the city). Based on the E-Mobility study the city has a clear idea of what the future demand for electromobility will look like, where the highest concentration of public charging needs will be concentrated, and what number of connection points will meet this demand. In the most optimistic scenario, the market will take care of building the infrastructure. Some locations, however, may not be prospective or sufficient from their point of view. Kladno can contribute to accelerating the construction of infrastructure by granting concessions. In this case, the city bears the costs of building the technical preparation for the station (i.e. construction costs from the substation to the cables from the ground of the future station), and the concessionaire bears the costs associated with the acquisition of the station itself and its operation.

According to the European Investment Bank (SmartPlan, 2022, p. 225), we can distinguish between the following suitable business models for the development of charging infrastructure in which a public entity (the city) plays a role:

1. The Public sector as the main promoter

The main driver of development is usually a municipality or other public authority. They also take on all the financial burden. Thus, in this case, the investor and operator are the city for the entire value chain, from building the connection to the public grid to operating the charging stations. The main advantages of the model include maintaining full control over the entire value chain, including for example pricing for charging in the initial phase.

2. Joint Venture (JV) model

A joint venture (JV) is a form of cooperation between two or more parties to implement a joint project within a business. Typical features are the effort to jointly achieve a defined goal, to exploit mutual synergies in a joint project, to achieve and share profits or losses, etc. Together with a partner, the city will create a new venture, the so-called JV, through which they will control the charging infrastructure.

3. The Concession Model

In this model, the city acts as the contracting authority of the concession pursuant to Act No. 134/2016 Coll. on Public Procurement, Part Eight, which prepares the concession project from which the procurement (concession) documentation is derived. The concession project (outline business case) is a technical, economic and legal study of the envisaged investment for the contracting authority. On the basis of these documents, the tender (concession) documentation is prepared and subsequently the concessionaire is selected. The concessionaire assumes the costs for the installation and subsequent operation of the stations (the location and connection are usually organised by the public entity). The conditions set for implementation and operation are defined in the concession project (or tender documentation).

In this case, the public sector retains a certain degree of control over the definition of the charging infrastructure objectives, installation and operation, allowing the development of stations even in unpromising locations.

4. A model based on station utilisation

This model is very similar to the concession model. The public sector retains a degree of control, and the risks associated with installation and operation are transferred to the private sector.

5. the Licensing Model

This model allows for the granting of permits by the authorities to private entities, which, subject to compliance with specific requirements, can obtain a permit (licence) to build, manage and operate charging stations in public space for the duration of the licence. The stations are usually built on municipal land. This model is widespread in smaller US cities. The private entity completely controls the infrastructure and also assumes most of the risks, from installation to operation, but also receives revenue from users.

2.1.5 Supporting Factors & Barriers

EVs do not burn fossil fuels, the entire energy chain is more efficient and makes it easier to integrate renewable energy sources. The development of electromobility thus leads to a reduction in dependence on fossil fuels, a significant part of which comes from politically unstable regions. Increasing the share of EVs will improve the city's environment by reducing pollutant emissions and noise pollution. These factors are thus in line with the city's strategic planning and its commitments (carbon neutrality by 2050); therefore, it can be said that the city's leadership is also in favour of building EV infrastructure. The development of electromobility presents an opportunity to implement new business models. Users of EVs will gain access to new services such as free charging at work, in shopping centres, etc., and can also receive a profit for providing a vehicle battery to smooth out fluctuations and sell electricity back to the grid. Similarly, property owners can join the scheme.

On the negative side of implementing this issue, the need to charge EVs at night does not match the capacity of renewable energy sources, especially photovoltaic power plants. This places great demands on the grid, with the necessary power has to be supplied by e.g. wind or hydro power plants from further afield or back-up battery storage.

Uncertain customer behaviour is closely related to another factor, namely the uncertain development of electricity and fuel prices.

Government incentives are an important factor for changing the current trend and accelerating the development of electromobility. The lack of state support may endanger the fulfilment of the EU's predictions and requirements. Poor or insufficiently formulated legislation may also pose difficulties in building adequate infrastructure (especially the lack of so-called "semi-public" charging infrastructure).

2.2 Market Consultation

2.2.1 Solution Requirements/Functions

The existing distribution network can be used to build the charging infrastructure, either directly or after appropriate modifications, so that its capacity is not exceeded, and its stability can be guaranteed under the increased load associated with the charging of EVs. As previously mentioned, some sites are already recommended to use the 11kW chargers due to already built infrastructure.

However, in the case of charging stations with an output of more than 22 kW per charging point and covered HUBs consisting of multiple stations (albeit with lower output), this is already a construction that requires a building and planning permit. In some cases, planning consent may be granted instead of planning permission. This can be issued if the construction is in a built-up area or in a buildable area, the conditions in the area do not change significantly and the project does not require new plans for public transport and technical infrastructure. Conversely, planning consent cannot be issued in the case of a construction requiring a binding opinion on an environmental impact assessment (EIA).

In addition, the distance from the distribution transformer station (DTS) is taken into account when selecting the sites for the location of the charging infrastructure. Where possible, a location within the immediate vicinity of the DTS is chosen to make it as easy and inexpensive as possible to make a new connection to the charging pole if necessary, or to place the wallbox directly on the substation. At the same time, land owned by the statutory city of Kladno was selected.

However, prior to the start of construction, consultation with ČEZ (CEZ Group, see below) is required to determine the feasibility from a technical point of view. The construction of superchargers containing multiple charging points with a capacity of 150 kW would in many cases require a major reconstruction of the distribution transformer station or the construction of a new one, as the existing one would no longer have spare capacity at the current load. An economic analysis taking into account the updated supply of other utilities will also be important.

The cost of an ultra-fast charging station with a charging capacity of 150 kW is about six times higher than the cost of a fast-charging station with a capacity of around 50 kW.

2.2.2 Market Consultation

Publicly accessible charging stations are often built by private entities such as an additional service for customers. Therefore, a questionnaire survey was conducted with the stakeholders concerned to determine their future intentions in terms of electrification fleets and building the corresponding charging infrastructure. Subjects were asked about the numbers of company and depot cars, their types (including the distinction between electric/plug-in hybrids), intentions to electrify the fleet (including reasons for not doing so), the number of parking spaces (including the possibility to reserve them for charging), the current state of charging infrastructure including planned future construction. At the same time, other relevant stakeholders (more than 40) were contacted: schools, social services, municipal services and organisations, rail/bus stations, hospitals and major employers. Large companies have already integrated emission-free vehicles and are preparing for their expansion, including building their own non-public charging stations. Municipal services/organisations tend to be more reticent.

Some of the contacted larger companies in the city:

- Česká spořitelna
- Energie – stavební a báňská a.s.
- Keinhin Thermal Technology Czech s.r.o.
- Komerční banka
- La Lorraine a.s.
- Lego

Within the significant stakeholders it is necessary to highlight the distribution network - ČEZ Distribuce. Furthermore, it is necessary to take into account the list of the most important charging station operators on the market. These are the following major operators:

- ČEZ, a.s.,
- Pražská energetika, a.s.,
- E.ON Energie, a.s.,
- ŠKO-ENERGO, s.r.o.,
- ELEKTRO-PROJEKCE, s.r.o.

Users of the charging infrastructure should make sure that they only pay for the electricity actually consumed, i.e. that the electricity consumed during charging is accurately metered. All points of consumption of the electricity network in all Member States must be equipped with a meter that is certified by a national authority. This certification ensures highly accurate metering, adequate billing and also safe operation. Each charging station must be equipped with this certified metre.

2.2.3 Proposed Technologies

Fast charging stations are to be located around major traffic routes. To some extent, the larger shops that have or will have a charging station as part of their car park are also helping to build charging infrastructure, see Figure 5.

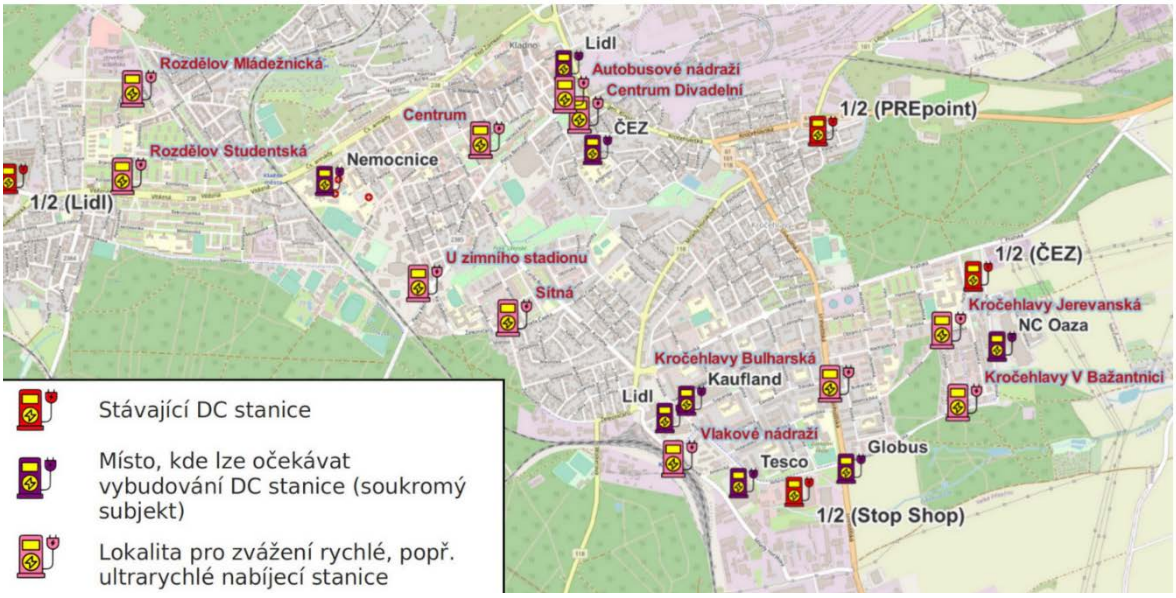


Figure 5: Existing and potential fast charging stations

Red colour = existing DC stations, purple = place where a DC station can be expected to be built, pink = location for consideration of a fast or ultra-fast charging station.

The design of the infrastructure for charging residents' vehicles was based on an estimate of demand and the requirement for a reasonable walking distance, which in this case should not exceed 500 m. Therefore, the stations are located to cover the different areas where resident charging is needed. Alternatively, or additionally, in areas of high population concentration, a system of multiple AC stations in one location may be considered. A system of at least two stations that are not connected to the network separately but share a single connection is called a **charging plaza** (see Figure 6).

Figure 6: Example of a charging column for two BEVs with a power output of 22 kW

In the case of the connection of several charging stations, the most suitable solution is the Master-Slave system, where one charging station (master) is connected to the network and to the back-office of the charging infrastructure operator. The master station determines the distribution of the available power among the stations, and therefore the charging rate they provide, and communicates with the back-office. From an economic point of view, a charging plaza should in principle be more advantageous than a simple cluster of individual charging stations because only one of them (the master) is connected to the grid and is therefore a single point of consumption.

As with public charging stations, the charging plaza should be linked to a reservation system. Users should be able to use a mobile application to manage reservations, make payments, invoicing, get an overview of the utilisation of the plaza, perform authentication, etc.

2.3 Detailed Assessment

2.3.1 Legal/Regulatory Framework

Directive 2009/33/EC and the follow-up Directive 2019/1161 of 2019 on the promotion of clean and energy-efficient road vehicles have provided an important impetus for the development of clean mobility. An important objective mentioned was for contracting authorities to purchase so-called "clean vehicles". For passenger cars and light commercial vehicles in the Czech Republic, the share of EVs was set at 29.7% of the total number of vehicles by 2025.

The concept of a public charging station is legislatively anchored in Section 2(n) of the “Fuel Act”, which divides stations into public and non-public (home charging). This definition fundamentally affects the obligations of the operator of these stations. Unfortunately, unlike foreign practice, Czech law does not provide for so-called "semi-public" stations, and therefore, if a station is even partially accessible to the public (for a limited period of time or to a limited circle of persons, e.g. customers), it is a public station and access to it must be non-discriminatory.

The operation of a public charging station is a trade that requires a trade licence (free trade) and is subject to other obligations. The law further distinguishes between the basic types of stations: normal (up to 22 kW) and high-performance (above 22 kW).

The proposed location of charging stations does not include development sites where larger new developments are planned. The city assumes that in accordance with European legislation, charging infrastructure will be a necessary part of the project in these cases. The study for example takes into account directive 2018/844 of the European Parliament and of the Council of 30 May 2018 which imposes several requirements for the installation of charging stations and cabling in parking spaces located in buildings or physically adjacent parking lots, such as ensuring that at least 1 charging station is installed and installation of conduit for at least 1 of the 5 parking spaces when it comes to new buildings.

National level

<u>Regulatory Framework in the local level for charging infrastructure:</u>

In Czech legislation, the requirements of the cited directive are included in Decree No. 266/2021 Coll., amending Decree No. 268/2009 Coll. on technical requirements for buildings, as amended regulations. The draft amendment to the Directive of the European

Parliament and of the Council on the energy performance of buildings further tightens these conditions.

Before the construction of the charging station, it is always necessary to mark out the position of the existing networks in the individual locations of interest and to coordinate with them the position and possibility of installing new power cables according to the provisions of ČSN (Trademark for Czech technical standards) 73 6005 (Spatial arrangement of technical equipment lines). When routing the supply cable, it is necessary to avoid collisions with the root system of existing mature greenery and to comply with the basic environmental requirements of ČSN 18 920, according to which the distance of the excavation from the tree trunk is 2.5 m. The protection zones for electricity system equipment are defined in Section 46 of the Energy Act No. 458/2000 Coll.

European level

Regulatory Framework in the EU for charging infrastructure:

European Green Deal: The main objective of the European Green Deal is climate neutrality by 2050 which consequently influences the European EV market. To accomplish this goal, a variety of policies have been suggested that promote the use of EVs and the development of charging stations throughout the EU. The EU aims to reduce CO2 emissions by 55% in 2030 and by 100% in 2035 from new cars. Furthermore, the Commission has suggested stricter emissions regulations for new vehicles and vans, as well as initiatives to encourage the use of zero-emission vehicles (EC, 2021).

EU ban on the sale of new petrol and diesel cars from 2035: The EU regulation has not been officially implemented as it requires the approval of individual EU member states. The voting scheduled for 7 March 2023 was deferred. It proposes by 2023 that all new vehicles that come to the market cannot produce any CO2, therefore the EU will ban the sale of new cars with combustion engines. The new legislation calls for a goal reduction in CO2 emissions of 55% for new cars and 50% for new vans by 2030 and additionally for a 100% CO2 emission reduction by 2035. The purpose of this regulation is to ensure that the transportation industry will achieve carbon neutrality by 2050 and is thus boosting the use of EVs and the implementation of charging infrastructure (Euronews, 2022).

Renewable Energy Directive (RED): Categorised as a Directive, which is legally binding since June 2021. The Directive sets a legally binding target for each EU member state to achieve a minimum share of renewable energy in final energy consumption. In 2020, member states were required to achieve 20%, and a new binding target of at least 32% was set for 2030 (RED II) with a clause for a possible upward correction by 2023. Based on each country's starting point and potential for developing renewable energy sources, a minimum share is determined. As a result, the 2021 study 'EU's global leadership in renewables' reveals that the EU has established a leading position for the implementation of renewable technologies that will increase in the next years, creating the perfect market for EV manufacturers, energy providers and also for charging infrastructure providers (EC, 2021).

Alternative Fuel Infrastructure Directive (AFID): The directive established in 2014, aims to reduce the reliance of the transportation sector on fossil fuels, improve air quality, and contribute to the EU's climate and energy targets. According to the AFID, infrastructure for alternative fuels like electricity, hydrogen, compressed natural gas (CNG), and liquefied natural gas (LNG) must meet certain minimum standards. The member states must ensure that each type of alternative fuel has a minimum number of publicly accessible refuelling stations by given deadlines. By 2025, for instance, member states must guarantee that there are regular EV charging stations along main highways (EUR-Lex).

Clean Vehicles Directive (CVD): Directive established in 2019, aims to promote the deployment of clean and energy-efficient vehicles in the EU. According to the directive, member states must guarantee that by 2030, at least 38.5% of all new public procurement for motor vehicles will be for clean, energy-efficient vehicles. The directive also contains provisions to encourage the implementation of clean vehicle refuelling and charging infrastructure, providing a way for drivers to operate these vehicles throughout the EU. The directive also urges on member states to create programs, such as tax benefits or other financial incentives, to encourage the use of clean vehicles in the private sector (EC, 2021).

The EU´s Transport White Paper: Policy document published by the European Commission in 2011. The White Paper sets out a plan for developing a sustainable and effective transportation system as well as the EU's vision for the future of transportation. The Transport White Paper outlines several goals and policy recommendations for the EU's transportation industry, including a minimum 60% decrease in transport-related greenhouse gas emissions by 2050, a move toward vehicles with low or no emissions like EVs and a decrease in the number of vehicles using conventional fuel on EU roads by 2050 (EC, 2021).

2.3.2 Technical Assessment

As previously stated, the GPPD will recommend using the concession model to the city council. Slow AC charging will mainly serve to the residents for charging vehicles overnight probably in the charging plaza format and the DC ones will be build close to the most important and used transport nods. The suggested locations for charging stations were consulted with the distribution company, therefore following the E-Mobility study is advisable since these locations have been analysed from several aspects, mainly in terms of load on the power grid. The study foresees an increase in the number of EVs in the Czech Republic to 220.000-500.000, having analysed different scenarios (low, medium, high increase), but of course the question is what the reality will be, e.g. if some crisis happens again.

2.3.3 Cost Assessment

The total cost of building one charging station can be divided into the following parts and the construction of 58 AC stations would require a financial outlay of the activities described in Table 1:

Table 1: Costs

Activity	Description	Cost
1) Construction activities	the cost of construction from the substation to the point of connection	3.5 Mill. CZK for construction activities
2) Investment activities	the cost of acquiring the charging station itself	23.3 Mill. CZK for capital costs
3) Fixed operating costs and variable operating costs	the cost of ensuring the operation of the stations,	19 Mill. CZK / year for variable and fixed costs

	including maintenance and customer service the cost of connecting the station according to the expected electricity consumption	

2.3.4 Business Model Identification & Financial Analysis

The fundamental question for the responsible entity for the development of charging infrastructure will be who will build, own, and operate publicly accessible charging points. This may be a public entity, a private entity, or a combination of both. The suitability of the model is influenced by various factors - most importantly, the future expected costs of installation and operation, and expected profits, the degree of control by the public entity and the (dis)interest of the private entity. All these aspects evolve over time (and market development), and therefore the municipality should periodically reassess.

The GPPD currently works with the option of following the German recommendations and procedure for individual municipalities in implementing a charging infrastructure strategy:

1. Creation of a charging concept and strategy called Masterplan

a) Defining charging demand with regard to development typology, traffic flows, socio-economic factors

b) Design of charging points - typology, performance

2. Coordination of communication and cooperation between local actors (especially the municipality - distribution network, businesses, points of public interest, residents)

a) Promotion of "semi-public" charging infrastructure - seeking cooperation with business to make their private charging infrastructure available to the general public, for example public (use of company car parks overnight)

b) Ensuring that staff capacity is fully dedicated to the issue (communication with stakeholders + implementation)

3. Coordination and cooperation at regional level

4. Implementation of the Masterplan - cooperation and agreement with important stakeholders

The GPPD also developed a Business Model Canvas, for the SPARCS project where the whole concept is more described and more understandable, see appendix 1. It is already counting with option of using the concession model and focuses on the essential points, so the vision is more tangible.

2.3.5 Risk Assessment

There are many variables that imply a certain level of risk to the good functioning of a set mechanism. These risks can be identified, but their degree is likely to vary and can only be better measured at the implementation stage of the overall project. These variables include e.g. uncertain behaviour of potential customers, uncertain development of electricity prices, uncertain impacts on the distribution system, uncertain development of electromobility, or other unpredictable variables such as environmental impact (battery production and lifetime), or social impact in the form of economic pressure on the socially disadvantaged (depending on the size of the boom and also the prices of EVs, the socially disadvantaged may feel socio-economically frustrated), etc.

2.4 Detailed Planning

2.4.1 Project Implementation Planning

The E-Mobility study (2022) divides the roadmap into 4 phases described in Table 2:

Table 2: Roadmap, 4 phases

Phase	Process: time estimate
1	planning: 2022-2023
2	preparation: 2023-2024
3	implementation: 2024
4	operation: 2025-2030

The study stresses out that the development of charging infrastructure should always be in line with the capabilities of the distribution network, and it is the timely and thorough planning of the deployment of stations that can ensure not only that future demand is met, but also that the load on the electricity network is balanced. The city must intensively negotiate with the owner of the distribution network about connection possibilities and future deployment plans. The most efficient solution would be to locate the stations directly on substation buildings. It is desirable to provide space for mutual communication between all concerned stakeholders. The city should continuously assess the development of the market for electric mobility and the need to build additional charging capacity. On the basis of these findings, then initiate and support further construction.

2.4.2 Citizen Engagement Strategies for Project Development

Three main user groups were identified: residents, customers and employees. Using massive data inputs, "heat maps" were created showing their concentration in each area. Combined with an analysis of major transport nodes, parking options, current public charging offer, technical facilities (electricity grid and fibre optic network), areas with future high concentration of demand for electromobility and opportunities to build adequate charging infrastructure were identified (SmartPlan, 2022).

Due to the prices of the EVs it is likely that the number of EV users will be more linked to the employees/companies which will decide to electrify their fleet. The city wants to start a communication campaign and at the same time would like to create a Manual for charging stations users in 2024-2030, personal ownership is currently partly blocked by insufficient public charging infrastructure. So, the timing of the communication campaign must be appropriately timed with the implementation of the charging station network.

The communication strategy is further developed in the E-Mobility study. The target when communicating with citizens is to let them know that the charging stations are:

- In sufficient quantity;
- In a convenient location (walking distance);
- On time (in what timeframe);

- Adequately staffed (will allow EV owners with a high probability of charging at a time that is convenient for them);
- Functional (the owner/operator will provide 24/7 service and guarantee the functionality of the system);
- Affordable (the cost of charging will not be a disincentive);
- User friendly (simple and intuitive operation, multi-channel payment options).

2.4.3 Risk Management Plan

The organisation of building a public charging infrastructure is a complex process demanding organisation, risk management, optimisation of financial costs, ensuring adequate (professionally educated) human capacities. The fundamental recommendation for Kladno is the establishment of a new working group / organisational unit that will have a clearly defined goal, responsibilities, competencies, the vision of the city (willingness to bear risks, the need for a degree of control of development) and will be the main guide, organiser, negotiator in this project. The practices of good cities confirm that this aspect is the most common threat to the successful implementation of the system.

2.4.4 Quality Management Plan

The feasibility study is aware of the potential risks and therefore warns of the main ones, which should be avoided:

- Inefficient / insufficient project preparation process - need for quality preparation, setup clear timelines (risk of time slippage) - setting up control mechanisms
- Poorly set priorities, unclear terms of reference, unrealistic objectives
- Incorrectly set project parameters
- Little experience in managing and implementing large-scale projects
- Insufficient preparation of negotiation conditions
- Inappropriate business model, poorly set terms and conditions, loss of control over infrastructure development

2.4.5 Key Performance Indicators (KPIs)

One of the key indicators will most likely be monitoring the shift from cars with internal combustion engines to EVs, which can also indicate whether the charging infrastructure is sufficient or oversized. Of course this will somehow reflect in the financial sphere, mainly for the concessionaire or the electricity distributor, who will have the data of which charging stations are mainly used and how often etc.

If the shift to EVs is successful we can probably expect changes also in the air quality, especially when it comes to busiest streets.

Economic KPIs:

- Investment costs**:** Cost of building the charging infrastructure
- Operating costs: The cost of maintaining and operating charging stations.
- Solution lifetime: The period of time for which the solution will generate the required amount of energy without the need for major investments.
- Energy costs

2.5 Securing Investment

2.5.1 Budget Allocation

The implementation of the planned 58 charging stations with a total of 114 charging points should cost approximately 26.8 Mill. CZK (according to the study, 2022[1]), although this amount may vary depending on external market factors. (unstable prices and high inflation due to Russia's aggression against Ukraine). This cost consists of the investment in excavation and other works leading to the availability of electricity in the planned location (R1) and the estimated costs for engineering, design and construction, documentation and the purchase and installation of charging stations (R2). See the detailed costs in Table 3.

Operating costs can be divided on the basis of costs that are not affected by electricity consumption and costs directly linked to consumption. On the basis of the processor's data, the fixed amount corresponds to annual operation of the fully implemented DS network at the level of CZK 928 thousand. CZK (average cost CZK 16.000/ station/year * 58 DS).

The variable cost component depends mainly on electricity prices and the capacity utilisation of charging stations. The budget is based on a cost per 1 kWh of energy consumed equal to 10 CZK excluding VAT.

Table 3: Detailed costs

Implementation	Total CZK (Phase 1, Phase 2), excluding VAT
R1	3.5 Mill. (P1: 1.9, P2: 1.6 Mill.)
R2	23.3 Mill. (P1: 9.9, P2: 13.4 Mill.)
Total R1 + R2	26.8 Mill.
Estimated annual operating costs	
Fixed component	0,9 Mill.
Variable component	18.2 Mill.
R3 total	19.1 Mill.

After the project documentation (or tender for the project documentation) including a thorough legal analysis the subsequent tender will result in a contractual partner, where its technical and economic competence (ideally also experience) should be taken into account.

The uncontrolled deployment of charging infrastructure can cause serious problems for the distribution system, which may not be able to cope with electricity demand at busy times or specific locations.

Therefore, before the actual construction phase begins, there must be close cooperation with the owner of the distribution network (connection options, energy management, network capacity, etc.) and the contractor itself, followed by the approval process and

[1] Prices fluctuate depending on external factors affecting the market. These prices are unlikely to be up to date given the high inflation in the Czech Republic in 2023.

obtaining the necessary permits for the connection of selected sites and the actual construction of the charging stations. In the case of the concessionaire model, the costs of networking the sites are borne by the city, while the costs of equipping the sites with charging stations and operating them are borne by the concessionaire.

2.5.2 Additional Sources of Funding

As building charging infrastructure is part of meeting the European Commission's charging infrastructure requirements, it is very likely that various forms of subsidy programmes will be available in this regard. At the national level there are regular calls, for example, for the purchase of EVs, which is one of the opportunities for Kladno to electrify its fleet more cheaply. However, at the time of writing, there was no national call to support the purchase of EVs for local authorities (there is a national call which supports private owners). However, there is a need to follow up on calls in this regard primarily from the Ministry of the Environment or the Ministry of Industry and Trade.

Some additional sources can also rise from participating in international projects (such as SPARCS). Most of the time, however, these are projects where building infrastructure is not an eligible expense. However, participation in these projects can help to a large extent, e.g. with the preparation of expert studies, etc., which would normally not be covered by the municipal budget. These supporting programmes are Horizon, LIFE, URBACT, Interreg and others. We have to take into account that this is only a hypothetical possibility, the calls in these programmes are very specific.

2.6 Procurement/Implementation

2.6.1 Procurement

Abroad, different levels of government are generally involved in infrastructure construction and the approach varies from country to country. The coordination of tenders is then under the responsibility of the individual municipalities. Regardless of the method chosen, the selected responsible body should coordinate its activities with national entities/strategies, other municipalities or regions. Cooperation and coordination of several cities within a region brings many advantages (not only economic but also purely practical in terms of technical uniformity and sharing of experience). The European Commission has set out recommended tender criteria based on national practice, which can be a major inspiration for others when building a public charging infrastructure network (SmartPlan, 2022, p. 240). These criteria/conditions should be reflected in the tendering process to make the infrastructure efficient, sustainable and feasible.

2.6.2 Implementation

The development of charging infrastructure should always be in line with the capabilities of the distribution network, and it is the timely and thorough planning of the deployment of stations that can ensure not only that future demand is met, but also that the load on the electricity network is balanced. The city must intensively negotiate with the owner of the distribution network about connection possibilities and future deployment plans. The most efficient solution would be to locate the stations directly on substation buildings. It is desirable to provide space for mutual communication between all concerned stakeholders. The city should continuously assess the development of the market for electric mobility and the need to build additional charging capacity. Based on these findings, it should then initiate and support further construction.

Municipalities should ensure that the location of all charging points is designed to allow the widest possible public use - particularly taking into account the specific needs of older people, people with reduced mobility and people with disabilities. This means ensuring that there is sufficient space around the charging point. This obligation is based on EU Directive 2019/882 on accessibility requirements for products and services.

The E-Mobility study (SmartPlan, 2022, p. 255) suggests following these steps of the E-Mobility Action plan, see Table 4.

2.7 Next Steps

It is important to point out that the situation with traffic in the city of Kladno is currently alarming, and therefore, as an essential part of the implementation of the charging infrastructure strategy, a strategic document should be prepared that addresses the parking issue in more detail (study in process). However, before work on the strategy document can begin, it is also necessary to complete the current analytical basis. Therefore, two projects should be prepared to provide all the necessary information for further development of charging infrastructure in Kladno. The first step (project) must be the digitisation (or also passportisation) of parking spaces in a GIS environment. The next project must be a Quiet Transport Strategy including outputs from the digitisation (passporting) of all parking spaces in the city. Only then will it be possible to ensure an integrated approach to the development of the infrastructure in question that takes into account all the necessary strategic links. It will also be possible to integrate these projects into the existing Sustainable Urban Mobility Plan, effectively complementing the document and expanding the sub-chapters, or increasing the level of detail in the case of quiet transport and the related electromobility. For specific next steps in the implementation of E-Mobility, see Table 4.

Table 4: E-Mobility Action plan

Step	Description
1	Electrification of the city fleet
2	Communication (establishing effective cooperation within the town hall and creating and establishing a communication campaign aimed at potential users)
3	Pilot projects
4	Organisation and cooperation
5	Localisation (final steps for choosing locations of the charging stations)
6	Preparation (determining and negotiating requirements and conditions for contractual partner)
7	Selection process (selection of a quality contractual partner – technical and economic competence, experience)
8	Coordination
9	Installation (project implementation)
10	Operation of the charging infrastructure
11	Evaluation

3. Public buildings on the pathway of higher energy self-sufficiency and resilience

3.1 Project Scope

3.1.1 Project Scope Definition

There are several reasons why the city needs to react on the climate and energy transformation. All necessary analytical and research work was done on the basis of the SECAP preparation incl. public buildings stock.

The key aim is to maximise local generation from RES to contribute to decarbonisation goals and increase the energy security and resilience of the city. Decreasing the consumption, increasing the clean energy production and finding the balanced economic model are essential part of city´s effort.

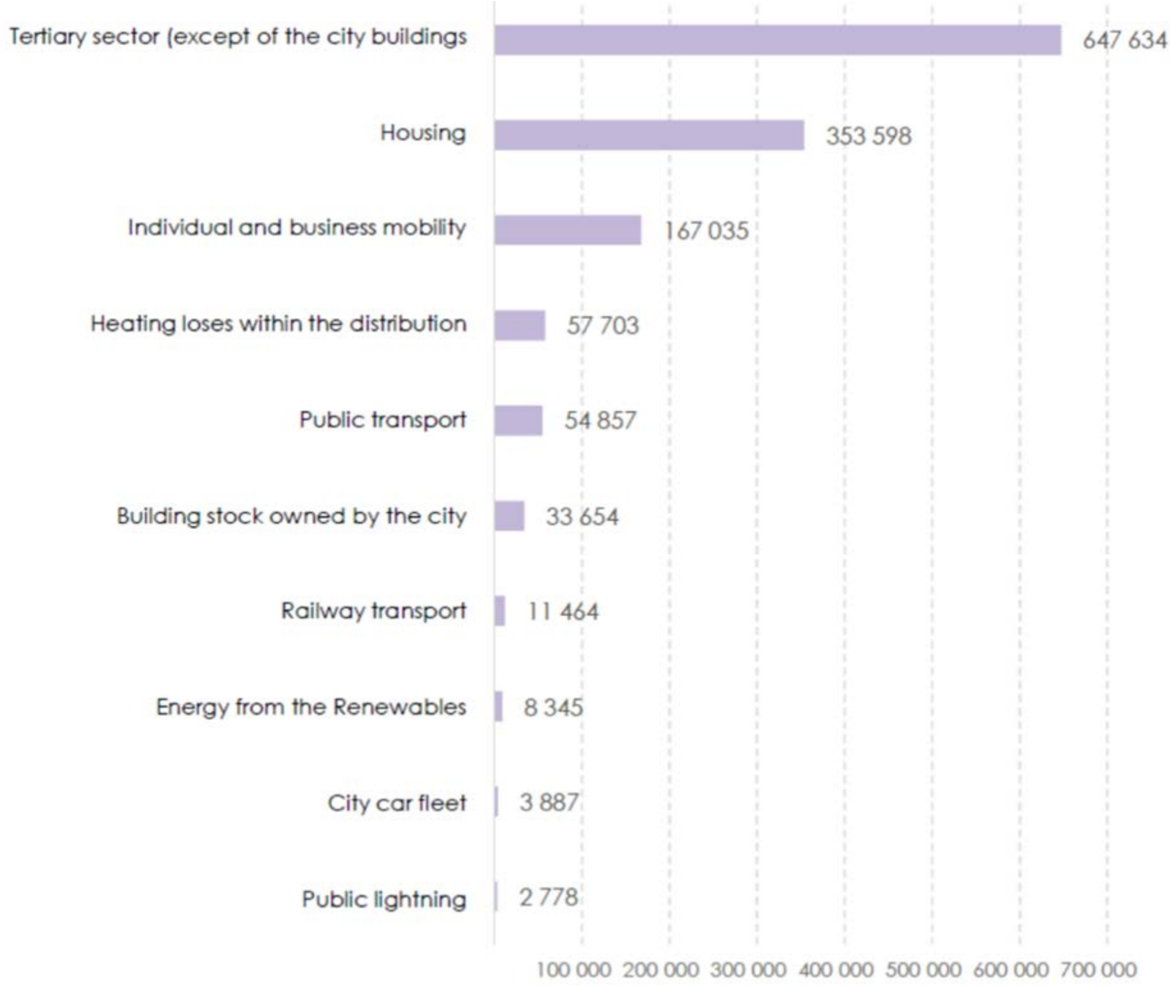


Figure 7: Single items of total energy consumption in MWh

The city wants to demonstrate the decarbonisation efforts by showing the good examples therefore it starts with its buildings. It owns around 190 buildings (it is approximately 582 energy consumption points). Specific category is the city´s residential buildings (approx. 82) that are under rent scheme to the tenants and buildings which are rented completely (e.g. for education purposes).

The total sum of all the energies in 2019 was 1,825,082 MWh (see Figure 7 for single items of the total sum). 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%.

The total energy consumption for municipal buildings in 2019 was 33,654 MWh, which corresponds to equivalent CO_2 emissions of 14,010 t CO_2/year.

The city buildings contribute 2.8% of the total emissions of the city of Kladno. The predominant source of emissions is electricity consumption, followed by heat from district heating. Emissions from natural gas account for the smallest part of the total emissions (see Figure 8).

The potential for achieving savings in municipal buildings is about 470 MWh of electricity, 830 MWh of natural gas and 1 625 MWh of heat per year. In addition, 279 MWh of electricity is expected to be produced by PV per year.

At an indicative cost of CZK 112,000 per 1 MWh of savings (but prices are currently at least 1.5-2 times higher), the total investment would amount to an estimated 327.6 Mill. CZK.

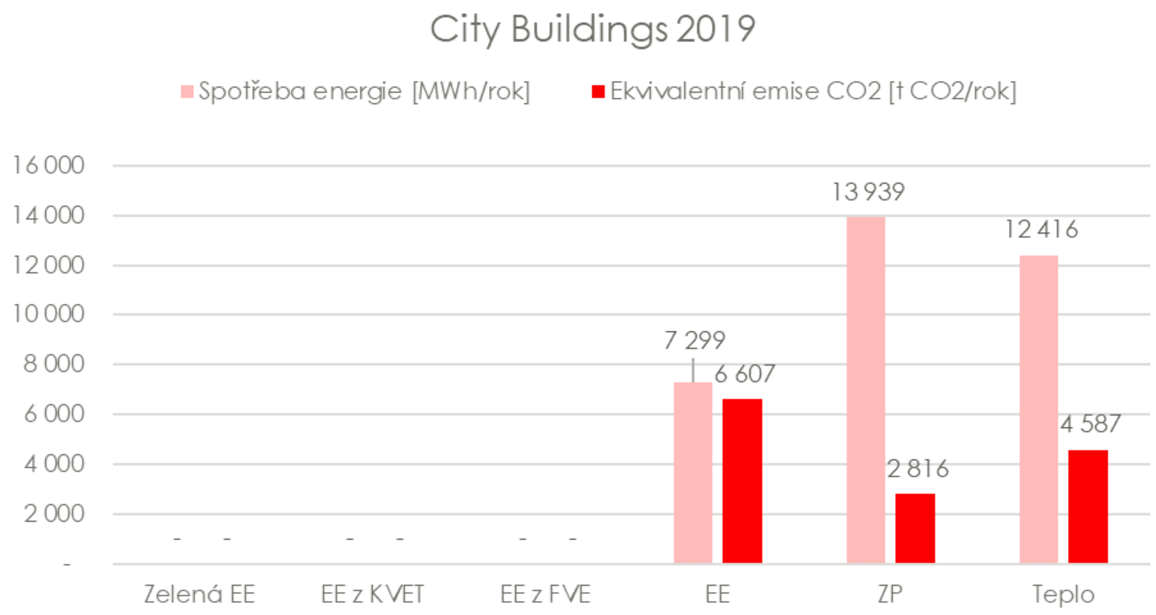


Figure 8: City Buildings 2019

Spotřeba energie = energy consumption; Ekvivalentní emise = equivalent emissions.

Zelená EE = green electricity; EE z KVET = electricity from CHP; EE z FVE = electricity from PVs, EE = electricity; ZP = gas; Teplo = heat.

Figures (9 and 10) below are showing potential targets in 2030 in comparison with 2019.

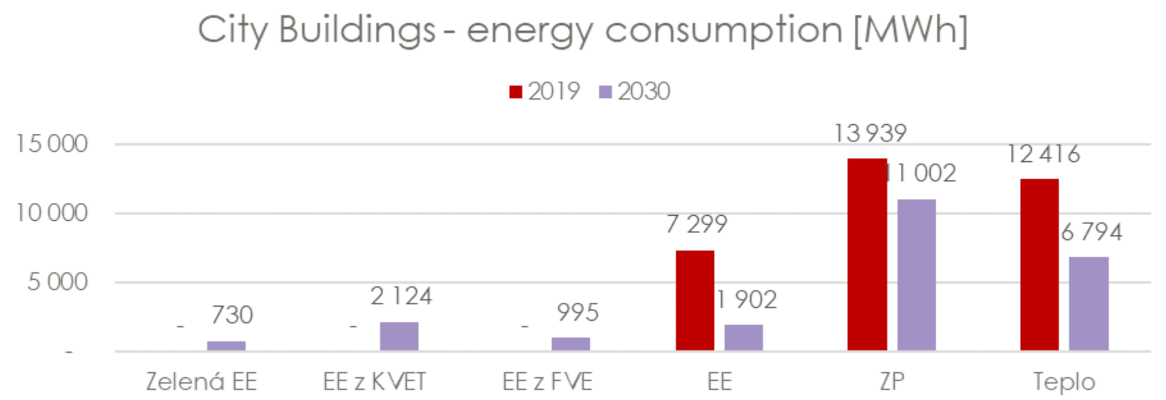


Figure 9: City Buildings – energy consumption

Zelená EE = green electricity; EE z KVET = electricity from CHP; EE z FVE = electricity from PVs, EE = electricity; ZP = gas; Teplo = heat.

But the reality might be different since the covid times and geopolitical crisis. The prices are extremely different (not only prices of energy but also prices of construction, services etc.). The strategy is continuously changing.

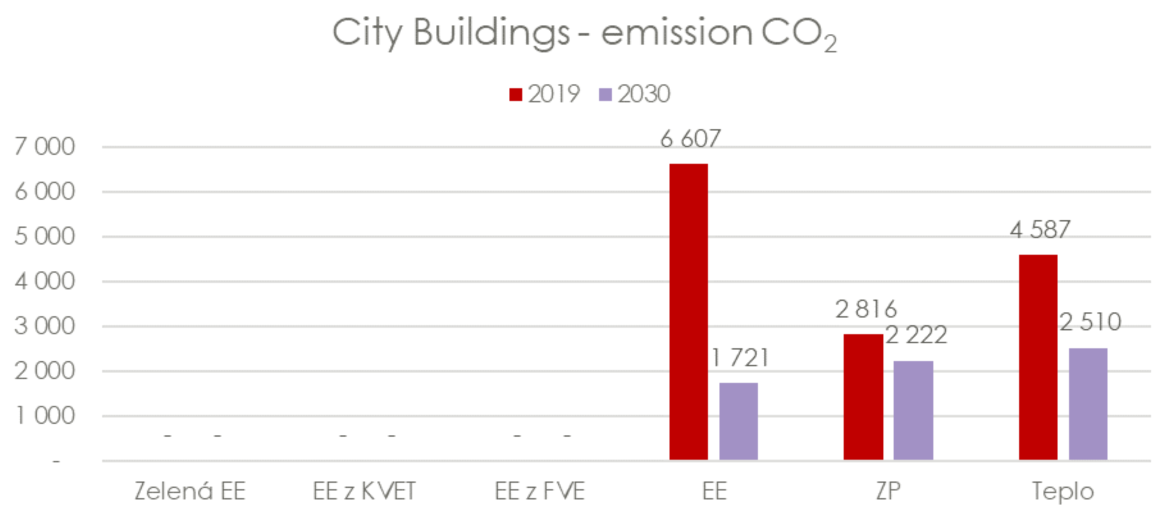


Figure 10: City Buildings – emission CO_2

Zelená EE = green electricity; EE z KVET = electricity from CHP; EE = electricity; EE z FVE = electricity from PVs, ZP = gas; Teplo = heat.

Overall aim

The overall goal of the city of Kladno is to increase the self-sufficiency of buildings and related infrastructure. It consists of several thematic components, see Table 5. The city will benefit from energy savings, CO_2 reduction, increased safety and comfort. Other benefits include the likelihood of meeting EU climate targets, support for decarbonising the city and the plan to have at least 100 districts by 2025. The PED de facto points to a possible direction and thus brings together different actors, which also helps with other cross-cutting issues.

Table 5: Thematic components

	Thematic components

1	Reducing energy consumption in the public buildings (= renovation component).
2	Increasing the share of renewable energy technology installations (= renewables component).
3	Optimising the heat supply system, e.g. modernisation and gradual increase of the share of RES in the network (= heating component)
4	Innovation and testing such as Positive Energy District - Sletiště; Positive Energy Buildings - Čabárna, aggregation of energy flexibility, energy communities etc. (= innovation component).
5	Processes and digitalisation such as ISO 50001:2019, energy management software solution, smart metering, expanding internet connectivity (= digitalisation component).

3.1.2 Geographical Location

The geographical distribution of the thematic components is very broad. The following maps (see Figures 11-14) represent the coverage across the city. A PED map (see Figure 16) and more information on PED can be found in Chapter 4.

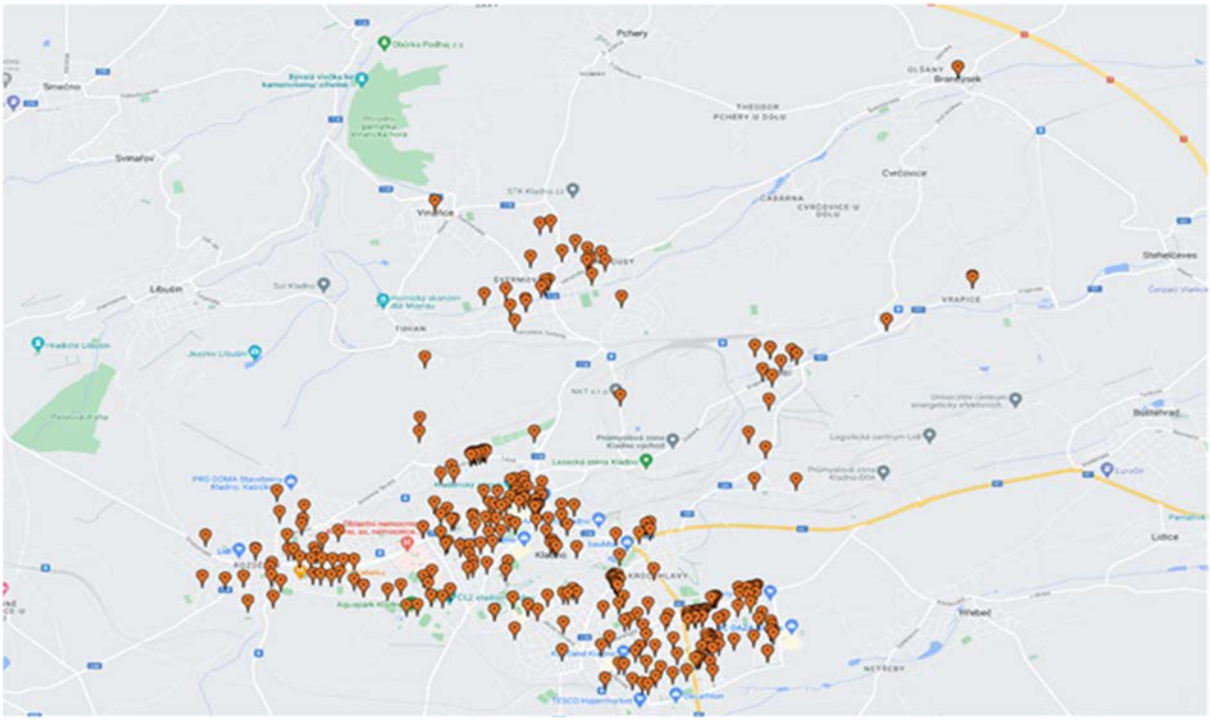


Figure 11: All public buildings (city tool for energy management, EnergyBroker)

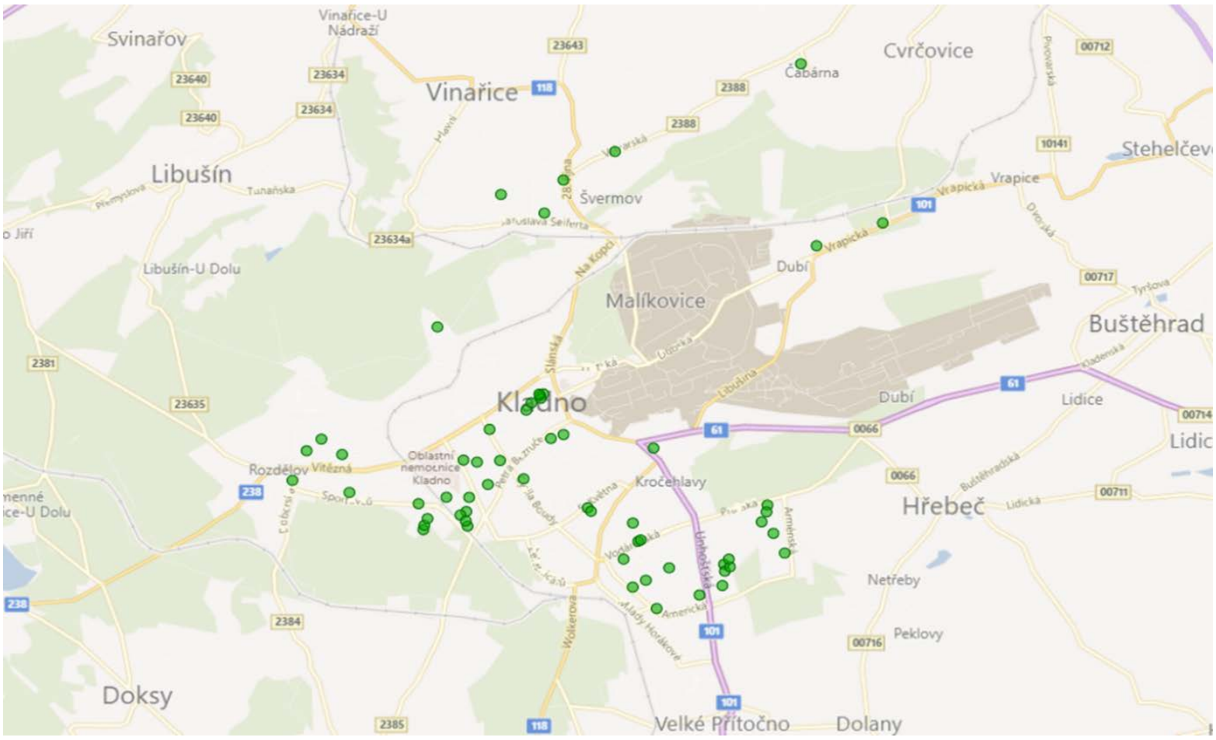


Figure 12: PV installation plan according to the study held by city in 2022

Figure 13: Central District Heating in the city

Figure 14: Location of the PEB Čabárna

3.1.3 Preliminary Technology Assessment

Detailed scope of the project consists of 5 components as it was defined above:

(1) Renovation component:

Some works have already commenced in 2020. An analysis of the potential for building and energy measures on city's 23 buildings was completed between 2021 and 2022, and further refined by consultants and the City team, including technical calculations, building walkthroughs and final design of measures that will generate the required energy savings. The City of Kladno is also cooperating with the National Development Bank, the municipal heat distributor and others on this.

The pathway for renovation has been divided into several phases, due to volume, logical framework, readiness, budget availability etc., see Table 6.

Most of the projects are tested via EPC use, and the use of EU funds (Operational programme Environment) is always considered.

In addition to classical measures such as insulation of the facade, ceilings, attics or roofs, replacement of windows or doors, there are also measures for installation of energy management, smart metering, optimisation of the source of the heat supply system, air conditioning, lighting and always other specifics at the level of individual buildings according to the proposal of energy specialists.

(2) Renewables component:

The overall potential of the city's buildings was analysed, filtering out those that were not relevant (due to poor condition, very low consumption, alternative building use plans, etc.). The cumulative potential in the next 3-5 years is currently estimated up to 5000 kWp at a value of 150-200 Mil. CZK, which is about 60 PV plants on buildings alone, generating a value of up to EUR 25-35 Mil CZK per year.

Table 6: Pathway for renovation

Phase	Pathway for renovation
1	Building and energy measures (5 buildings: primary schools – 2 buildings Vodárenská; 1 building Velvarská; administration building of Floriánské square, and Žižkova-Švermov).
2	Building and energy measures (9 buildings: Moskevská Primary School; Brjanská Primary School; Amálská Primary School; Special Primary School Pařížská; Cyril Bouda Primary School; Public administration building no. 44; Public administration building no. 45, 48, 49 and Doberská Primary School).
3	Energy and technological measures without major construction interventions and without subsidies (9 buildings: Dubí Municipal Office; Zdeněk Petřík Primary School; Pplk. Stříbrný Primary School, R. Svobodové Primary School; Školská Primary School; Sports Hall; Ukrajinská Primary School; Norská Primary School swimming pool; Aquapark).
4	Building and energy measures for other buildings; analytical work needs to be done (several sub-packages should be exploited: construction package, technological package, housing package etc.).

There are several phases. The first is focusing on the installations of about 2,8 kWp on 23 buildings. The output is designed to be as high as possible, i.e. using the maximum available roof area. It is assumed that the overflows to the grid can also be traded on favourable terms by using them in other city operations or in future energy communities, which are still being set up legislatively at the time of the investment plan preparation. Battery energy storage is also included.

This is followed by verification of the roof load capacities and their orderly resistance. Next, the extent to which the entire concept will be implemented by the municipal company or by external entities will be considered. At the end of the first quarter of 2023, it is also possible to apply for grants for the installations, e.g. to the modernisation fund.

The composition of the overall business case for city company at the level of work breakdown is shown in Table 7 (see below).

(3) Heating component:

Total energy production for the power generation sector was 230 593 MWh (= 208 746 t CO_2 total). Heat distribution losses account for 57,703 MWh of heat per year, which represents 23 % of the energy input to distribution (equivalent heat losses through distribution calculated in CO_2 emissions is 21,317 t CO_2/year).

(4) Heating component:

Total energy production for the power generation sector was 230 593 MWh (= 208 746 t CO_2 total). Heat distribution losses account for 57,703 MWh of heat per year, which represents 23 % of the energy input to distribution (equivalent heat losses through distribution calculated in CO_2 emissions is 21,317 t CO_2/year).

(5) Heating component:

Total energy production for the power generation sector was 230 593 MWh (= 208 746 t CO_2 total). Heat distribution losses account for 57,703 MWh of heat per year, which represents 23 % of the energy input to distribution (equivalent heat losses through distribution calculated in CO_2 emissions is 21,317 t CO_2/year).

Table 7: Work breakdown

Item	Sector
Project documentation	Expert work
Photovoltaic panels	Technology
Inverters	Technology
Cables	Equipment
Metal construction	Equipment
Roof installation	Expert work
Inverters installation, connection, wiring and preparation of the report	Expert work
Control unit, connection with the control room of the distribution system operator	Technology
Battery	Technology
Other - applications for network capacity reservation, connection, ERA (Energy Regulatory Authority) licence, or registration to OTE (electricity market operator), project management	Management, administration

The systematic modernisation of the district heating system is taking place at regular intervals, in particular with regard to the continuous replacement of older parts of the heat supply system, the reconstruction of heat exchangers and transfer stations and the extension of new parts of the network. The key input to the calculation of savings is the mix of sources within the production of electricity and heat by the Kladno power plant, (privately owned) which enters the balance in a fundamental way. Partial modernisation is taking place in the framework of building renovation.

In the future, it is assumed that gradual modernisation will be carried out every year. Significant changes are to take place at the level of the Kladno power plant with a view to reducing coal combustion and gradually replacing it with other sources. These cleaner sources then supply, among others, municipal, residential and other buildings.

A significant contribution to savings and emissions reduction is the elimination of higher losses in the network. The reduction is a rough estimate by the partners based on upgrades that have been made and planned. A 30% reduction in losses can be expected by 2030. For Phase I, i.e. 2022-2025, a slower rate of reduction of line losses is assumed, also in view of the current geopolitical problems and in relation to price increases; up to 5 times lower than the original estimates. By 2030, the actual heat consumption of the heating plant is also expected to decrease from 195,83 to 166,85 MWh per year. By 2030, electricity consumption from the distribution grid is also expected to fall from 230 593 to 74 937 MWh per year.

(6) Innovation component:

A systematic approach by the city administration is also observed when it comes to the gathering of innovation. Regarding the connection with this project outline several very relevant innovations could be mentioned:

- Positive Energy District - Sletiště (details can be seen below, as a part of the 3rd project outline).
- Positive Energy Buildings - Čabárna (NSEV Čabárna is a provider of ecological education and runs an eco-center that demonstrates practical environmental measures; a new building with a positive energy status is prepared for construction).
- Aggregation of energy flexibility (Winter Stadium. Eco-centre Čabárna)
- Energy communities etc. (current pilot with three private community housing units and city housing management fund).

They are flagships with a high potential of bringing significant results for multiplying the energy prosumers' concepts thus the balancing consumption-production issue with high effectiveness.

For the purpose of increasing efficiency and working with buildings, the city has implemented an intelligent energy management tool, now comprising over 400 energy consumption points. The development of this tool is planned. At the same time, the city is preparing the implementation of the ISO 50001:2019 standard for effective energy management in the city. The city is also preparing a research and application project to test energy flexibility and pilot the implementation of community energy with household participation.

(7) Digitalisation component:

The city is continuously implementing smart solutions inside and outside the buildings. Between 2021 and 2022, it has completed a number of smaller projects and is preparing larger ones. There have been partial installations of smart metering within City buildings (sensors, energy meters), as well as other activities such as parking sensors, cloud systems, waste sensors, and cameras.

A key first stage for the expansion of smart features is the implementation of building renovation (see the mentioned activity), as well as a more widespread strengthening of broadband in city buildings (17 schools in the first stage) and the introduction of software solutions to strengthen cyber security. As they do not have a direct impact on achieving savings or emission reductions, these amounts are not included in the balances including investments.

3.1.4 Preliminary Assessment of Business Models

The renovation wave should bring more than 400 Mil. CZK (= EUR 16 Mil.), the average payback period after deducting the subsidy for all of them is about 13 years, the average energy savings is about 40% (= 4.000 MWh, expressed in financial terms it is about CZK 15 Mil. per year). This amounts to around 1 5000 tCO_2. Funding should be composed of EU funds, own resourced and attention was also focused on the EPC model.

Regarding the RES the cumulative potential in the next 3-5 years was currently estimated at up to 5000 kWp at a value of 125-180 Mil. CZK (EUR 5-7.1 Mil.), which is about 60 PV plants on buildings alone, generating a value of up to 25-35 Mil. CZK per year. Under Phase 1, installations of about 2,8 kWp on 26 buildings were considered. The output is designed to be as high as possible, i.e. using the maximum available roof area. It is assumed that the surpluses to the grid can also be traded on favourable terms by using them in other city operations or in future energy communities, which are still being set up legislatively at the time of the investment plan preparation. Battery energy storage is also included. The energy use in the buildings is calculated at 1.303 MWh, with an overflow of 1 552 MWh and emission savings of 1 121 tCO_2. The other stages have a potential of 2.82 MWp.

3.1.5 Supporting Factors & Barriers

Supporting Factors

There were several options available to the city for the implementation of PV systems. By contacting the company or through their own company. At the same time, the city knows what costs it has to invest in the whole project (both on the CAPEX and OPEX side, including the cost of building the team). The assessment of the potential for clean energy production included a series of scenarios reflecting different prices, costs, and scope of new activities. And city decided to approach all RES installation via the city company, so far based on the heating business, newly based on the electricity model (incl. getting a new license).

Awareness raising about the energy transition including renovation, PV installation, energy sharing, and decentralisation is important.

Finding and applying for other sources is also very important. Kladno is engaged in the EUCF project and national subsidies also help with implementation – e.g. from the State Environmental Fund. Some of the actions were already implemented (e.g. reconstruction of the Winter Stadium). The investment was foreseen sooner. Due to the complexity of work, the procurement process, market distortion, lack of experts, lack of funding, and consolidated package of the government that has an impact on the funds. Most of the work is time-consuming and depends on external factors (technical documents, quality of contractors' work).

Barriers

Regarding the energy sector, there are several challenges such as a scattered local context and changing environment, low rate of renovation of installation of buildings, low rate of RES in the public, private, and housing sectors, high rate of fossil sources in the overall energy balance, social and energy poverty in housing, lack of clear set-up of the energy communities, from the legislation point of view; financial, technical (regulation, distribution, network capacity) and participatory aspects remain challenging as well, or insufficient capacities, knowledge and space for communication, participation, and other work. Regarding the RES there is still a low pace of installation within the public and private infrastructure.

An important context is the Covid and post-Covid situation and the impact on the budget. The past few years have been critical regarding the volume of possible investment. In addition, the extreme increase in energy, material, and labour prices, and the geopolitical situation with respect to Russian aggression have had an impact on the planning and implementation of the measures the city sets out to take. It will also have social impacts, for example in the context of energy poverty. These negative aspects also had an effect on the city council and the way of thinking about energy.

3.2 Market Consultation

3.2.1 Solution Requirements/Functions

The renovation of the buildings is very demanding due to the complexity of the proposed measures. It consists of the construction aspects and technical ones on the other side. The greatest savings potential in most buildings is related to the insulation of the building envelope, which is inadequate in terms of current thermal technical requirements. However, these measures are characterised by high investment requirements and long payback times. Most of the heat exchanger or transfer stations located in buildings are in relatively good technical condition, the savings potential is partly limited, and these stations are, with a few exceptions, owned by the heat supplier, city company TEPO. Although the gas boiler plants are owned by the city, most of them have been recently upgraded. Checking or replacing thermostatic valves (TRVs) on the heating units and fitting electronically controlled heads, which make it possible to individually regulate the heating in each room of the building (IRC system); modernising control nodes, adding actuators to the heat distribution systems (e.g. mixing, etc.), replacing circulators, adding thermal insulation to the distribution systems, and other measures incl. energy management are designed for getting savings.

In relation to the RES and PV installation, the grid capacity could be a challenge since the grid operator might not approve larger photovoltaic power plants. Also, the technical status of the roofs is a bit problematic. However, prior to the start of construction, permissions from the grid operator ČEZ were required.

3.2.2 Market Consultation

Regarding the renovation, the EPC model was tested. The EPC model is then based on a tender for an ESCO company, a negotiated procedure with publication (PPA). Once the ESCO company has been awarded the contract between the city and the ESCO company is mainly about a well and precisely modelled contract. The City guarantees that for the duration of the contract, it will consider the same operating energy costs as "before the project" and use the difference generated by the savings to repay all project costs, the ESCO company bears the cost of the investment and guarantees that if the expected savings are not achieved, the city is not obliged to "top up" for the unreached savings, i.e. the ESCO will have less income from repayments. Repayment of the project is based solely on the energy savings achieved.

However, after some reviews and discussions with the potential contractors, and based on the fact the city should pay a high extra cost for interest, energy management, and also is not able to run the construction and operation of the PV power plants due to ESCO character the EPC model was cancelled.

There were several options available to the city for the implementation of PV systems. Through contacting or through the company itself, thus several companies were asked (to check the CAPEX and OPEX parts; to check other parts of the contractors and supplier chain regarding the costs, services, administration, etc.). The evaluation of the clean energy potential included a series of scenarios reflecting different prices, costs, and scope of new activities.

Based on this the city has decided to run its own business model via the city company called TEPO, so far focused on the heating supply. The new business model concerning electricity production, sharing, and selling has been started.

For investments in PV plants and their operation, it will be necessary to obtain a building permit, which will include a statement from the Fire Protection Department, an inspection report on the connection of the PV plant, and a license from the Energy regulator for the PV plant operator. A professionally qualified person will need to be nominated to obtain the license. The purchase of technology and services will require a public tender. The approval of the distribution system operator will be required to connect the PV plant to the grid. For all these, the public consultation was done.

3.2.3 Proposed Technologies

The consultation focused on the business side and also on the technologies that should be installed. The renovation doesn´t include any heritage protected buildings thus the city can freely focus on the wide range of options, both regarding the construction part and technological part.

However, running the preparatory works, and discussing technical and business models haven´t required detailed technologies analysis. Also, the energy potential, for instance, what type of boilers or PV system should be installed, has been designed in terms of performance, capacity, the power supply, not from the "brand" perspective.

However, specific issues are still being tested, eg. lightweight panels for the construction of the roof of the winter stadium as it will not be possible to put conventional PV panels there due to the load capacity of the roof.

3.3 Detailed Assessment

3.3.1 Legal/Regulatory Framework

There is long-term pressure on the renovation of the buildings, going from the EU legislation and the Czech one. The Energy Performance of Buildings Directive (EPBD) serves as a means to prepare the European building stock for zero-emission operation by 2050. This framework is essential since it creates a compulsory background and pathway for renovation waves in the cities, regions, and states.

According to the legislation, also all new buildings should be emission-free from 2028. New buildings occupied, operated, or owned by public authorities will be obliged to do so from 2026. All new buildings should be equipped with solar technologies by 2028, if technically appropriate and economically feasible. Residential buildings undergoing major renovations must meet these requirements by 2032. Residential buildings should achieve at least energy performance class E by 2030 and class D by 2033. Non-residential buildings will have to reach the same standard from 2027 and 2030. EU countries will have to ensure that the use of fossil fuels in heating systems is not allowed from the date of transposition of the Directive for new buildings and buildings undergoing major renovation or refurbishment of the heating system. Fossil sources would be phased out completely by 2035 unless the European Commission does not allow their use until 2040, as stated by the European Parliament.

No specific legislation acts or implementing regulation dealing with renovation of the building is adopted at the level of the city.

Regarding the RES (PV power plant) there is plenty of legislation in place and several acts are under preparation (especially those concerning sharing of the electric energy and the concept of energy communities as such). There are law acts, decrees, ISO standardisation, and another legal establishment for the RES.

The installations producing the energy from RES (e.g. photovoltaics on the roof or on the building envelope) are permitted depending on the category of the building, in which they are classified. Depending on the type of building category, a permit is required or not from the relevant building authority, and at the same time other obligations under the Building Act are also attached to the category of construction. Construction modifications for a RES´s installation with a total installed power of up to 50 kW, provided that they do not interfere with the load-bearing structures of the building, do not change the use of the building, do not require an environmental impact assessment, and the following conditions are met in particular fire safety according to the legal regulation governing requirements for safe installation.

Concerning the grid a producer can only supply electricity to the grid on the basis of a contract with DSO (distribution system operator). If the PV plant is connected to the point of consumption, it is not possible to have another supplier and another buyer of the surplus. Thus, the purchase of electricity and the sale of surplus are usually linked to price. The surplus price is contractual. The city must negotiate the price with DSO. This applied before the novelisation of the act for sharing electricity and is even revised in greater detail with regard to the LEX OZE III legislation for electricity sharing.

3.3.2 Technical Assessment

Construction measures:

- Insulation of the building envelope.
- Insulation of the roof attic, ceilings and other parts.
- Replacement of windows and doors.
- Replacement of power lines and switchboards
- Other construction works.

Technological measures:

- Replacement of the source of heating.
- Installation of the RES (e.g. PV system, heating pumps).
- Replacement of existing or implementation of new HVAC systems.
- Replacement of thermostatic valves on heating units.
- Installation of electronically controlled heads.
- Water savers, pearl valves, toilet traces.
- Complex optimisation of regulation system.
- Indoor lighting modernisation, LED system.
- New smart meters.
- New energy management system control.
- Digital tools.
- Etc.

Regarding the PV system, for the very first draft the sunpower MAXEON 5 COM panels (see technical details in Table 8). These are panels that combine high production efficiency and microinverter technology. This combination allows for fewer panels to be placed on the roof compared to conventional installations, while at the same time not requiring space to accommodate string inverters. Each panel operates independently, making the system more reliable if there is a failure on one link in the system.

Table 8: MAXEON 5 COM panels technical details

Parameter	SunPower MAXEON 5 COM SPR-MAX5-450-COM
Panel performance (W)	450

Area (m2)	1,94
Efficiency (%)	22,2
Weight (kg)	21,6
Inverter type	microinverter
Performance after25 years	92%
Guarantee	25

3.3.3 Cost Assessment

Table 9 shows planned costs (investment and preparation part).

Table 9: Planned costs

Investment component	Description	Estimated investment (Mil. EUR)
Renovation (I. wave)	Analytical work, proposals, public tenders	20
	Renovation itself	
	Winter Stadium renovation (done)	20
PV installation	Business model, project documentation, connection to the grid, tendering, statical assessment, Fire protection Permissions	9
	Reconstruction of the roof	
	Installations with batteries	
Modernisation of the central heating system	Modernisation of the system and reduction of line losses	4-5
	Decrease in heat consumption from the heating plant	Private capital
	Decrease in electricity consumption from the distribution network	
Innovation and digitalisation	Positive Energy Building Čabárna	1
	Broadband connectivity in city buildings and implementing software solutions to strengthen cyber security	7
	Energy management ISO 50001:2019	0,2
	Deploying smart metering in selected buildings	0,2
	Energy communities piloting	0,1
	Energy flexibility testing	0,2

3.3.4 Business Model Identification & Financial Analysis

The GPPD has developed a Business Model Canvas (BMC) also for the topic of energy self-sufficiency, see appendix 1. Here you can find a deeper insight concerning the partners + stakeholders, city government role, the typology of the business model which includes several components, funding & financing vision, cost structure and other elements which makes the BMC a useful tool with a good overview of all the unnecessary layers included. One of them is also the issue of environment – risks and benefits are also mentioned here.

3.3.5 Risk Assessment

Overall systematic approach is described in the chapter 4.4.3 Risk Management Plan.

3.4 Detailed Planning

3.4.1 Project Implementation Planning

The roadmap of implementation is presented Table 10. Several small and quasi-steps are made. The deviations are foreseen, the division of the building's renovation could be done in a different timeframe in comparison to the submission of the proposal to the EU grant call.

3.4.2 Citizen Engagement Strategies for Project Development

The typology of the investments doesn´t require the wide involvement of the citizens. Renovation, PV installations, Positive Energy Buildings, and innovation are driven by the city administration and specific partners such as schools, owners of power plants, city companies (heating supplier TEPO, sports area provider SAMK, city maintenance, etc.), and organisations (police, housing management fund SBF, etc.), homes for the elderly and similar facilities.

However, there are several specific activities that require a very intensive connection to the citizens. The key action here is piloting energy communities. It consists of three community unit owners (private ones) and the housing management fund of the city. The piloting includes an analysis of possible energy community models, complex technical design for buildings of community of unit owners, proposal of investment, business and organisational model of PV operation for model objects, draft documentation for the establishment of an energy community for selected types and preparation of a summary report for the model buildings.

3.4.3 Risk Management Plan

Summary of the risks and measures that mitigate them are shown in Table 11. There are several risks that can occur. In fact, problems have already occurred, regarding the choice of model (EPC vs. regular approach towards renovation), increasing prices in the market, political uncertainty, lack of cooperation, the technical status of the buildings (especially roofs), etc.

Table 10: Implementation roadmap

Investment component	Description	From	To
Renovation (I. wave)	Analytical work, proposals, public tenders	2021	2025
	Renovation itself	2025	2029
	Winter Stadium renovation (done)	2021	2024
PV installation	Business model, project documentation, connection to the grid, tendering, statical assessment, Fire protection Permissions	2021	2025
	Reconstruction of the roof	2025	2028
	Installations with batteries	2025	2028
	Modernisation of the system and reduction of line losses	2021	2023

Modernisation of the central heating system	Decrease in heat consumption from the heating plant	2021	2030
	Decrease in electricity consumption from the distribution network	2021	2030
Innovation and digitalisation	Positive Energy Building Čabárna	2022	2025
	Broadband connectivity in city buildings and implementing software solutions to strengthen cyber security	2023	2026
	Energy management ISO 50001:2019	2020	2030
	Deploying smart metering in selected buildings	2025	2030
	Energy communities piloting	2024	2025
	Energy flexibility testing	2024	2027

Table 11: Risks, impact, measures

Risk	Impact	Measures
Deepening crisis; rising energy prices; lack of investment; shortage of materials	Rising prices and other commodities are forcing the city to invest less and cover more of its operating costs. Unavailability of materials, technology, etc. Significant delays in project implementation.	Engaging in a national debate on how to get out of the crisis. Finding other models for financing projects. Early planning. Regular screening of prices and market situation.
Insufficient financial resources for preparation and implementation	Failure to implement the planned scope of the project. Missing documents/data. Significant delays in project implementation	Diversification of financial resources Timely communication with city management and investment entities
Limited capacity for the preparation of technical and project documentation	Higher than expected prices. Lack of experts on the market. Significant delays in project implementation.	Capacity building. Competing for potentially problematic parts of the contract separately. Early communication and fixing of experts.
Unwillingness of partners to cooperate and negotiate	Disagreement on the form and planned measures. Impossibility to implement projects on the planned scale. Significant delays in project implementation.	Regular communication and working within work teams. Finding win-win strategies.

Failure to obtain subsidy support.	Multiple demands on own resources. The need to invest more in the light of new realities. Significant delays in project implementation.	Emphasis on precise preparation of project applications. Involvement of other experts. Preventive consultation with relevant stakeholders.
Inadequate condition of buildings	The need to invest more in the light of new realities. Significant delays in project implementation.	Preparation of expert assessments (e.g. statical assessment, fire protection of the buildings). Building inspections with experts. Investments in repairs.
Increase in investment due to related modifications to connect the power generation plant to the existing infrastructure	Some PV plants will not receive approval for connection within the expected timeframe.	Preparation of a professional assessment of the feasibility of connecting the production plant. Preparation of project documentation and submission of connection application as soon as possible. Appointment of a person for preventive and ongoing communication.

3.4.4 Quality Management Plan

Project and Quality management is ensured by the city administration., esp. energy team within the GPPD (execution level), the Council of the city, and the Mayor (political level). The important roles are also dedicated to the technical partner UCEEB and the Energy Platform (= stakeholder ecosystem).

Risk management (see another chapter) detects all potential problems and barriers in the preparation and implementation phase. The city administration also manages the ISO 50001:2019 energy management which includes an extensive system of tasks, projects, procedural measures, etc. This project outline is part of it.

3.4.5 Key Performance Indicators

There are several KPIs directly established in the project, more or less there are driving factors of the overall outline.

- **Investment costs (Mil. CZK)**: renovation, installation, new technology.
- **Operating costs (Mil. CZK):** the cost of maintaining and operating the installation; salaries of the experts, certifications, etc.
- **Cost savings (Mil. CZK):** energy saved by reconstruction and installation of new technology.

- **Energy savings (GWh/year):** decreasing the original energy consumption or energy saved by reconstruction and installation of new energy-friendly technology.
- **Renewable energy production (GWh/year):** clean energy produced from renewable energy technology, eg. photovoltaic systems, heating pumps, wind power plants, and other technology sources.
- **Avoided CO_2 emission (tCO_2eq/year):** avoided emissions refer to the greenhouse gas emissions that have been 'avoided', more or less by replacing fossil fuel energy sources.
- **Innovation (number):** innovation of new services and technology embedded in buildings or another asset of the city in relation to the project.

3.5 Securing Investment

3.5.1 Budget Allocation

The total estimated budget is shown in the following Table (12). As far as the business model for the city company TEPO several calculations regarding the OPEX were designed.

Table 13 shows an example of the calculation of the staff costs, internal contracts (incl. long-term establishment of the team) vs. external contractors. Not all aspects are covered in the summary (e.g. statical assessments, roof and building repairs, etc.). All prices are in EUR.

Table 12: Estimated budget

Investment component	CAPEX/OPEX	Estimated investment (Mil. EUR)
Renovation (I. wave)	CAPEX	35
	OPEX	5
PV installation	CAPEX	6
	OPEX	3
Modernisation of the central heating system	CAPEX	4
	OPEX	1
	CAPEX – private capital	Private capital
Innovation and digitalisation	CAPEX	6,7
	OPEX	2

Table 13: Calculation of the staff costs

Roles	FTE/year	Model internal staff (4 years)			Model external staff (4 years)		
		Internal FTE	Internal costs	External costs	Interna l FTE	Internal costs	External costs
Leadership	60.000	1	240.000	400.000	1	240.00	1.040.000

Project management	30.000	2	240.00		1	120.000	
Administration	20.000	2	160.000		1	80.000	
Project documentation	40.000	1	160.000	0	0	0	280.000
Installation	30.000	3	360.000	60.000	0	0	920.000
Overheads			240.000			104.000	
Summary		9	**1.850.000**		3	**2.780.000**	
Operation costs	30.000	2x0,5	36.000 / year	0	0	0	54.000 /year

3.5.2 Additional Sources of Funding

Table 14 shows the overall funding strategy in terms of sources the city uses for funding and how the city sees the payback period of the investment. The payback period includes grants and other sources.

Table 14: Funding strategy

Investment component	Description	Payback	Sources
Renovation (I. wave)	Analytical work, proposals, public tenders	15	National fund EFEKT; EU funds; Own budget; City company TEPO
	Renovation itself		
	Winter Stadium renovation (done)	30	National Sport Agency; Own budget; State fund; Financial Instrument
PV installation	Business model, project documentation, connection to the grid, tendering, statical assessment, Fire protection Permissions	10	EU funds, Own budget; EUCF; City company TEPO
	Reconstruction of the roof		
	Installations with batteries		
Modernisation of the central heating system	Modernisation of the system and reduction of line losses	Nr.	City company TEPO; EU funds
	Decrease in heat consumption from the heating plant	Nr.	Private capital of the power plant owner
	Decrease in electricity consumption from the distribution network	Nr.	
Innovation and digitalisation	Positive Energy Building Čabárna	Nr	EU funds; Own budget
	Broadband connectivity in city buildings and implementing	Nr.	EU funds, Own budget

	software solutions to strengthen cyber security		
	Energy management ISO 50001:2019	5	National fund EFEKT; Own budget
	Deploying smart metering in selected buildings	5	Own budget; EU funds
	Energy communities piloting	5	SPARCS, Own budget
	Energy flexibility testing	5	Horizon Europe project

3.6 Procurement/Implementation

3.6.1 Procurement

Kladno has been using electronic tendering systems and procedures in accordance with Publ. Law No. 134/2016 Coll.

The procurement of components will be held individually and in line with the Czech and EU legislation but also with the EU fund's methodological environment.

The public procurement within the project relates to small, medium, and large-scale tendering. Originally the EPC model was considered. The current focus is on regular tenders and contracts. The technological package of the renovation (= the package that doesn´t include any construction works) will be implemented by the city company TEPO in terms of in-house execution.

3.6.2 Implementation

All necessary measures and overall timetable are defined in chapter 4.4.1 Project Implementation Planning.

According to the plan, the next major steps foreseen are these:

- Renovation – first package is now under evaluation by state fund (= proposal under EU funds call; 7,2 Mil. EUR – almost 50% of the grant); second package is finalised, and the intention is to submit it in 2025; third package will be directly implemented by city company TEPO in 2024-2026).
- The PV system - first package (incl. renovation of the roof, installation of the panels, and battery) has been finalised in 2024; the next packages will follow; the current finalisation of the statical assessment and fire protection permissions are also under finalisation, also the preparation of the project and construction documentation.

3.7 Next Steps

3.7.1 Monitoring & Evaluation

Monitoring and evaluation are part of the quality management plan and internal system of the ISO 50001:2019 project, procedures, and other activities. It includes responsible bodies, schedules, and other relevant aspects.

There are no milestones for monitoring and evaluation since the work, escalation, and development as such are executed continuously.

3.7.2 Impact Assessment

The impact assessment is part of the continuous evaluation of SECAP. It is necessary to consult all aspects of the project from the budgetary perspective, environmental point of view, and the spatial development. Other insights are taken into account if relevant.

3.7.3 Post Management & Communication

The project is very complex, and it generally includes several stages, continuities and conditionalities. Renovation wave due to the EU legislation is an ongoing process and if the city has a capacity, funding and proper knowledge, also in terms of the smart city approach, the project will have other packages in the future. It is the same with the PV system which has considerable impact to the sharing of energy and energy communities/decentralisation models. Continuous work is also connected with the decarbonisation and modernisation of the central heating system and innovation gathering. Kladno has been strengthening its personnel capacity as well as energy management competences in the last years. The city’s plan is to further increase the professionalism of energy system management and communication capacities. Kladno already belongs to some of the most visible innovating cities in the Czech Republic and has also gathered attention internationally.

4. Positive energy district Sletiště

4.1 Project Scope

4.1.1 Project Scope Definition

A Positive Energy District (PED) is understood in a narrower sense as a location where a positive annual energy balance is achieved within a given system boundary. The specific calculation may vary according to the chosen definition of PED.

According to the definition used for the Czech Republic by the H2020 SPARCS project, a PED is "a part of a city that, through a series of technological and organisational innovations, achieves a plus energy balance while offering a high standard of quality of life. More renewable energy is produced than consumed in the district per year." (UCEEB, 2023).

Kladno has been for a long time dependent on its central source of district heating (covering two thirds of the city heating needs, with the remaining part covered by decentralised gas boilers). The district heating (DH) is controlled by the company TEPO, owned by the city but somewhat autonomous in making strategic decisions. The source itself (Kladno power plant) is operated by the private partner Sev.en Energy, big enterprise in the field of power production and mining, covering the whole value chain from coal production to selling electricity and heat, thus ensuring price of fuel control. It is a political priority of the city to keep stable supply of heat for reasonable prices.

The predominant fuel (close to 100 %) in recent years was coal. This situation is different from 2015 (baseline for SPARCS) when biomass accounted for about 20 % on the input. Kladno power plant produces power that is sent to grid. Heat is considered by the city as a „waste product“.[2]

In 2019 SPARCS came in with a vision to challenge status quo with potentially diversifying the heat supply (with potentially feeding heat from new renewable sources to the DH network or operating RES independently from the central distribution in selected localities where DH does not have economic sense) as well as decentralising power production. PED was imagined as a testing ground for adding new RES to the city energy mix.

The size of the proposed PED compared to the overall city heat consumption was small (around 2-4 GWh_h/an vs. approximately 250 GWh_h/an). However, PED would still represent a breakthrough at the local district level that shows the way for future decentralisation. In order not to disturb the central DH network, it was decided that the PED pilot could be implemented in either a new or existing district that is not connected to DH (potential connection of PED to DH later became one of the variants of the prefeasibility study). If successful, the PED would show an example to other Kladno districts to become more energy efficient, self-sufficient and flexible, contributing to overall city sustainability strategy and energy transition SECAP (2021).

For most of Kladno representatives, PED was a completely unknown concept before 2019. Thanks to the interaction with SPARCS consortium and close collaboration between the city and the UCEEB, PED became more familiar among the city representatives. The

[2] This approach has its pros and cons and it became a contentious point during the SECAP goals definition.

ambition to implement PED was taken up cautiously by some members of the city leadership and municipal office already during the proposal phase of SPARCS (Winter 2018-2019). The ambition was confirmed by the new leadership that came in 2019 and then again after the change of the City Council in 2020. After the initial period of stakeholder mapping and analysis of potential localities that took place in 2020 a decision was taken in March 2021:

"At its meeting on 8 March 2021, the Kladno City Council discussed the selection of sites for further examination of the feasibility of the PED and instructed the City Development Councillor O. Rys to analyse other suitable sites for the implementation of the energy-plus district, including the Růžové pole site and the Sletiště site. During follow-up discussions in the spring of 2021, the Sletiště site in Kladno and its surroundings was selected as a priority site" (UCEEB, 2023).

The city decided to first assess the feasibility and benefits of the proposed PED with the following objectives:

1. Verification of technical feasibility at the concept level,
2. Verification of economic feasibility,
3. Verification of stakeholder interest and readiness.

A Pre-feasibility study was then developed from March 2021 with updates being done until January 2023. This section of the Project Development Report is based on the aforementioned Pre-feasibility study (UCEEB, 2023).

The main added value of the study is the formulation of a conclusion on the three objectives. An important starting point is the fact that the construction and energy concept of the Sletiště site has not yet been addressed in an integrated way. The implemented study was therefore one of the first steps towards the development of an integrated energy concept for the entire site with the SAMK (sports area) complex as a key component.

At the concept level, the study verifies whether it is possible to achieve a positive energy balance on a selected set of buildings. The main technical alternatives and their variations in scope are identified and the recommended phasing is defined.

The verification focuses on the energy balance variables and abstracts to some extent from possible barriers, in particular the load capacity of the roofs for the installation of PV plants (this parameter is examined in the framework of parallel analyses carried out by the city's contractors).

Achieving an energy-plus balance on a selected set of buildings is one of the targets where feasibility can be assumed. The study shows that the economically viable option is not necessarily plus in the sense of local production. In this case, economic feasibility is the first priority in agreement with the city.

The study was designed as a basis for a discussion on the feasibility of the project. A phasing was outlined, whereby the plus balance is achieved gradually over a longer period (e.g. n+5, n+10, etc.) or as a "virtual" PED using a so-called green certificate. It was foreseen that the ambition can be adjusted from PED to "Towards PED", i.e. below the plus standard while still keeping main characteristics of the PED definition. The study considered also the concept of a Zero Emission Neighbourhood (ZEN) or achieving a plus balance in terms of non-renewable primary energy (as opposed to the current requirement for a net balance measured by the on-site energy ratio indicator.

For a preliminary examination of the economic feasibility, an indicative budget was calculated separately for the heat and electricity supply and the available financing options were analysed in combination with the operational model options considered. The zero option (gas) was compared. Separate models can be combined to achieve synergies, especially for heat production using a heat pump (HP).

In addition to technical and economic feasibility, the third key variable is the interest and readiness of the stakeholders to implement PED. A working group "Sletiště" coordinated by Kladno has been established to continuously exchange information and verify the assumptions for PED. A series of meetings were held both within the narrower "Sletiště" working group (a group of stakeholders from city organisations) and within the wider circle of partners (owners and investors in the area) to continuously complete information, verify assumptions and verify interest and willingness to cooperate on the project.

4.1.2 Geographical Location

Potential locations were analysed in a comprehensive pre-study by CVUT in 2020 (Výběr lokality pro energeticky plusovou čtvrť na Kladně (ČVUT UCEEB, 2020), in Czech). The methodology for locality selection was the following:

1. Analysis of the areas in which the zoning plan requires a zoning study or regulatory plan. Of these, several were selected as suitable for PED.

2. The analysis was subjected to a critique, on the basis of which the original area was expanded to include all known relevant projects in the area.

3. Everything was re-analysed first in terms of spatial layout. Consideration was given not only to the location of the PED within the city and the functional mix, but also to the size of the area, the number of owners, whether the land was contaminated, and whether, in the opinion of city officials and representatives, there was a prospective investor interested in implementing a Positive Energy District on the site.

4. Based on the energy and economic considerations, four broad areas were selected for further analysis of possible PED implementation. These four areas, or parts of them were described in more detail in the pre-analysis.

The common denominator of all the selected areas is the proximity of the DH network, which presents the potential for connecting existing developments to low energy distribution in the PED in the future. At the same time, the existing district heating system can be used as a backup source for the PED. The connection of the existing buildings is conditional on the implementation of energy saving measures, such as the reduction of heat loss of the buildings, etc. However, before that, it is necessary to measure the electricity and heat consumption of the individual buildings of the existing development.

5. Identification of priority sites for further investigation and negotiations by the Kladno city management.

6. Mapping and analysis of the baseline parameters for possible cooperation with partners for individual areas. For this step it was not yet required to have detailed technological proposal for a solution. Its aim was mainly to verify the opportunities for cooperation with investors in the territory.

7. Gradual narrowing down of the number of territories and further steps for the preparation of the investment plan for the selected territories and solutions in line with the SPARCS plan as defined in the Grant Agreement with the European Commission. The parallel discussions on the city vision served as one of the bases for further decision-making.

The four sites analysed in more detail (see map, Figure 15) have the working titles: Vítězná (including the Sletiště/SAMK area) (1), Siedlung (2), Jih/South (3) and Oáza (4). These areas have been examined in more detail from an urban planning, energy and economic point of view. For locality 1 there were three sub-areas (1.1 Sletiště sports area/SAMK, 1.2 greenfield defined by the Regulation plan no. 4 (Binding land use study) and 1.3 Central (with a shopping centre).

For each of the potential PED areas, the description contained:

1) a basic overview of the perspective of the pros and cons from the urban planner,

2) preliminary energy concept (technology evaluation),

3) preliminary economic concept (business model evaluation).

Figure 15: Four shortlisted potential areas for PED in 2020

From the four "big" localities, altogether divided between 6 sub-localities, no. 1.1 was selected as the most suitable. The locality was rebranded for the purpose of the Pre-feasibility study as "PED Sletiště" (Sletiště is a place of sports convention). In the next sections, only this locality is considered. For more details on the other three localities consult the document Výběr lokality pro energeticky plusovou čtvrť na Kladně (ČVUT UCEEB, 2020).

PED Sletiště boundaries were defined according to phases into the core, mostly city-owned sports area (phase 1), and further development and outlook, beyond the sports area itself (phase 2), see the map (Figure 16). Phase 1 was further considered in detail in the Pre-feasibility study.

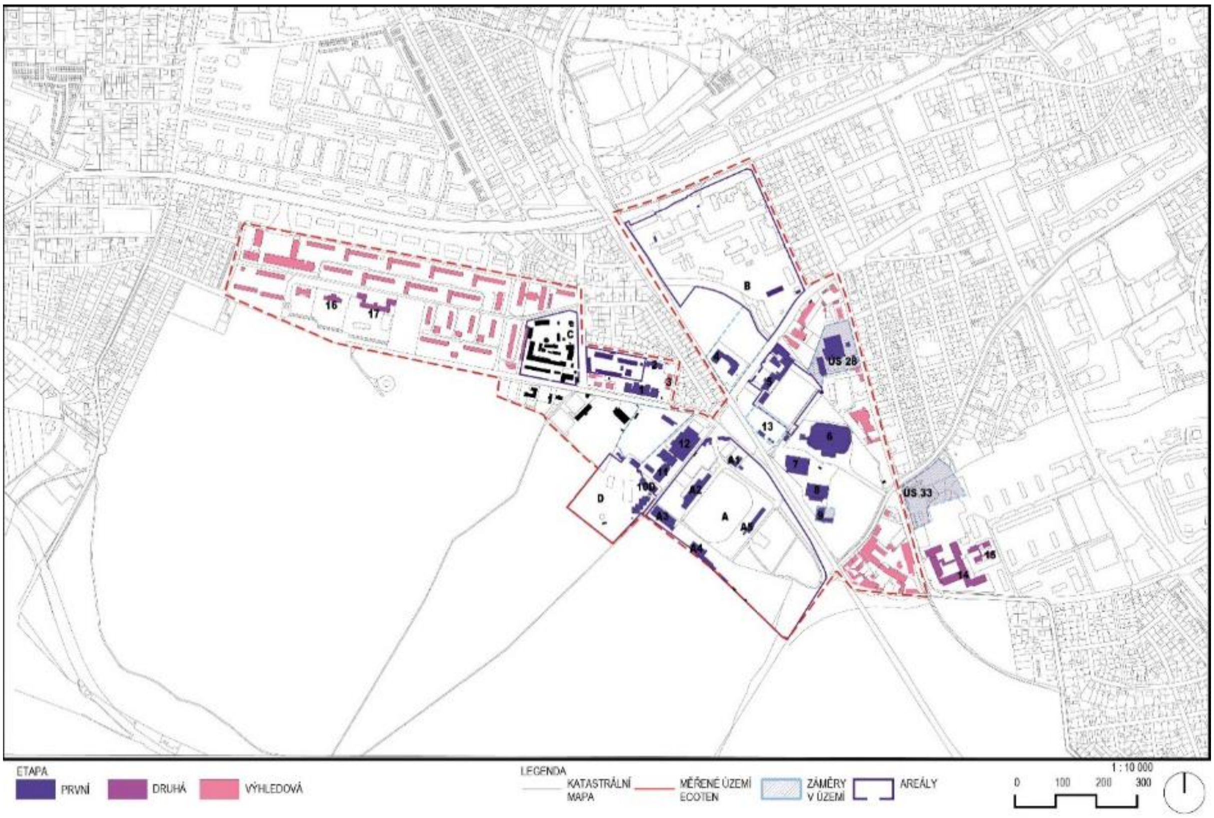


Figure 16: Phases of PED

PHASE 1 (dark violet)*: 1 CVUT barracks, 2 Barracks (Faculty of Biomedical Engineering – FBMI), 4 Senior house, 5 Stadium Fr. Kloze, 6 Winter stadium, 7 BIOS sports hall, 8 Hockeyball tribunes, 9 Sauna - reconstruction, 11 Aquapark: main pavillion + old indoor pool, 12 Kladno sports hall, 10D Hotel, Restaurace, A Sletiště (A2 Tribunes and sports hall, A3 Athletic hall, A4 Stables), D Summer pool, ÚS 28 – Mrazírny, ÚS 33 – Ke Stadionu;*

PHASE 2 (purple and pink)*: 3 Healthcare facility, 14 Sports gymnasium, 15 Kindergarten Plzeňská, 16 Kindergarten Moskevská, 17 Kindergarten Moskevská.*

The heart of the site is the Sletiště/Areál SAMK (Sportovní areály města Kladna, s.r.o.). SAMK is one of the key stakeholders of the area, as it also manages other sports facilities, which are located from the perspective of the main area "behind the railway line" from Sletiště (it is the railway line between the stops Kladno and Kladno-Město). The second part of the site is represented by privately owned residential and tertiary buildings.

The broader definition of the locality "Sletiště" is given by Ke Stadionu, P. Bezruče, South-West border of the SAMK area, Sportovců Street, nám. Jana Masaryka Street, Petrohradská Street, U Vodojemu Street, Sochorova Street, Žerotínova Street, railway line Kladno - Prague, Československé armády Street, Vančurova Street, František Kloz Street. See coloured objects on the map (Figure 16).

Sletiště itself is located at the southeastern tip of Kladno. It brings together several major sports venues with facilities and buildings for sport and leisure. Behind the railway there are other sports facilities such as the ice rink or the František Kloze football stadium.

The detailed profile of each of the buildings in Phase 1 was created. Then the buildings in Phase 1 were divided into two subgroups, i.e. two main PED Sletiště alternatives: 1) PED Winter Stadium („PED ZS“), 2) PED Aquapark.

Table 15: List of buildings in PED Sletiště Phase 1, divided into two alternatives: PED ZS and PED Aquapark

Map code	Name	Adress	State**	Owner	PED ZS	PED Aquapark
1	CVUT barracks	Sportovců 2311	S	Statutární město Kladno		YES
4	Senior house	Františka Kloze 1178	S	Statutární město Kladno		YES
11	Aquapark: Main pavillion + old indoor pool	Sportovců 818	R	Statutární město Kladno		YES
12	Kladno sports hall	Sportovců 817	S	Statutární město Kladno		YES
10D	Hotel, Restaurace	Sportovců 818	S	Statutární město Kladno		YES
A2	City stadium	Sportovců 456	R	Statutární město Kladno		YES
A3	Athletic hall	Sportovců 456 (parc. č. st. 1358) *	S	Statutární město Kladno		YES
A4	Jízdárna Kladno / Stables	Sportovců 714	S	Tělocvičná jednota Sokol Jízdárna Kladno		YES
5	Stadium Fr. Kloze	Fr. Kloze 2609	R	Statutární město Kladno	YES	YES
6	Winter stadium	Hokejových legend 2531	R	Statutární město Kladno	YES	
7	BIOS sport hall	P. Bezruče 3368	S	Statutární město Kladno	YES	
8	Hockeyball tribunes	Sportovců 1085	S	Statutární město Kladno	YES	
9	Sauna reconstruction	Plot číslo 1085/3, 1066*	R	Statutární město Kladno	YES	
ÚS 28	ÚS 28 – Mrazírny	Ke stadionu (plot č. 1098, 1099, 1100, 1102/1, 1102/2, 1104) *	Z	Residential area U STADIONU – Kladno a.s.	YES	

*All plot numbers refer to the cat. territory of Kladno Rozdělov. **S = existing; R = to be reconstructed; Z = planned.

4.1.3 Preliminary Technology Assessment

For the initial PED design the following technologies were suggested based on expert assessment of local potentials, considering the technology risk attached to different technologies (i.e. no space/untested technologies were considered):

Ground-to-water heat pump – source of low-potential heat in ground boreholes under new housing construction ÚS 28.

Solar water heating plant – on or near the roof of the aquapark. The summer surplus of the solar heating plant can be used to heat the pool water.

Low-temperature local heating network – for apartment buildings in new development, senior citizens' home, FBMI area and water park.

Waste heat – waste heat from the ice rink cooling can be used in the low-temperature local heating network. Waste heat cannot yet be used in the hospital as the cooling in the hospital is not centralised, but this is a challenge for the future.

Photovoltaic panels – advantageous areas for the installation of photovoltaic panels are on the stands of the sports grounds, the ice rink and the FBMI (Faculty of biomedical engineering) campus.

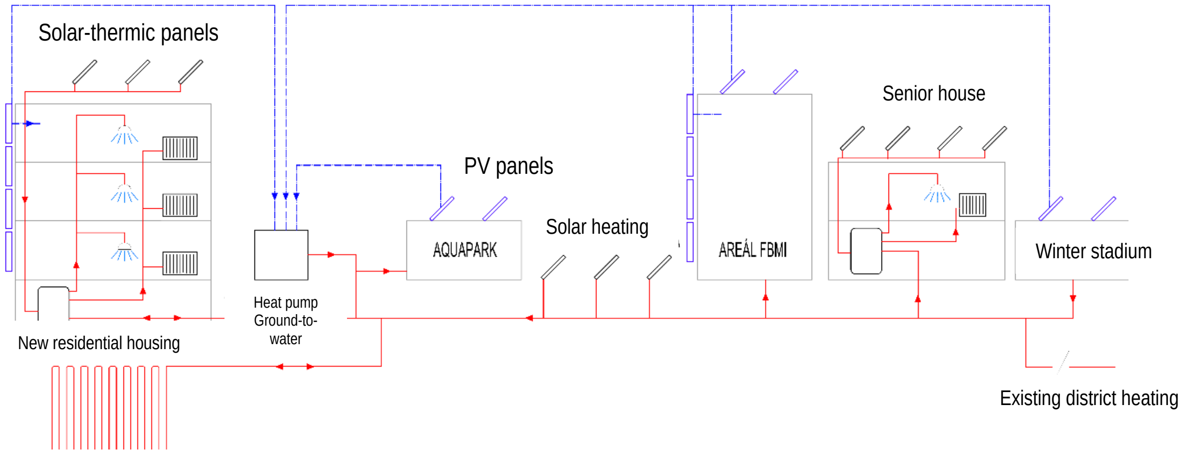


Figure 17: The diagram of an energy-positive district of new apartment buildings combined with an aquapark

This initial diagram (see Figure 17) considers only one alternative integrating almost all available types of buildings in the locality PED Sletiště before it was disaggregated into two main alternatives with five variants in each of the alternatives.

4.1.4 Preliminary Assessment of Business Models

The city was considered a main sponsor of the solution, pursuing its decarbonisation as well as sustainable economic development strategies. Ultimately, the city was considered the main investor, teaming up with other public (e.g. the university, senior house etc.) and private partners (residential real estate developer) whose vested interest would be to save on energy costs in operation thanks to supply by the PED. The city would not act directly, but rather through its heating distribution company TEPO that is 100% public limited liability company. This arrangement has been consistently considered as the baseline investment model throughout SPARCS (2020-2024). Special purpose vehicle (possibly with private participation) would then be only a specific sub-variant of this alternative.

The preliminary assessment of the economic potentials considered only the type of potential (city) investor. For the whole wider locality PED Sletiště it became clear that the locality requires some form of partnership of smaller number of established investors. The analysis concluded that "the complexity of the solution will be supported by the strong role of the investor and the operator of the whole system. The economic sustainability of the project could be guaranteed financially and organisationally by a strong partner or consortium that can:

- withstand large investment costs with a long payback period,
- efficiently raise financing for innovative projects,
- ensure the transfer of energy within the PED and its marketing outside.

The added value on the end-user side will vary depending on the chosen asset-operating solution. Cities abroad have a relatively large experience with such projects, which presents a greater opportunity to apply already tested, successful models." (ČVUT UCEEB, 2020).

4.1.5 Supporting Factors & Barriers

In Kladno, the following factors were mapped during the project design phase on the way towards the PED development in general:

Supporting factors:

- PED became one of the measures listed in the Kladno SECAP (2021).

Barriers:

- No previous experience with high-complexity energy projects on district level;
- Conservative approach to heat supply, ensuring stability of energy supply before decarbonisation or decentralised solutions, perceived high risk aversion.

Within the locality PED Sletiště:

Supporting factors:

- functional mix, strong city role, adaptation of amenities, close to buildings with one owner (CVUT FBMI, seniors' home)

Barriers:

- separation of the site by a busy road and the future reconstruction of the railway line (may be an advantage), relatively small construction project

PED-EU-NET mapping for Winter Stadium variant (ZS)

Within the scope of mapping by COST Action PED-EU-NET Working Group 1 in 2022 a comprehensive mapping of unlocking factors and barriers (see Table 16) took place for Sletiště with the following assessment (on Likert scale). The result is available at https://pedeu.net/map/.

Table 16: Results of the comprehensive mapping of unlocking factors and barriers

Unlocking Factors, Barriers	Level of Importance in Kladno Sletiště (Winter Stadium, ZS)
C1P001: Unlocking Factors	
C1P001: Recent technological improvements for on-site RES production	4 - Important
C1P001: Innovative, integrated, prefabricated packages for buildings envelope / Energy efficiency of building stock	4 - Important
C1P001: Energy Communities, P2P, Prosumers concepts	3 - Moderately important
C1P001: Storage systems and E-mobility market penetration	3 - Moderately important
C1P001: Decreasing costs of innovative materials	3 - Moderately important
C1P001: Financial mechanisms to reduce costs and maximise benefits	4 - Important
C1P001: The ability to predict multiple benefits	2 - Slightly important

C1P001: The ability to predict the distribution of benefits and impacts	3 - Moderately important
C1P001: Citizens improved awareness and engagement on sustainable energy issues (bottom-up)	3 - Moderately important
C1P001: Social acceptance (top-down)	2 - Slightly important
C1P001: Improved local and national policy frameworks (i.e. incentives, laws etc.)	2 - Slightly important
C1P001: Presence of integrated urban strategies and plans	4 - Important
C1P001: Multidisciplinary approaches available for systemic integration	3 - Moderately important
C1P001: Availability of grants (from EC or other donors) to finance the PED Lab projects	5 - Very important
C1P001: Availability of RES on site (Local RES)	4 - Important
C1P001: Ongoing or established collaboration on Public Private Partnership among key stakeholders	4 - Important
C1P001: Any other unlocking factors	4 - Important
C1P001: Any other unlocking factors (if any)	Collaboration with the local partners
C1P002: Driving Factors	
C1P002: Climate Change adaptation need	3 - Moderately important
C1P002: Climate Change mitigation need (local RES production and efficiency)	4 - Important
C1P002: Rapid urbanisation trend and need of urban expansions	3 - Moderately important
C1P002: Urban re-development of existing built environment	3 - Moderately important
C1P002: Economic growth need	4 - Important
C1P002: Improved local environmental quality (air, noise, aesthetics, etc.)	3 - Moderately important
C1P002: Territorial and market attractiveness	3 - Moderately important
C1P002: Energy autonomy/independence	4 - Important
C1P002: Any other driving factor	3 - Moderately important
C1P003: Administrative barriers	
C1P003: Difficulty in the coordination of high number of partners and authorities	4 - Important
C1P003: Lack of good cooperation and acceptance among partners	5 - Very important
C1P003: Lack of public participation	4 - Important
C1P003: Lack of institutions/mechanisms to disseminate information	3 - Moderately important
C1P003: Long and complex procedures for authorization of project activities	4 - Important
C1P003: Time consuming requirements by EC or other donors concerning reporting and accountancy	3 - Moderately important
C1P003: Complicated and non-comprehensive public procurement	3 - Moderately important
C1P003: Fragmented and or complex ownership structure	5 - Very important

C1P003: City administration & cross-sectoral attitude/approaches (silos)	5 - Very important
C1P003: Lack of internal capacities to support energy transition	4 - Important
C1P003: Any other Administrative barrier	4 - Important
C1P003: Any other Administrative barrier (if any)	Fragmented financial support; lack of experimental budget for complex projects, etc.
C1P004: Policy barriers	
C1P004: Lack of long-term and consistent energy plans and policies	3 - Moderately important
C1P004: Lacking or fragmented local political commitment and support on the long term	5 - Very important
C1P004: Lack of Cooperation & support between national-regional-local entities	4 - Important
C1P004: Any other Political barrier	4 - Important
C1P004: Any other Political barrier (if any)	Different priorities: overall problematic system od decentralisation powers; non-functioning model of local development funding, etc.
C1P005: Legal and Regulatory barriers	
C1P005: Inadequate regulations for new technologies	3 - Moderately important
C1P005: Regulatory instability	3 - Moderately important
C1P005: Non-effective regulations	4 - Important
C1P005: Unfavourable local regulations for innovative technologies	4 - Important
C1P005: Building code and land-use planning hindering innovative technologies	4 - Important
C1P005: Insufficient or insecure financial incentives	5 - Very important
C1P005: Unresolved privacy concerns and limiting nature of privacy protection regulation	3 - Moderately important
C1P005: Shortage of proven and tested solutions and examples	3 - Moderately important
C1P005: Any other Legal and Regulatory barrier	1 - Unimportant
C1P006: Environmental barriers	
C1P006: Environmental barriers	n/a
C1P007: Technical barriers	
C1P007: Lack of skilled and trained personnel	4 - Important
C1P007: Deficient planning	4 - Important
C1P007: Retrofitting work in dwellings in occupied state	4 - Important
C1P007: Lack of well-defined process	5 - Very important
C1P007: Inaccuracy in energy modelling and simulation	3 - Moderately important
C1P007: Lack/cost of computational scalability	2 - Slightly important
C1P007: Grid congestion, grid instability	4 - Important
C1P007: Negative effects of project intervention on the natural environment	3 - Moderately important

C1P007: Energy retrofitting work in dense and/or historical urban environment	3 - Moderately important
C1P007: Difficult definition of system boundaries	4 - Important
C1P007: Any other Technical barrier	4 - Important
C1P007: Any other Technical barrier (if any)	Inadequate regulation towards energy transition
C1P008: Social and Cultural barriers	
C1P008: Inertia	3 - Moderately important
C1P008: Lack of values and interest in energy optimisation measurements	4 - Important
C1P008: Low acceptance of new projects and technologies	5 - Very important
C1P008: Difficulty of finding and engaging relevant actors	4 - Important
C1P008: Lack of trust beyond social network	3 - Moderately important
C1P008: Rebound effect	3 - Moderately important
C1P008: Hostile or passive attitude towards environmentalism	3 - Moderately important
C1P008: Exclusion of socially disadvantaged groups	3 - Moderately important
C1P008: Non-energy issues are more important and urgent for actors	5 - Very important
C1P008: Hostile or passive attitude towards energy collaboration	3 - Moderately important
C1P008: Any other Social barrier	1 - Unimportant
C1P009: Information and Awareness barriers	
C1P009: Insufficient information on the part of potential users and consumers	3 - Moderately important
C1P009: Perception of interventions as complicated and expensive, with negative socio-economic or environmental impacts	4 - Important
C1P009: Lack of awareness among authorities	4 - Important
C1P009: Information asymmetry causing power asymmetry of established actors	3 - Moderately important
C1P009: High costs of design, material, construction, and installation	5 - Very important
C1P009: Any other Information and Awareness barrier	1 - Unimportant
C1P010: Financial barriers	
C1P010: Hidden costs	4 - Important
C1P010: Insufficient external financial support and funding for project activities	4 - Important
C1P010: Economic crisis	3 - Moderately important
C1P010: Risk and uncertainty	4 - Important
C1P010: Lack of consolidated and tested business models	4 - Important
C1P010: Limited access to capital and cost disincentives	1 - Unimportant
C1P010: Any other Financial barrier	1 - Unimportant
C1P011: Market barriers	
C1P011: Split incentives	5 - Very important

C1P011: Energy price distortion	5 - Very important
C1P011: Energy market concentration, gatekeeper actors (DSOs)	5 - Very important
C1P011: Any other Market barrier	1 - Unimportant

4.2 Market Consultation

4.2.1 Solution Requirements/Functions for heat distribution

For both alternatives of PED Sletiště: 1) PED ZS (4 variants) and 2) PED Aquapark (4 variants) a basic energy solution (sources) was defined, see below. The PED ZS alternative with its first variant (V1) was selected to be further developed.

PED Winter stadium V1 - local distribution with heat pump waste heat/water

The first option considers a local heat distribution system with a heat pump as the main heat source, using waste heat from the ice rink cooling as a source of low-potential heat. The current gas boilers installed in the boiler room of the ice rink (990 kW) are considered as a backup heat source. For the installation of the heat pump it will be necessary to properly size the heat storage according to the ice rink's operating schedule. For the basic design a heat pump of 550 kW was chosen. The temperature gradient in the distribution system was considered to be 70/40°C. The electricity consumption of the heat pump was 729 MWh/year and the delivered heat was 2552 MWh/year.

PED Winter stadium V2 - installation of heat pump and connection to DH

In the second variant, the city's heat distribution system is considered as a backup heat source. Assuming a reduction in the district heating temperatures, it would be possible to use the surplus from the heat pump in the district heating system in the future for this option. The temperature gradient in the local part of the distribution system was considered to be 70/40 °C. The electricity consumption of the heat pump was 729 MWh/year and the delivered heat was 2552 MWh/year.

PED Winter stadium V3 - connection to district heating

The third option considers the connection of the site to the district heating with a temperature gradient of 90/60 °C.

PED Winter Stadium V4 - decentralised gas boilers

The fourth option corresponds to the current state of installed decentralised gas boilers. The installation of decentralised gas boilers with an output of 630 kW is considered in ÚS 28 - freezer rooms.

PED Aquapark V1 - local distribution with ground/water heat pump and gas cogeneration

In the first variant, local distribution between the buildings was considered. A ground/water heat pump with an output of 560 kW together with a gas cogeneration unit with a nominal output of 120 kWe was considered as the main heat source. The electricity consumption of the heat pump was 811 MWh/year and the delivered heat was 2840 MWh/year. The gas boilers installed in the boiler room of the aquapark with a capacity of 1800 kW can be used as a backup heat source. The temperature gradient in the distribution system was assumed to be 70/40 °C.

PED Aquapark V2 - local distribution with gas CHP

In the second option, a gas CHP unit with an installed capacity of 320 kWe is considered. The gas CHP unit was sized to cover 50% of the total heat demand. The gas boilers installed in the boiler room of the aquapark with a capacity of 1800 kW can be used as backup heat sources. The temperature gradient in the local part of the distribution system was considered to be 90/60 °C.

PED Aquapark V3 - connection to city district heating system

The third option considers the connection of the site to CHP with a temperature gradient of 90/60 °C.

PED Aquapark V4 - decentral gas boiler rooms

The fourth option corresponds to the current state of installed decentralised gas boilers.

Based on the preliminary decision to prioritise PED Winter Stadium V1, draft list of technology priorities (see Table 17) was introduced and will be further refined during internal discussions within city leadership and the market consultation.

Table 17: Draft list of technology priorities for the Winter Stadium

Solution (PED Winter Stadium, V1)	Priority PED Phase I	Status
New energy centre for the Winter Stadium	High	Procured, implemented[2]
Connection to the city district heating	High	Planned, implementation started[3]
Heat pump waste heat-water	High	Feasibility assessment ongoing
Winter Stadium PVs and smart metering	High	Market consultation ongoing
Other buildings PVs and smart metering	High	Market consultation planned
Energy management software for buildings	High	Procured, implemented[1]
Interconnection of buildings within PED with the local low temperature district heating	Medium	Feasibility assessment planned
Energy community establishment by the city	Medium	Planning phase[7]
Energy communities on the residential housing level	Medium	Planning phase[4]
Other buildings heat energy source refurbishment	Optional	Individual feasibility assessment needed
Winter Stadium, power demand-response pilot	Optional	Planned, implementation started[5]
IoT applications (different use cases)	Optional	Scoping and roadmapping phase[6]

1) The SW Energy Broker was implemented for city owned buildings; a full-fledged solution will require a robust integrated solution for the entire PED; 2) National project funded by SFP (State fund for Environment); 3) Implemented by the TEPO company; 4) Pilot planned by the city, several expressions of interest from private owner associations; 5) Part of the Horizon Europe GLocalFlex project (GA ID 101096399); 6) A separate plan for IoT solutions has been in development in 2024 by *the city and CVUT; 7) The TEPO company obtained a licence for PV production and trading by the regulatory authority, ER.*

4.2.2 Market Consultation

Majority of the PED solutions require further planning and feasibility assessment (e.g. the waste heat harvesting heat pump) and handful of them has been already implemented (e.g. energy management software for municipal buildings), see previous section 4.2.1. As of 9/2024 the market consultation went on for the PV solution and metering for the Winter Stadium (2023-2024).

Market consultation process was based on detailed model of possible solutions by CVUT that assessed the technical feasibility and overall potential for PV installation. CVUT established the maximum area for installation to be 4 200 m^2. The Excon company was consulted to learn details on the roof construction, surface materials and options for mounting of the PV.

Roof construction requires very sensitive and innovative approach because it was not originally designed to carry photovoltaic panels. It was established that no drilling into roof metal sheets covered by bituminous membrane was possible, therefore only glued PV panels can be applied.

Figure 18: Winter stadium roof

Author: Petr Wolf, UCEEB

Only European PV solutions were considered due to bad experience with Asian semi-flexible solutions[3] and risks associated with guarantees and service level conditions. Three solutions manufactured in the EU were assessed for technical feasibility and expected cost. The companies were addressed in person (SOLSOL), information was extracted from published materials (SoliTek) or through correspondence (DAS Energy).

[3] This decision was inter alia based on test with multiple Asian-made semi-flexible solutions carried out at CVUT FEL (Faculty of Electroengineering). This finding should not be generalized to non-flexible standard solutions.

Fact-finding mission to Austria (DAS Energy) was planned for 2024 as their solution seems represent the most suitable option for Kladno's needs. The installation procedure was also discussed. See Table 18 for assessed companies.

Table 18: Companies and stakeholders assessed/spoken to

Company name	Role	Activity
Excon (Czech Republic)	Delivered the static assessment	Consulted feasible solutions for mounting the PV (3-6/2023)
SoliTek (Lithuania)	Solution provider	Provided information about available PV solution (e.g. SoliTec SOLID Bifacial 60 cell)
DAS Energy (Austria)	Solution provider	Provided information about available PV solution (e.g. DAS Energy 11x6 modules)
SOLSOL s.r.o. (Czech Republic)	Solution provider	Provided information about available PV solution (e.g. AEG AS-M3607-S)

4.2.3 Proposed Technologies

The market consultation (see Section 4.2.2) assessed mainly the innovative photovoltaic solution for the Winter Stadium, which lies at the core of PED Sletiště. Here are the characteristics of the solution pre-selected as the most fitting to the needs of the city of Kladno, see Figure 19.

			Segment									Weight [kg]				
			Segment number	Slope [°]	Length [m]	Width [m]	Area [m2]	Number of modules [pcs]	Power [kWp] (approx.)	PVSOL yield [kWh/kWp]	Annual production [MWh]	PV modules	Construction (estimate)	Other (cabling,...)	Total	Specific weight [kg/m2]
DAS Energy 11x6		Southern orientation	1	**23**	3,3	63,4	209,22	80	26,4	**1004**	26,5	400	24	24	448	2,1
			2	**20**	5,1	63,4	323,34	124	40,9	**994**	40,7	620	37	37	694	2,1
			3	**16**	4,1	63,4	259,94	99	32,7	**977**	31,9	495	30	30	554	2,1
			4	**13**	4,2	63,4	266,28	102	33,7	**961**	32,3	510	31	31	571	2,1
			5	**10**	4,2	63,4	266,28	102	33,7	**943**	31,7	510	31	31	571	2,1
			6	**7**	4,1	63,4	259,94	99	32,7	**924**	30,2	495	30	30	554	2,1
			7	**4**	4,1	63,4	259,94	99	32,7	**902**	29,5	495	30	30	554	2,1
			8	**1**	4,1	63,4	259,94	99	32,7	**878**	28,7	495	30	30	554	2,1
		Northern orientation	9	**-1**	4,1	63,4	259,94	99	32,7	**860**	28,1	495	30	30	554	2,1
			10	**-4**	4,1	63,4	259,94	99	32,7	**833**	27,2	495	30	30	554	2,1
			11	**-7**	4,1	63,4	259,94	99	32,7	**804**	26,3	495	30	30	554	2,1
			12	**-10**	4,2	63,4	266,28	102	33,7	**774**	26,1	510	31	31	571	2,1
			13	**-13**	4,2	63,4	266,28	102	33,7	**743**	25	510	31	31	571	2,1
			14	**-16**	4,1	63,4	259,94	99	32,7	**713**	23,3	495	30	30	554	2,1
			15	**-20**	5,1	63,4	323,34	124	40,9	**673**	27,5	620	37	37	694	2,1
			16	**-23**	3,3	63,4	209,22	80	26,4	**643**	17	400	24	24	448	2,1
			Total				**4 210**	**1 608**	**530,6**		**452**	**8 040**	**482**	**482**	**9 005**	**2,1**

Figure 19: Model specification for PV solution

4.3 Detailed Assessment

4.3.1 Legal/Regulatory Framework

From the point of view, including with regard to implementation of the PED Sletiště, the following legal documents are crucial on the national level:

The Energy Act (No. 458/2000 Coll.), adopted in 2000 and amended in 2023, is the main legal framework for heating and cooling policies in the Czech Republic. It regulates the production, distribution, transmission, storage, trade and consumption of energy. The Ministry of Industry and Trade (MPO) is the authority with overall cross-sectoral responsibilities, coordinating the national policies and plans for increasing the share of RES, the energy efficiency and the security of the heating and cooling sector.

The Act on Supported Energy Sources (ASES) (No. 165/2012 Coll.), adopted in 2012, regulates the guarantees of origin for renewable sources, and supports the market competitiveness of renewable energies for achieving the national targets while minimising the economic impacts on energy prices".

The Act on Energy Management (No. 406/2000 Coll.), adopted in 2000 and amended several times, regulates energy efficiency measures, including the efficiency of heating and cooling systems. It sets standards and requirements for energy consumption in buildings and for energy-using appliances. It defines the "state energy concept", a strategic document expressing the state's goals in managing energy in accordance with the principles of sustainable development, ensuring the security of energy supply, competitiveness of the economy and social acceptability for the population.

For the implementation of any PED, the key aspect is the energy sharing between production facilities (e.g. roof photovoltaics) and points of consumption (buildings or other). At the beginning of 2024, the existing legal acts in the Czech Republic did not fully account for energy sharing schemes (Citizen Energy Community, Renewable Energy Community) envisaged by relevant European Directives (especially Renewable energy directive 2018/2001/EU or RED II). The transposition process was much delayed, with only partial process innovations in place (such as the legal framework for energy sharing within residential buildings). However, since July 2024 the energy sharing (especially self-produced electricity for community/small owner groups) became possible (so called Lex OZE II). The foreseen format is "energy active customer" (with limited number of connected consumption points, or EANs) or "energy community" (theoretically up to 1000 points of consumption). One form can be later turned into the other. For Kladno we foresee ultimately the energy community as the relevant approach (see the following).

4.3.2 Technical Assessment

The main innovative technical aspect is the integration of energy production and consumption into the local grid, which allows efficient energy sharing. From the point of view of increasing the own use of locally generated electricity, it is advantageous to create clusters of buildings. In the current state, the listed buildings of Sletiště have individual points of consumption (PoCs), i.e. interfaces at which both consumption and supply to the grid are billed. If the buildings act separately, each with its own off-take point, situations arise where surplus electricity from the PV plant in a particular building is delivered to the external grid and at the same time in other buildings where there is a shortage of energy, energy has to be purchased, including all components (i.e. power cost, including distribution, taxes, etc.).

In the case of energy sharing between several buildings (e.g. in the case of Winter Stadium), the situation arises that if the surplus production in one building is not currently used, this energy can be used in another consumption point. The sharing of energy between multiple existing consumption points can be achieved in several ways.

1) Merging of points of consumption

This method requires the selection of the initial PoC (usually one of the existing PoC), then increasing its capacity to the value corresponding to the required maximum concurrent consumption of the merged PoC, creating its own interconnection line from this PoC to the other objects and then cancelling the other unused PoCs. See the diagram of merging of PoC in Figure 20.

Advantages:

- Real creation of own microgrid, without the need for third party interaction and conditions during operation (e.g. distribution);
- Possibility to reduce the capacity and thus the monthly payments of the default PoC.

Possible problems/risks:

- Sometimes it may not be technically feasible to increase the capacity of the selected PoC;
- Problems in implementing interconnection lines between facilities (land, roads in different ownership, technical constraints...);
- Line losses when objects are distant;
- Shared facilities will have only one PoC, therefore one energy supplier - limitations if there are multiple operators or building owners;
- Possible restrictions on the conditions of use of existing tariffs (e.g. pooled flats may no longer get a favourable tariff for households);
- Need to ensure sub-metering and distribution of payments between building operators.

For the PED options considered, this model seems less appropriate due to the complexity of the building ensembles. However, it can be implemented locally at the level of a selected subset, e.g. a residential complex.

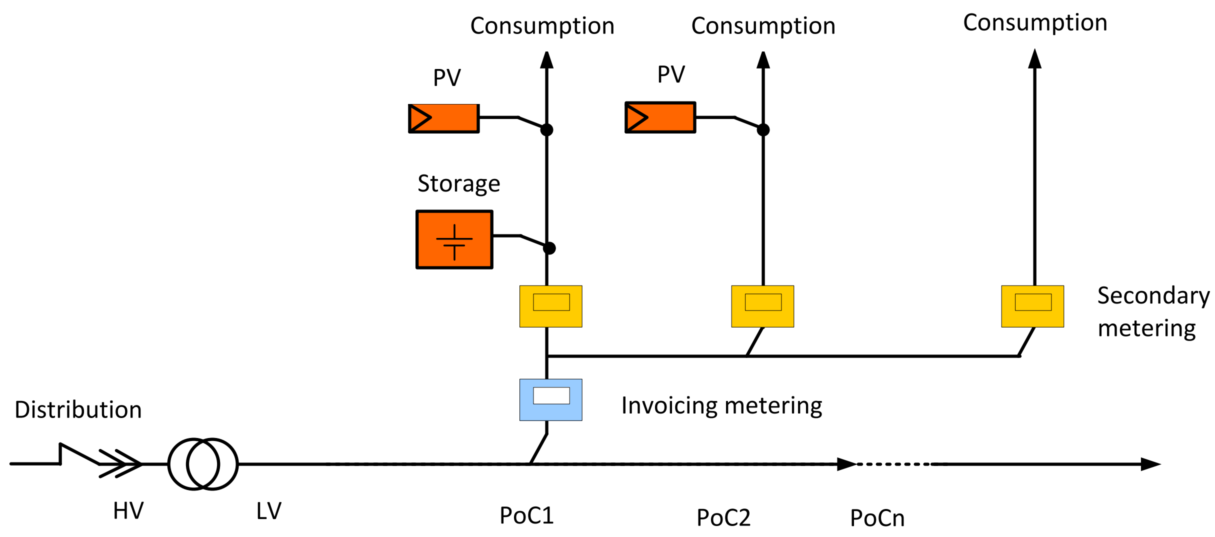


Figure 20: Diagram of Merging of points of consumption

HV – high voltage, LV – low voltage, PV – Photovoltaics, PoC – Point of consumption.

Author: Petr Wolf, UCEEB

2) Creating Local Distribution Network (LDN)

This form is often used within industrial or commercial centres. The LDN operator is responsible for the operation and maintenance of the local network, either owning it or leasing it. It is the operator's responsibility to define in the code the rules for the operation of this local embedded distribution network (often based on rules similar to those of the external network). The LDN operator manages a number of PoCs within the LDN and is entitled to the charges associated with the operation of this network. See the diagram of LDN in Figure 21.

Advantages:

- Legally enabled, long used in the Czech environment.

Potential problems/risks:

- Need to build new or lease or buy out existing electricity network;
- Legally more complex implementation and operation process.

For the PED options considered in this study, this model appears to be inappropriate due to the existing topology of the distribution network in the area and the cost of investing in its eventual change.

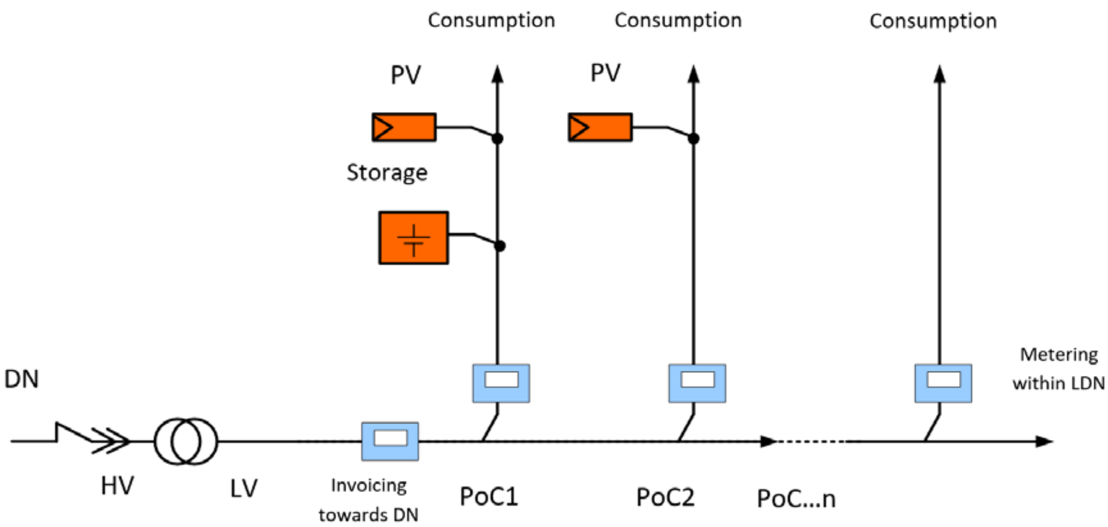


Figure 21: Diagram of Local Distribution Network

HV – high voltage, LV – low voltage, PV – Photovoltaics, DN – master distribution network, LDN – local distribution network, PoC – Point of consumption.

Author: Petr Wolf, UCEEB

3) Energy sharing within the energy community or „energy active customer"

This method of energy sharing has been enabled and anchored in the Czech Republic as of mid-2024 with the New Energy Act and related other legislative changes (so called Lex OZE II). It should enable the creation and operation of a simple model of electricity sharing using existing electricity networks under fair conditions (savings on both power electricity price component, however not yet on distribution component). See the diagram of the transition to electricity sharing in the energy community in Figure 22.

Advantages:

- Expected simplicity of the solution, both legislative and technical,

- No need to build additional infrastructure,
- The management of PoC remains the responsibility of the respective distributors in the territory,
- Possibility of choosing individual energy suppliers for each PoC.

Potential problems/risks:

- Very freshly enabled by legislation in the country, not much experience yet,
- Necessity to install continuous metering (smart metering) for OM integrated into the community; however, this shall be arranged by the distribution company.

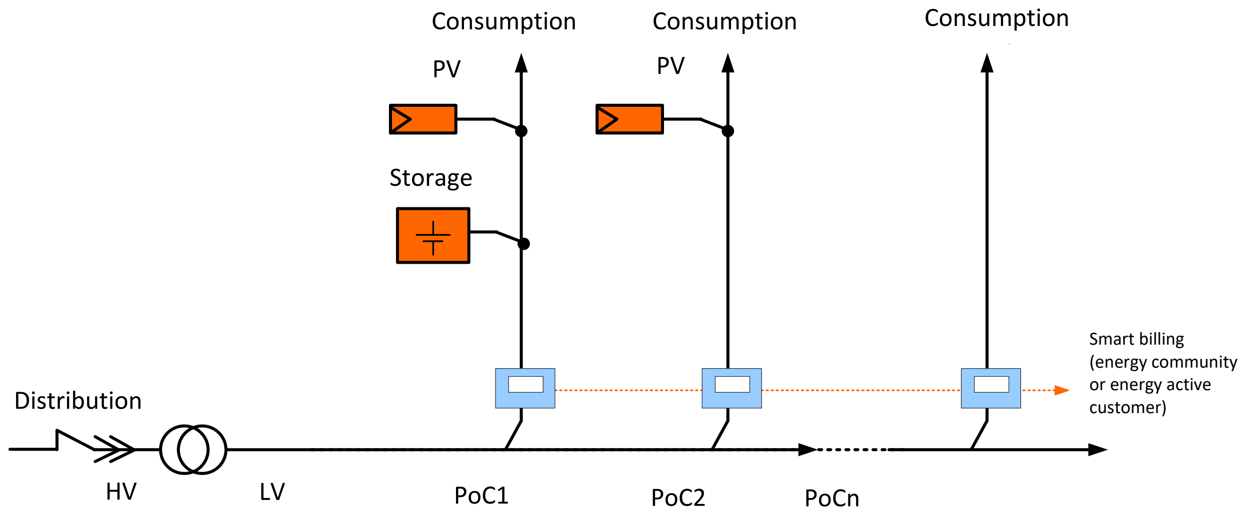


Figure 22: Diagram of the transition to electricity sharing in the energy community

HV – high voltage, LV – low voltage, PV – Photovoltaics, PoC – Point of consumption.

Author: Petr Wolf, UCEEB

As of 2024, the energy community approach seems to be the most suitable energy-sharing mechanism.

4) Simplified model of electricity sharing in apartment buildings

From January 2023, there is a possibility of using a special tariff issued by the Energy Regulation Authority (ER) to share electricity produced locally in residential buildings from PV power plants. It allows, under fixed conditions (one so-called leading point of consumption, installation of flow metres), the sharing of locally produced electricity from PV power plants (measured by the metre at the leading point of consumption) while ensuring the right to choose the electricity supplier of individual households connected to this community (in so-called associated points of consumption). The use of this model will significantly contribute to increasing the efficiency of PV use in residential buildings. Some of the residential buildings in the PED Sletiště area are foreseen to become pilots, with private owners and the city together with CVUT in the role of moderator. This is appropriate to apply within the U Stadionu 28 housing development or similar new residential housing projects.

Advantages:

- Legislation prepared and approved,
- Simple sharing model for residential buildings,
- No need to build additional infrastructure,

- Management of the PoC remains the responsibility of the respective distributors in the territory,
- Possibility of choosing individual energy suppliers for each PoC.

Potential problems/risks:

- Restriction to residential houses, may be conditioned by the installation of local PV generation (defined as so-called leading PoC),
- Need to install continuous metering (smart metering) for PoCs integrated into the community.

4.3.3 Cost Assessment

The investment and cumulated life-cycle cost were estimated separately for heating infrastructure and power infrastructure, and for both alternatives of PED Sletiště: 1) PED ZS (4 variants) and 2) PED Aquapark (4 variants).

Table 19: Heating infrastructure investment costs (Mil CZK)

Name of variant	Distribution pipelines	Source	Investment total
PED ZS V1	3,0	6,5	9,5
PED ZS V2	11,7	6,5	18,2
PED ZS V3	11,7	0,0	11,7
PED ZS V4	0,0	3,8	3,8
PED Aquapark V1	6,7	24,8	31,5
PED Aquapark V2	6,7	6,4	13,1
PED Aquapark V3	11,6	0,0	11,6
PED Aquapark V4	0,0	0,0	0,0

For heating, the total cost of operation from the investor's point of view was calculated for 5 different input price scenarios. For example, for 10% gas price increase y-o-y the comparison of PED ZS variants shows that V1 (with the waste heat recuperation heat pump at winter stadium) has the lowest total cost of operation from all variants (163 Mil CZK/20yrs), see Table 19 for details.

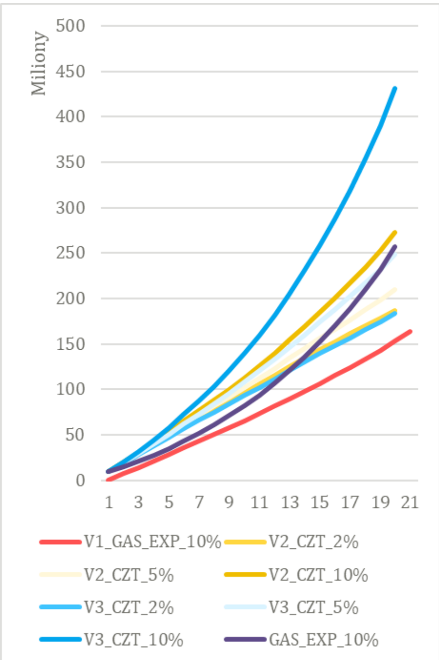


Figure 23: PED ZS Total Cost of Operation under 10% gas price y-o-y increase

For electricity, the comparison shows that integration into a microgrid brings a positive effect and leads to a payback period of ca. 6 years in all scenarios assessed. The expected investment cost for power infrastructure for the PED ZS alternative is around 52 Mil CZK.

4.3.4 Business Model Identification & Financial Analysis

The business model was identified with the key stakeholders, and the findings were later summarised in the Business Model Canvas. For all variants, the business model is analogous with differences in the results of the financial analysis. For the sake of simplification, we use the example of Variant 1. We present the (1) end user perspective and (2) investor/operator perspective. The city-owned company is in the role of investor. The customer is (a) the city itself or another city-owned company and (b) private owners within the area (real estate developer/household owners, etc.). In the future, both sides can be incorporated within a single energy community. The numbers were updated in 2023.

(1) The first variant envisages investment costs of ca. 10 Mill. CZK, of which 2.85 Mill. CZK will be invested in the project. CZK would be allocated to subsidy financing, while 6.65 Mill. CZK would be allocated to subsidy financing. 6.6 Mill. CZK would be allocated to loan financing. The balance of the projected investment expenditure turns negative in the seventh year after the start of the project. Therefore, to improve the liquidity of the project, it would be advisable that the solution be fully operational by then.

Under this variant, the main source of thermal energy is the waste heat from the ice rink, which will be used by a heat pump that will cover 82% of the heat energy needs of the site. The backup source under this option is the gas boilers installed on the ice rink. The bulk of the operational costs of the solution are represented by the electricity needed to power the heat pump, 30 % of which will be covered by the photovoltaic panels and 70 % by the grid. For the cost calculation, prices of CZK 1 000/MWh for PV energy and CZK 2 900/MWh for grid energy were used, assuming a long-term (exponential) growth of both values by 2% per year (in line with the Czech National Bank inflation target).

The operator's margin was added to the operating costs calculated in this way, which roughly corresponds to the differences between the prices of buying and selling heat by DH operators found on the Czech market. For the remaining 18% of the energy required, the decisive cost is the gas price, for which 5 scenarios were considered as for the cost calculation of the gas variant (V4). In the case of this solution variant, it should be taken into account that a higher gas price increases the disadvantage both for the PED (V1) and the gas variant but has a much smaller impact on the profitability of PED due to the lower share of gas in total energy consumption. Investment costs are reflected in the operating costs, which will ultimately be borne by the end customer.

(2) In the case of PED Option V1 at the Winter Stadium site, the return on investment, regardless of the gas price scenario, falls below 20 years if the operator of the proposed solution would offer thermal energy to end users at half the price they would have to pay (in the corresponding scenario) for thermal energy from decentralised gas boilers. This shows that Variant 1 of the PED Winter Stadium provides both sides of the model with a relatively wide scope for compromise, where end-users could save significantly on heating costs and the investor could expect to recover its investment. However, for this to

happen, it is necessary on the part of the operator (in the described model identical to the investor) to operate the newly installed source cost-effectively and to make do with a smaller margin on the sale of the heat generated therein. Similarly to the balance sheet from the point of view of the end customer, we consider here the same parameters for the operation of the heat pump (also for variant 2), i.e. 30 % coverage of electricity consumption from photovoltaics (price of CZK 1 000/MWh, increasing every year in accordance with the inflation target of 2 %) and 70 % from the grid (price of CZK 2 900/MWh, also increasing by 2 % per year).

4.3.5 Risk Assessment

The continuous risk assessment is conducted by the Kladno project department in collaboration with UCEEB. Identified risks were compiled into the table overview together with mitigation measures, see Section 4.4.3 Risk Management Plan.

4.4 Detailed Planning

4.4.1 Project Implementation Planning

The municipality of Kladno has the leading position as initiator, while TEPO Ltd. (city-owned DH operator) can become the main implementer and operator of the PED infrastructure in cooperation with SAMK and other partners. Additionally, it is appropriate to consider the interest of the investor/operator in the residential area U Stadion 28 and CVUT FBMI, who are potentially on the consumer side with the possibility of the role of local PV operator of selected installations. Below listed are the main steps for the Municipality and TEPO Ltd.

The Municipality of Kladno is potentially on the side of the investor and the consumer in this model. Key milestones:

- 6/2024: Decide on the selection of one main alternative and option(s) for further elaboration in the form of a detailed Feasibility Study and step-by-step investment plan,
- 12/2024 Collaborate on the refinement to the Feasibility Study phase and to this end coordinate the progress of TEPO Ltd, SAMK and the private partners of the selected alternative,
- 6/2025 Ensure the commissioning of smart metering on all objects owned by the city for the purpose of further preparation for the energy interconnection of the objects of the selected option,
- 12/2025 Commission and supervise the implementation of already known necessary modifications to the design documentation of the HVAC systems and energy infrastructure for the ongoing reconstructions (an example is the addition of a heat pump for waste heat recovery and a rooftop PV plant at the ice rink),
- 06/2026 Use the available special-purpose financial resources (especially the Modernisation Fund, e.g. RES+ and New Green Savings, etc.) for the acquisition of PV plants for individual buildings, installation of heat sources (especially CHP for waste heat recovery), completion of infrastructure (same point for TEPO Ltd.),
- 06/2026 + beyond Seek to further improve the building-energy performance of the included buildings (resulting in an increase in the plus balance), develop and revise building-energy concepts for new and renovated buildings beyond the EPC.

TEPO Ltd. is potentially on the side of the operator in the above model, whose interest significantly coincides with the investor's perspective.

- 6/2024 Obtain a license for electricity generation (to operate PV plants) and electricity trading,

- 12/2024 Conduct negotiations and initiate business cooperation with partners aiming at the implementation of PED: ČVUT FBMI, Residential complex U STADIONU - Kladno a.s/another relevant investors,
- 12/2024 Evaluate economically and subsequently implement the gradual takeover of the heat and electricity supply in the Sletiště complex and adjacent buildings managed by SAMK,
- 12/2024 Based on the economic evaluation, decide on the connection of the Sletiště site (or its part) to the DH system. Create a study/concept of heat supply complementary to the PED - the selected option,
- 6/2025 Actively work toward the formation of a model that allows for sharing/trading of electricity in the locality (see Chapter 6.12). Explore the suitability of using legislation to create an energy community (assumed from 2024) with the participation of TEPO Ltd. Establish a partnership with ČEZ Distribuce,
- 6/2025 Use available special-purpose financial resources (especially the Modernisation Fund, e.g. RES+ and New Green Savings, etc.) for the acquisition of PV plants for individual buildings, installation of heat sources (especially CHP for waste heat recovery), completion of infrastructure (same point for the Municipality).

4.4.2 Citizen Engagement Strategies for Project Development

Due to the composition of stakeholders within the PED project, citizen participation relates mostly to Phase 2 with higher involvement of households. No particular strategy has been designed yet; however, it is foreseen that Kladno will create a support system for newly established energy communities in both publicly and privately owned apartment housing. For this purpose, a separate citizen engagement strategy will be developed (beyond the SPARCS project) and will be available for Phase 2 of the PED project itself.

4.4.3 Risk Management Plan

The outline of the risk management plan covers the basic risks that are typical of large-scale building integrations projects, see Table 20 for further details.

Table 20: List of potential risks

No	General description	Severity	Likelihood	Risk	PED relevance and mitigation measures
1	Unclear roles and responsibilities between participants	Moderate	Very unlikely	Low	Between the city and the city-owned company, a clear council decision who bears the responsibility for the implementation of PED, including specific steps and sub-projects.

2	Weak commitment of participants to the project plan and deadlines. Potential for serious delays as lack of progress in one or more tasks may cause delays for linked or subsequent tasks, and hence for the project as a whole	Moderate	Possible	Medium	Besides the city itself the commitment needs to be ensured both for the city-owned company and newly acquired private partners. The common memorandum is a soft starting point.
3	Delays in technology deployment & constructions	Moderate	Possible	Medium	Kladno is aware of the risk and employs sufficiently manned project department. However, other partners need to allocate at least one dedicated person to ensure smooth implementation. Some risks associated with deployment are linked to supply chains and cannot be easily controlled. Flexible funding schemes must be adopted wherever possible.
5	Failure in partnership co-operation leading to failure to build ecosystem with advanced technology. This would be causing lower results than expected	Moderate	Unlikely	Low-medium	In the first phase, the partnership has a limited number of public (city) partners. In theory, cooperation should be smooth. However, mutual coordination and confidence building measures need to be exercised continuously.
6	Financial risks: Due to economic inflation and, consequently, an increase in prices, the planned budget could not be enough to supply the planned equipment at the pilot sites. Changing conditions might also have an effect to external funding.	Minor	Unlikely	Low	The investment costs are foreseen to be covered by at least 30% public subsidy. Increased costs can change individual technological priorities, but the overall course is mostly dependent on political will.
7	Viability of business models for the pilot sites	Moderate	Possible	Medium	The viability is subject to various external factors and systems. Risks determined by external factors (regulatory, market, external collaboration, etc.) are always possible. Since the early stage, the overall project plan tries to anticipate the changes and adjust in due time (e.g. monitoring legislation, market trends etc.). The core of the business model is based on intra-city trade in energy.
8	Political risk, loss of political support to the project	Moderate	Possible	Medium	Kladno priorities are largely influenced by pro-social policies. PED is not an easy topic to explain to the public. Framing the investment as one benefiting inhabitants through improved public services is likely a viable strategy.

4.4.4 Quality Management Plan

Project and Quality management is ensured by the City of Kladno. The quality will be overseen by the key technical partner, the UCEEB. The (pre-)feasibility study that was carried out is aware of the potential risks and suggests a phased approach, starting with municipal structures and a reasonable number of private partners to be expanded in the second stage. The main risks to be avoided are basically the same as for the other projects:

- Inefficient/insufficient project preparation process – need for quality preparation; set clear timelines (risk of time slippage) – set up control mechanisms.
- Poorly set priorities, unclear terms of reference, unrealistic objectives.
- Incorrectly set project parameters.
- Little experience in managing and implementing large-scale projects.
- Insufficient preparation of negotiation conditions.
- Inappropriate business model, poorly set terms and conditions, loss of control over infrastructure development.

4.4.5 Key Performance Indicators

The KPIs used to assess the feasibility of PED were both technical and economic.

Technical KPIs include:

- **On-site energy ratio (OER):** Comparison of the energy production in a given neighbourhood and the energy needs for hot water, heating, cooling, and user electricity.
- **Annual mismatch ratio (AMR)/Hourly mismatch ratio (HMR):** Takes into account the annual/hourly amount of energy imported into the district. As a rule, the indicator is evaluated for the whole year/per hour.
- **Self-sufficiency index** [%], (fs): Share of locally produced renewable energy in total consumption.
- **Self-consumption ratio**, (fu): The fraction of the RES production consumed within the PED to cover consumption.
- **Network interaction index**, (fi): The rate of exchange of energy between PED and the public (upstream) network. It can be calculated as the sum of energy imports and exports to consumption in PED.

Economic KPIs include:

- **Investment costs:** Cost of building the PED (IC)
- **Capital cost:** In the case of external financing, the weighted average cost of capital, the “Weighted Average Cost of Capital” (WACC) / in the case of self-financing, the opportunity cost (OC) should be taken into account.
- **Operating costs:** The cost of maintaining and operating the PED solution.
- **Solution lifetime:** The period of time for which the solution will generate the required amount of energy without the need for major investments.
- **Energy costs:** The updated energy (electricity, heating) accumulated by end users at the site over the lifetime of the solution.
- **Savings achieved:** Comparison of the energy costs of the PED solution with the energy costs that the customer would have to bear if an alternative solution (zero option, non-PED solution) were chosen.
- **Price sensitivity:** A measure of the sensitivity of the solution to global changes in energy carrier prices that are autonomous in nature for the PED stakeholders (compared to the alternative solution).
- **Payback period:** The amount of time over which an investor recovers the costs incurred in implementing a PED solution.

- **NPV – net present value:** The value, updated to year 0, of the cash flows generated by a PED solution over its entire lifetime, including residual value or disposal costs.
- **ROI – return on investment:** The ratio of the return and change in value of an investment to the cost invested, including the cost of capital.
- **SROI – Social Return on Investment:** The ratio of returns and savings achieved by all stakeholders (not only the investor) to the costs incurred by them, this indicator is particularly important for the evaluation of investments with important non-economic (social, environmental, technological, organisational, etc.) impacts on diverse interest groups, especially for evaluations carried out by bodies representing the public interest.

4.5 Securing Investment

4.5.1 Budget Allocation

Indicative costs of investment (CAPEX) were provided in 4.3.3. To summarise for the main V1 variant which represents a core of a future wider PED, see Table 21 for details.

Table 21: Investments

Main cost category	EUR (2/2024)
CAPEX – Building retrofit	To be assessed
CAPEX – Heat infrastructure	0,76 M
CAPEX – Power infrastructure	2,08 M
OPEX (20yrs, discounted)	6,52 M

In a conservative funding scenario, a minimum 30% subsidy is foreseen, while 70% can be covered by loans and municipal companies' investment budget. Part of the (most likely) power infrastructure (PVs on apartment housing) can be invested by private partner.

4.5.2 Additional Sources of Funding

The current period is exceptional in the abundance of subsidies for energy projects. So called modernisation fund seeks to disburse around 20 billion EUR for increasing share green energy. Few examples of the funding programs include: New Green to Savings programme (apartment buildings), HEAT programme (new or modernised district heating infrastructure), RES+ programme (new photovoltaics), KOMUNERG (establishing energy communities) and many more. Example of the most relevant technologies (elements of PED, based on the current design) that can be funded through these subsidy programs, are presented in Table 22.

Table 22: Subsidy Funding Sources for PED elements

Subsidy program	Eligible element of PED	Max funding rate
New Green to Savings program	Technologies and retrofit for apartment buildings (esp. Phase 2): insulation, PV, EVs, solar heating of DHW.	Publicly owned 70 % Privately owned 50 %
HEAT program	Modernisation and new construction, waste heat use (Winter Stadium),	To be established in the awarding procedure, this subsidy is considered public support.
RES+ program	PVs, battery systems on/in city-owned buildings	50 %
KOMUNERG	Energy management system for energy communities, power and heat storage	TBD

4.6 Procurement/Implementation

4.6.1 Procurement

Kladno has been using electronic tendering systems and procedures in accordance with Publ. Law No. 134/2016 Coll. The procurement of individual systems for PED Sletiště will require preliminary market consultations. So far, these have been done as part of research into market-ready technologies. However, a more rigid approach will be adopted where necessary and required by the legislation.

4.6.2 Implementation

According to the project implementation planning, next step is to develop a full-fledged feasibility study with updated cost estimates and specification of technology parameters to serve as an input for engineering phase. See section 4.4.1 for more detailed plan with milestones.

4.7 Next Steps

4.7.1 Monitoring & Evaluation

Monitoring and Evaluation are foreseen to be carried out by the respective key stakeholders on the following levels (to be specified at later stage):

- Building level (e.g. consumptions, energy standards, as part of the EnMS etc.)
- District level (e.g. OER, AMR)
- SECAP city indicator (e.g. GHG savings in operation)

4.7.2 Impact Assessment

The impact assessment will be designed in detail at later stage. It is expected to cover budgetary impacts, (socio-)economic impacts, impacts on the energy system, and environmental impacts (contribution to SECAP).

4.7.3 Post Management & Communication

Proper operational management of the PED is pivotal to the success of the project. All innovation projects are at increased risk of inadequate adaptation of operating procedures by stakeholders. New processes and internal procedures will need to be adopted. Kladno has been strengthening its personnel capacity as well as energy management competences in the last years with ISO 50001 certification, SECAP monitoring, PV production and trading licence for city owned company etc. The city's plan is to further increase the professionalism of energy system management and communication capacities. Kladno already belongs to some of the most visible innovating cities in the Czech Republic and has also internationally.

5. CONCLUSION

Every country, every region, every city has its own specifics, and Kladno is no exception. Kladno is infamous in the Czech Republic for its coal-related history. People associate it with social problems, marginalised minorities, bad air and the Poldi site, which is still considered a giant brownfield site that makes up a large part of the city. However, times are changing, real estate prices, availability of services and the city's proximity to Prague suddenly make Kladno a city with great potential. Add to this the ongoing reconstruction of the railway and there is no wonder about the predictions of the expected increase in the city's population. The city's management is aware of this potential and is trying to move in the direction of the modern cities of the rest of Europe. Participation in the SPARCS project has played an absolutely crucial role in this direction. SPARCS helped steer the city, the project caught the city in a kind of transformation phase and gave it the opportunity to kick-start changes, changes in the transition to sustainability and moving away from its mining past. Sharing experiences with foreign partners helps to break out of a certain narrow vision, the visits to Leipzig, Espoo (but also other partner cities) showed Kladno what the opportunities in the energy sector actually are and also that the problems associated with implementation are similar across Europe and there is no need to hang your head about them.

Sometimes the GPPD's proposals have not met with the understanding of the leadership, as this is still a political level where politicians have to look at the reactions of people who are not always in favour of more modern steps, or who are, for example, even eurosceptic and resist the transition to green politics. However, it is up to the city leadership to be able to justify its actions; due to the change in the composition of the population and the lead over other Czech cities, it is likely to look back on participation in SPARCS very positively. The city was not careful with unnecessary energy waste, did not know the exact condition of its buildings, and did not have a concept/plan to improve this. All of this has been changed. One could call it first of all one big clean-up in the case of Kladno, which of course took some time, but was absolutely necessary for the city to move forward. Unfortunately, some things have still remained on paper, so we need to keep the momentum.

One of the key things during the project turned out to be the communication aspect. The need to understand each other with colleagues from other departments is crucial. Having multiple cross-cutting issues related workshops definitely helped in this manner.

6. ACRONYMS AND TERMS

AFID – Alternative Fuel Infrastructure Directive

BEV – Battery Electric Vehicle

BSU – Basic Settlement Units

CNG – Compressed Natural Gas

CVD – Clean Vehicles Directive

CVUT – Czech Technical University in Prague

CZK – Czech Koruna

DHW – Domestic Hot Water

DTS – Distribution Transformer Station

EIA – Environmental impact assessment

EV(s) – Electric Vehicle(s)

FC – Fellow Cities

GPPD – Grants and Project Preparation Department

HP – Heat Pump

KPI – Key Performance indicators

LDN – Local Distribution Network (LDN)

LNG – Liquefied Natural Gas

MPO – Ministry of Industry and Trade

PoC(s) – Point(s) of Consumption

PED – Positive Energy District

PV – Photovoltaics

RED – Renewable Energy Directive

SAMK – Sportovní areály města Kladna, s.r.o.

SECAP – Sustainable Energy and Climate Action Planning Kladno

SUMP – Sustainable Urban Mobility Plan

TRV – Thermostatic valves

UCEEB – University Centre for Energy Efficient Buildings

US – United States of America

7. REFERENCES

ČSÚ (2024). Český Statistický Úřad. Online: Počet obyvatel v obcích - k 1. 1. 2024 | Produkty (gov.cz)

ČVUT UCEEB (2020). Výběr lokality pro energeticky plusovou čtvrť na Kladně, Site selection for a Positive Energy District in Kladno, in Czech.

EC (2021). European Commission, Directorate-General for Energy, Hørman, M., Georgiev, I., Wessel, R. et al., EU's global leadership in renewables – Final synthesis report – July 2021, Publications Office of the European Union, 2022. Online: https://data.europa.eu/doi/10.2833/523799

Miškovský, J., et al. (2021). Sustainable Development Strategy of the City of Kladno until 2030, 216. Online: Sustainable Development Strategy of the City of Kladno until 2030,

SmartPlan s.r.o. (2022). Feasibility study of individual electromobility connection points, 355.

CityTraffic s.r.o. SUMP (2023). Sustainable Urban Mobility Plan, 108. Online: Plán udržitelné městské mobility: Kladno (mestokladno.cz)

Grossi & Pianezzi (2017). Smart cities: Utopia or neoliberal ideology? 69, 79-85.

Timeus, K., Vinaixa, J. & Pardo-Bosch, F. (2020). Creating business models for smart cities: a practical framework. Public Management Review, 20 (5), 726-745.

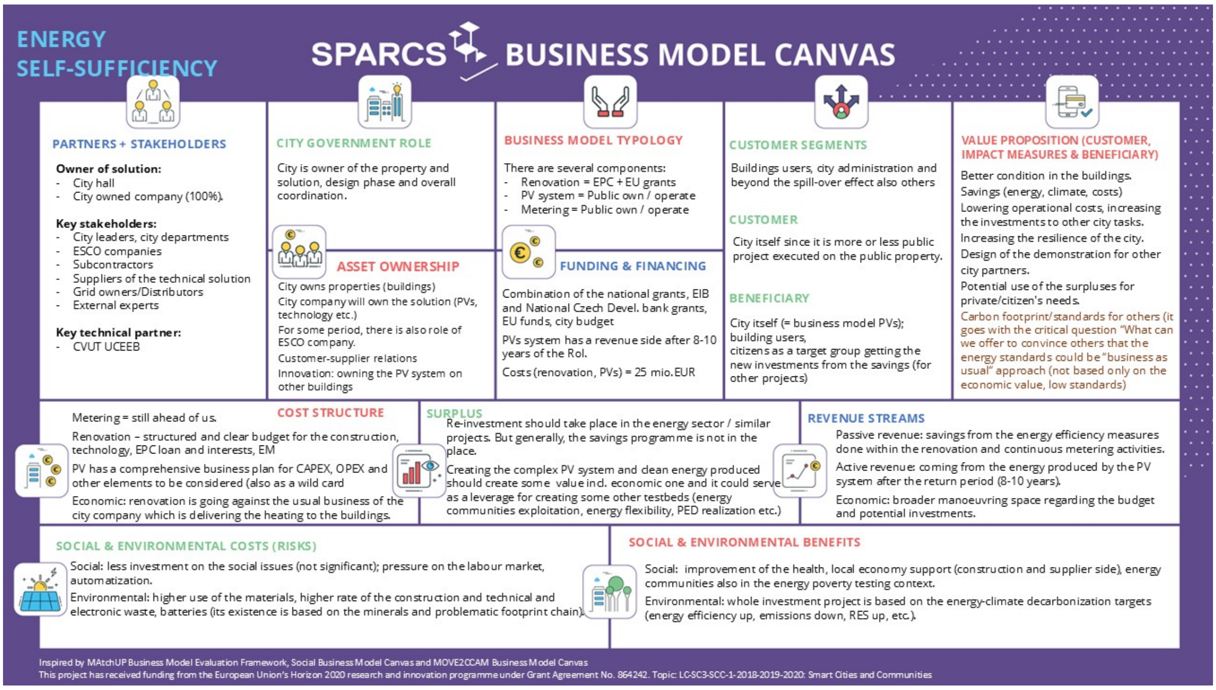
UCEEB (2023), Univerzitní centrum energeticky efektivních budov (ČVUT UCEEB), Statutární město Kladno (12/01/2023). ENERGETICKY PLUSOVÁ ČTVRŤ KLADNO: Lokalita Sletiště: Předběžná studie proveditelnosti; available in Czech.

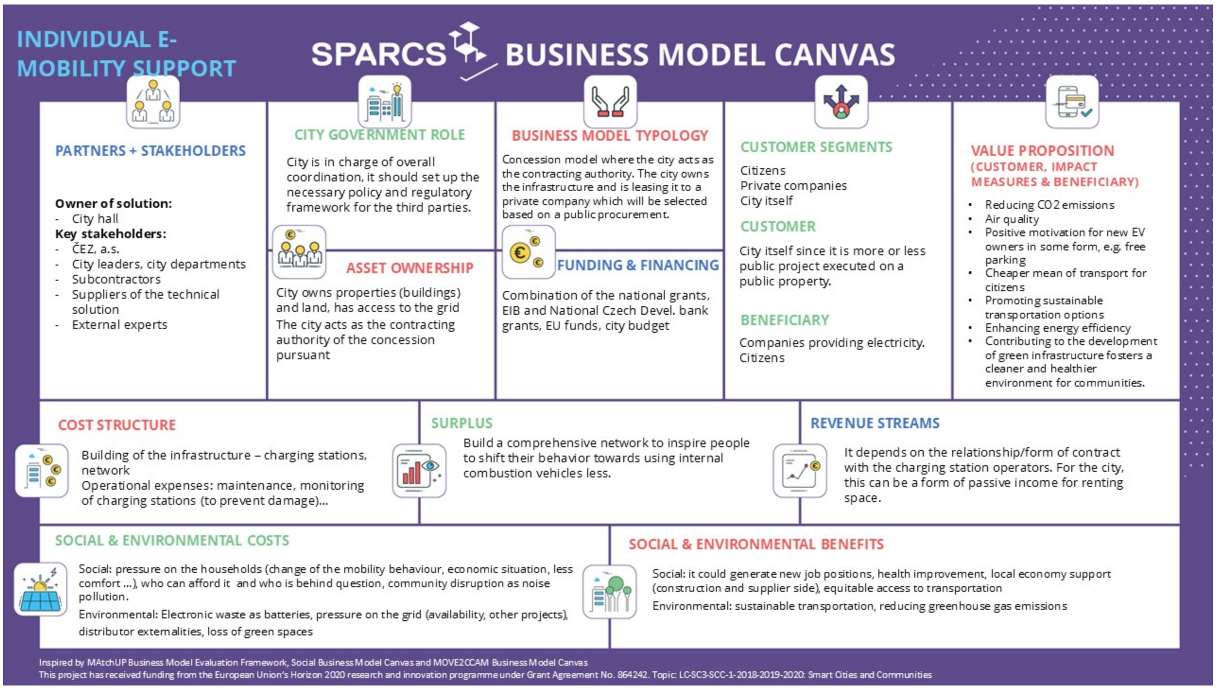
SECAP (2021). Sustainable Energy and Climate Action Planning Kladno, 133.

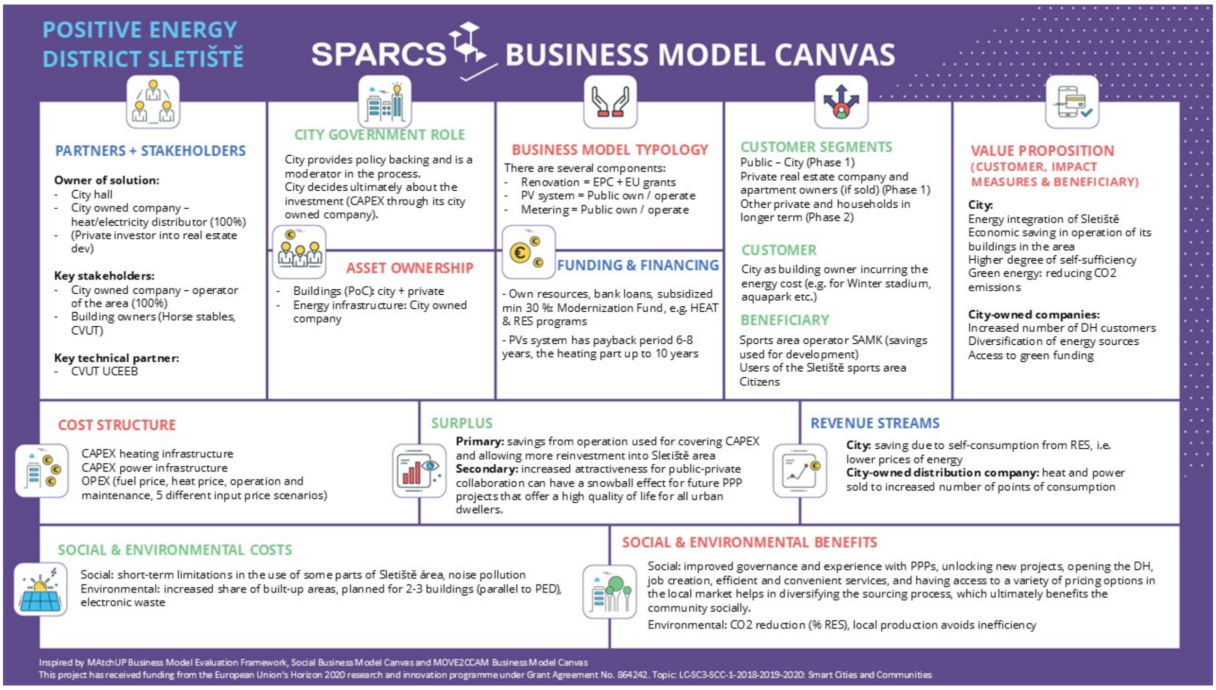
8. Appendices

(1) 3x Business Model Canvas (Energy self-sufficiency, Individual e-mobility support, Positive energy district

1)






POSITIVE ENERGY DISTRICT SLETIŠTĚ
SPARCS BUSINESS MODEL CANVAS
PARTNERS + STAKEHOLDERS
Owner of solution:
- City hall
- City owned company – heat/electricity distributor (100%)
- (Private investor into real estate dev)
Key stakeholders:
- City owned company – operator of the area (100%)
- Building owners (Horse stables, CVUT)
Key technical partner:
- CVUT UCEEB
CITY GOVERNMENT ROLE
City provides policy backing and is a moderator in the process.
City decides ultimately about the investment (CAPEX through its city owned company).
ASSET OWNERSHIP
- Buildings (PoC): city + private
- Energy infrastructure: City owned company
BUSINESS MODEL TYPOLOGY
There are several components:
- Renovation = EPC + EU grants
- PV system = Public own / operate
- Metering = Public own / operate
FUNDING & FINANCING
- Own resources, bank loans, subsidized min 30 %: Modernization Fund, e.g. HEAT & RES programs
- PVs system has payback period 6-8 years, the heating part up to 10 years
CUSTOMER SEGMENTS
Public – City (Phase 1)
Private real estate company and apartment owners (if sold) (Phase 1)
Other private and households in longer term (Phase 2)
CUSTOMER
City as building owner incurring the energy cost (e.g. for Winter stadium, aquapark etc.)
BENEFICIARY
Sports area operator SAMK (savings used for development)
Users of the Sletiště sports area
Citizens
VALUE PROPOSITION
(CUSTOMER, IMPACT MEASURES & BENEFICIARY)
City:
Energy integration of Sletiště
Economic saving in operation of its buildings in the area
Higher degree of self-sufficiency
Green energy: reducing CO2 emissions
City-owned companies:
Increased number of DH customers
Diversification of energy sources
Access to green funding
COST STRUCTURE
CAPEX heating infrastructure
CAPEX power infrastructure
OPEX (fuel price, heat price, operation and maintenance, 5 different input price scenarios)
SURPLUS
Primary: savings from operation used for covering CAPEX and allowing more reinvestment into Sletiště area
Secondary: increased attractiveness for public-private collaboration can have a snowball effect for future PPP projects that offer a high quality of life for all urban dwellers.
REVENUE STREAMS
City: saving due to self-consumption from RES, i.e. lower prices of energy
City-owned distribution company: heat and power sold to increased number of points of consumption
SOCIAL & ENVIRONMENTAL COSTS
Social: short-term limitations in the use of some parts of Sletiště área, noise pollution
Environmental: increased share of built-up areas, planned for 2-3 buildings (parallel to PED), electronic waste
SOCIAL & ENVIRONMENTAL BENEFITS
Social: improved governance and experience with PPPs, unlocking new projects, opening the DH, job creation, efficient and convenient services, and having access to a variety of pricing options in the local market helps in diversifying the sourcing process, which ultimately benefits the community socially.
Environmental: CO2 reduction (% RES), local production avoids inefficiency
Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242. Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities