ARV

CLIMATE POSITIVE CIRCULAR COMMUNITIES

D4.4 DESIGN GUIDELINES FOR THE ZERO-EMISSION & POSITIVE ENERGY RENOVATION OF THE HEALTH CARE CENTRE IN KARVINA

WP4 SUSTAINABLE BUILDING (RE) DESIGN

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[1] *ARV is a Norwegian word meaning "heritage" or "legacy". It reflects the emphasis on circularity, a key aspect in reaching the project's main goal of boosting the building renovation rate in Europe.*

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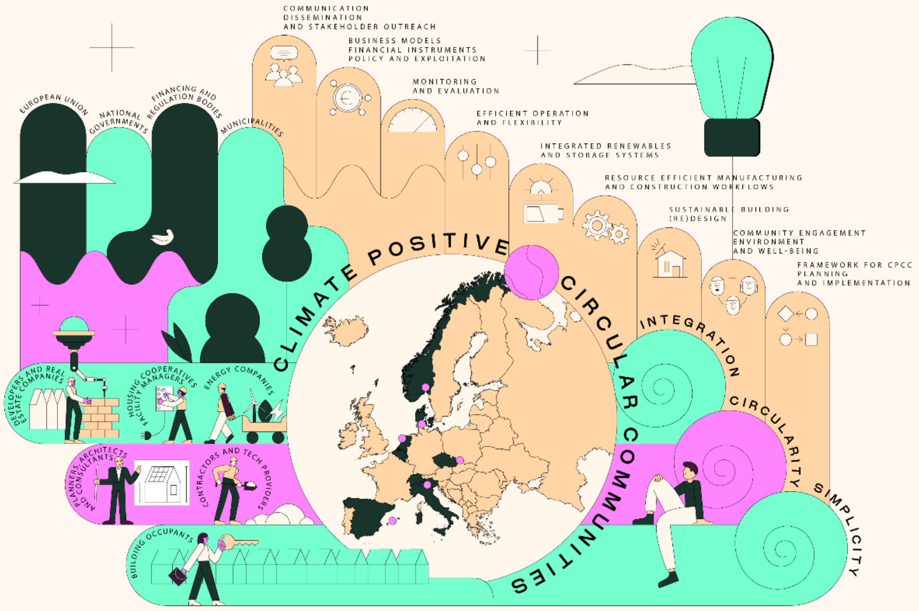
ABOUT THE ARV PROJECT

The vision of the ARV project is to contribute to speedy and wide scale implementation of Climate Positive Circular Communities (CPCC) where people can thrive and prosper for generations to come. The overall aim is to demonstrate and validate attractive, resilient, and affordable solutions for CPCC that will significantly speed up the deep energy renovations and the deployment of energy and climate measures in the construction and energy industries. To achieve this, the ARV project will employ a novel concept relying on a combination of 3 conceptual pillars, 6 demonstration projects, and 9 thematic focus areas.

The 3 conceptual pillars are integration, circularity, and simplicity. **Integration** in ARV means the coupling of people, buildings, and energy systems, through multi-stakeholder co-creation and the use of innovative digital tools. **Circularity** in ARV means a systematic way of addressing circular economy through integrated use of Life Cycle Assessment, digital logbooks, and material banks. **Simplicity** in ARV means to make the solutions easy to understand and use for all stakeholders, from manufacturers to end-users.

The 6 demonstration projects are urban regeneration projects in 6 locations around Europe. They have been carefully selected to represent the different European climates and contexts, and due to their high ambitions in environmental, social, and economic sustainability. Renovation of social housing and public buildings are specifically focused. Together, they will demonstrate more than 50 innovations in more than 150,000 m² of buildings.

The 9 thematic focus areas are 1) Effective planning and implementation of CPCCs, 2) Enhancing citizen engagement, environment, and well-being, 3) Sustainable building re(design) 4) Resource efficient manufacturing and construction workflows, 5) Smart integration of renewables and storage systems, 6) Effective management of energy and flexibility, 7) Continuous monitoring and evaluation, 8) New business models and financial mechanisms, policy instruments and exploitation, and 9) Effective communication, dissemination, and stakeholder outreach.



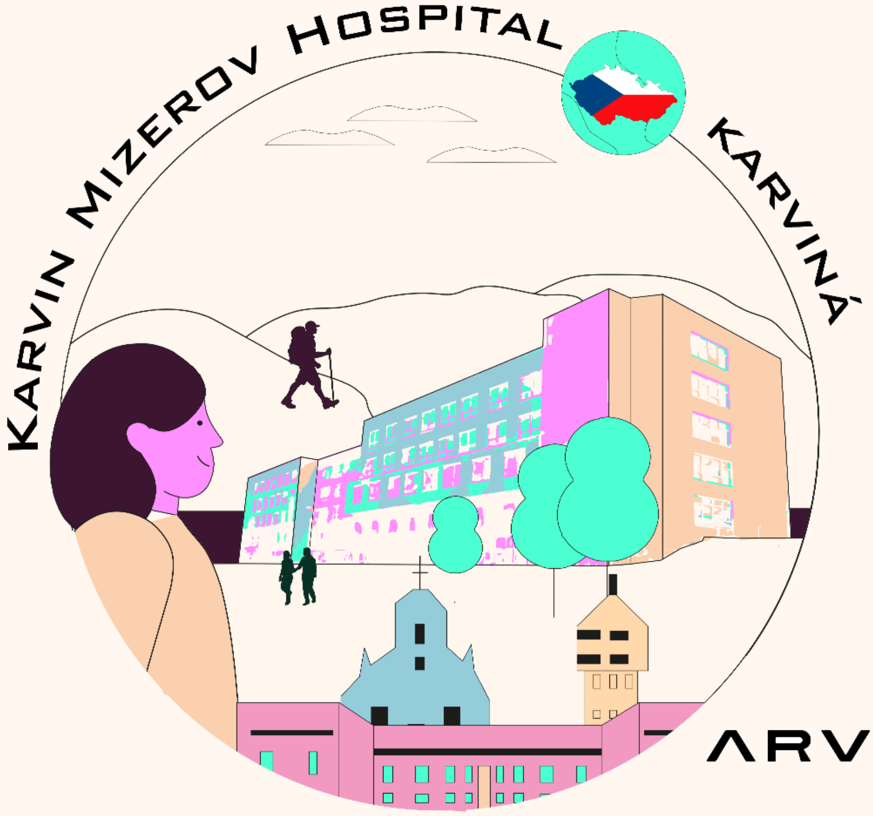
The ARV project is an Innovation Action that has received funding under the Green Deal Call LC-GD-4-1-2020 - Building and renovating in an energy and resource efficient way. The project started in January 2022 and has a project period of 4 years, until December 2025. The project is coordinated by the Norwegian University of Science and Technology and involves 35 partners from 8 different European Countries.

EXECUTIVE SUMMARY

The Task 4.5 Integrated Circular Design of Demo Project in Karviná deals with the redesign of the existing building as a nearly zero energy building in sustainable climate positive circular communities. The main objectives for the demo building project are to reduce embodied energy & emissions, increase energy efficiency and match sustainability with aesthetics and quality of life, by integrated circular design processes.

The first version of the document is introducing and describes the first steps towards the integrated circular design with respect to the relationship of the building with its surroundings, the current state of the demo building, and the main integrated circular design principles.

This is the first version of the Design Guidelines for the Zero-emission & Positive Energy Renovation of the Health Centre in Karviná are introduced as a part of the ARV project. This report will be regularly updated on annual bases, in Month 24 (2nd version in December 2023), and in Month 36 (final version in December 2024) of the ARV project.



1. INTRODUCTION

Work package 4 within the ARV project deals with the (re) design of new and retrofitting of existing buildings as zero-emission positive energy-buildings in Sustainable Climate Positive Circular Communities (CPCCs). The main objectives are to

- Reduce the embodied energy
- Reduce emissions during operation
- Increase the energy efficiency
- Increase or maximize the renewable energy production on-site

The ARV integrated circular design includes adaptation to local climate conditions, deep renovation with minimum disruption for buildings occupants, significant reduction of CO_2 emissions, and high energy efficiency. It involves applying active or passive energy solutions, and a high focus on circularity, reduction, re-use & recycling of materials & modules, and resource & energy efficient integration of PVs i.e., BIPV & BAPV, while satisfying occupant, well-being, and architectural considerations. The design considerations will address the scalability, flexibility, durability, maintainability, fire & seismic safety of buildings. The circular positive energy buildings & neighbourhoods will be embedded in the spatial, economical, technical, environmental, regulatory, and social context of the demo sites. The ultimate goal of WP4 is the integrated circular design that cultivates aesthetics and improves amenities for the building's occupants while improving the performance of the buildings in line with the new European Bauhaus strategy.

Specifically, the Czech demo case encompasses the renovation of the Karviná Mizerov - Health Centre in the city of Karviná. The focus for the Demo project in Karviná is in:

- Become a nearly zero energy building (nZEB).
- Digital design and 3D simulations (digital twins) for solar irradiation potential and design of optimum shading devices.
- Small-scale pilots of climate change resilient solutions – use of heat pumps for summer cooling.
- LCA of HVAC systems with a focus on carbon footprint.
- BIPV BAPV, solar thermal (PVT), heat pumps, active shading systems with the weather forecast, innovative cooling solutions. BIPV integrated into the facade.
- Green roof sample for reducing heat islands and slowing down the water runoff, application of recycled materials.

This document describes an approach that the ARV team carried out to meet the objectives. There are also stated the recourses, methods, and technical measures and innovations, that are considered for application. The final version of the report will also include the evaluation of the efficiency and the impact of these processes.

This is the first version of these guidelines, it will be further enhanced and improved as the development continues.

2. SUMMARY OF THE PROJECT DATA – KARVINÁ, CZECHIA

Table 1. *Summary of the project data – Karviná, Czechia*

Name and Address	**Poliklinika Žižkova 2379/54a 73301, Karviná, Czech Republic**
Project type and ambition level	Refurbishment, nearly zero energy building (nZEB)
Building types	Healthcare centre
Location	Karviná, Moravian-Silesian Region, Czech Republic
Building owner	Statutární město Karviná (Karviná Municipality)
Design team	Atris, s.r.o, Lukáš Ehl, ARCHCON atelier, s.r.o.
Number of occupants	n/a (37 micro and small enterprises – health care and services
Mean average annual temperature	9 °C
Degree-days HDD/CDD	3066/110
Design phase/construction phase/completion date	In use, before renovation. Completion in 1993.
Plot area	2 720 m^2
Conditioned/heated floor area	11 130,3 m^2
Gross volume	39 145,9 m^3

3. VISION AND GOALS

3.1. VISION

The design guideline for the zero-emission & positive energy renovation of the health care centre in Karviná is focused on four main pillars – architectural, social, energy, and environmental. The design guideline introduces innovative solutions to reach the CPCC concept. The aim of the Karvina demo project is to be a model for boosting the building renovation rate and to enable rapid and wide-scale deployment of CPCCs around Europe. The overall goal is to contribute to fast market uptake and cost-efficient replication of the CPCC concept, and thus significantly contribute to the full decarbonisation of Karvina, Czech Republic as well as Europe by 2050.

The Czech demo case will become a lighthouse and living lab for planned innovations with a high potential for replicability within the city of Karvina and the whole Czechia. The municipality has been preparing several concepts and strategies focusing on CO_2 emissions reductions and the improvement of the city environment. The discussions about the positive energy district (PED) concept have already started. The first phase of PED includes 9 municipality buildings (schools, sports facilities, nursing home, and our demo building) located within a radius of 500 meters, and it can be extended to other stakeholders and communities in the future. Based on these municipality strategies/plans, the ARV innovative solutions piloted in the demo building will have a great potential to be replicated in other buildings, as well as scaled up to a larger scale (district level).

The Czech demo building vision includes the use of digital guideline concepts and digital tools to achieve the ARV goals of cost and time reduction, as well as simplicity. The vision is to boost the development and deployment of digital technologies not only within the design concept. The digital twin model of the demo building will be created to verify the design guideline concept in line with the introduced key innovations on the building. Digitalization will scale up, speed up the design processes and boost the replicability and scalability within the other municipal buildings.

3.2. GOALS

The overall aim of the ARV demo building renovation is to demonstrate innovations the zero-emission & positive energy renovation of the Health Care Centre in Karviná. The specific objectives of ARV are aligned with the overall objectives of the call and are designed to reach the target values. The Czech demo case objectives are designed carefully to reach the CPCC goals. The objectives are divided into 5 categories: Architecture, Environmental, Energy, Social and Economic. We set very ambitious goals for the Czech demo case that will be demonstrated and carefully reflected in design phase:

- At least 50% reduction in energy needs compared to pre-renovation level. Achieving nZEB standard
- At least 30% improvement of IEQ compared to pre retrofitting levels according to EN 16798-1:2019
- At least 30 % reduction of noise and dust level in occupant disruption during retrofitting compared to current practice
- At least 50% reduction of embodied emissions compared to local current practice
- At least 30% reduction of retrofitting time compared to local current practice
- At least 20% reduction of life cycle cost for the community compared to local current practice
- At least 30% reduction of retrofitting compared to local current practice

The project goals will be presented via a digital twin and on-site innovations. The digital twin will allow to design and validate design concepts and innovations using parametric design in many variants to reach the project goals.

The architectural quality of the building is not singular, so the improvement in general technical quality will be addressed also by architectural updates. As the possibilities for implementing many different solutions are limited, different possible solutions will be presented using the digital twin and will serve as the baseline for further and larger refurbishments.

The environmental objectives are strongly connected to the economic objective in the operational phase of the building and are in line with the ARV's Key Performance Indicators (KPIs). The most challenging objectives from the perspective of environment, lies in the goal of achieving the 50 % reduction in energy needs and embodied emissions. The reduction is crucial but limited by the economic boundary conditions – the total cost of the refurbishment cannot exceed the usual price for the renovation, and it should bring savings in life cycle cost analysis.

From the social point of view, the main targets are in gaining feedback from the community, designing user-friendly environment, communication, dissemination, and stakeholder outreach. Important activities include multi stakeholder co-creation, monitoring, and evaluation of the process.

4. URBAN DEVELOPMENT

4.1. HISTORY OF THE CITY OF KARVINÁ AND THE SITE

Karviná was originally established in 1268. However, the town as we know it today was not created until 1948, when several separate communities were merged to form a single urban area, which took its name from one of the original communities. Today, Karviná is home to around 50,000 people. It is mainly known as a centre of coal mining, but not many people are aware that the local mines existed in a fragile symbiosis with the Darkov spa for more than 150 years.

At one point in history, the spa's future seemed bleak, and it was expected to close due to the expansion of the local mines. However, more recent developments in Karviná have shown how history sometimes takes a different direction. Coal mining is being scaled down, and many mines have already been closed – so the town is now at a turning-point in its development. The area where the ARV demo project is located, formerly dominated by heavy industry, will become the focus of new activities based around tourism. It will be wonderful and impressive – we'll just have to wait a little before we can enjoy it.

The Darkov spa in Karviná is one of the oldest spa resorts in the whole of Central Europe. It has high-quality iodine-bromine water, which originated in the Tertiary period. Many people may be surprised how green Karviná is. The town and its surrounding area have several unique or rare attractions – and perhaps the most striking of these is the leaning church known locally as "Pisa", which has become the setting for a popular trilogy of novels. The Fryštát chateau is the only survivor from four former aristocratic residences that were once situated in Karviná, and it is now open to the public for guided tours. A covered walkway links it to the adjacent Church of the Elevation of the Holy Cross – the oldest documented building in the town. The Demo site and district development form 1950s until today are presented on Figure 1 - Figure 6.

Figure 1. *Demo site 1950s*[2].

[2] Pictures from: https://gis.karvina.cz/mapa/historicke-letecke-snimky/?c=-450624.5%3A-1100200.75&z=8&ly=hr&lb=osm&lyo=&lbp=76 and https://www.karvina.cz/mesto-karvina/publikace

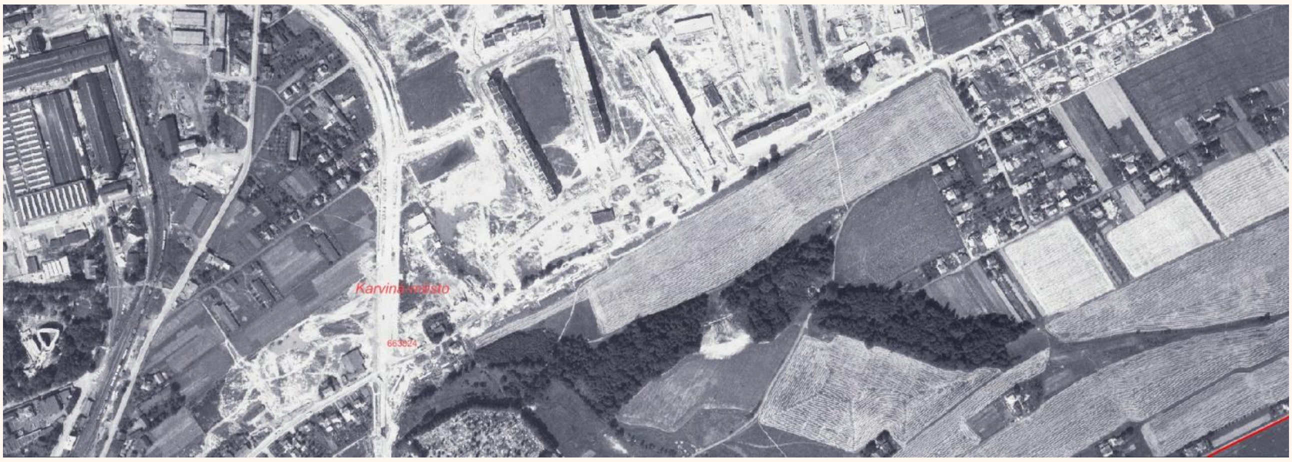


Figure 2. *Demo site 1966.*

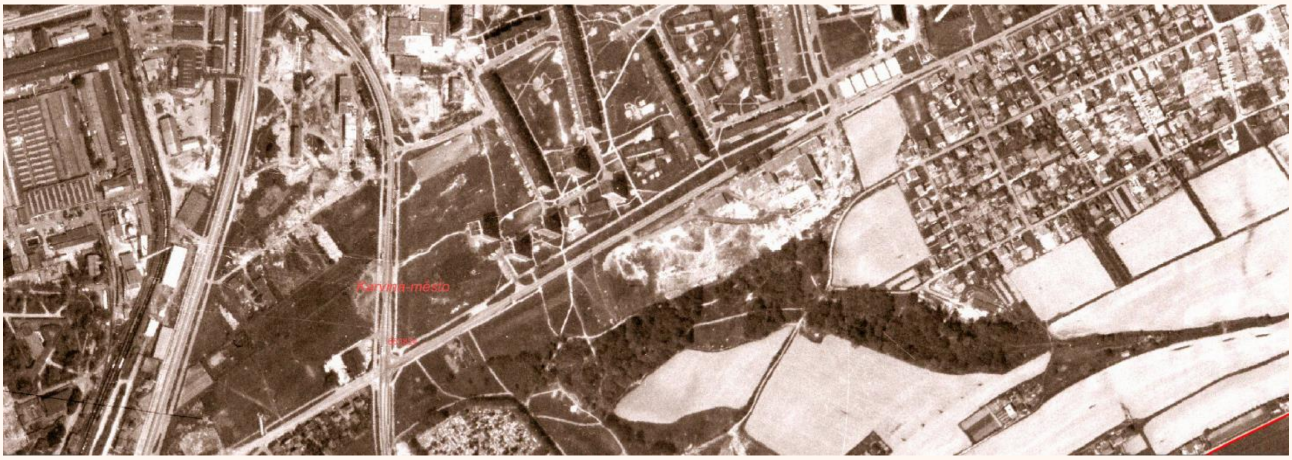


Figure 3. *Demo site 1979.*

Figure 4. *Demo site 2000.*

***Figure 5**. Demo site 2012.*

***Figure 6**. Demo site 2022.*

4.2. ENERGY IN THE CITY OF KARVINÁ

In the city of Karviná there are 2 main players in the energy generation and distribution. Veolia Energie is responsible for heat generation and distribution in the city, while the ČEZ company is providing electricity.

HEAT GENERATION AND DISTRIBUTION

In the city of Karviná, Veolia Energie owns and operates most of the primary and secondary district heating networks and transfer stations. The construction of both heating plants, Teplárna Karviná (TKV) and Teplárna Československé armády (TČA) started in the 1940s and 1950s, while the construction of the district heating network started in the 1960s. The district heating network is being further extended by the construction of primary and secondary network connections.

The temperature gradient of the district heating network for hot water distribution system is 130/60 °C. The main heat sources output of TKV is 248 MWt and TČA is 171 MWt[3]. Teplárna Karviná operates 4 coal-fired boilers and Teplárna TČA operates 3 coal-fired boilers. Both sources have installed equipment for combined heat and power production. The overall energy efficiency of the combined heat and power production of the heating plants is 67% for TČA and 75% for TKV.

[3] E-expert, spol. s r.o., „Energetický dokument Statutárního města KARVINÉ (Územní energetická koncepce st. Města KARVINÉ), Aktualizace," 11 2011. [Online].

Veolia Energie plans to shut down the coal boilers in TČA in 2023[4] and make a replacement by gas boilers. In 2026 onwards, the Veolia plan is to operate a new multi-fuel boiler to burn RDF (refuse derived fuel) and biomass in place of the heating plant.

ELECTRICITY GENERATION AND DISTRIBUTION

In the city of Karviná, the distribution system operation for electricity is ČEZ Distribuce. The distribution network is connected to the 110/22 kV distribution substation Karviná - Petrovice (equipped with transformers with a total capacity of 100 MVA). The 22 kV distribution system is operated in the city in urban areas and districts by underground lines and in the outskirts of the city through overhead lines.

Electricity generation in the Karviná is provided by following power plants:

- The Dětmarovice power plant was built in 1972-1976 and is operated by ČEZ, a.s. It is a coal-fired power plant, its installed capacity is 800 MW, and annual production is around 2.5 TWh of electricity and more than 800 TJ of heat. The plant is equipped with four turbines, each with a rated output of 200 MW. In block transformers with a capacity of 225 MVA, the electricity is transformed to 110 kV and it is exported to substations in Bohumín, Vratimov, Albrechtice and Doubrava.
- The Teplárna Československé armády (ČSA) Power Plant has an installed capacity of 24 MWe, which is generated in two steam turbines; the annual electricity production is around 71 GWh. The thermal power plant burns black pulverized coal, natural gas, degasification gas and biomass (more information can be found in chapter Heat generation and distribution).
- The Teplárna Karviná (TKV) power plant has an installed electrical capacity of 55 MWe with an annual production of around 298 GWh. Energy is produced by burning pulverized coal, degasification gas and biomass. Most of the electricity produced is supplied to the ČEZ distribution network. From 2026 onwards, it is planned to operate a new multi-fuel boiler in the CHP plant (more information can be found in chapter Heat generation and distribution).

4.3. REGULATORY PLAN OF KARVINÁ

BUILDING PERMIT PROCESS AND ITS STAKEHOLDERS

In general, the parties to the building permit process are:

- The builder (building owner or developer).
- Owner of the land on which the development is to be carried out. This is not always the same person as the builder
- Owners of neighbouring properties (land and buildings) and those who have an easement over them, if they may be directly affected by the construction project. Also, these may be properties "across the road", but also more distant properties.
- Owners of other buildings on the land on which the building is to be constructed.

If the proceedings follow the Environmental Impact Assessment (EIA) process, environmental associations may also intervene in the construction proceedings. The associations must notify the authority of their interest in taking part in the procedure within 30 days of the publication of the notice of commencement of the construction procedure on the official notice board. The subjects of the procedure have more opportunities to get involved: make objections, which the building authority must

[4] https://karvinsky.denik.cz/zpravy_region/konec-uhli-teplo-chteji-vyrabet-spalovanim-odpadu-20220930.html

deal with individually in the building permit. The building permit process in Czech Republic is unfortunately one of the slowest in the Europe (see Figure 7).

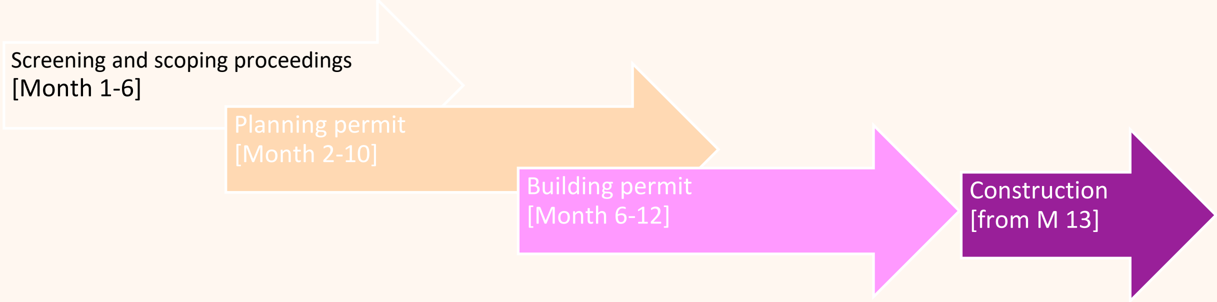


Figure 7. *Average permitting procedure with short EIA in the Czech Republic*[5]

DISTRICT DEVELOPMENT

The City of Karviná launched the new Karviná Land Use Plan in 2018. shows land use plan for the Karviná city district Hranice, Nové město and Mizerov, where the demo site is located. The main objectives of the city land use plan concept are to create territorial and technical conditions for the development of the city as one of the important centres of the region, with emphasis on a balanced relationship between economic development, social cohesion and quality living conditions and environment. A brief description of the three main pillars is given below:

Society, quality of life

- Create an attractive city - a place with a diversity of life in harmony with the environment, a modern prosperous city of spa, innovation, and a centre of education.
- Build the status and prestige of Karviná as a university town with an attractive environment for residents, visitors.
- Build the status and prestige of Karviná as a spa town with an attractive environment for visitors and residents - to attract new spa guests by increasing the capacity of spa facilities and the capacity of accommodation.
- Build new attractions for tourism and leisure activities for visitors and residents (for example sport, relaxation).
- Strengthen the attractiveness and recreational potential of the area by appropriate use of the reclaimed areas, to change the philosophy of using the reclaimed areas in Karviná-Doly - to enable the use of this valuable background of Karviná not only for production but also for civic amenities, housing, sports, recreation, and tourism development.
- Make use of industrial and historical monuments as a specific phenomenon of the Karvina.

Economic development

- Take advantage of the location and position of Karviná, which is part of a major industrial agglomeration.
- Promote entrepreneurship, tourism, innovative entrepreneurship, research, and development.

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[5] AITOM, „Permitting processes". https://www.czechbusinessguide.com/content-of-book-permitting-construction-permitting-processes/ (visited 2022).

- Increase the potential of the city by designating areas for the business development and the creation of new jobs opportunities.
- Build a connection to the national transport corridors - it is a prerequisite to support business and tourism development and to stabilise the economy.
- Use the attractiveness of the spa town and the revitalised landscape for the development of tourism.

Environmental quality

- Create territorial and technical conditions for improving the standard of living of the population with quality social infrastructure, services, educational facilities.
- Minimize the negative effects of mining on the quality of the environment and public health in the addressed area, to improve the quality of life by recultivating areas devastated by mining, to improve the appearance of the landscape.
- Address the gradual redevelopment of production areas existing in the vicinity of residential development, thus freeing up space for improving the quality of housing, for locating areas of civic amenities and sports, for traffic calming and increasing the proportion of greenery.
- Ensure the quality of the environment, especially housing - protection against noise and emissions from transport and production, new areas should be designed in terms of eliminating negative effects on the quality of the environment and public health.
- Create the conditions for improving the air quality by gradually restructuring production into light manufacturing and reclaiming areas after mining.
- Make use of the natural environment penetrating the urban structure of the town for leisure activities.
- Implement the proposed system of urban and suburban greenery with the possibility of short-term recreation.
- Improve and expand the infrastructure for culture and leisure, promote a healthy way of life.

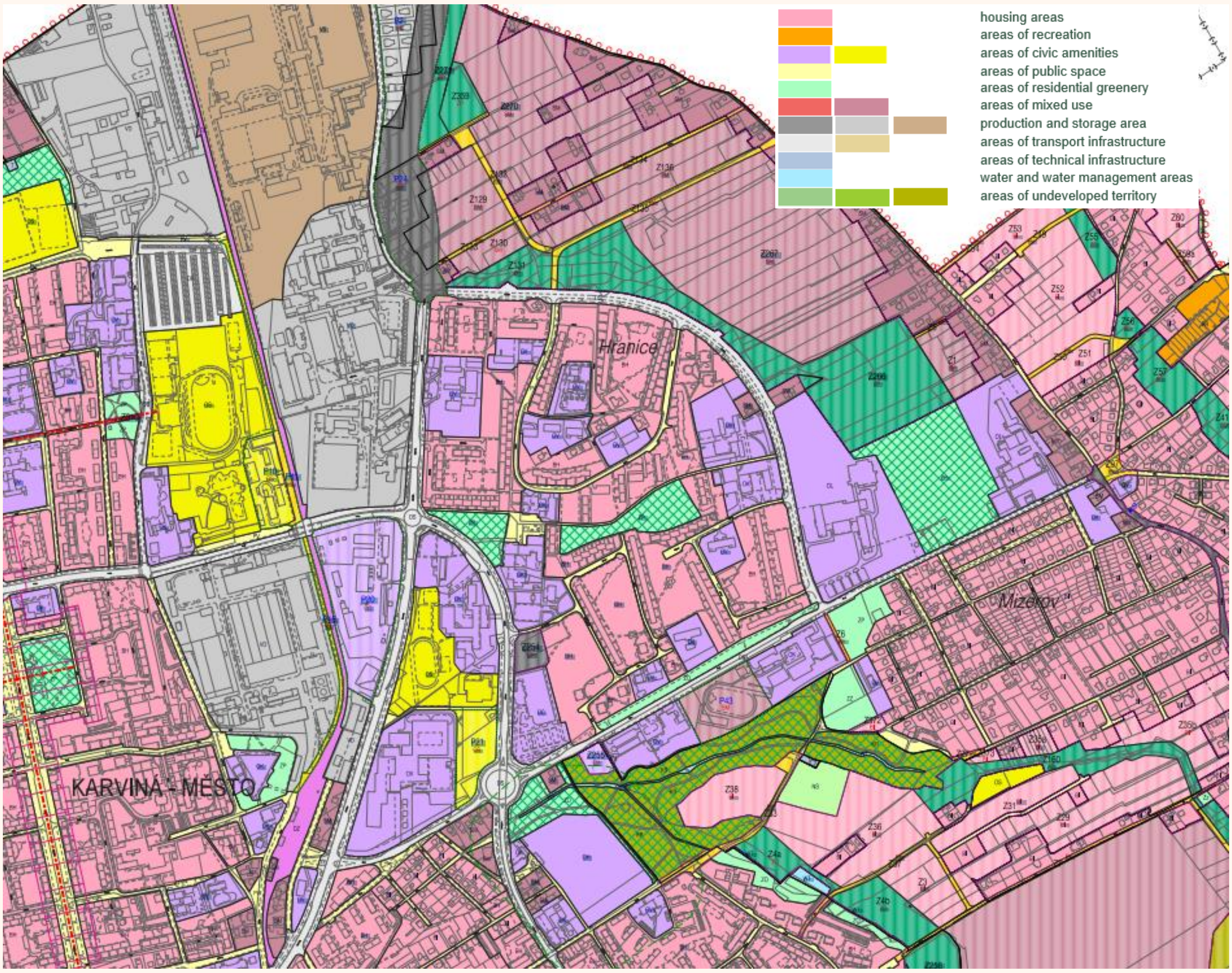

Figure 8. *Land use plan of Karviná Hranice, Nové město and Mizerov.*

4.4. DISTRICT DESCRIPTION

An Initial Site Analysis has been prepared for the site in the past. The analysis provides a comprehensive view of the sites that were first considered for potential implementation of positive energy district (PED). The objectives of this preliminary feasibility study were:

1) Map and describe the opportunities available for the installation of local energy sources in the territory with the aim of achieving a positive balance (RES heat generation, electricity),
2) Test the proposed solutions in a participatory discussion with selected stakeholders (workshop format).
3) Evaluate the overall balance of advantages and disadvantages from the perspective of the three key expertise for the selected site in order to make a policy decision.
4) Provide the basis for the city's application to the Just Transition Fund with a focus on local energy and specifically on the PED.

The following are the main objectives to be achieved in the context of PED as proposed by the ČVUT UCEEB:

1) Retrofitting of buildings,
2) Increasing the attractiveness of the site for living and working,

3) Reduction of operational energy costs,
4) Shifting the energy mix towards renewable energy sources.

These objectives will be demonstrated with the demo building of the healthcare centre.

The buildings and premises that are to initiate the creation of a plus energy district in Karviná are located along Red Army Street at the border of the cadastral areas of Karviná 6 and 8 (Nové město and Hranice).

It is assumed that on the heat source side for district heating there will be a change to a multi-fuel boiler burning biomass and RDF. A low temperature heat distribution system with its own heat source has been designed for the OSP area (see Figure **9**). A ground-to-water heat pump is considered as the heat source with a borehole field under the buildings on the site.

A suitable solution for the PED concept in the electricity sector is the creation of an internal 'microgrid' to allow the use of locally generated surplus energy at a single connection point within this network. There are several technical and legislative ways of doing this, ranging from the already used LDS (local distribution systems), to the supply of so-called direct lines, e.g., within one or several apartment buildings. In the future, the legislative possibility of so-called energy communities can be expected. These should provide the long-awaited appropriate transparent and liberal models for commercial connection of consumption points, which will be economically advantageous from the point of view of the owners of these consumption points. With regard to the current legislation, it would be advisable to inquire with the existing distributor and energy trader about the possibility of creating a virtual network by contracting the possibility of using surpluses within a group of consumption points.

For the analysis of local energy production and consumption, the different were options evaluated, and showed the potential to achieve a positive PED balance. If the PED is implemented, it is a very complex and innovative project from an economic (investment and commercial) point of view. The extension of PED to private entities provides scope for an alternative solution in which the risks and costs associated with large investments would be shared by multiple actors. This could be done by establishing a unique joint venture in the Czech Republic, which could be a larger property owner and operator of the existing and/or future heat supply system. A combination of EPC models, energy community share models, etc. may be recommended.

The next steps leading to the successful implementation of a PED project in the selected location in Karviná will include in particular activities aimed at the creation of a PED working group, of which the City of Karviná should be the main coordinator, other participants should also be research organisations, which should play the role of the PED concept carrier and especially the technical guarantor. Other actors should be profiled, in particular from among private entities that see in the PED concept further opportunities to develop their business, CSR and other activities.

In the next phase, it is recommended to follow the outline of activities and proceed with a detailed inventory of the condition of the buildings, preparation of building and energy concepts and a detailed feasibility study of PED, including financing options.

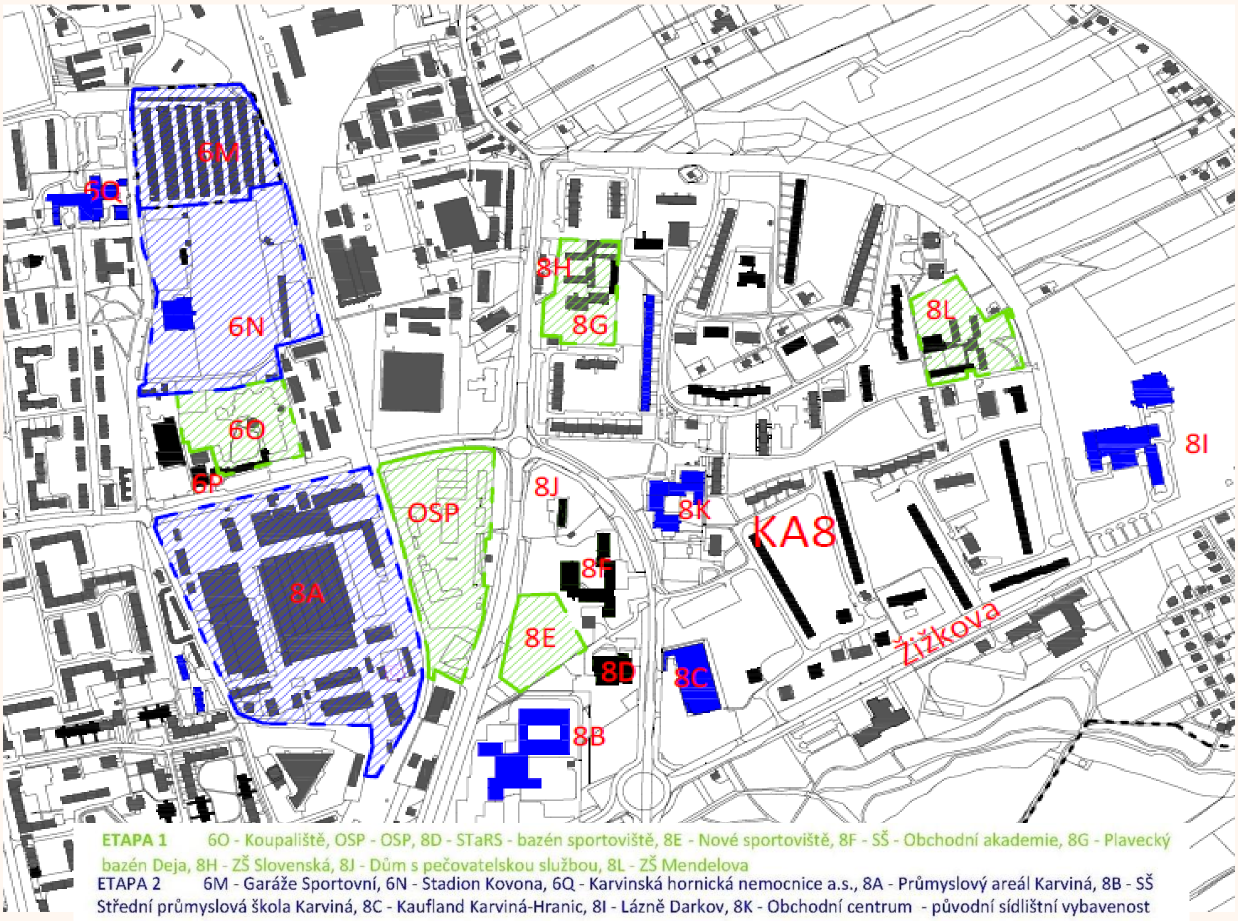

Figure 9. *Map of the objects of interest of Stages 1 (Etapa 1) and 2 (Etapa 2).*

The buildings and complexes that are to initiate the creation of a positive energy district in Karviná are located along the Rudé armády street at the border of the cadastral areas Karviná 6 and 8 (Nové město and Hranice). There are two public transport stops Karviná, Hranice, Pekárna and Karviná, Nové město, Koupaliště. The railway siding follows the north-south direction of Red Army Street. The buildings that were identified as suitable for piling in previous phases are largely owned by the city or its contributory organisations. The existing school buildings, the Nursing Home, the existing swimming pool and swimming pools are complemented by the largest development area of the Karviná intravilan, the OSP brownfield area and the planned sports ground. This concentrated core is loosely linked to other buildings and housing developments that may be incorporated into the system in the next phase.

The site in question is an intersection of the originally analysed sites Karviná 6, OSP, and Karviná 8. The PED can be commissioned in two phases (Stage 1 and Stage 2). In Stage 1, there are 8 existing or currently under construction buildings (6O, 8D, 8E, 8F, 8G, 8H, 8J, 8L) and one brownfield development area (OSP), all owned by the City of Karviná. In Stage 2, there are 8 existing individual buildings and two residential development sites (KA6 and KA8). In the case of the residential development in KA6, priority is given to buildings close to the OSP area from the west (owned by Heimstaden Czech s.r.o.), in the case of KA8, buildings close to the OSP area from the east are considered (the two main owners are Heimstaden Czech s.r.o. and SBD Drubyd), specifically one representative building owned by SBD Drubyd was selected. Overview of objects and sites selected for more detail PED analysis are in Table .

Darkov Spa is working on its own energy concept. The buildings are not included in the PED calculation, but a possible interconnection within the microgrid will be considered in Phase 2.

Table 2. *Overview of objects and sites selected for more detailed analysis*

Name of the building	Owner	Code on map (**Figure 9**)	Status	Stage
Swimming pool	SMK	6O	R	1
OSP	SMK	OSP	Z	1
STaRS – swimmingpool of sports area	SMK	8D	R	1
New sports area	SMK	8E	N	1
High school of business	SMK	8F	P	1
"Deja" Swimmingpool	SMK	8G	P	1
Elemenetary school "Slovenská "	SMK	8H	R	1
Nursing home	SMK	8J	P	1
Elementary school "Mendelova"	SMK	8L	R	1
Garages "Sportovní "	Více vlastníků	6M	P	2
"Kovona" stadium	Sportovní centrum MFK Karviná s.r.o	6N	P	2
Karvinská hornická nemocnice a.s. – hospital	Karvinská hornická nemocnice a.s.	6Q	R	2
Residential houses KA6	Heimstaden Czech s.r.o.	-	*	2
Industrial Park Karviná	BAMKI s.r.o.	8A	-	2
High school of industry Karviná	Moravskoslezský kraj	8B	R	2
Shopping mall Karviná-Hranice	Immo - Log - CZ Alpha Beta s.r.o.	8C	R	2
Residential houses KA8	SBD Drubyd Heimstaden Czech s.r.o.	-	*	2
Spa "Darkov "	WF Group SICAV a.s.	8I	R	2
Commercial area – original	Merano a.s.	8K	P	2

N – newbuild, P – current, R – refurbishment, Z – plan, * Varied

For the site location and the surrounding the map of urban heat island areas are available. The surfaces temperature are presented in **Error! Reference source not found.**. The demo building is surrounded by the forest and has a surface temperature around 23 °C. The area facing the north has the surface temperature around 30 °C.

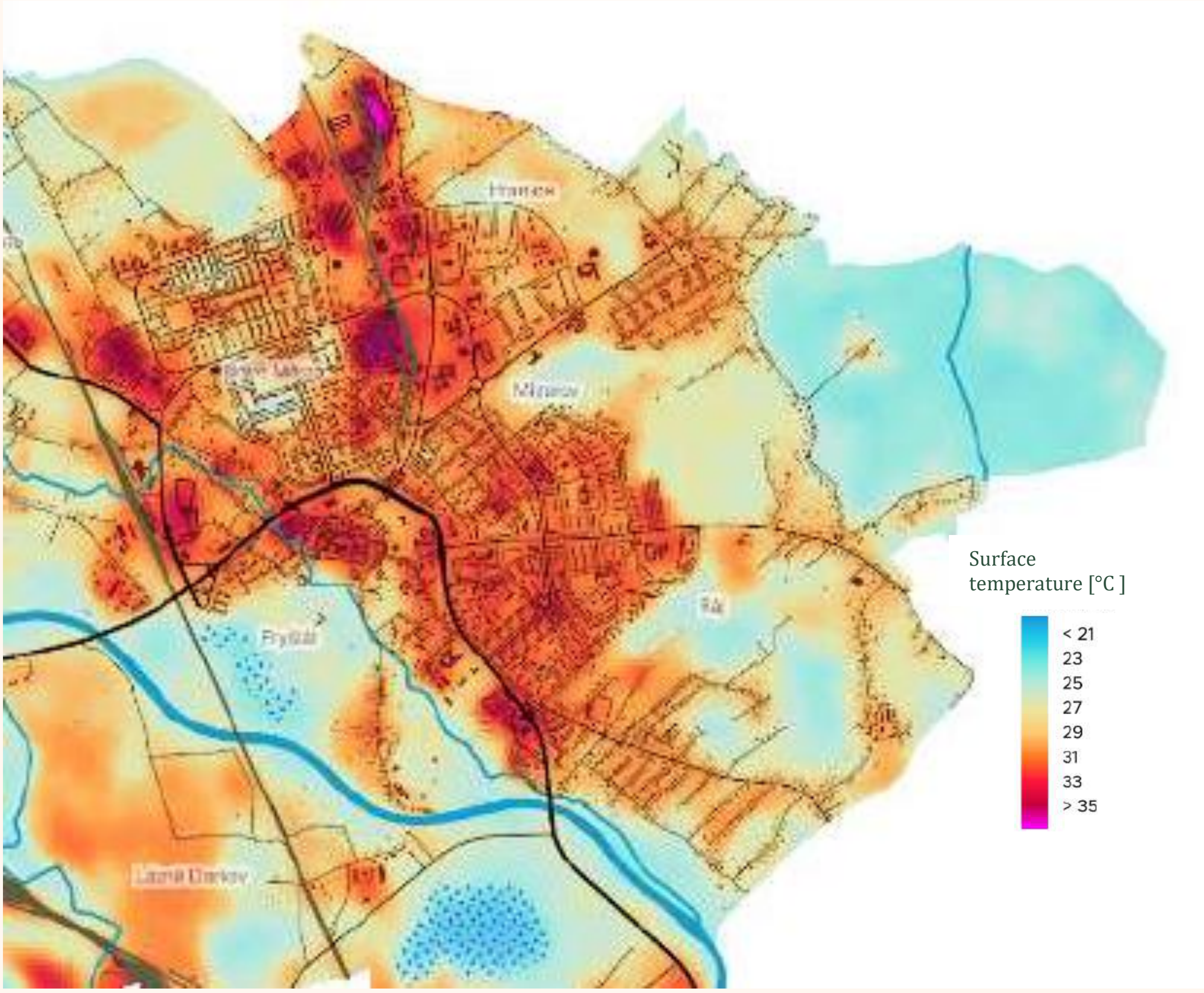

Figure 10. *Map of urban heat island areas[6].*

For the site location and the surroundings, the map of greenery is available (Figure 11). It divides the greenery info different categories:

- Trees
- Grass
- Vegetation areas
- Vegetation elements
- Tree groups

[6] Adaptační strategie na změnu klimatu statutárního města Karviná, ASITIS s.r.o., 2021

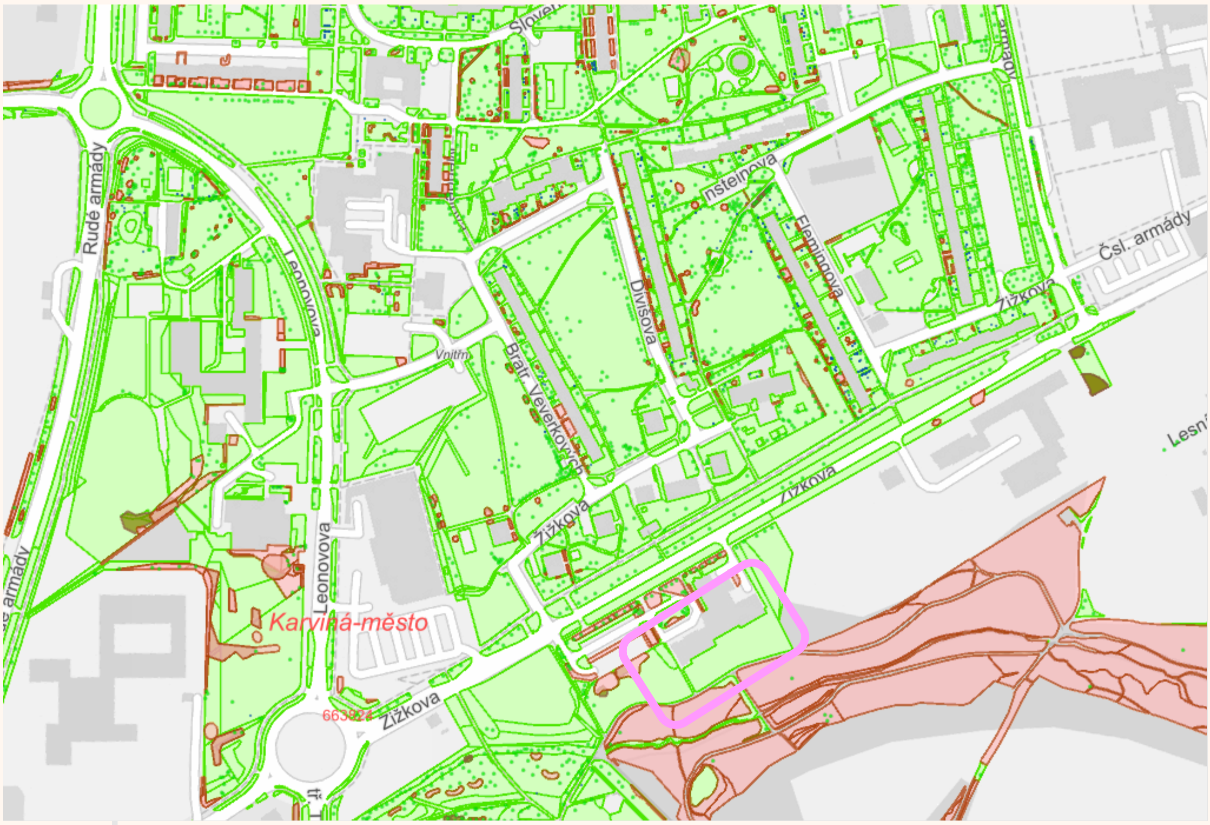

Figure 11*. Map of greenery nearby the demo site location from [https://gis.karvina.cz/mapa/pasport-zelene/.](https://gis.karvina.cz/mapa/pasport-zelene/)*

For the site location and the surroundings, the map of charging stations for e-mobility is available. In the district there is only one charging station, with the following parameters: 1 x 50 kW and 1 x 22 kW (Figure 12).

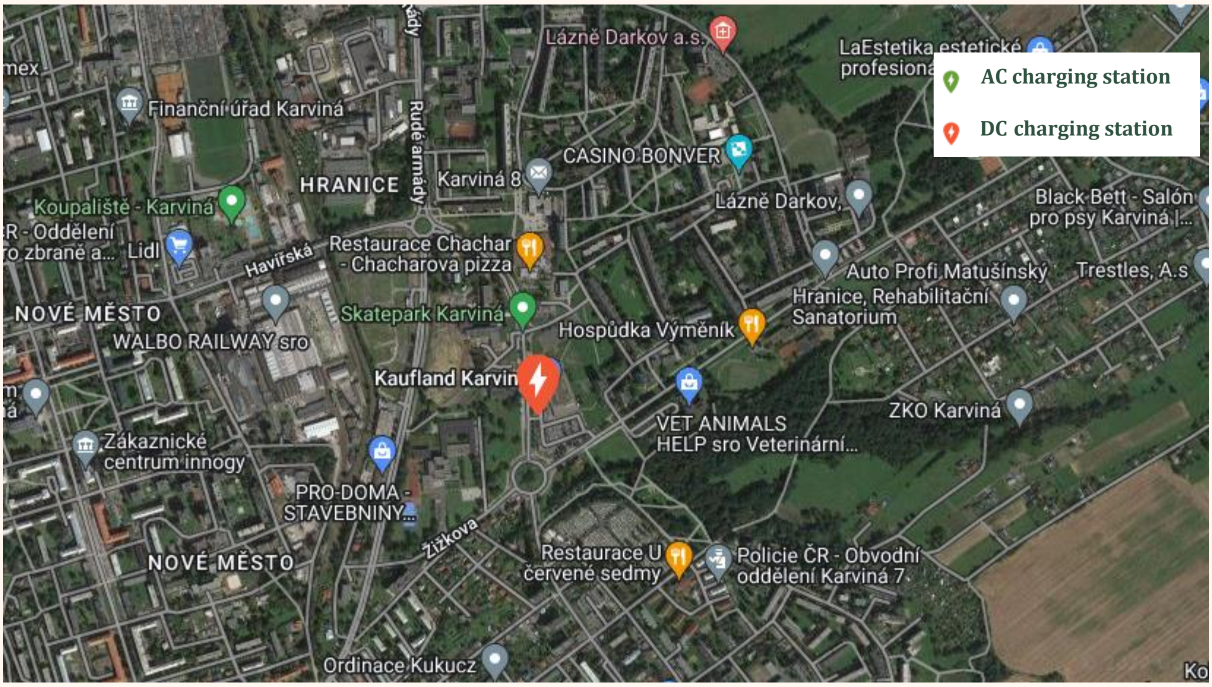

Figure 12*. Map of charging stations nearby the demo site location from [https://fdrive.cz/mapa-nabijecich-stanic.](https://fdrive.cz/mapa-nabijecich-stanic)*

4.5. PARTICIPATION AND STAKEHOLDER INVOLVEMENT

GENERAL PRINCIPLES TO BE FOLLOWED

This is a very broad draft that will further be adapted to Karviná's Health Care Centre.

1) Intention

The whole project of renovation usually starts with an intention, in case of publicly owned buildings (such as Karvina's Health Care Centre) the intention typically comes from the municipality. In this phase usually the site is already known and a general and broad idea of what is supposed to be done and why should be it done exists.

2) Stakeholder mapping

Based on the initial intention and plan, main interest groups should be defined. Desk research should be conducted and internal knowledge of the representatives of the municipality should be used. The interest groups can include members of general public in various different roles (such as residents, employees of concerned businesses, frequent passers-by, members of various community groups, etc.), representatives of local businesses, cultural and sport venues, municipal organizations (such as schools and other institutions), local experts and many more.
Questions such as the following should be answered to help identify the target groups:

- Who are the tenants/residents of a given building?
- What are the other groups, that happen to spend some time in the building or in its surroundings (frequent passers-by etc.)?
- What are the groups that are not currently connected to the building but might be after the reconstruction is done?
- What are the groups that are going to be affected by the construction site?
- Are there any groups with unmet needs that might be fulfilled by the reconstructed building?
- What are the municipal departments and other city organizations that are connected to the building or might be after the reconstruction?
- Who are the local experts that are not necessary connected to the building but might be invited to join the process and share their know-how?

A database with contact details of the representatives of the defined groups and institutions (heads of defined institutions, community groups or sports clubs, local opinion leaders etc.) should be made and an initial plan of how to best contact representatives of these groups should be put in place.

The relevant stakeholder groups should be informed on a priority basis throughout the whole process and invited to co-design or provide feedback in appropriate phases of the project (exact moments or methods might vary due to the specifics of a given project and not all the groups need to be always involved). Apart from the moments where representatives of the selected groups are invited to cooperate, updates on the project should be provided continuously throughout the whole project (suitable channels might include a website dedicated to the project, website of the municipality, city hall newspaper, or others) and there should be an easy way to contact the project

3) Co-design of the main goals of the reconstruction, initial contact with the defined groups

A general idea of targets of building reconstruction already exists (phase 1. Intention). The intention should be presented to the defined interest groups and should be completed and confirmed in cooperation with them. Needs and other ideas of the target groups concerning the given building and surrounding area should be gathered and incorporated into the design where possible. As stated above various methods to complete these objectives can be used.

4) Design phase
When the first draft of the design is done, it should be again introduced to the defined groups. Explanation why some needs and ideas were incorporated and why others were not should be provided. Feedback on the solution design draft should be gathered. The design should be adjusted based on the gathered feedback if possible. The final version of the design should be introduced and discussed.

5) Reconstruction
Regular updates should be provided.

6) Operation of the building
On the occasion of the opening of the building some kind of formal event can be organized, representatives of the target groups can be invited and taken for an excursion around the new building systems etc.

After appropriate time period the operation of the building can be assessed in cooperation with representatives of selected target groups and adjusted.

Participation methodologies
List of existing participation methodologies (including the overview of possible methods and other tips) will be later provided here.

5. DESIGN

5.1. ORIGINAL STATUS

GENERAL INFORMATION ON DEMO BUILDING

The building on Žižkova street No. 2379 in Karviná – Mizerov was built and put into use in 1993 and it was owned by Moravian-Silesian Region. In January 2021, the building was donated by the City of Karviná by the Moravian-Silesian Region. The reason for the building takeover was the fact that the municipality wanted to bring life back to the building which was for a long time an important landmark of the city, not only the medical centre. The plan of the City of Karviná is to restore the building to its original importance. The building will become a modern multifunctional object that provides visitors not only medical care, but as well small business services. The municipal goal is to make the environment more pleasant for the existing building tenants and visitors, but also to attract new tenants so that the building will be fully occupied again.

Figure 13*. Picture of the current status of the building*

The building is four-storey, with a basement, and having five tracts. The area of the typical floor is about 1850 m^2. In the basement, there is a hospital pharmacy area, technical facilities of the building, workshops, and a food dispensing room. On the first floor there is a porter's lodge, cloakroom, and fast food in the entrance hall, and in the tracts, there are rooms for rehabilitation, including a swimming pool. Part of the premises is accessible only from the outside from the car park (sales units). On the second to fourth floors are surgeries and other tenants providing various services (optician, cosmetic, massage, travel agency, etc.). A central staircase with a pair of lifts runs through the centre of the building, one of the tracts is terminated by an escape staircase, the second tract is additionally supplemented by a lift. The fourth elevator is a two-storey elevator for the purpose of food dispensing. On the roof of the building are located the technical rooms of the lifts and technology for HVAC systems. Current status of the building can be seen in Figure 13 – Figure 19.

Figure 14*. Current status of building envelope.*

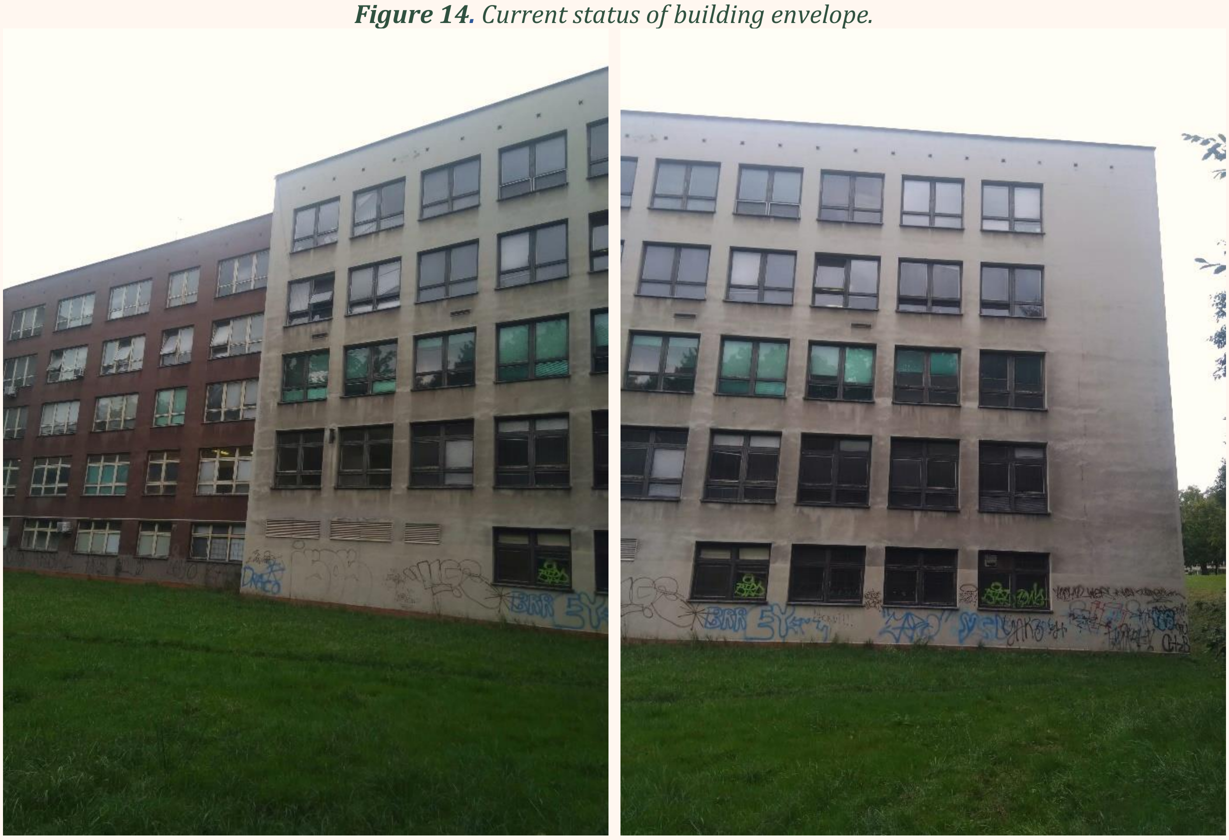

***Figure** 15. Current status of the façade in detail. Most of the structures are beyond its lifetime.*

Figure 16*. Current status of the ground floor structures with significant moisture transport in the left and typical obsolete window in detail in the right.*

***Figure** 17. Roof structures in current state.*

***Figure** 18. Interior of Healthcare centre.*

***Figure** 19. Interior of Healthcare centre.*

The building is currently not fully utilized and occupied by tenants (approximately 50% occupancy). The provision of rehabilitation care was discontinued in 2018, the food dispensary is only used for the dispensing of packed lunches, the fast-food area, the bank, and the convenience store are currently without tenants, and the public locker room and swimming pool are not functioning. The stairwells in each tract are closed. The elevator in this tract and the elevator for the food service area are closed.
During the June 11, 2020, an inspection of the building found that its original condition had been unmaintained, with no structural modifications, and not up to current requirements and time. Due to the fact that the subject building is in a dismal condition, the first steps were planned to improve the current condition.

LIST A PLAN OF CURRENT TENANTS

The current tenants are located in all four parts of the building. The enterprises are mixed without specific key and located in Pavilions A1–A4 (Table). The B pavilion contains machinery and other supportive facilities. The current tenants are partners for participative design process.

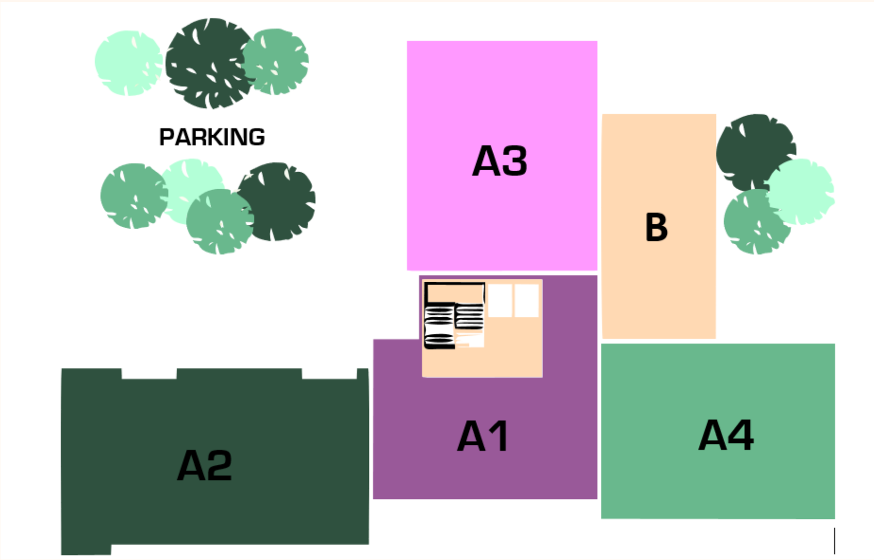

***Figure** 20. Building orientation plan. A-parts are for regular use (commercial areas), part B includes the technical background of the building, machine rooms.*

***Table 3.** List of current tenants (enterprises) located in Healthcare center.*

Name	Enterprise	Loc.	Name	Enterprise	Loc.
MUDr. Bartoň Martin	doctor	A3	STOLDENT s.r.o., MDDr. Stolarz	doctor	A2
MUDr. Bizoňová Božena	doctor	A3	MUDr. Tomalová Kristina	doctor	A3
Mgr. Drozdová Sylva	doctor	A2	VIDACARE s.r.o., MUDr. Linzerová	doctor	A2
MUDr. Donocik René	doctor	A2	Veterinární ordinace Karviná-Mizerov	vet	A2
MUDr. Franková Lucyna	doctor	A3	DSlaborator s.r.o.	shops and services	A4
MUDr. Harazim Vít	doctor	A4	Mgr. Fáber Daniel	shops and services	A4
Logopedie Krhovják s.r.o.	doctor	A1	Galanterie	shops and services	A1
MUDr. Kowalski Stanislav	doctor	A3	Glanc Optik	shops and services	A2
KARDIO-NET s.r.o.	doctor	A2	Mandincová Jiřina	shops and services	A4
MUDr. Leikep Petr	doctor	A3	Műlllerová Kateřina Františová	shops and services	A1
Mařákovi-Dent s.r.o., MDDr. Josef Mařák	doctor	A3	Optika Jakešová	shops and services	A1
NEUROLKA s.r.o.	doctor	A3	PARIS vzdělávací agentura s.r.o.	shops and services	A4

Name	Enterprise	Loc.	Name	Enterprise	Loc.
Mgr. Novotná Lenka	doctor	A1	PROMESA - zdravotní prodejna	shops and services	A2
MUDr. Ondruch Zbyhněv	doctor	A2	Relax Tour - Cestovní agentura	shops and services	A1
PROCEVA MUDr. Cuberová cévní interní ambulance s.r.o	doctor	A2	Sunny impex s.r.o.	shops and services	A1
MUDr. Pindurová Blanka	doctor	A2	Tetování, permanentní make-up, piercing - Sekelová Zdeňka	shops and services	A1
STENYMED s.r.o., MUDr. Stenchlá	doctor	A2	TaRealitka	shops and services	A2
MUDr. Sirota Rudolf	doctor	A3	UnikaCentrum, z.ú.	shops and services	A1
SPADIA LAB, a.s.	medical services	A1			

ENERGY PERFORMANCE OF ORIGINAL BUILDING

Thermal resistance of building envelope

The Healthcare centre is an atypical building, because the envelope consists of a sandwich masonry construction. The envelope has a different composition depending on the location, whether it is adjacent to the soil or located in the lower (more load-bearing materials are used) or higher floors (lighter masonry). The roofs of each pavilion are double-skinned and have a uniform composition.

The polyclinic building consists of several pavilions A1, A2, A3, A4 and pavilion B.

- Pavilion A1 has one underground floor, four floors above ground and a technical floor on the roof of the building. The perimeter masonry is sandwich composition.
- Pavilion A2 has one underground floor, four floors above ground and a technical floor on the roof. The perimeter masonry is also sandwich composition.
- Pavilion A3 has one underground floor, four floors above ground and a technical floor on the roof. The perimeter masonry is sandwich composition.
- Pavilion A4 has one underground floor, four floors above ground and a technical floor on the roof.
- The perimeter masonry is sandwich composition.
- Pavilion B has one underground storey and one storey above ground. The perimeter masonry is sandwich composition.

In 2022, there was done an energy assessment and calculation by Ing. Světlana Kravčenková, the data presented here are based on that assessment.[7] The overview of thermal properties of building envelope are stated in Table **4**. Most of the structures are non-compliant to either recommended nor required values of thermal transmittance coefficient (U-value).

Table 4. *Overview of thermal properties of current building structures and components*

Composition	Type of the structure	Thermal transmittance coeficient Up (W/m²K)	Recommended thermal transmittance coeficient $U_{rec,20}$ (W/m²K)	Required thermal transmittance coeficient $U_{N,20}$ (W/m²K)	Condensation	
					G_k (kg/m²)	G_v (kg/m²)
SO1	Exterior sandwich wall ceramic masonry	0,534	0,250	0,300	0,0250	0,1000
			non-compliant	non-compliant	compliant	
SO2	Exterior sandwich wall ceramic masonry/aerated concrete	0,490	0,250	0,300	0,0360	0,1000
			non-compliant	non-compliant	compliant	
SO3		0,544	0,250	0,300	0,0070	0,1000

[7] Kravčenková Světlana, Ing.: Zateplení budovy č.p. 2379 na ul. Žižkova v Karviné-Mizerově. Energetické posouzení. 7.4.2022,

Composition	Type of the structure	Thermal transmittance coeficient Up (W/m²K)	Recommended thermal transmittance coeficient $U_{rec,20}$ (W/m²K)	Required thermal transmittance coeficient $U_{N,20}$ (W/m²K)	Condensation	
					G_k (kg/m²)	G_v (kg/m²)
	Exterior sandwich wall reinforced concrete/aerated concrete		**non-compliant**	**non-compliant**	compliant	
SO4	Exterior sandwich wall reinforced concrete/ceramic masonry toward earth	0,446	0,300	0,450	For adjacent structures, the balance of condensed steam is not determined	
			non-compliant	compliant		
SO5	Exterior sandwich wall reinforced concrete/brick	0,603	0,250	0,300	0,0030	0,1000
			non-compliant	**non-compliant**	compliant	
PDL1, PDL2, PDL4, PDL5	Floor on the ground A1, A2, A4, B	1,210	0,300	0,450	For adjacent structures, the balance of condensed steam is not determined	
			non-compliant	**non-compliant**		
PDL3, PDL52	Floor above the basement A3, Floor above the basement B	1,041	0,400	0,600	0,2890	0,1000
			non-compliant	**non-compliant**	**non-compliant**	
PDL21, PDL51	External floor above A2, External floor above B	0,553	0,160	0,240	0,0060	0,1000
			non-compliant	**non-compliant**	compliant	
SCH1-SCH5	Roof A1-A4, B	0,405	0,160	0,240	0,0450	0,1000
			non-compliant	**non-compliant**	compliant	

The assessment concludes that the thermal-technical properties of the building envelope correspond to the time of its construction, but from today's point of view (even without the target of nZEB/CPCC), the hygrothermal performance of the building structures is inadequate.

Energy systems

The building is connected to the district heating network that is operated by Veolia Energie. In the building (pavilion B) there is installed an object heat interface unit preparing heat for heating and domestic hot water. The installed capacity is 2x550 kW for heating and 475 kW for domestic hot water preparation. The domestic hot water preparation includes a storage tank with a capacity of 1500 l.

According to the original design, the building was naturally and mechanically ventilated. In the pavilion technical rooms on the roofs, the mechanical ventilation units without heat recovery or with non-functional heat recovery are installed. The HVAC units are not in operation during the heating period, when the heating of the spaces is provided by hot water radiators. In some areas, split units or mobile air-condition units are installed to provide cooling for selected spaces.

For the needs of the building's electricity supply, there is a substation in the building connected to the 400/230 V distribution system. The main consumer of electricity is lighting and medical equipment. The building has a backup source of electricity - a diesel generator.

The artificial lighting of the space is provided by old fluorescent tubes with high energy consumption. Most of the spaces in the building have twin fluorescent light fittings with an input power of 94 W. In a smaller part of the building, mainly sanitary facilities are equipped with incandescent luminaires with an input of 60 W.

The current state of the building regarding the Building Automation System (BAS) is very closely related to the BEMS. The building (before the renovation) is mostly poorly equipped with isolated control systems, e.g., for heating. However, it is equipped with a utility metering with a sufficient resolution, so the overall energy performance of the building after the renovation can be compared to the state before renovation.

The building as well the energy systems in the building have remained mostly unchanged since they were originally installed, only the most important repairs have been carried out. Most of the building service technology is beyond its lifetime with high-energy consumption for operation needed (see Figure 21 – Figure 23).

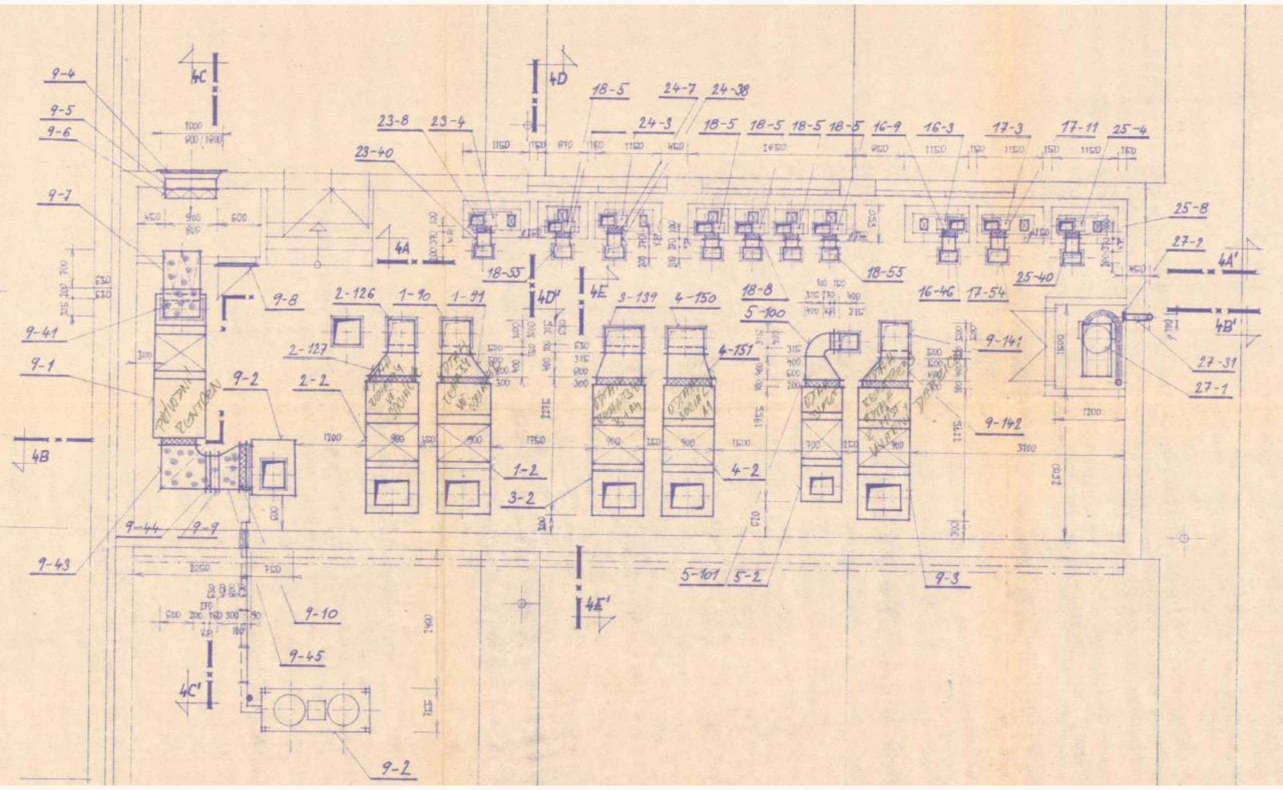

Figure 21*. Original project documentation of the HVAC system in technical room system, pavilion A4, 5th floor. The technology has been preserved up to this day.*

Figure 22*. Current status of the HVAC system in the building. The heat exchange station is modern and operated by third party.*

Figure 23. *Current status of building interiors and old fluorescent tubes in offices and corridors. Mobile air–condition unit is placed in the office space.*

The energy monitoring is only at building level and provides information of energy consumption for electricity and heating. The energy consumption data from year 2019 and 2020 are presented in Figure 24.

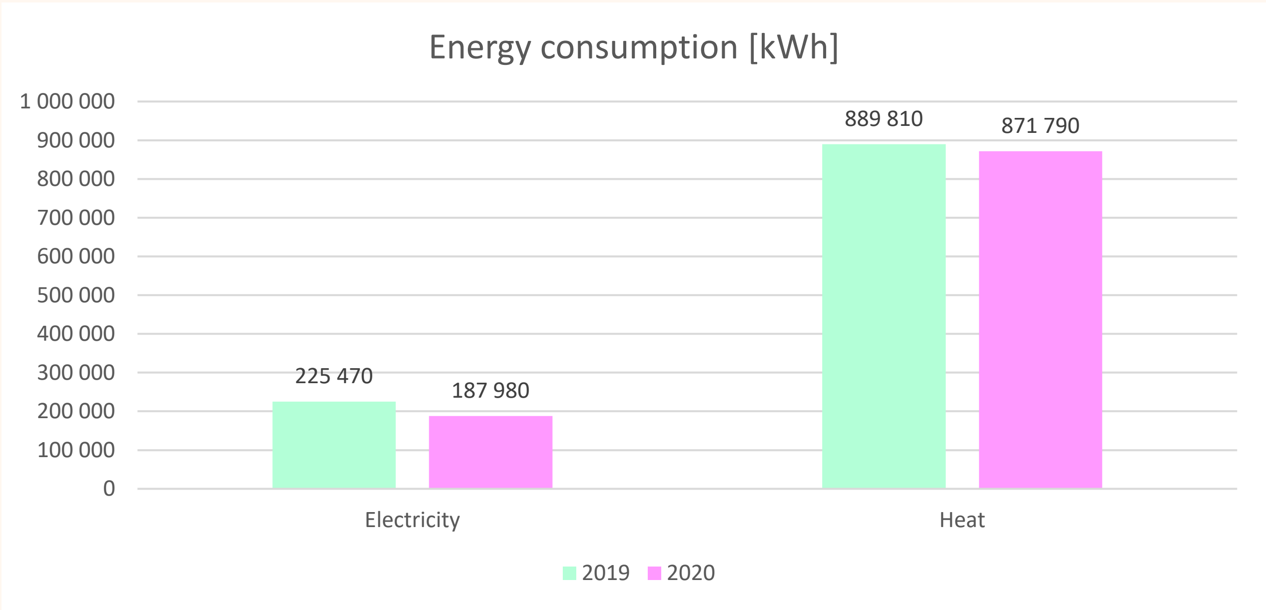

Figure 24. *Monitored building energy consumption in 2019 and 2020.*

The building energy performance certificate was calculated for the building before the building envelope renovation and is presented in Figure 25.

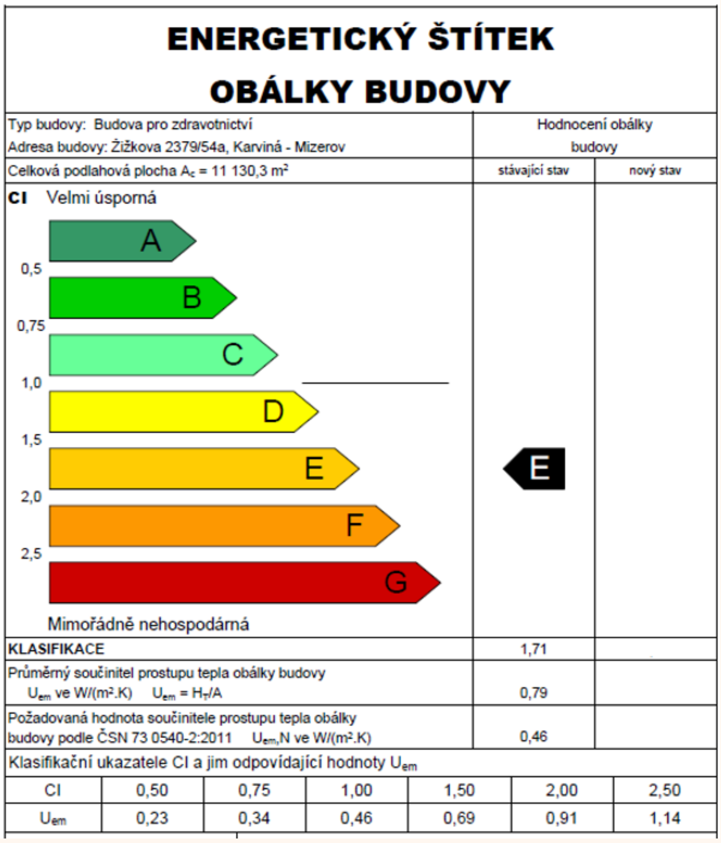

***Figure 25**. Building energy performance certificate before the renovation*[8]

5.2. CONCEPT DESIGN

STRATEGY & FRAMEWORK FOR REACHING CPCC IN KARVINÁ

The Healthcare centre was selected as a demonstrator for the nearly zero energy building (nZEB) prepared in Karviná. The main aim is to demonstrate nZEB refurbishment of the building with potential improvements pushing the building towards energy active building and thus founding the CPCC in Karviná. Even though the realization of the technical measures will be limited by cost, the experience gained from the process will serve as models for further development of the building and other buildings in the district beyond ARV project. A digital twin of the building is created and used to show the impact and set up the roadmap for future refurbishment of the demo building beyond the ARV's timeline but still heading towards the project's goals.

The design process will be carried out on following steps:

1. **Research on status of the building.** The building technical and operational status will be described, the tasks for the refurbishment will be defined. The outcomes are reported earlier in this report.
2. **Identification of the potential.** Based on the possibilities of the current building, the potential of the energy savings, application of the renewable resources and measures on HVAC system will be calculated and analysed. The potential in the operation scheme will be identified.

[8] Kravčenková Světlana, Ing.: Zateplení budovy č.p. 2379 na ul. Žižkova v Karviné-Mizerově. Energetické posouzení. 7.4.2022

3. **Preliminary design.** The preliminary design is necessary for improvement of the analyses, feasibility evaluation, and cost calculation. ARV innovations will be tested and evaluated in this step.
4. **Detailed and realized design.** The most detailed design will be carried out and realized with the demo building.
5. **Nearly zero energy building** is the result of the process. The building of healthcare centre will reach the at least nZEB level, if no extra measures will be applied.
6. **Digital twin** is a crucial tool that will provide the support for the design process. The inputs from the model will shape the design from the preliminary stage to realized building and beyond.
7. **Positive energy building with potential to reach CPCC Karviná.** Knowledge, experience, and data will be a catalysator of change in larger scale. The stakeholders will get comprehensive information on how the innovations and technical measures can affect the buildings' behaviour and help to draw the roadmap to CPCC Karviná in the future.

These principles illustrates Figure 26.

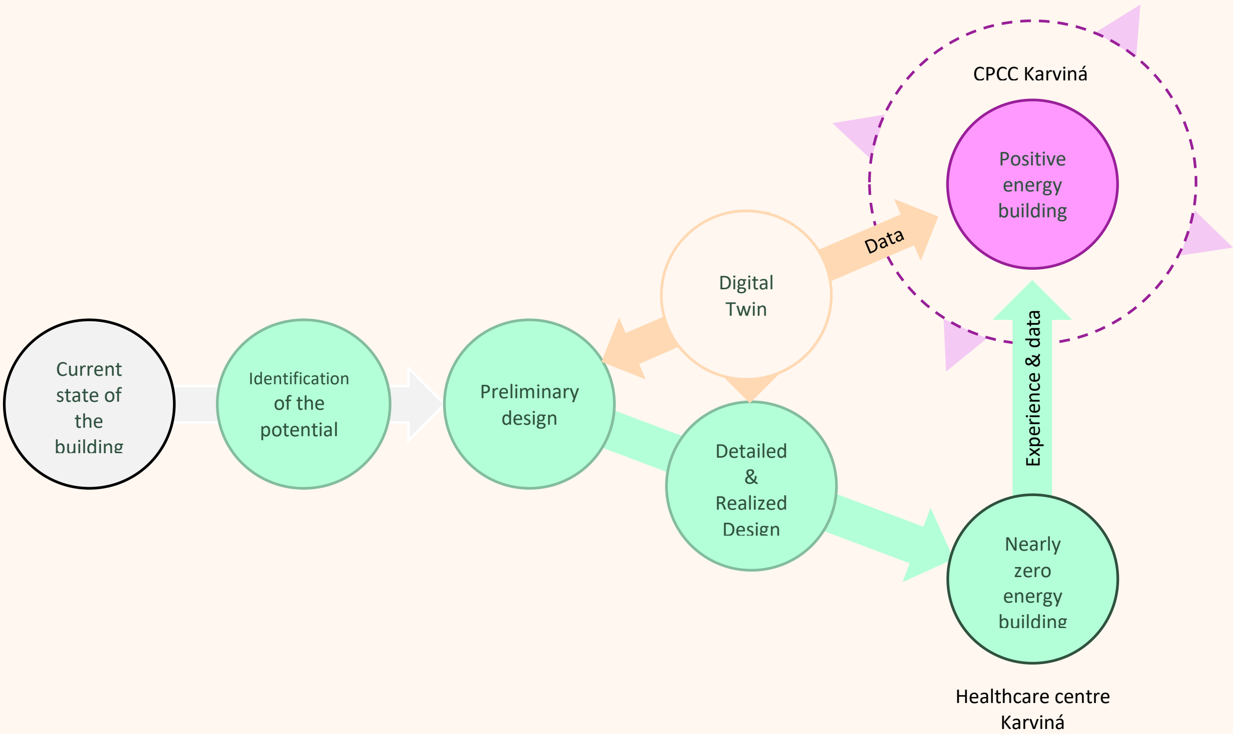

***Figure 26**. Design strategy of CPCC in Karviná.*

Even though the principles described above definitely have limited possibility of application within either the ARV project scope and the building owner (municipality) budget, there will be the applied number of innovations (see chapter 7 – Innovations in the Karvina Health Care) and further technical measures, that will move the building performance towards the desired goal.

PROJECT KPI'S

The Healthcare centre refurbishment project KPI's are derived from ARV Project KPI's. These are stated in following Table. Starting from the preliminary design, the measures are heading to reaching the required goals.

The specific measures to reach the KPI's are described in following Table 5**.**

Table 5. Measures and innovations to meet the KPI's

Category	KPI	Demo actions impacting the KPIs
Energy	**Non-renewable Primary Life Cycle Energy in the Built Environment**	NZEB level of refurbishment of building envelope, application of renewable energy sources
		BIPV, BAPV, PV-T (Photovoltaic-Thermal) integration
	Renewable Energy Ratio	BIPV, BAPV, PV-T Integration
	Net Energy/Net Power	Forecasting of electricity and heat load profiles
	Flexibility Index	A central second-life energy storage
Environment	**Life-cycle GHG Emissions in CPCC**	Green roof sample for reducing heat islands and slowing down the water runoff, application of recycled and/or secondary materials. LCA of HVAC systems with focus on carbon footprint. Small-scale pilots of climate change resilient solutions – use of heat pumps for summer cooling
	Air Pollution from the Energy Consumption	BIPV, BAPV, PV-T Integration
	Dust during Retrofitting	Analysis will be provided
	Noise during Retrofitting	Analysis will be provided
	Social Inclusion	Creation of Living Lab
	Social Engagement	Creation of Living Lab
	Social Interaction and Cohesion	Analysis will be provided
	Energy & Environmental Consciousness	Analysis will be provided
	Access to Sustainable Mobility	EV charging stations and the implementation of V2G/vehicle-to-home (V2H) services
Architecture	**Aesthetics and Visual Qualities**	Keeping architectural aesthetics of the BIPV, digital twin
	Solar and Daylight Access	Digital design and 3D simulations (digital twins) for solar irradiation potential and design of optimum shading devices
	Accessibility	Analysis will be provided
	Indoor Air Quality	IAQ monitoring platform
	Thermal Comfort	Innovative cooling solutions, analysis will be provided
	Overheating Risk	Analysis will be provided
	Acoustic Comfort	Analysis will be provided
	Outdoor Comfort	Analysis will be provided

Circularity	**Materials from Cycled Sources**	Green roof sample will be installed – with application of recycled and/or secondary materials
Economics	**Global Cost**	Analysis will be provided
	Energy Renovation Rate	Analysis will be provided
	Construction Time Reduction	Installation of alternative swappable façade elements with integrated RES

DESIGN PRINCIPLES

To fulfil the architectural, environmental, social, and economic goals, the following general design principles are considered, evaluated and upscaled with the digital twin. For some measures (green roof, façade elements, renewable resources), it cannot be reached optimal application with the Healthcare centre (cost, technical issues, current legislation etc.), but these principles and measures can be widely applied later with the further buildings possibly joining the CPCC Karviná in the future. Therefore it is important to define the principles in general way.

Reducing buildings' energy consumption

- Minimisation of heating energy: design for passive energy standard of the building or its part, additional insulation of the building envelope, replacement/refurbishment/renovation/re-glazing of windows, improvement of airtightness of the building envelope.
- Minimisation of energy for ventilation and emphasis on indoor air quality: Installation of mechanical ventilation systems with heat recovery combined with CO2-VOC-humidity-temperature sensors.
- Minimisation of cooling energy: Installation of efficient shading systems for large-glazed areas, automatic shading control systems (south, west, and east windows).
- Use of renewable energy sources: Solar panels for hot water heating, photovoltaic systems to cover operating energy, biomass energy sources, etc. Waste heat from the hot water is used for preheating. The energy can be stored in a battery system.
- Energy-saving terminal devices: Appliances, lighting, automatic control systems, etc. For instance, indoor lighting fittings are controlled by sensors that react by dimming the lighting according to the current intensity of outdoor daylight.

Water efficiency (within the building) and blue infrastructure (in the building's surroundings):

- Rainwater is accumulated and evaporated from the open surface or vegetated areas of the building and its surroundings: Ponds, water areas, but also soakaways or permeable surfaces of paved and handling areas, green roofs and green facades are used for accumulation. These measures both reduce the effects of torrential rainfall and contribute to reducing the heat load on the environment.
- Rainwater is accumulated and, after proper treatment, used for maintenance of the building surroundings i.e. for watering the garden, green roofs and façades, and maintenance and cleaning of outdoor areas, etc. These measures reduce the need for drinking water and, through functional greenery, the heat load on the environment, and can also reduce costs of water and sewerage charges.
- Rainwater is accumulated, purified and used inside the building: This is the most technically demanding solution; the internal use includes mainly toilet flushing, cleaning etc. These measures save drinking water consumption and can also reduce the costs of water charges.
- Greywater, especially from restrooms, can be used as service water (so-called white water) for flushing toilets and urinals or maintaining outdoor areas; thus, it can reduce drinking water consumption, both indoors and outdoors.

Green infrastructure (indoor/outdoor)

- Maximise the green areas on the site: Grassed paved areas, planting mature greenery, using grassed blocks and stencils for paved areas, etc.
- Green roofs: Extensive green roofs with a substrate thickness of up to about 15 cm are planted with plants extending (with minimum maintenance) into the area. These are mainly perennials, rock plants, grasses or mosses that can withstand extreme conditions of alternating heat, drought, and frost. Intensive green roofs are suitable for creating gardens using herbs, shrubs and low trees, and the substrate can be up to 1.3 m thick.
- Green facades: The covering (shading) of the opaque and non-transparent parts of the façade, either in the form of climbing plants or plants in containers with a substrate. Climbers will create an enjoyable light atmosphere in the growing season, while outside of that season, the leaves will fall, and nothing will prevent daylight and solar gains.
- Greenery in the interior: interior green walls, mature greenery in central common areas, etc.

Environmentally responsible and friendly behaviour of users

- Waste sorting: Installation of waste sorting bins
- Responsible behaviours on resources consumption: Responsible approach to drinking water consumption, the installation of presentation systems of implemented climate change adaptation measures (e.g., an indicator of current energy production from PV systems, the current status of rainwater use, etc.).

Building envelope and construction details

- Retrofitting: Implementation of thermal insulation, window replacement, heat pump installation, water-saving devices, etc.
- Possible material solutions that can be considered:
    - Packwall - board from the beverage cartons (tetra pack) - recycled material
    - PV integrated (one or two panels)- Several tests could be run to measure the electrical performance (efficiency, operation in different weather conditions (some panels perform better in cloudy weather which would be important for CZ) and thermal performance (temperature, irradiance). One potential panel is SKALA for solar facades by Avancis (BIPV) scalable in terms of size and colour.
    - Recycled concrete façade panels
    - Textile reinforced concrete (TRC) facade panels with a washable surface
    - Concrete tiles made with recycled ceramic or clay
    - Steel facade panels (corten sheet)
    - Climbing plants planted on pots
    - Wood facade (larch) - whole panel or wooden laths or thermal wood (thermally treated)
- Generally, the recycled materials and regional materials (local materials) are preferred.

Circular design

- Maximising asset utilisation: Co-location, shared and flexible spaces are becoming increasingly common. By occupying less space and minimising the time an asset is idle, fewer resources are needed to deliver the same function or service, and thus less waste is produced

- Reusing assets: Reusing materials and components through resale or redistribution can create economic as well as social and environmental benefits.
- Optimising system performance: Durable materials and robust construction standards can reduce maintenance costs and extend the economic viability of a building or structure.
- Keeping products and materials in cycles, prioritising inner loops: Focusing on disassembly during the design phase increases the chance of effective second use and reuse pathways for components and materials.
- Remanufacturing and refurbishing products and components: Remanufacturing keep materials, components and even structures in use for longer, helping to reduce or lower waste.
- Recycling materials: Buildings and structures can be designed to allow component parts to be easily separated and recycled.
- Selecting resources and technology wisely: Selecting these resources and mechanisms enables efficiency gains and minimises waste and other negative externalities.

NATIONAL FRAMEWORK TO CIRCULAR DESIGN

Even though the demo building was built about 30 years ago, from the point of circularity, there must be answered the crucial question: when to reconstruct and renovate a building and when is it better to build a new one?

In general, there must be conducted an analysis of the options for reconstruction vs. demolition - reuse or not - the analysis should include, in addition to standard assessments, e.g., consultation and discussion with the investor, residents and other stakeholders and carry out an assessment of the impacts of maintaining or building a new building. In the case of Karviná Health centre, the refurbishment must be done only with innovations with limited area of application (part of energy system, façade, roof etc.), but these will show the potential for reuse or recycle in larger scale. Also, there will be some structures demolished and replaced and that can be done in sustainable way.

How to carry out demolition sustainably

The use of materials obtained through selective deconstruction can lead to the production of cheaper materials from recycling processes and thus more affordable housing - (see e.g. SDG 11 - Sustainable Cities). Given that the construction sector is responsible for more than 30% of waste in the EU, selective deconstruction leading to increased reuse or recycling of products (or materials) is a way to contribute to lower waste production (e.g., SDG 12 (Responsible Production and Consumption)). Circular measures can lead to a reduction in the carbon footprint of construction as materials and products are recycled or reused (alternatively SDG 13 (Climate action)) .

The basic measure for environmentally sound building removal is to carry out a pre-demolition audit. This audit should estimate the number and amount of materials present in the building and determine their potential use while following the deconstruction plan.

The pre-demolition audit should be followed by selective deconstruction, the first step of which is to clear the building of equipment, remove harmful and disturbing substances and the deconstruction itself consists of the gradual dismantling of the structures. The materials or products from the dismantled structures are collected separately under predefined conditions. The best way to manage construction & demolition waste is in a way that results in no waste being generated.

The first option is to consider whether the structure (or parts of it) from the deconstructed building can be used in a new building, or whether secondary raw material (from demolition) can be used on site.

To increase the usability of the secondary materials, it is advisable to collect them separately so that they are not mixed with other materials. Secondary raw materials from construction can be recycled in designated facilities (so-called recycling centres) or can be used to produce new construction products with recycled content.

Recycling options for used building elements

Recycling of used building elements for their original use is possible if the product has properties that are suitable for the original use. In the case of Health centre Karviná, there is no plan of reusing original structures, as its decay and age does not allow the use in original way. But these may be recycled and used as a secondary material i.e., for the green roofs and other applications.

It is important to bear in mind that according to the requirements for buildings set out in Act No 283/2021 Coll., the Building Act (Czech Republic) only products, materials and structures may be used in a building, whose properties guarantee that the building, when properly constructed and normally maintained for its intended lifetime, will meet the essential requirements for buildings under Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products. In other words, we can use for the buildings only such materials, that will deliver sufficient quality for the building and will provide it for desired lifetime. Therefore, the use of these materials will be tested with the demo building: recycled aggregate in green roofs, replaceable façade elements or second life batteries in the energy system.

5.3. PRELIMINARY DESIGN

BUILDING AND CONSTRUCTION DESIGN

There is prepared the energy refurbishment on the building by the design office ATRIS[9], that covers major improvements in the building's energy consumption. The description here is based on the energy assessment report prepared for Municipality of Karviná[10]. Beside these measures, there will be the ARV innovations applied. The schedule of realisation is dependent on the procurement and building permit process and is still developing (see Figure 27).

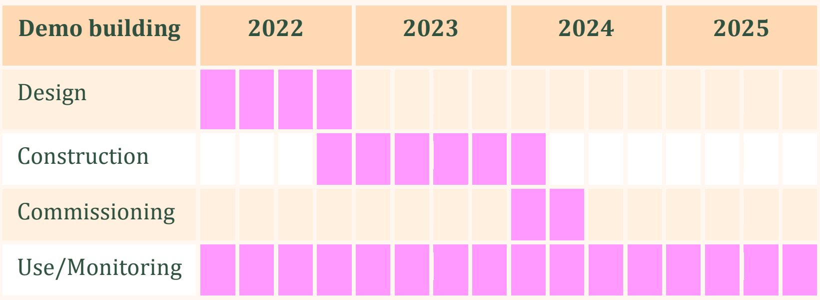

***Figure 27**. Preliminary building process schedule.*

Planned improvements on thermal envelope

Pavilion A

Exterior walls. Insulation of the socle part will be made with XPS insulation 12 cm thick, λ≤0.037 W/(mK). The insulation of the facade masonry will be made with mineral wool insulation 18 cm thick, λ≤0.039 W/(mK). Part of the facade will be designed as ventilated with MV insulation 18 cm thick in the supporting grid.

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[9] ATRIS, s.r.o.

[10] Kravčenková Světlana, Ing.: Zateplení budovy č.p. 2379 na ul. Žižkova v Karviné-Mizerově. Energetické posouzení. 7.4.2022

The existing roof structure will be removed down to the existing ceiling structure. Furthermore, the existing attic will be removed. *New roof structure* will be as following:

- PVC-P waterproofing, thickness 1,5 mm
- separating foil - glass fibre non-woven 120g/m^2
- thermal insulation EPS 150S, thickness 2x140 mm
- EPS 150S thermal insulation - 2% gradient wedges, thickness 20-380 mm
- vapour barrier glued all over, fused asphalt mod. strip, thickness 2x4 mm
- penetration
- existing structure

Window fillings will be replaced with plastic ones with U_w=0,9 W/m^2K. External blinds will be installed on the south side. The entrance door and the internal door separating the vestibule will be replaced with new automatic doors. The glazed walls in the 1st floor will be replaced with new aluminium glazed walls. New entrance doors will be installed with an overall heat transfer coefficient of max. 1.7 W/(m^2K). External blinds will be installed on the south side.

The *insulation of the ceiling* of the receding floor above the exterior will be made of mineral wool insulation with a thickness of 18 cm, λ≤0.039 W/(m.K). This insulation does not meet the recommended value of the heat transfer coefficient, which is currently set by the CSN, but insulation to the recommended value is not technically possible in this case. The ceiling of the technical floor will be insulated with 8 cm thick mineral wool, λ≤0.039 W/(m.K).

Pavilion B

Insulation of the plinth part of the *exterior walls* will be made with XPS insulation 12 cm thick, λ≤0.037 W/(m.K). The insulation of the facade masonry will be made with mineral wool insulation 18 cm thick, λ≤0.039 W/(m.K).

The existing roof structure will be removed down to the existing ceiling structure. Furthermore, the existing attic will be removed. *New roof structure* will be as following:

- PVC-P waterproofing, thickness 1,5 mm
- separating foil - glass fibre non-woven 120g/m2
- thermal insulation EPS 150S, thickness 2x140 mm
- EPS 150S thermal insulation - 2% gradient wedges, thickness 20-380 mm
- vapour barrier glued all over, fused asphalt mod. strip, thickness 2x4 mm
- penetration
- cleaning of the existing structure

Figure 28. *Visualized status of the building after renovation (Atris).*

Window fillings will be replaced with plastic ones with U_w=0,9 W/(m^{2}K). New entrance doors with a total heat transfer coefficient of max. 1.7 W/(m^{2}K) will be installed. The ceiling of the unheated part of the basement will be insulated with 8 cm thick mineral wool, λ≤0.039 W/(m.K). The insulation of the ceiling of the receding floor above the exterior will be made of mineral wool insulation with a thickness of 18 cm, λ≤0.039 W/(m.K). This insulation does not meet the recommended value of the heat transfer coefficient, which is currently set by the CSN, but insulation to the recommended value is not technically possible in this case.

The building energy performance certificate was calculated for the building after the building envelope renovation. The calculation does not yet include ARV innovations.

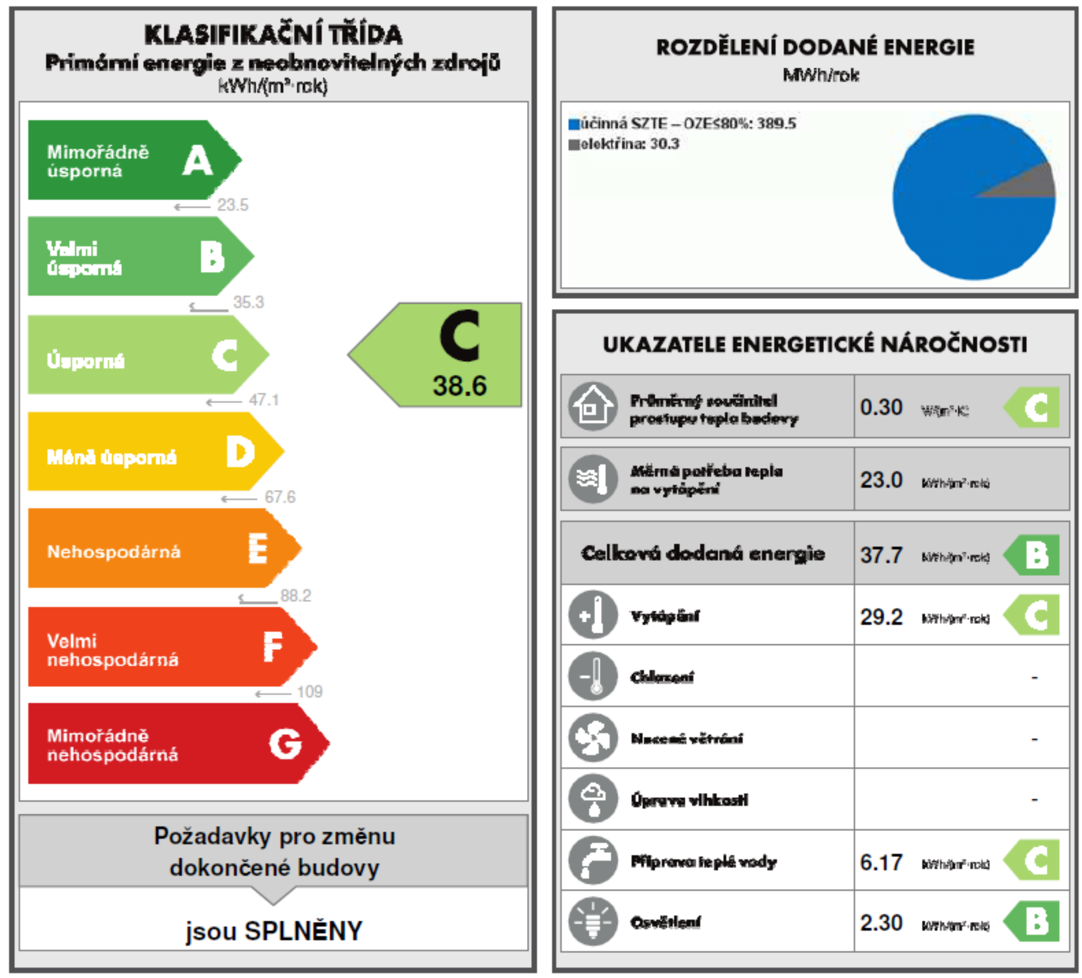

Figure 29. Building energy performance certificate after building envelope refurbishment.

Digital twin

In order to assess as much as possible within the digital twin, this has to be a complex model of the building and its operation. For this purpose, a complex 3D model containing detailed information about the building is being created within the Rhino 3D modelling environment. Specialized parametric plugins using third-party verified calculation engines (such as Radiance or OpenStudio) will allow for detailed assessment of different approaches in variants of measures. Access of daylight and direct solar irradiation is crucial in multiple KPIs, be it visual comfort, energy performance or energy production. A detailed 3D model of the surroundings is necessary for these simulations. The demo site has been described in previous chapters. In order to maximize the precision of simulations a 3D model of the immediate shading surroundings has been created from the available 3D maps data (Figure 30). This model will be further simplified in order to shorten the computation time in simulations.

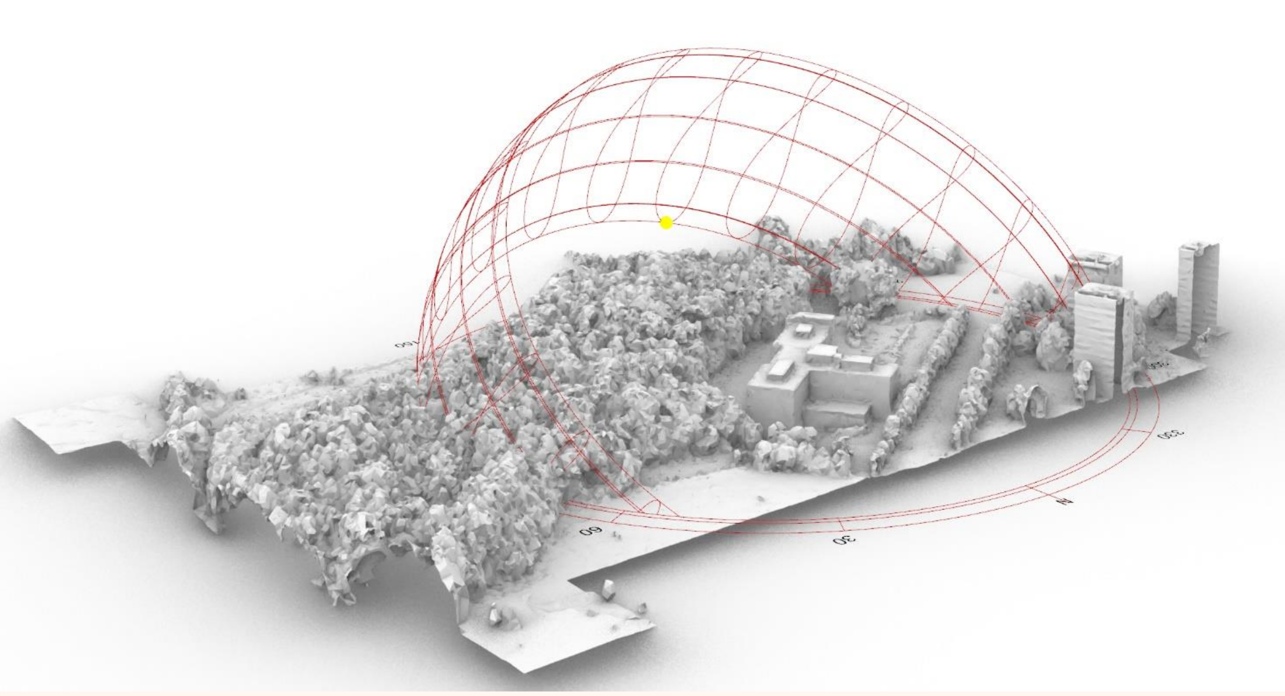

Figure 30. *3D model of the surroundings for the digital twin*

As the demo building is complex and large, the results of performed whole-building simulations will be validated by comparison with smaller, more specific simulations and measured data. One of these smaller models aimed to evaluate the current energy performance of the fourth floor in the A4 wing of the building. Here a detailed zoning into individual rooms with detailed construction setups and use schedules took place within Transient system simulation tool TRNSYS[11] (Figure 31).

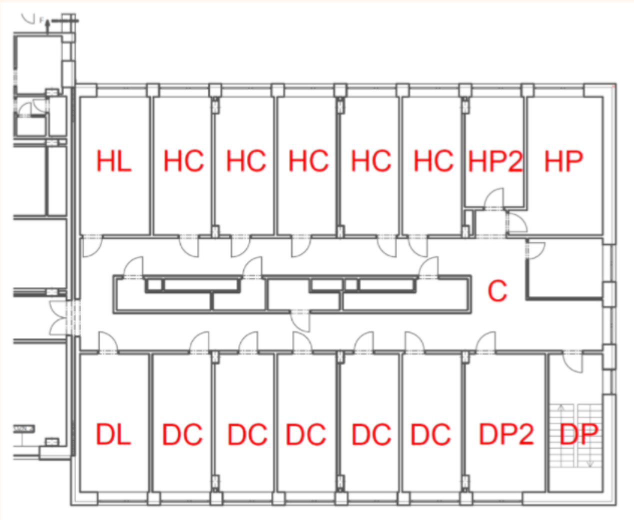

Figure 31*. Detailed zoning of the selected building part*

The characteristics included in the TRNSYS model included individual material composition of each construction within the simulated building floor, dependency of daylight and solar energy transmission through windows on the incidence angle, detailed occupancy, equipment usage, ventilation (example for a workday shown in Figure 32) and shading schedules.

[11] Software available at https://www.trnsys.com/

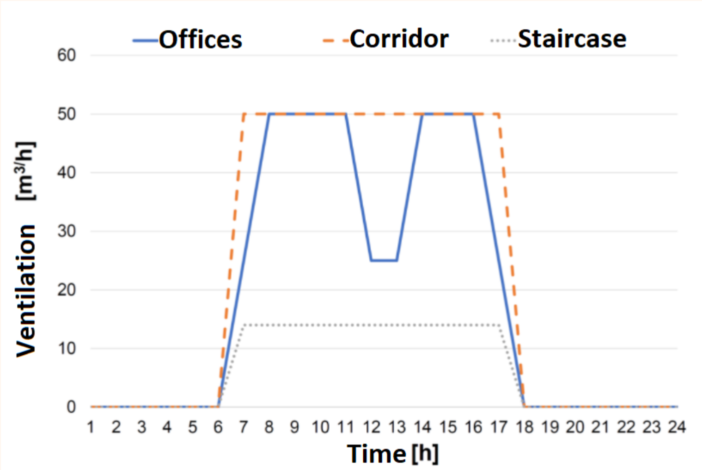

***Figure 32**. Occupancy based ventilation schedules for a workday in individual zone types.*

The simulation results will be compared with existing energy assessment documentation required by local legislation and also with the complex 3D model simulations and measured data in order to maximize the precision of the digital twin.

Apart from the already mentioned comfort and energy related KPIs, the digital twin will also provide the input for LCA and LCC related KPIs in terms of operational energy and material volumes in current state as well as in the alternatives for retrofitting.

In contrast to the above-mentioned zoning of just one part of the building, the ongoing whole-building zoning based on existing documentation is shown in Figure 33.

***Figure 33.** Ongoing zoning of the demo building for energy simulations*

ENERGY SYSTEM DESIGN

The design concept of the energy systems of the demo Karvina goes in line with the vision and goals of the demo site and the design principles stated in section 5.2. The following criteria (related to environment and energy, social and architecture, and economics) were part of the integrated energy design:

- Energy efficiency: maximizing the local energy production while reducing the energy demand and GHG emissions.
- Improved indoor environment: daylighting control, heating & cooling, and air quality.
- Socially and architectural accepted solution: the choice of the technologies provides high quality of architecture and indoor environment allowing satisfaction of the tenants.
- Economical viable solutions that could spread and replicate to other buildings in the phase of refurbishment.

As there is limited possibility of the constructional changes of the building, the energy system design becomes a crucial part of the refurbishment. The main energy savings will be reached by an improvement of the building thermal envelope (described above) and using efficient and innovative energy sources.

The design of the energy systems for the Karvina case is based on the digital twin model of the building following the integrated approach given in Figure 34. Energy systems design approach

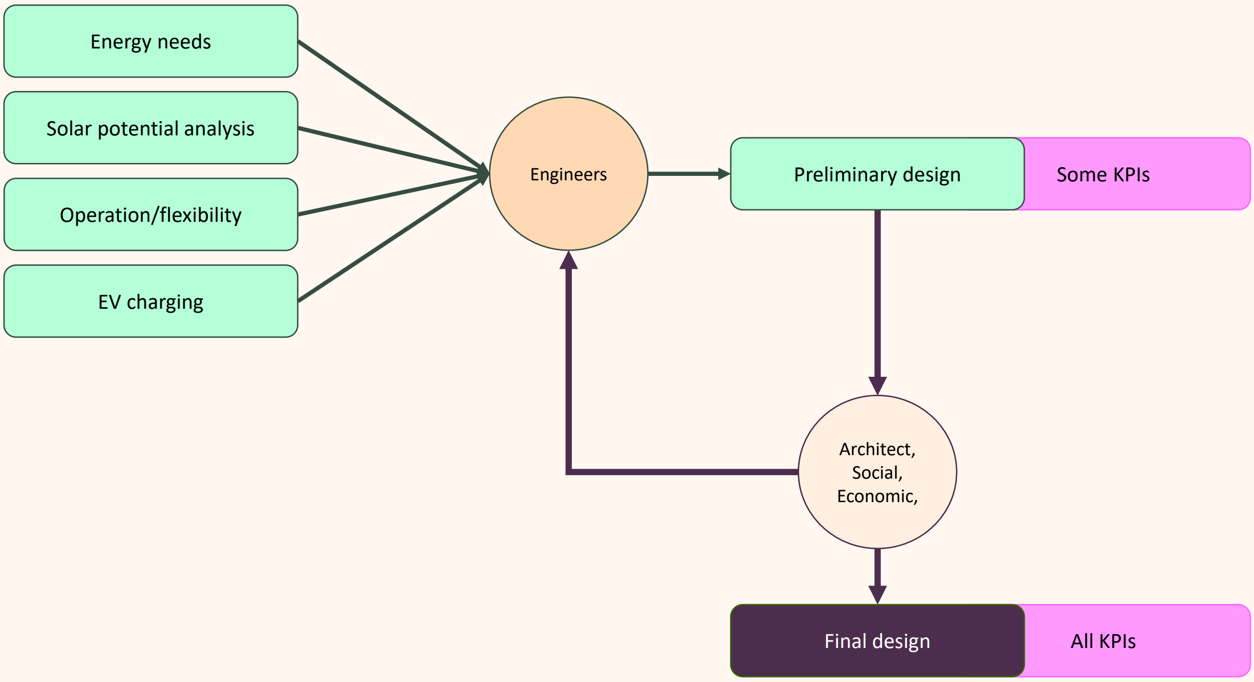

***Figure 34**. Energy systems design approach.*

Solar technologies (PV and PVT) were selected for the contribution in the fulfilment of some of the expected impacts (EIC1-EIC5, EIC8, EIC9 of the ARV project in the demo Karvina. The selected systems are key technologies for local energy generation as they can be easily applied/integrated into the building and scaled-up to the energy needs when there is enough available surface area. The implementation of the PV panels in the built environment can be achieved through Building Applied PVs (BAPV) and/or Building Integrated PVs (BIPV) concepts. The BAPV concept is referred to a PV installation in the building (mostly rooftop PVs) with a sole purpose of electricity generation. While the BIPV concept represents the case of PV panels installed as part of the building envelope (roof, façade, or glass surfaces) as they can be semi-transparent, coloured, rigid, or flexible, and can have different shapes and sizes. In addition, aside from the electricity generation BIPV provide the following benefits:

- Material savings, reducing the cost of alternative finishing of the building envelope.
- Energy economy, the electricity generated is used locally within the building, maximizing the self-consumption rate.
- Reduced heat transfers and solar radiation penetration, such as shading, daylighting, or thermal insulation

The design of the BAPV and BIPV systems is associated to the analysis of the solar potential of the building surfaces using the 3D model. The solar analysis allows to determine and assess the available place (surface) for installing PV panels as well as to consider the effect from surrounding context, shadow casting elements (such as surrounding buildings and trees).

Another important point to consider is the energy demand of the building. In the case on new constructions, this can be estimated based on dynamic simulations using the 3D model, while, for renovation cases, historical monitored data can be available and directly used. The analysis of consumption data (profile) is very important to understand the energy behaviour of the building. This will help to design the PV system to match the generation with consumption by considering different tilt and azimuth angles.

Other inputs related to the future operation of the building and the flexibility/control (e.g., load-shifting and peak-shaving), as well as the operation schedule of other systems – such as HVAC, storages, and EV charging stations – are important parameters at the engineering phase for optimizing the size of the storage and generation systems.

Considering all the above-mentioned parameters allows to provide the preliminary design of the energy systems which is mainly linked to technical aspects and fulfils the KPIs linked to energy and environment. Furthermore, the preliminary design provided by engineers help in defining some constraint linked to technical feasibility of the systems.

The final stage of the design approach for the energy systems is the inclusion of inputs from other aspects linked to architecture, economics, social, and discuss the preliminary solution in multidisciplinary way. This will allow to identify gaps and enhance the overall design of the building including the energy system. Therefore, offering an aesthetically appealing solution with high energy performance and socio-economic acceptance.

6. SUMMARY

Three main topics were described in the first version of this Design Guideline.

1) The **relationship of the building with its surroundings**, the urban design, and the plans of the Statutory City of Karviná. There is a number of opportunities, that can be addressed by the lighthouse refurbishment of the Healthcare Centre. The potential of upscaling the ARV solutions in future developments is high.
2) The **current state of the demo building** was described, the problems of the building were identified and the baseline parameters for further design and stakeholder involvement were established. The overall reconstruction is supported by adverse status of majority of important structures and technologies. With the support of the ARV project, the quality of the building will be dramatically improved.
3) The **main design principles** that will lead to the achievement of the project objectives and KPIs were presented. Even though all the principles cannot be followed with particular demo building, they can be applied to many of the other buildings, e.g., positive energy district. This will lead to further design development of each innovation applied in the project to ensure future replicability and scalability. The overview of planned actions in relation to KPIs is presented in next table.

From this baseline, the future detailed design will be created. In the case of Karviná Health Care Centre, this baseline will be used also for digital twin alternatives and thus provide necessary information and data required for the analyses of real building.

7. INNOVATIONS IN THE KARVINA HEALTH CARE CENTRE DEMO

INNOVATIONS AND TECHNICAL MEASURES

The innovations developed in ARV and showed at this building will be scaled up and used in the other building connected to the PED. These are:

- Digital design and 3D simulations (digital twins) for solar irradiation potential and design of optimum shading devices.
- Small-scale pilots of climate change resilient solutions – use of heat pumps for summer cooling.
- LCA of HVAC systems with focus on carbon footprint.
- BIPV BAPV PV-T, solar thermal, heat pumps, active shading systems with weather forecast, innovative cooling solutions.
- Green roof sample for reducing heat islands, rainwater management (rain gardens, greenery)
- Installation of swappable façade-integrated RES (flexible solution enabling easy application of PV/PV-T/solar thermal/façade heat exchangers for possible coupling with heat pumps).

A digital twin as a core for the design guideline of demo will be used. It will show how to ideally fulfil nZEB and positivity, describe concept design workflow – KPIs, Architectural, environmental, energy, social, economic goals. The outputs from the digital twin simulations will affect the upscaled retrofit presented with the model, but also later the final design of innovations used with the building. This approach is described in separate chapter and will be further developed and described.

Integrated design solutions for the application of various renewable energy sources within the demo building, in particular technologies such as BIPV, BAPV and PV-T in combination with heat pumps and HVAC will be tested and analysed. The main objective is to find the optimal solution and integration of these technologies in the design phase of building retrofitting and its operation, both in terms of energy, environment, economics, and aesthetics.In order to improve the quality of the integrated design of the renovated buildings, especially in terms of energy performance, environmental and resilient aspects of the building envelope, different solutions for the application of green roofs and swappable façade panels will be tested and analysed.

At the time of finishing the first version of this report, the status of the innovations is following:

- First version of digital twin (digital model) was created and is prepared for evaluation.
- The resilient heat pumps for summer cooling are under preparation.
- Started a data collection for LCA of HVAC systems, the data for upscaled will be used from digital twin.
- Preliminary models for installation of BIPV BAPV PV-T, solar thermal, heat pumps, active shading systems with weather forecast were created and the preliminary design was carried out.
- Green roof sample was designed, the measurement setup is defined and prepared for realization.
- The swappable façade samples with RES are preliminary designed, the detailed design was carried out for anchoring elements.

Detailed results from innovation and technical measures design and application described above will be presented in the next version of the design guideline document. Detailed information about ARV Innovations were collected and described in ARV Innovation Passports.

8. BEST DESIGN PRACTICES AND CHALLENGES

This chapter will be provided after the completion of construction phase of the project, which is expected in 1st quarter of 2024.

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