KARLOVAC

Green City Action Plan

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The Green City Action Plan for Karlovac

City of Karlovac, often called the "City on Four Rivers" or the "City in a Park," has, over the past eight years, strengthened its commitment to protecting its rich natural environment while ensuring its sustainable management for future generations to enjoy.

In this spirit, we have developed the Green Cities Action Plan for Karlovac (GCAP Karlovac), a key step in making Karlovac a proud member of the European Bank for Reconstruction and Development's (EBRD) Green Cities community. With this initiative, Karlovac becomes the first city in continental Croatia to adopt this important plan and embark on its implementation—setting a benchmark for sustainable urban development in the region.

With the completion of the GCAP Karlovac, our city joins a network of around sixty others within the EBRD's Green Cities Programme, united in the pursuit of a more sustainable and resilient future. This milestone aligns with the commitments made under the historic Paris Agreement of 2015, when the global community resolved to take decisive action against climate change.

Among the initiatives outlined in this plan, one of the most transformative is the development and utilization of geothermal resources. This project holds immense potential for Karlovac, driving progress in key sectors such as heating, tourism, and agriculture while reducing our environmental footprint.

The Green City Action Plan for Karlovac represents more than just a vision—it is a concrete step toward a healthier, more sustainable city. By embracing green development, we are not only improving the quality of life for our citizens today but also laying the foundation for a thriving, climate-resilient Karlovac for generations to come.

Mayor

Damir Mandić

Mrežnica river, Karlovac

Acronyms and abbreviations

ABBREVIATION	TERM
API	Application Programming Interfaces
BEVs	Battery Electric Vehicles
BIM	Building Information Modelling
CAPEX	Capital Expenditure
CF	Cohesion Fund
CHP	Combined Heat and Power
CSO	Civil Society Organisations
DH	District Heating
DHMZ	the National Meteorological and Hydrological Service
DHW	Domestic hot water heating
DT	Digital Transformation
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EE	Energy Efficiency
EEO	Energy Efficiency Obligation scheme
EIB	European Investment Bank
EPBD	Energy Performance Building Directive
EPEEF	Environmental Protection and Energy Efficiency Fund
EQ	Environmental Quality
ERDF	European Regional Development Fund
ESCO	Energy service company
EU	European Union
EWS	Early Warning System
GBCC	Green Building Council Croatia
GCAP	Green City Action Plan

Acronyms and abbreviations

ABBREVIATION	TERM
GCO	Green City Officer
GDP	Gross Domestic Product
GHG	Greenhouse gas
GI	Green Infrastructure
GIS	Geographic Information System
GUP	General Urban Plan
ICE	Internal Combustion Engine
ICLEI	International Council of Local Environmental Initiatives
ICT	Information and Communication Technologies
IEQ	Indoor Environmental Quality
IFI	International Financing Institution
IoT	Internet of Things
ISO	International Organisation for Standardisation
ISGE	Integrated Sustainable Governance Evaluation
IT	Information Technology
KPIs	Key Performance Indicators
MCA	Multi-Criteria-Analysis
MSW	Municipal Solid Waste
NbS	Nature-based Solutions
NGO	Non-governmental organisation
nZEB	Nearly zero-energy buildings
OECD	Organisation for Economic Cooperation and Development
OPEX	Operational Expenditure
ORC	Organic Rankine Cycle
P&R	Park & Ride

Acronyms and abbreviations

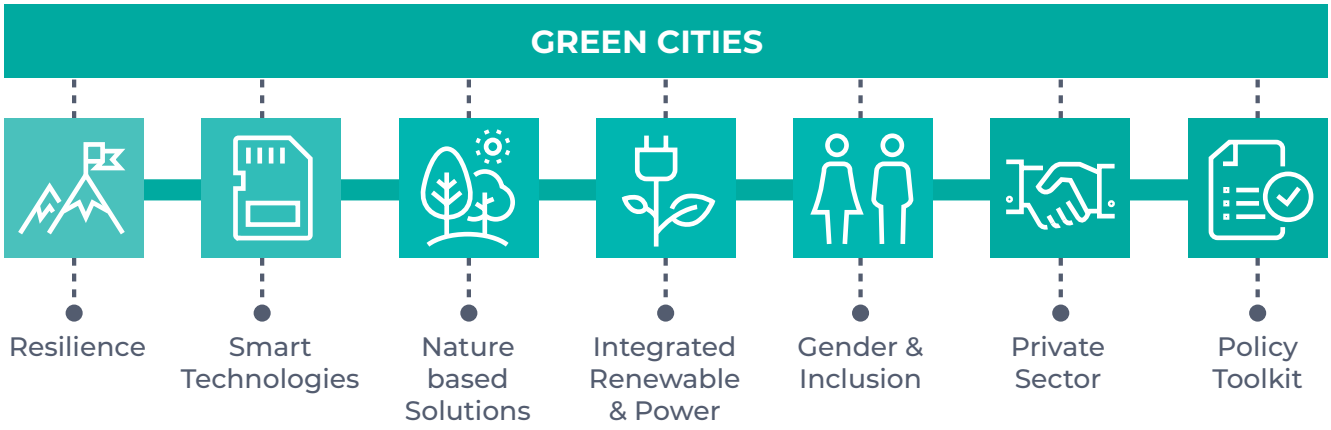
ABBREVIATION	TERM
PAYT	Pay-As-You-Throw
PM	Particulate Matter
PMT	Private Motorised Transport
PSC	Project Steering Committee
PSO	Public Service Obligation
PSR	Pressure-State-Response framework
PT	Public Transport
PV	Photovoltaic
PWG	Project Working Group
RES	Renewable Energy Systems
RVA	Risk and vulnerability assessment (RVA)
SCADA	Supervisory Control and Data Acquisition
SEA	Strategic Environmental Assessment
SECAP	Sustainable Energy and Climate Action Plan
SEIA	Strategic Environmental Impact Assessment
SI	Smart Initiatives
SO	Strategic Objective
SRC	Sports and Recreation Centre
TA	Technical Assistance
TAR	Technical Assessment Report
ViK	Vodovod I Kanalisacija
WMC	Waste Management Centre Project
WWTP	Wastewater treatment plant
ZE	Zero Emission
ZEMO	Zero Emission Mobility

EXECUTIVE SUMMARY

The Karlovac Green City Action Plan (**GCAP**) outlines a clear path aimed at advancing the City's sustainability, improving the environmental state and negative impacts, and enhancing the overall well-being of its citizens. This plan serves as a blueprint for integrating green initiatives into urban development, focusing on key areas such as transport, energy and buildings, water and wastewater, solid waste, land use, and others. The City of Karlovac is part of the EBRD Green Cities network. EBRD Green Cities takes a broad approach to identifying and prioritising environmental challenges and connecting them with infrastructure investments and policy measures. It draws on best practice.

approaches linking strategic Green City planning to investments. In so doing, the EBRD introduces cities in:

- a systematic approach to urban planning;
- an innovative approach linking strategic urban planning to investment;
- a planning process that emphasises engagement with civil society; and
- a focus on converting urban planning instruments into financed investments.



The City of Karlovac started developing this GCAP in June 2023 with the objectives of diagnosing, prioritising and proposing responses to a range of environmental challenges faced by the city. This plan follows a systematic approach and methodology set out by the European Bank for Reconstruction and Development (**EBRD**), developed in conjunction with the Organisation for Economic Cooperation and Development (**OECD**) and the International Council of Local Environmental Initiatives (**ICLEI**). The process included guiding the City through four main steps:

This GCAP is the result of the above-mentioned process. The document in front of you contains all the elements envisaged by the process and it contains key findings, strategic objectives, identified transformative actions, and guidance on the monitoring and implementation of the GCAP itself.

Step

1 **Prepare and organise**

Establish the process framework, define priorities, and set baselines to guide the development of the GCAP.

2 **Identify and prioritise challenges:**

Conduct data collection, technical assessments, and stakeholder engagement to identify key environmental challenges.

3 **Plan Green City Actions**

Develop and evaluate policies and investment options, draft the GCAP, and secure consensus on proposed actions.

4 **Implement and monitor**

Launch actions and policies, monitor progress, and update the GCAP as needed to ensure ongoing alignment with objectives.

The City is the key actor throughout the process, leading the validation of findings, defining and approving actions, and overseeing their implementation. The consultant and EBRD play a supporting role, providing technical expertise and guidance to facilitate the development of the GCAP.

Introduction

This GCAP document was completed in November 2024 and is the result of a close collaboration between the City officials and City-owned companies, other key stakeholders, a range of international and national experts, and other various stakeholders.

This GCAP was developed through a series of analyses and stakeholder engagement as defined later in the documents. All the relevant stakeholders that include the City departments, City-owned companies, national institutions, representatives of private sector, civil society organisations (**CSO**), and experts were consulted and contributed to the development of the Karlovac GCAP. In order to ensure the GCAP is objective and evidence-based, the GCAP methodology's Pressure-State-Response framework (PSR Framework) was applied.

The work undertaken on this GCAP can be summarised into two main pillars:

1. Green City Baseline

   Identification of the status of the City in terms of environmental challenges and planned responses to those challenges.

2. Identification of Karlovac Green City actions to steer City towards Green City, based on defined Vision and Strategic objectives

   Set of carefully designed and identified GCAP actions is defined by this GCAP. These are the mechanism for achieving identified Vision and strategic objectives.

Green City Baseline

The analysis of the baseline involved the following:

- Identification of GCAP Indicators for the Karlovac GCAP. These Indicators are defined by the EBRD and are building blocks for identification of state, pressure, response overview within the City of Karlovac.
- Identification of Strategic and Policy responses of the City.
- Identification of environmental challenges of the City of Karlovac.
- Identification of the gender, social, and vulnerable group baseline within the City.

The detailed analysis of sectors that include transport, energy and buildings, water and wastewater, solid waste, and land use.

Key environmental challenges

Based on the baseline analysis, stakeholder and expert inputs, and overall prioritisation exercise, the following are the main environmental challenges to be directly addressed and targeted by the GCAP:

High level of GHG emissions from various sectors such as energy, buildings, and transport - Reduction of GHG emissions is one of the main priorities of the GCAP.

Still present Gaps in the city's resilience to climate change impacts - Flooding issues, relatively climate vulnerable City areas.

Losses in the water supply systems are substantial - Even though, the Agglomeration project* is addressing this to some extent, the GCAP looks into scaling up those efforts and identify other actions that might contribute to overcoming this issue.

There is a significant **lack of understanding of the potential that green infrastructure** might pose in the City of Karlovac.

Still high level of generated waste per capita and low level of waste separation.

* Improvement of the Water Utility Infrastructure of the Agglomeration Karlovac–Duga Resa, valued at approximately €56 million, aims to enhance regional water management systems. Key components include constructing a 65-kilometer sewage network, reconstructing 7 kilometers of existing sewage pipelines, rehabilitating 56 kilometers of the water supply network, building 27 pumping stations, and establishing a solar-powered sludge drying facility. The project is scheduled for completion within three years.

Green City Vision and Strategic Objectives

As part of the GCAP development process, one of the key steps is defining the City's Vision and Strategic objectives for the Karlovac GCAP.

Karlovac GCAP Vision

> *Karlovac is a green and sustainable Star where every person takes responsibility for future generations.*

Thematic Area	Strategic Objective	Description
Transport	1.1	Ensure the highest quality of public transport, multimodal transport integration, and stationary traffic capacity through flexible organisation of the system, implementation of low carbon infrastructure, and digitalisation.
	1.2	Leverage on opportunities of Karlovac as a commuting City and secure long terms sustainable development in this context.
Energy and Buildings	2.1	Ensure the decarbonisation, efficiency, and resilience of current and future heating systems by introducing renewable energy and energy efficiency measures.
	2.2	Ensure decarbonisation of the city's building stock through the renovation, implementation of RES, introduction of smart metering, awareness raising, and building in an efficient, resilient, and sustainable way.
Water and Wastewater	3.1	Ensure efficiency of water systems and preservation of water resources while achieving high level of climate resilience.
	3.2	Enhance capacity of key stakeholders and achieve satisfactory awareness level on water sustainability among citizens and stakeholders.
Solid Waste	4.1	Develop and strengthen a modern system for waste management based on a "zero-waste" model.
	4.2	Accelerate, encourage, build capacity, and monitor circular economy related solutions, especially recycling and reuse of materials and waste.
Land Use	5.1	Maintain existing and develop new green infrastructure to ensure environmental, social and economic benefits and improve the City's resilience to the impacts of climate change.
	5.2	Intensify use and regeneration of existing underutilised urban structures with the aim of achieving higher urban quality and limit the expansion of urban and other construction land.
Environmental Monitoring & Green City System	6.1	Establishment of relevant KPIs, monitoring, and coordination of activities needed for achieving strategic objectives.
	6.2	Have an effective and efficient Green Cities coordination, monitoring, and management system in place to drive and coordinate the implementation of KPIs and the Karlovac GCAP successfully.

Green City Actions

The next important task is to understand and prioritise the opportunities to address those challenges. To do this the City has followed the Green Cities Programme's process to formulate Green City Actions. This involved identifying a long-term vision for the City, setting strategic goals for the next 10 to 15 years, establishing mid-term targets so that we can monitor progress towards our vision and finally establishing the specific short-term actions that need to be taken into account to make the long-term vision a reality.

The GCAP has identified a total of 24 actions, requiring a combined investment of 245,072,000 EUR, with a CAPEX of 236,177,000 EUR. Notably, 98% of this investment is allocated to investment actions, emphasising the significant focus on infrastructure and capital development within the GCAP. Please note that funding is expected to be secured from various sources, not solely from the City budget, as stated in action descriptions and chapter 5. Potential sources include the government budget, EU funding sources, lending from international financing institutions, private sector, and mobilised through the involvement of citizens depending on the type of actions.

#	Action	GHG reduction potential over lifetime of investment (in tCO_{2eq})	Estimated investment costs (in million EUR)	Type of city investment
Transport				
T1	Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	599	1.65	Investment
T2	Construction of primary and secondary cycling network and improving cycling infrastructure.	114,975	12.00	Investment
T3	Transport infrastructure development policies stimulating the use of non-motorised transport.	Undetermined at this stage	0.11	Policy
T4	Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.	1,198	4.50	Investment
Energy and buildings				
EB1	"15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.	4,486	50.17	Investment
EB2	Utilisation of geothermal energy potential in the City of Karlovac.	780,000	63.09	Investment
EB3	Strengthening the DH system for sustainable, efficient, and innovative energy services.	14,999	2.85	Investment
EB4	Decarbonisation of multi-apartment buildings in the City of Karlovac.	47,940	40.34	Investment
EB5	Decarbonisation of public buildings in the City of Karlovac.	7,272	10.00	Investment
EB6	Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.	Undetermined at this stage	0.30	Policy
Water and Wastewater				
W1	Reduction of water consumption and water network losses.	19,316	16.3	Investment
W2	Increase of water storage capacity and installation of solar-powered pump systems.	32,318	6.05	Investment
W3	Introduction of heat pump and CHP Systems into Karlovac Wastewater Treatment Plant.	20,247	11.58	Investment
W4	Increase climate resilience against flooding in the City of Karlovac.	N/A	5.45	Investment

#	Action	GHG reduction potential over lifetime of investment (in tCO_{2eq})	Estimated investment costs (in million EUR)	Type of city investment
Solid Waste				
SW1	Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.	Undetermined at this stage	0.35	Investment (TA only)
SW2	Feasibility assessment and landfill gas plant construction at Ilovac post-closure.	40,366	5.10	Investment
SW3	Improving municipal solid waste separation at the source level.	Undetermined at this stage	1.00	Policy and Investment
Land Use				
L1	Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.	Undetermined at this stage	3.00	Investment
L2	Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.	Undetermined at this stage	10.6	Investment
L2	Protection and revitalisation of urban forest Kozjača.	Undetermined at this stage	0.50	Investment
L2	Innovative instruments for stimulating use of green infrastructure elements through spatial plans.	N/A	N/A	Policy
Cross sectoral				
CS1	Technical assistance for establishing a portfolio approach to project management "Smart Maturity".	N/A	0.05	Investment
CS2	Development of an Updated Smart City Strategy.	N/A	0.03	Policy
CS3	GCAP Web site for monitoring and implementation.	N/A	0.05	Investment
Total		**1,083,716**	**245.07**	

1. INTRODUCTION

1.1 Background

Cities, with their dense populations, infrastructure, housing, and economic activities, are often seen as significant contributors to climate change, pollution and the depletion of natural resources. However, they also face heightened risks from climate change impacts and disasters. This necessitates a comprehensive strategy for urban planning and management that addresses a wide spectrum of climate and environmental issues while integrating in economic and social goals to uncover viable solutions suitable for investment. Additionally, it is increasingly recognised that decentralised urban governance is key to executing eco-friendly and sustainable initiatives in cities. In line with this understanding, the European Bank for Reconstruction and Development (EBRD) endorses municipal efforts towards climate finance, environmental, and sustainability targets through its Green Cities strategic planning.

1.2 The Green Cities Action Plan (GCAP)

The Green City Action Plan (GCAP) facilitates an organised assessment of challenges in the urban environment, setting a comprehensive Vision for long-term objectives and identifying Strategic Goals that align to meet the demands of that Vision based on stakeholders' preferences. Additionally, the initiative aids in recognising various initiatives and interventions tailored to bolster the realisation of these established Goals.

Each GCAP follows the methodology developed by EBRD, the Organisation for Economic Co-operation and Development (OECD) and the International Council for Local Environmental Initiatives (ICLEI)[1].

1.3 How the Karlovac GCAP was produced

1.3.1 Setting the scene

The City of Karlovac has committed to joining the EBRD's Green Cities Programme by agreeing to develop a Green City Action Plan (GCAP). In June 2022, Mott McDonald was contracted by the EBRD, alongside E Co. Ltd, Enviros and WYG, to help developing and execute the GCAP for Karlovac.

The GCAP is composed of the following chapters:

Chapter 1: Introduction

Chapter 2: Green City Baseline

Chapter 3: Green City Vision and Strategic Goals

Chapter 4: Green City Actions

Chapter 5: Summary of Funding requirements for GCAP actions

Chapter 6: Summary of Benefits

Chapter 7: GCAP Implementation and Monitoring

To identify pivotal stakeholders for the GCAP, an analysis was conducted that included representatives from the private sector, academia, civil society organisations (CSO), and municipal service entities in sectors such as energy, water management, waste disposal, and transportation. These identified groups have remained actively involved throughout the GCAP's formulation process.

In conjunction with this, a thorough examination of existing policies, legislative acts, and ongoing strategies and initiatives was undertaken to guarantee the alignment of the GCAP with the existing regulatory frameworks. This review further evaluated the level of political endorsement at the municipal level, scrutinised any legal or political obstacles that might impact the execution of the GCAP, and considered the scope for subsequent investments at the municipal level. A detailed Policy and Regulatory Framework Report emerged from this comprehensive review.

1 - https://www.ebrdgreencities.com/assets/Uploads/PDF/6f71292055/Green-City-Action-Plan-Methodology.pdf.

1.3.2 Green City baseline

The Green City baseline (see Chapter 2) forms the diagnostic component of the GCAP methodology recording City's existing climate-related (mitigation and adaptation), environmental performance, including the governance frameworks that affect it. Importantly, it identifies a set of priority environmental challenges which the City will address via a programme of actions developed as part of this Plan.

The team gathered information and assessed the City's performance relative to the EBRD Green City benchmarks, rooted in the OECD Pressure-State-Response model integral to the GCAP approach.

An analysis of the work related to the Technical Assessment was performed to identify various challenges within each Green City sector. The research team identified critical "environmental priorities" which included the existing state of environmental assets, possible emerging pressures due to development, and a review of any disparities in policy or strategies across applicable sectors.

A collaborative workshop was convened with participants from the public sector, private enterprise, academia, and non-profit organisations to establish the principal challenges brought forth from the Technical Assessment. This process, in unison with an analysis of policies and regulations, offered a data-driven examination of the pressing issues facing the City. It also assisted the consultants in determining key areas for possible strategic priority that required the city's attention.

GCAP Pressure-State-Response Framework

To ensure that our Green City Action Plan is objective and evidence-based, the GCAP methodology's Pressure-State-Response framework (PSR Framework) was applied. This PSR Framework identifies human activities that:

- Exert pressures on the urban environment (Transport, Energy, Buildings, Industries, Water, Solid Waste and Land Use) complemented by the challenges of Climate Change ("GCAP Sectors"); and
- Change its state in terms of environmental performance.

It also identifies how society responds to these pressures and changes through general environmental, economic and sectoral policies, and through changes in behaviour. Therefore, the Green City PSR Framework builds linkages between:

- The environmental performance of a Green City characterised by its States;
- The key associated economic activities exerting their Pressures on these States; and
- The investment, services and policy instruments representing Responses to these challenges.

1.3.3 Vision, Strategic Objectives, and Green City Actions

Guided by the results of the Technical Assessment Report (TAR) and the prioritisation of challenges, a follow-up stakeholder workshop took place in February 2024. The purpose of this gathering was to create a Vision for Karlovac (see Chapter 3) and outline strategic objectives for the GCAP, which are elaborated on in the following chapters of this strategic document. During this phase, several Green City Actions (see Chapter 4) were identified to be implemented within the next five years or more. These actions consist of short-term initiatives arranged into specific categories.

The comprehensive set of GCAP measures was finalised after multiple rounds of refinement. Initially, a preliminary extensive list of actions was created in partnership with the consulting team, incorporating suggestions that emerged during stakeholder workshops.

Input from discussions with also played a role in enriching this compilation with their perspectives and ideas on potential actions within different sectors. An exhaustive range of options was formulated based on analytical studies and involvement from stakeholders and reviewed by the City Technical Team. Afterward, GCAP actions were analysed applying a Multi-Criteria Analysis (MCA) appraisal methodology, which was o rganised around several specified criteria:

1. Assessment of level of resulting benefit (economic, social, environmental) (see Chapter 6);
2. The potential to receive funding support (see Chapter 5);
3. Level of technical deliverability; and
4. Policy alignment.

The result was a shortlist of options that was subject to further consultation with stakeholders to help derive a final set of 26 actions for inclusion in the GCAP.

CATEGORY	DESCRIPTION
Investment	Actions involving capital investment in built environment.
Policy or Regulation	Concept, National or municipal policy, strategy, action plan, law, regulation, technical standard or similar.
Stakeholder Engagement	Actions involving individuals or organisations who may be affected by the GCAP or can influence its implementation, such as publicity campaigns, workshops, seminars, and other public fora.
Capacity Building	Action aimed at obtaining, improving, and/or retaining the skills, knowledge, tools, equipment and other resources needed to perform their roles competently or to a greater capacity.
Data Management	Actions involving acquiring, validating, storing, protecting, and processing required data to ensure the accessibility, reliability, and timeliness of the GCAP-related data for its users.
Study, Monitoring & Assessment	Actions consisting in a detailed investigation and analysis of a subject or situation (e.g. feasibility study, climate resilience assessment, etc.).

1.3.4 Implementing and Monitoring Green City actions

A GCAP Implementation Plan (see Chapter 7) identifies the timescales and resources required to deliver and allows for tracking of the status of the GCAP actions. An Impact Monitoring Plan allows to track the City's environmental performance. This sets out responsibilities within the Municipality to ensure that activities are coordinated across relevant departments, with appropriate leadership and financial resources allocated accordingly. The City will monitor the progress against the plan in terms of progress of delivery and also collect data relating to each action to help determine the outcome and level of impact that investments have had.

1.3.5 Stakeholder engagement process

The Development of the GCAP has been guided by multiple rounds of stakeholder engagement and consultation – comprised of a series of workshops, meetings, focus groups and thematic discussions. In addition, the development of the GCAP has been overseen by the Project Steering Committee (PSC) and the Project Working Group (PWG), represented by official and technical experts from the City. Engaging with stakeholders was essential for identifying the environmental issues and requirements of the City, and to refine our strategy in the most productive and successful manner. The following stakeholder engagement events were conducted:

Kick Off Meeting

On 12 June 2023, a combined in-person and virtual meeting took place, consisting of the internal working group members, including municipal representatives, EBRD members, and consultants. The agenda encompassed introductions of the team members as well as presentations and deliberations on process protocols and management structures. In this session, City officials presented preliminary details about various challenges and existing response measures to both the EBRD and consulting teams.

Karlovac GCAP Official Launch

The official inauguration of the GCAP for Karlovac was held at the Edison cinema on 17 October 2023, convened by a varied assembly of stakeholders which included journalists, governmental dignitaries, and other interested parties. The event began with remarks from the Mayor of Karlovac, Damir Mandić, the Green City Officer (GCO) Viktor Šegrt (Local Coordinator of the Administrative Department for Economy, City Development, and EU Funds), and EBRD delegates Lin O'Grady (Deputy Head Sustainable Infrastructure Policy and Project Preparation and EBRD Green Cities lead) and Lyza Rossi (Climate Strategy and Delivery Analyst and EBRD Green Cities team member). Following this, the consulting body revealed the GCAP procedure and its pivotal dates. Subsequently, a panel dialogue addressing the central obstacles and strategic intentions, joined by Lin O'Grady, Vesna Ribar (Head of Administrative Department for Spatial Planning and Implementation of Urban Development Documents), and the lead consultant of the GCAP team, wrapped up the gathering. A notable turnout of more than 60 people included municipal officials, city-run enterprises, state organisations, developmental groups, tertiary institutions, research bodies, commercial trade representatives, and non-profit entities. The event was very well attended and covered by local media representatives.

1st stakeholder engagement workshop

The workshop took place concurrently with the Official Launch event. Members of the working group, alongside important stakeholders from the public, private, academic, and CSOs, engaged in dialogue about prioritising the environmental issues facing the City of Karlovac.

2nd and 3rd stakeholder engagement workshops

The workshops that took place in Karlovac on 15 February 2024, were dedicated to discussing significant progress steps in developing the GCAP for Karlovac. Attendees examined the city's vision for a Green City, its strategic objectives, and a comprehensive catalogue of initiatives, focusing on classifying and ranking these features. This document updates on the latest developments concerning the Karlovac GCAP initiative, encompassing community stakeholder participation and elucidating the draft City vision and strategic goals for the GCAP. This involvement of stakeholders contributed to the formation of the Green City Baseline and the evolution of the GCAP. To fulfil the ambitious objectives set out in the GCAP, an organisational framework has been established and is detailed in the monitoring and reporting plan. Designated roles have been allocated and appropriate municipal representatives appointed. These entities will supervise and/or coordinate the enactment of envisioned Actions within the GCAP, track their advancement and outcome throughout the execution period, and ultimately guide the formulation of Karlovac's second Green City Action Plan for the ensuing cycle.

4th stakeholder engagement workshop

The workshop was held in the City of Karlovac on 25 September 2024. The workshop focused on the presentation of the GCAP, specifically covering the developed and identified Karlovac GCAP actions for each relevant sector. The objective was to secure final inputs, corrections, and suggestions, as well as to gain overall confirmation of the selected actions. Additionally, the presentation included comprehensive discussions and Q&A sessions for every relevant sector to ensure thorough understanding and feedback.

2. GREEN CITY BASELINE

2.1 City Context

Karlovac is a City in central Croatia located 56 km southwest of Zagreb and 130 km northeast of Rijeka. Covering an area of 402 km^2 [2], the City of Karlovac has a total population of 49,377 inhabitants according to the national census from 2021[3]. In the population breakdown, women constitute 53.09% (26,207) while men make up 46.91% (23,170). The City stands as the hub for administration, politics, economy, culture, and sports within Karlovac County. Its pivotal position at the crossroads of key highways and railways from Zagreb to Rijeka and Split is integral to Croatia's transportation network.

2 - Growth strategies. (2021). Studija javnog prijevoza putnika na području grada Karlovca. Available at https://www.karlovac.hr/UserDocsImages/2021%20dokumenti/Studija%20javnog%20prijevoza%20putnika%20na%20podrucju%20Grada%20Karlovca_Final.pdf?vel=36275850

3 - Croatian Bureau of Statistics. (2021). Popis 2021. Prvi digitalni Popis stanovništva, kućanstava i stanova u Republici Hrvatskoj. Available at https://podaci.dzs.hr/hr/podaci/stanovnistvo/popis-stanovnistva/

Karlovac, located in central Croatia near lowland and mountainous regions, is framed by the rivers Kupa, Korana, Dobra, and Mrežnica. Situated in Croatia's narrowest part, just 50 km from Slovenia and Bosnia and Herzegovina, the City holds significant traffic and economic importance. Karlovac is renowned for Zvijezda, its historic 16th-century district built as a Renaissance fortification with a star-shaped layout. Despite its historical and typological value, Zvijezda faces challenges, including an aging population and deteriorating buildings. Over time, Karlovac expanded in all directions, resulting in urban layers from various periods. Today, the City has a low population density but continues to expand through greenfield investments, primarily individual houses, residential complexes, and commercial facilities in peri-urban and suburban areas.

The population density trend data is given below, and it is based on the GIS data. More specifically, the available GIS data provide an overview of population density within the City's GUP limits, sourced from national census data for 2001, 2011, and 2021. The following trend data are available:

Table 1
Land Use Data Summary

Year	Karlovac City Population	Population within GUP limits	Area of GUP km²	Population density capita/km²
2001	49,082	45,600	24.5	1,861
2011	46,833	43,500	24.5	1,776
2021	41,977	39,000	24.5	1,592

Source: Consultant on the basis of Croatian Bureau of Statistics

Figure 1.
Localisation of Karlovac

Karlovac, known as the 'City of Meetings' for its location at the crossroads of four rivers and major traffic routes, is also called the 'City of Parks' due to its abundant green spaces. Its administrative area is 34% forested, primarily used for timber, but also supports hunting, tourism, and ecological services like air purification and water preservation. Additionally, 14 rural areas are part of the NATURA 2000 initiative, protecting 12 unique and threatened ecosystems.

Source: https://orthopediewestbrabant.nl/karlovac-karta/

2.2 Demographics

Like many regions in Croatia, Karlovac has experienced population decline due to low birth rates and youth outmigration. From 2011 to 2021, the population dropped by 11.5%, or 6,328 people. The 2021 Census reports that Karlovac County has 112,596 residents, with 48.5% men (54,652) and 51.5% women (57,944). Of those, 97,743 are over the age of 15, with 48.18% men (47,077) and 51.82% women (50,666)[4]. Data from 2023 show that there was a total of 47,233 in the economically active population, of which 22,034 were woman.[5] The City of Karlovac has around 49,377 inhabitants, with a total of 19,385 households. Of these, 30% (5,863) consisting of one-person households, while on the other end of the spectrum, there are 12 households with 11 or more members. Most residents in Karlovac (86%) reside in private property or co-ownership arrangements.

Figure 2
Population trend in Karlovac from 1948 to 2021

Source: Croatian Bureau of Statistics (2023) Statistical Information. Available at: Karlovačka županija - broj stanovnika po gradovima/općinama

As per the table above, and the data from 2021 census, the overall population is 49,377, out of which the following vulnerable groups with fewer economic opportunities that are particularly at risk of natural hazards and increasing impacts of climate:

4 - Croatian Bureau of Statistics. (2021). Popis 2021. Prvi digitalni Popis stanovništva, kućanstava i stanova u Republici Hrvatskoj. Available at https://podaci.dzs.hr/hr/podaci/stanovnistvo/popis-stanovnistva/

5 - Croatian Bureau of Statistics. (2023) Employment – administrative sources. Available at https://podaci.dzs.hr/hr/podaci

Figure 3
Population age distribution

Children aged
0-15 y.o.
14%

People aged
65+ y.o.
25%

Proportion of female
population
54%

Source: Croatian Bureau of Statistics (2023) Statistical Information. Available at: Karlovačka županija - broj stanovnika po gradovima/općinama

Karlovac faces a growing elderly population due to low birth rates and increased life expectancy, straining healthcare, social services, and the workforce. Additionally, younger residents often migrate to larger cities or other EU countries for better education and job opportunities, worsening the region's aging demographic.

2.3 Policy and Strategic Framework

A variety of strategies, policies, and actions demonstrate the City's advancements and its reactive measures to current environmental challenges. Comprehensive plans are in action across several sectors at both national and local levels. The environmental policies listed below underpin the establishment of GCAP's strategic objectives and measures across different areas, such as water and wastewater, public transportation, energy generation and usage, building management, waste management, climate adaptability, urban regeneration, and conservation of natural resources. Additional key documents that were taken into consideration for the definition of the GCAP content are listed below:

Table 2
Overview of the key strategic and regulatory framework relevant for the Karlovac GCAP

Document	Timeframe	Description
Development Plan of the City of Karlovac 2021–2030	2021-2030	The Development Plan presents a comprehensive strategy for managing urban resources and the environment, emphasising the enhancement of urban life and identify areas for improvements and growth potential.
General Urban Plan of the City of Karlovac	Not time bound	It details the policies on urban planning and land use, shaping the city's development to meet local needs while adhering to wider regulatory standards.
Implementation programme of the City of Karlovac for the period 2021-2025	2021-2025	Karlovac's Implementation Programme for 2021-2025 is an all-encompassing agenda that prioritises sustainable progress, economic expansion, and the betterment of citizens' quality of life. The City intends to advance various projects ranging from infrastructure and social services to environmental conservation and technological innovation, utilising diverse funding avenues and collaborative efforts.
2014 – 2024 Karlovac's Cultural Development Strategy	Until 2024	Cultural Development Strategy is founded on this vision: Karlovac, a City where residents appreciate its cultural and natural heritage, embracing cultural creativity and art as foundational to their identity and connection to the City. This cultural development aims to make Karlovac distinctive nationally and internationally, fostering a reputation as a City of diverse encounters.
Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac	2014-2024	The SECAP for the City of Karlovac (2014-2024) outlines the city's strategic framework to address climate change and promote sustainable energy practices. SECAP is a key component of the Covenant of Mayors for Climate and Energy initiative, which encourages local governments to commit to reducing carbon emissions and enhancing resilience to climate impacts.
Development Strategy of the Karlovac Urban Area for the period 2021-2027	2021-2027	The Karlovac Urban Area Development Strategy for 2021-2027 is designed to promote sustainable development and improve living standards through targeted initiatives and investments. This strategy zeroes in on critical domains such as bolstering the economy, rejuvenating infrastructure, ensuring environmental sustainability, and fostering social unity. It sets out to stimulate local businesses, modernise transportation and utilities, support eco-friendly energy and preservation endeavours, and improve vital public services like education and health. In accordance with EU cohesion policy and by tapping into various financial resources, it aims to contribute to a robust and lively urban region that balances economic growth, ecological integrity, and societal welfare.
Air Quality Program for Karlovac 2021-2024	2021-2024	The "Air Quality Program for Karlovac 2021-2024" is an initiative aimed at improving and maintaining air quality in the City of Karlovac, Croatia. This program focuses on several key areas to address air pollution.

Document	Timeframe	Description
The Regulation on the Monitoring of Greenhouse Gas Emissions, Policies and Mitigation Measures in the Republic of Croatia	Non time bound	This piece of legislation details a system for categorising greenhouse gases, as well as protocols for supervision, compilation of data, and reporting requisites. It is structured to align with EU directives and regulations, thus fulfilling Croatia's commitments to the United Nations Framework Convention on Climate Change and the European Commission.
Waste Management Plan of the Republic of Croatia for the period 2017-2022	2017-2022	Karlovac's waste management protocol falls under the larger scope of Croatia's national agenda for waste handling. The city-specific strategy intensifies the push for recycling and composting, betters public education on waste sorting, and pursues EU mandates to lessen reliance on landfills while advancing towards a circular economy.
National Plan for Gender Equality 2021-2027	2021-2027	The Croatian National Plan for Gender Equality 2021-2027 presents an extensive framework aimed at fostering gender equality and tackling discrimination in all facets of life. The document spotlights the significance of granting women and men equal opportunities in employment, educational realms, and political engagement.
The Smart City Strategy 2018	Until 2018	Karlovac's Smart City Strategy released in 2018 depicts the city's ambition to harness technological innovation to upgrade the quality of urban life, advance sustainability and stimulate economic progress. This strategy commits to the adoption of digital technologies within different sectors, including transport systems, energy sustainability, public amenities, and administrative operations.

Source: Consultant

In addition to the SECAP there are strategies that are aimed at the development of urban units through specific development strategies of the wider urban area should be highlighted:

- Development Strategy of the Karlovac Larger Urban Area for the period 2019-2020.
- Development Strategy of the Karlovac Metropolitan Area for the period 2021-2027.

The Strategies outline development initiatives for lasting urban revitalization in Karlovac. The 2019-2020 development plan for the Larger Urban Area Karlovac was adopted by the City Council on 12 May 2020, with oversight extending through 2023 and a final evaluation in 2024. The plan and its triennial Action Plan include the following projects:

1. Complex of the former "Luščić Barracks";
2. Sports and recreation centre Korana;
3. Revitalization of the hot water network of the City of Karlovac, Program / Fund: Operational Program: Competitiveness and Cohesion 2014 – 2020 / European Structural and Investment Funds in the financial period 2014-2020 Holder: Gradska toplana d.o.o. Karlovac; and
4. Exploration and exploitation of geothermal potentials.

2.4 Baseline environmental overview

The following section presents the summary of the state of the environment in the City of Karlovac.

Quality of Environmental Assets: Air

Air Quality context and findings

Air quality in Karlovac has been monitored since 1975 and is generally satisfactory, with management measures integrated into key policies. Pollution mainly stems from road traffic, especially in summer due to the City's role as a transit hub, and from firewood heating in winter. However, vital PM values are not measured.

Key Challenges

PM values are not measured at any station in Karlovac, creating a critical gap in monitoring this key indicator. As a result, data from a similar City has been used for rough estimates. To address this, the City implemented the Air Quality Program for 2021-2024. PM particles are likely a moderate issue due to pollution from industry, transport, and district heating, but the lack of data makes it difficult to assess the full impact.

Quality of Environmental Assets: Water

Water Quality context and findings

Water quality in Karlovac is regulated by standards based on EU directives, and test results for the urban area are satisfactory. The water is of high quality and requires only chlorination before being pumped into the supply system. However, there are challenges in securing sufficient water, particularly during dry periods.

Key Challenges

Even though it is evident that there are no issues when it comes to quality of water, there are still gaps in terms of monitoring the quality of water. The sector would benefit in improved measurement system that would also provide reporting in quantitative manner.

Quality of Environmental Assets: Soil

Soil Quality context and findings

Soil contamination in Karlovac does not appear to be an issue, but there is no recent data to confirm this. The only available data, from 2005, identifies road transport, military activities, agriculture, waste management, industrial zones, rail transport, and economic zones as sources of soil pollution with heavy metals.

Key Challenges

Soil contamination has not been identified as a significant issue in Karlovac, but this is based solely on expert observations, with no studies or data available. There is a need for soil quality analysis, especially for potential.

Availability of resources: Green space, biodiversity, and ecosystems

Green space context and findings

The population density in urban Karlovac is low and the City generally has sufficient green spaces in its land use structure with minor issues with accessibility in some urban districts. However, given the expected heat waves and heat islands issues, there is a need for additional green spaces and other green infrastructure elements on the most vulnerable locations. Regarding the biodiversity outside urban limits, the most important is an ecological network area of about 140 km² important for birds (POP 1000001 Pokupski bazen).

Key Challenges

The population density in urban Karlovac is too low, resulting in high per capita land consumption, a point all consulted stakeholders agreed on. Some participants also highlighted valuable green areas, such as Kozjača Forest Park, which deserves protection and has been proposed for formal protection in the draft Spatial Plan (ID PPUG Karlovac 2023).

Climate Change: Mitigation GHG emissions

Climate Change Mitigation context and findings

The City of Karlovac contributes 1% to Croatia's national GHG emissions, with the energy sector accounting for 74% (buildings 42%, transport 17%, industry 14%, and public lighting 1%), followed by agriculture (15%) and waste (1%). To address this, Karlovac has been implementing climate mitigation measures, including the development of a Sustainable Energy and Climate Action Plan (SECAP) in 2020.

Key Challenges

Despite the City's strategic move towards energy self-sufficiency using geothermal and solar energy, many buildings are still heated with firewood or fuel oil. Given its smaller size, the City has significant potential to reduce traffic emissions by promoting public and non-motorised transport, but it has yet to implement substantial measures to green its fleet, public buses, or private vehicles.

Climate Change: Adaptation and Resilience

Climate Change Adaptation context and findings

Karlovac has a warm, temperate climate with hot summers and cold, snowy winters. Climate change has led to rising temperatures, decreasing precipitation, and more extreme weather events. Due to its proximity to four rivers, Karlovac is highly susceptible to flooding, especially during heavy rainfall or snowmelt, and also faces risks from storms, heat waves, and landslides. The City is in the early stages of climate change adaptation, with its SECAP 2020 containing measures that lack a thorough risk and vulnerability assessment.

Key Challenges

There are number of chronic and acute climate impacts pressuring the City. Furthermore, there is a need to build on the risk and vulnerability assessment (RVA) produced under this GCAP development process to better understand the situation and to integrate it into various planning activities.

2.4.1 Sectoral environmental baseline overview

Transport

Status and main findings

Karlovac has long been a crossroads for major roads linking coastal and inland Croatia. The City's urban area includes 1,432 unpaved roads (totalling 600.3 km) and 226 City-managed parking lots, with unauthorised parking near public spaces being an issue. The bus network, operated by Autotransport d.d., consists of 32 diesel-powered lines with 103 buses. The average car fleet age is 15 years, with 64% being diesel, significantly affecting air quality. Private transport accounts for 89% of commuting trips and 41% of total trips.

Key Challenges

Karlovac has a high dependency on individual motorised transport, with an aging, mostly diesel-powered car fleet. The City also faces pollution from transit traffic, particularly from those traveling to the coast or from Bosnia and Herzegovina. There is a lack of integrated transport planning focused on public and non-motorised transport, and the City suffers from a significant shortage of transport data.

Buildings

Status and main findings

Karlovac's residential buildings include individual houses, collective buildings, and 27 skyscrapers. Most were built between 1950 and 1990 and have not undergone major energy efficiency renovations, making the sector largely inefficient. The City also has many historical buildings, mainly in public and residential use, which are protected as cultural assets and located in the central area. Residential heating is provided through district heating, heating oil, and firewood. Numerous renovation projects are currently underway, particularly through SECAP and the Smart City Development Strategy.

Key Challenges

Reconstruction of existing buildings should prioritise energy efficiency, earthquake and fire resistance, and user well-being, incorporating digital systems as needed. More building units need to connect to the District Heating network, and firewood heating should be phased out. Frequent river floods and heavy precipitation cause water infiltration and damage to foundations, with repair costs partly covered by the City budget. National funds for building renovations are insufficient, and the adoption of smart metering remains limited.

Energy

Status and main findings

Karlovac has complete electricity coverage and a heating industry with a nearly 50-year tradition, centred around a City heating plant with a total installed capacity of 116 MW, mainly using a 56 MW natural gas boiler. The district heating (DH) system spans 22.1 km and serves five city districts. Private companies can develop renewable energy projects if they obtain privileged producer status in the feed-in-tariff system. The City also has significant geothermal energy potential, which is planned for use in the DH network. Karlovac is successfully implementing the “Karlovac District Heating” project in partnership with the EBRD.

Key Challenges

Energy poverty is a challenge for Karlovac. When designing the heating network, it is important to consider that some apartments in multi-apartment buildings still use wood heating. The City also faces climatic extremes, such as hailstorms.

Industry

Status and main findings

Karlovac, with its long industrial heritage, remains heavily reliant on industry for its economic stability, particularly in manufacturing sectors such as food and beverage production, metal products, machinery, rubber and plastics, wood processing, and textiles. Industrial investments typically align with national energy efficiency strategies and EU requirements when EU-funded. The City has limited influence over resource efficiency in new industrial facilities, waste recycling, and wastewater treatment, as these are regulated nationally. No industry reports are available, and while 2,000 companies produce industrial waste, there is no data on recycling, suggesting most waste is sent to landfills. However, all industrial wastewater appears to be treated at the local wastewater treatment plant.

Key Challenges

Currently, no industrial waste appears to be recycled, but the Waste Management Centre Babina Gora is expected to address this issue. While industrial entities can access EU funds through national programs, the City has a potential to explore developing incentive mechanisms to further support this effort.

Water and Wastewater

Status and main findings

Karlovac, located at the confluence of four rivers, is vulnerable to flooding. Drinking water is sourced from six active groundwater pumping stations, with water pipelines spanning 640 km, averaging 32 years old. In 2011, the City implemented a modern water management system, including advanced wastewater purification to remove nitrates and phosphates, improving water quality within the City and downstream. An ongoing project, "Improvement of the Water Utility Infrastructure of the Agglomeration Karlovac-Duga Resa," valued at approximately 56M EUR, aims to expand the sewage network, partially replace the water supply system, and build a solar sludge drying plant.

Key Challenges

Karlovac and its region face ongoing challenges in flood defence, resulting in financial strain due to repair costs. While efforts to improve water defence infrastructure are underway, delays persist. Non-revenue water losses in the network are significant, at around 58%, and reducing these losses is a top priority. The "Improvement of the Water Utility Infrastructure of the Karlovac-Duga Resa Agglomeration" project, though substantial, does not cover the entire area and will not fully address the issue. Installing water meters with remote reading modules is planned to enhance billing efficiency.

Solid Waste

Status and main findings

Karlovac's waste collection system, initiated in 2015, covers both mixed municipal solid waste (MSW) and biodegradable waste using a "door-to-door" model. The City-owned company "Čistoća" d.o.o. handles waste collection, removal, and disposal at the "Ilovac" landfill, operational since 1978, where over 800,000 m^3 of waste has been disposed of. Waste separation is introduced at the household level, with 50 green islands equipped with containers for paper, plastic, glass, and metal, and 20 also featuring textile containers. While awaiting the operational WMC Babina Gora, Ilovac landfill remains in use. WMC Babina Gora will address critical waste sector issues, though the City has limited influence, as decisions are made at the national/county level.

Key Challenges

The construction of the WMC project is expected to address sectoral challenges. However, there is potential for improving waste policies at the City level, particularly focusing on measures to encourage waste separation and reduce waste generation at the source, particularly in households. This should be complemented by awareness-raising campaigns.

Land Use

Status and main findings

Karlovac has significant potential for urban regeneration, particularly in its historical core, Zvijezda. The City's General Urban Plan (GUP) promotes mixed-use development, requiring at least 32% of construction land to be allocated for such purposes. Available data only covers the occupancy or lease status of 97 City-owned and 20 City-managed business premises. In 2011, there were 25,960 apartments in the City, with 20,855 occupied. The City is also advancing brownfield redevelopment projects in Gaza, Luščić, and ŠRC Korana, with plans to incorporate green infrastructure to support active mobility like bicycle and pedestrian paths.

Key Challenges

The sector faces a lack of data, particularly regarding brownfield and green infrastructure potential for adaptation. Challenges include low population density, low occupancy of residential and commercial spaces, and untapped sites with protection potential, such as Kozjača Forest.

2.5 Summary of environmental challenges prioritised for the GCAP

Based on the baseline analysis, stakeholder and expert inputs, and overall prioritisation exercise, the following are the main environmental challenges to be directly addressed and targeted by the GCAP:

Green City Challenge	Priority	Challenge elaboration and points of action
GHG emissions - High level of GHG emissions from various sources such as poor energy performance of buildings, motorised transport, water sector pumping and similar	High	Reduction of GHG emissions is one of the main priorities of the GCAP. This area has been identified as one of the most pression environmental challenges and one where GCAP has very high potential for an impact. As already elaborated, the transport sector is inefficient with high dependency on motorised transport consistent of an old fleet of cars. There is as strong need to decarbonise the sector with offering alternative modes of transport. Furthermore, local DH system is being modernised but with no share of renewable energy. This is valid for renewable sources in general throughout the City limits. The GCAP is actively looking at adding more RES in all the relevant sectors in order to increase this share. Finally, private and public building stock is substantially energy inefficient and there is a need to decarbonise the sector. This is also going to be targeted by the GCAP directly.
Flooding and physical climate risks - The City is vulnerable to these impacts and requires improved climate resilience	High	Flooding issues, relative to climate vulnerable City areas as well as a need to build on the RVA produced under this GCAP development proves. Though there are jurisdictional limitations, the GCAP looks closely into addressing these issues through different set of actions that would directly and indirectly have an impact.
Water losses - High level of losses in water supply system	High	Losses in the water supply systems are substantial. The GCAP implements actions that will contribute to overcoming this issue through rehabilitation of the water network supply network.
Low uptake of green infrastructure - Low level of green infrastructure and population density	High	There is a gap in understanding of the potential that green infrastructure might pose in the City of Karlovac. The GCAP looks into unlocking the potential through set of tailored actions. These would overcome the challenge of low population density, low level of brownfield development, and overall utilisation of green spaced in a sustainable manner.
Waste generation and management - The City of Karlovac presents high level of generated waste per capita and low level of waste separation	Medium	The sector is expected to be highly improved once the Waste Management Centre becomes active. However, this challenge will also be directly and indirectly addressed by the GCAP through set of actions that would support the improvement of the sector.

2.6 Risk and Vulnerability Assessment

As part of the baseline assessment, a Risk and Vulnerability Assessment of City of Karlovac was undertaken. The following section presents the main findings.

2.6.1 Environmental Hazards

Karlovac's climate, characterised by warm summers and cold winters, is undergoing discernible changes, with rising temperatures, decreased precipitation, and a surge in extreme weather events. The vulnerability assessment identifies seven prominent environmental hazards: extreme temperatures, drought, wildfires, floods, storms, landslides, and earthquakes.

The following presents summary of occurrence of environmental hazards in the City of Karlovac:

- The highest temperature recorded in Karlovac was 42.4°C on 5 July 1950[6]. However, despite not reaching record temperature, heatwaves during recent summers have impacted the entire central Croatia, including Karlovac with temperatures reaching 37.2°C in 2023. Climate change projections suggest increase in mean and extreme temperatures, thus increasing the likelihood of heatwaves.

- The latest recorded droughts in the Karlovac area were during summers of 2022 and 2021[7] and resulted in impacts on agriculture such as damage to crops and reduced yield.

- Wildfires in the Karlovac area were recorded in 2013 and in March 2022 when a fire destroyed 100ha forested area[8].

- Floods classed as natural disasters were recorded in the City in 1939, 1966, 1972, 1974, 1996, 1998, 2001, 2005, 2010, 2012, 2013, 2014 and 2015 . Two record flood events in Karlovac were recorded in 1939 when Kupa River water level was 872cm and in 1966 when water level was 832cm. More recently, the City flooded in May 2023, when water level was higher than 840cm resulting in an estimated damage of 16.8M EUR, mainly to buildings.

- There are numerous records of storms in the Karlovac area in recent years which noted damage to infrastructure and industry, especially agriculture.

- In the City of Karlovac, landslides most commonly occur alongside roads and dwellings. In 2015, landslides were classed as natural disaster due to the severity of their consequences[9].

- Although not as frequent as other hazards, Karlovac is located in a region with seismic activity[10]. The biggest earthquake recorded in central Croatia happened in December 2020. Due to the proximity of the epicentre to the City of Karlovac, the earthquake caused significant damage to the City and was classed as a natural disaster.

6 - Croatian Meteorological and Hydrological Service (2022) The highest recorded temperatures in Croatia. Available at: DHMZ - Državni hidrometeorološki zavod [Accessed November 2023]

7 - TrendTV (2022) Drought in Karlovac. Available at: Suša pogodila i poljoprivrednike u Karlovačkoj županiji, u OPG-u Fanjek: Lješnjak je sitniji, dio stabala presušio – Trend.com.hr [Accessed November 2023]

8 - Radio Mreznica (2022) Milijunska steta jucerasnjeg pozara na podrucju Perjasice: U pepeo otisla smrekova I borova suma. Available at: Milijunska šteta jučerašnjeg požara na području Perjasice: U pepeo otišla smrekova i borova šuma – Radio Mrežnica (radio-mreznica.hr) [Accessed November 2023]

9 - Stimac Nika (2022) Poplave na podrucju Grada Karlovca – undergraduate thesis. Available at: https://repozitorij.pmf.unizg.hr/islandora/object/pmf%3A10422/datastream/PDF/view [Accessed November 2023]

10 - Think Hazard (2020) Croatia – Earthquake. Available at: https://www.thinkhazard.org/en/report/62-croatia/EQ#:~:text=Earthquake%20Hazard%20level%3A%20Medium%20In%20the%20area%20you,your%20project%20area%20in%20the%20next%2050%20years [Accessed September 2023]

Extreme temperatures

Climate projections indicate a potential increase in high temperatures exceeding 35°C for up to 15 days in summer by the century's end. Mitigation measures involve urban greening, heat-resistant materials, and resilient building designs.

Drought and water scarcity

The impact of longer and more frequent droughts on agriculture and water resources necessitates an adaptive water resource management strategy, considering both current demands and future risks during hot summers.

Wildfires

Forested areas are susceptible to wildfires, accentuated by rising temperatures. Strengthening early warning systems, disaster preparedness plans, and collaboration with relevant stakeholders form essential components of wildfire preparedness.

Floods

Proximity to rivers makes Karlovac prone to fluvial flooding, with recorded events posing significant risks to residential areas, infrastructure, and businesses. Recommendations include nature-based solutions, built interventions, and collaboration with the government for planned flood protection in the Kupa River basin.

Storms

Changes in extreme rainfall events suggest an increased likelihood of storms, evidenced by recent records of damaging storms in the Karlovac area affecting infrastructure and agriculture. Infrastructure resilience measures and adjustments to outdoor work schedules during extreme weather events should be implemented.

Landslides and ground movements

Increased heavy rainfall events may elevate the risk of riverine and surface water flooding, subsequently increasing the potential for landslides near rivers, impacting areas within Karlovac and emphasising the need for protective measures such as retaining walls and good land management practices.

Earthquakes

Despite infrequency, seismic activity such as the 2020 earthquake and the ageing infrastructure poses risks and emphasising the importance of earthquake-resilient design and collaboration with stakeholders for appropriate resilience measures.

2.6.2 Technological and socio-economic hazards

It is anticipated that the population in Karlovac will persist in its decline in forthcoming years, with projections suggesting an increase in median age and a shift towards an older demographic. Meanwhile, Croatia is consistently advancing its economic integration with the European Union. As identified in this analysis, there are four primary technological and socio-economic risks: transportation incidents, industrial mishaps, economic disruptions, and health emergencies.

Economic crisis

The probability of an economic crisis remains stable, but the report underscores the importance of addressing depopulation trends, an aging population, rising infrastructure costs, and reduced EU contributions to mitigate economic crisis risks.

Epidemics

Recent global health crises highlight the need to assess health-related risks that are accentuated by higher residential densities and require ongoing assessment and modern developments in prevention and treatment.

Karlovac's resilience hinges upon the robustness of its critical urban systems, each playing a pivotal role in sustaining the city's functionality and well-being. Comprehensive evaluations of these systems provide insights into potential vulnerabilities and inform strategic measures to enhance adaptability.

These critical components encompass a well-maintained water supply network, an operational wastewater treatment system, and strategic waste management practices. The City boasts a well-connected and efficiently maintained transport infrastructure, along with reliable energy networks, emphasising the importance of ongoing technological upgrades. In terms of housing, Karlovac's commitment to seismic resilience is evident in stable provisions with earthquake-resistant structures. The City's healthcare services, including facilities like the General Hospital Karlovac, play a vital role in community well-being, emphasising the need for continuous investments in healthcare infrastructure and public health awareness campaigns.

The urban landscape is shaped by efforts to balance industrial dominance with sustainability, as seen in the transition of industries to business zones outside the City centre. Moreover, initiatives to increase greenspace and biodiversity, both within peri-urban areas and along rivers, underscore the City's commitment to environmental conservation.

In navigating these critical urban systems, ongoing collaborations, technological advancements, and community engagement are pivotal. These efforts collectively contribute to fortifying Karlovac against emerging challenges and ensuring its continued resilience in the face of evolving urban dynamics.

The table below was developed to provide comprehensive assessment matrix that evaluates the impact of identified hazards on Karlovac's critical urban systems. This matrix analyses the vulnerability of each system, the likelihood of hazard occurrence, the potential consequences, the overall risk to the City, and the confidence level associated with these assessments. The integration of hazard assessments and urban system vulnerabilities provides a nuanced understanding of the City's resilience, aiding strategic planning and risk mitigation efforts.

Hazards	Flooding	Landslides	Earthquake	Wildfire	Drought / Water scarcity	Extreme temperatures	Storms	Transport accidents	Industrial accidents	Economic crises	Epidemics / Pandemics
Vulnerability of urban systems	1- Low, 2 – Minor, 3 – Moderate, 4 – High, 5 – Extremely High										
Community health	4	1	5	3	4	4	5	4	3	4	5
Water	4	4	5		4	2	3	5	3	4	
Solid waste		4	5	1		2	1				
Transport and mobility	4	4	5			3	3	2	2	4	
Energy and lighting	4	4	5			4	4			4	
Buildings and housing	4	4	5	3		3	2		2	4	
Land use and biodiversity	4			4	5	4		5	3		
Industry / City economy	3	4	5	4	5	3	3	1	3	4	4
Likelihood	1 – Rare, 2 – Unlikely, 3 – Possible, 4 – Likely, 5 – Almost certain										
	5	3	1	4	4	4	3	3	1	3	3
Consequences	1- Insignificant, 2 – Minor, 3 – Moderate, 4 – Major, 5 – Catastrophic										
	5	4	5	4	4	4	4	3	4	3	4
Risk to the City	1 – Low, 2 – Medium, 3 – High, 4 – Extremely high										
	4	4	3	3	4	3	4	1	1	2	2
Level of confidence	1 –Highly Reliable, 2 –Reliable, 3 -Somewhat reliable, 4 -Unreliable										
	2	3	2	3	3	2	2	2	3	2	3

Figure 4:
Risk and vulnerability assessment summary

Source: Consultant

Within the spectrum of strategic measures proposed to address priority risks, a multifaceted approach is outlined:[11]

River flood defences:

The strategy involves substantial investments in nature-based solutions and the implementation of robust built interventions, such as concrete defences. Collaborative efforts with the government are vital for the execution of planned flood protection initiatives. Immediate emergency flood measures, including the deployment of sandbanks, pumps, and early warning systems, are complemented by a focus on enhancing flood resilience in buildings.

Landslide protective measures:

To mitigate landslide risks, the approach encompasses thorough research and strategic investments in protective measures. Simultaneously, the implementation of effective land management practices plays a pivotal role in reducing vulnerabilities in both transport and building systems.

Extreme heat mitigation:

Mitigating the impacts of extreme heat involves a combination of urban greening initiatives, the selection of heat-resistant materials in construction, and the designation of urban cooling refuges. Adapting maintenance schedules during heatwaves further contributes to the overall resilience against rising temperatures.

Earthquake resilient design:

Emphasis on earthquake-resilient design principles guides future building and infrastructure investments. Disaster preparedness exercises and training courses at the local level empower communities to respond effectively. Collaborative engagement with relevant stakeholders ensures the appropriateness of earthquake resilience measures.

Water resource management:

Adapting water resource management to incorporate considerations of increased drought risk is essential. Addressing groundwater supply security and anticipating future water demand during hot summers form integral components of this adaptive strategy.

Wildfire preparedness:

The wildfire preparedness strategy focuses on establishing and fortifying early warning systems. Periodic reviews and updates to disaster preparedness plans, such as the Protection and Rescue Plan, ensure the City's readiness to respond effectively to wildfire incidents.

11 - Kindly note that full alignment between these recommendations and the GCAP actions is not mandatory, given certain jurisdictional constraints. Albeit not included as specific actions, these are overarching considerations for the city to integrate into its urban planning and infrastructure development efforts. Additionally, many of these challenges are currently being addressed through national-level initiatives.

2.7 Smart Maturity Assessment

The City of Karlovac is on the path to becoming a Smart city, having achieved considerable strides in this area lately. Although the City has crafted a strategic framework for the advancement of smart initiatives, there is an absence of a comprehensive Smart City strategy at the national level within Croatia; instead, it is fragmented across various strategies. Key local stakeholders encompass the city's governing body, municipal enterprises, the commercial sector, the general population, academic institutions, and civil society groups. Despite a shared interest in the transformation toward a Smart city, these groups may have divergent and potentially conflicting objectives. While businesses eye the economic prospects a Smart City may yield, citizens are drawn to the prospective enhancement in life quality. Consequently, it remains vital for the municipal authority to maintain its role in outlining the vision and overarching strategy for Smart City projects and to retain control over their execution.

The City has a clear and shared vision for Digital Transformation (DT) and Smart Initiatives (SI) in the City, a well-defined governance structure that ensures that all stakeholders are involved in the decision-making process, clear policies and procedures in place for managing digital transformation and smart initiatives, a strong focus on continuous improvement and innovation, a culture of collaboration and cooperation between different departments and stakeholders, and a commitment to transparency and accountability. The City is still in the early stages of developing its integrated Information and communication technologies (ICT) infrastructures, but it is committed to these efforts and is making progress.

The City is working with its partners to develop the necessary standards and protocols for data sharing. It is also investing in the necessary hardware and software to support the integration of its ICT systems.

Regarding fundamental amenities like internet connectivity, the City boasts reliable and high-quality Internet services. It is actively enhancing connectivity by engaging in initiatives aimed at bolstering fibre-optic networks and collaborating with major optical infrastructure providers throughout Croatia. Its widespread fibre-optic network ensures rapid Internet access across various districts. Efforts are also underway to expand the reach of public Wi-Fi. Building robust ICT infrastructure is essential for Karlovac's Smart City goals. Harmonising ICT frameworks can boost efficiency, improve decision-making, and enhance quality of life. However, challenges remain, including fragmented systems and limited data-sharing. Addressing these gaps requires expanded data collection, accessibility, and investment in analytics and training. Karlovac is shifting from a reactive to a proactive approach, with progress on its Smart City framework.

The following section presents the key strengths and weaknesses of the City of Karlovac in this context:

Strengths:

- Strategic vision: Karlovac has a clear digital transformation and Smart City framework, prioritising transparency and accountability.
- Stakeholder engagement: Inclusive governance actively involves local authorities, businesses, academia, and civil society.
- ICT and connectivity: Investments in high-speed internet and expanded public Wi-Fi support Smart City infrastructure.
- Proactive governance: The City is moving toward a strategic, forward-thinking approach in Smart City leadership.

Weaknesses:

- Lack of national strategy: With no national Smart City framework, efforts rely heavily on local initiatives.
- Diverse stakeholder goals: Differences in priorities, such as economic growth vs. quality of life, may cause conflicts.
- Data integration gaps: Limited data-sharing and fragmented ICT systems hinder efficiency.
- Data and training needs: Improved data accessibility, updates, and analysis skills are essential for future growth.

2.8 Gender and Social Inclusion Assessment Baseline

2.8.1 Gender baseline

At the national level, Croatia faces significant demographic challenges, including an aging population and population decline. By 2050, nearly half of Croatia's population is projected to be over 60 years old, with women outnumbering men, particularly in older age groups. In response, Croatia has made substantial progress in promoting gender equality through legislative advancements and policy frameworks. Key initiatives include the Gender Equality Act of 2017 and the National Plan for Gender Equality 2021-2027, aimed at eradicating discrimination and promoting gender equality across sectors. Women in Croatia have made strides in educational attainment but continue to face challenges in the labour market, with lower representation in decision-making positions and leadership roles. Gender disparities persist in sectors such as employment, education, and economic participation, despite advancements in legislation and policy frameworks. While there have been improvements in gender representation in political and educational spheres, significant gaps remain, particularly in local governance and the judiciary.

Table 3
Gender inclusion by category

Category	Details
Population demographics	Women outnumber men in Karlovac County and the City of Karlovac, particularly in older age groups.
Employment sector	Women are prominently represented in certain sectors but underrepresented in others traditionally associated with men; gender wage gaps persist.
Unemployment and economic challenges	Women face higher unemployment rates compared to men; region grapples with economic challenges such as poverty rates, particularly among women; LGBTQ+ community fears employment discrimination.
Education	Women exhibit slightly higher rates of higher education attainment compared to men in younger age cohorts; disparities in educational attainment across genders persist.
Political leadership	Efforts to promote gender equality in political leadership face challenges; higher female representation observed in governance in Karlovac County.
Urban planning and development	Gender-sensitive strategies in urban planning are lacking; need for mechanisms to gather women's input on environmental issues and prioritise women's needs in green initiatives.
Workforce diversity and inclusion	Some stakeholders promote gender diversity and inclusivity in the workforce; gaps in gender-inclusive practices and initiatives targeting gender equality in City development.

Source: Consultant

2.8.2 Social inclusion of vulnerable groups in Karlovac

One of the significant demographic challenges in Karlovac is the aging population. As birth rates have remained low and life expectancy has increased, the proportion of elderly residents has been growing. This demographic shift poses implications for healthcare, social services, and the labour market.

Additionally, regarding homeless people, the City of Karlovac has opened a Homeless Shelter that provides users with the opportunity for one warm meal, and breakfast and dinner. Users are offered various educational opportunities, allowing them to obtain certificates for specific professions, enhancing their prospects in the labour market. Workshops are also available, such as gardening enabling users to produce their own food as a supplement to their diet and for preserving.

The Councils of National Minorities of the City of Karlovac are established based on the Constitutional Act on the Rights of National Minorities with the aim of advancing, preserving, and protecting their position. The councils and representatives of national minorities act as advisory bodies to the City of Karlovac, and the funding and working conditions are provided for in the budget of the City of Karlovac. The Councils of National Minorities are specific non-profit legal entities established by individual national minorities to exercise the rights of their members to participate in public life and represent their interests at the level of local and regional self-government units, all in accordance with the provisions of the Constitutional Act on the Rights of National Minorities.

3. GREEN CITY VISION AND STRATEGIC GOALS

3.1 Overview

As outlined in the opening chapter, the second stakeholder engagement workshop focused on delineating the City's vision and strategic goals across various sectors. This section, dedicated to the Vision & Strategic Objectives of the Karlovac Green City Action Plan, offers an overview of the developments pertinent to the Karlovac GCAP initiative, encompassing stakeholder interaction and the preliminary identification of the City of Karlovac's vision and strategic targets within its GCAP.

All GCAPs necessitate a Green City strategy statement. This statement outlines the vision for a 15-year period and identifies key sector strategic objectives spanning 10 to 15 years. These strategic objectives are designed to tackle the priority green challenges specific to Karlovac, as identified during the baseline phase of the GCAP development process.

Developing a common Green City Vision for the City is key element of the Karlovac GCAP as it will provide the basis for all subsequent Strategic Objectives, Mid-Term Targets, and Actions with concrete targets and measures.

The Vision is an important qualitative description of the desired future which will be underpinned with specific Strategic Objectives that indicate the type of change desired; and there is a clear relationship between the Vision, Strategic Objectives (incl. Targets) and Actions that are developed as part of the Karlovac GCAP.

3.2 Karlovac City Vision Statement

> ***Karlovac is a green and sustainable Star where every person takes responsibility for future generations.*** [12]

The forthcoming environmental programs within different City sectors will be guided by this vision statement, which is grounded in a series of clear strategic environmental goals designed to improve environmental outcomes. Consistent with the Green City Vision, extra strategic objectives have been established to tackle unique issues within the field of environment.

3.3 Karlovac GCAP Strategic objectives

The GCAP process sets out that Strategic Objectives are required to define long term goals (10-15 years) and guide the direction of the GCAP to contribute to the Vision. These should relate to the priority areas and policy gaps identified in the Technical Assessment Report. These Strategic Objectives are then supported by Mid-Term Targets (5-10 years) which set more tangible targets to build towards achieving the Strategic Objectives.

A range of potential Strategic Objectives and Mid-Term Targets for the GCAP was identified, based purely on the outcome of the Technical Assessment process, which was largely based on the analysis of internationally benchmarked indicators, which were collected as a part of the technical assessment processes.

Subsequent engagement with stakeholders, through a prioritisation workshop helped to refine the City's key priorities and provided additional information used to refine the defined strategic objectives. Based on the outcome of this process the following Strategic Objectives and Mid-Term targets were defined:

12 - Please note that the word „Star", used in the vision statement, refers to the star-shaped city centre/old town (Zvijezda in Croatian) which is also a City's symbol. In Croatian, Zvijezda literally means star.

Table 4
Identified Strategic Objectives for the Karlovac GCAP

Thematic Area	Strategic Objective	Description
Transport	1.1	Ensure the highest quality of public transport, multimodal transport integration, and stationary traffic capacity through flexible organisation of the system, implementation of low carbon infrastructure, and digitalisation.
	1.2	Leverage on opportunities of Karlovac as a commuting City and secure long terms sustainable development in this context.
Energy and Buildings	2.1	Ensure the decarbonisation, efficiency, and resilience of current and future heating systems by introducing renewable energy and energy efficiency measures.
	2.2	Ensure decarbonisation of the city's building stock through the renovation, implementation of RES, introduction of smart metering, awareness raising, and building in an efficient, resilient, and sustainable way.
Water and Wastewater	3.1	Ensure efficiency of water systems and preservation of water resources while achieving high level of climate resilience.
	3.2	Enhance capacity of key stakeholders and achieve satisfactory awareness level on water sustainability among citizens and stakeholders.
Solid Waste	4.1	Develop and strengthen a modern system for waste management based on a "zero-waste" model.
	4.2	Accelerate, encourage, build capacity, and monitor circular economy related solutions, especially recycling and reuse of materials and waste.
Land Use	5.1	Maintain existing and develop new green infrastructure to ensure environmental, social and economic benefits and improve the City's resilience to the impacts of climate change.
	5.2	Intensify use and regeneration of existing underutilised urban structures with the aim of achieving higher urban quality and limit the expansion of urban and other construction land.
Environmental Monitoring & Green City System	6.1	Establishment of relevant KPIs, monitoring, and coordination of activities needed for achieving strategic objectives.
	6.2	Have an effective and efficient Green Cities coordination, monitoring, and management system in place to drive and coordinate the implementation of KPIs and the Karlovac GCAP successfully.

4. GREEN CITY ACTIONS

The development of the Green City Baseline has helped to confirm and prioritise the City's various challenges. The subsequent critical phase is to discern and rank the potential solutions to these challenges. In accordance with the procedure outlined by the Green Cities Programme, we have devised Green City Actions. This entailed envisioning a long-term future for the city, defining strategic objectives for the coming 10 to 15 years, setting intermediary goals to gauge progress, and identifying the immediate steps necessary to actualise the long-term vision.

Strategic objectives all have dedicated and defined mid term and final targets. Targets have been set in alignment with the PSR framework benchmarks, EU standards, and national, City, and local strategic objectives, as well as the replicability potential of proposed actions, ensuring consistency with broader EU and City goals. While these targets provide guiding benchmarks, they are not intended as strict upper limits. For instance, in the case of non-revenue water, a target of 30% is set; however, achieving 25% would be an even better outcome.

This approach allows flexibility to strive beyond initial goals in alignment with the PSR framework benchmarks, EU, and City objectives.

The table below offers a condensed overview of the actions aligned with the strategic goals. It is clear from the table that most actions will impact multiple strategic objectives positively. These benefits are categorised through two distinct levels:

- Primary benefit – the action is specifically targeting the strategic goal and is designed to have benefit in this area. These are highlighted with a Dark Blue
- Secondary benefit – the action is not primarily designed to benefit this strategic goal but may support improvements. These are highlighted with a Light Blue

Table 5 Contribution of GCAP actions towards Strategic Objectives

Primary benefit
Secondary benefit

	Transport		Energy and buildings		Water and Wastewater		Solid waste		Land Use		Cross cutting	
	SO 1.1 Sustainable transport	SO 1.2 Commuting & sustainable city	SO 2.1 Decarboni-sation of heat-ing system	SO 2.2 Commuting & sustainable city	SO 3.1 Efficient water system	SO 3.2 Capacity and awareness level increased	SO 4.1 Zero waste model	SO 4.2 Circular econ-omy capacity	SO 5.1 Green infrastructure	SO 5.2 Regeneration of urban sector	SO 6.1 KPIs and monitoring	SO 6.2 GCAP coordination
TRANSPORT												
T1: Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	■	■									▪	▪
T2: Construction of primary and secondary cycling network and improving cycling infrastructure.	■	▪									▪	▪
T3: Transport infrastructure development policies stimulating the use of non-motorised transport.	■	■									▪	▪
T4: Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.	■	▪									▪	▪
ENERGY AND BUILDINGS												
EB1: "15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.	▪		■	■					▪	▪	▪	▪
EB2: Utilisation of geothermal energy potential in the City of Karlovac.			■	■							▪	▪
EB3: Strengthening the DH system for sustainable, efficient, and innovative energy services.			■	▪							▪	▪
EB4: Decarbonisation of multi-apartment buildings in the City of Karlovac.			▪	■							▪	▪
EB5: Decarbonisation of public buildings in the City of Karlovac.			▪	■							▪	▪
EB6: Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.			■	■							▪	▪
WATER AND WASTEWATER												
W1 Reduction of water consumption and water network losses.					■	■					▪	▪
W2 Increase of water storage capacity and installation of solar-powered pump systems.					■	▪					▪	▪
W3 Introduction of heat pump and CHP Systems into Karlovac Wastewater Treatment Plant.			■		■	▪					▪	▪
W4 Increase climate resilience against flooding in the City of Karlovac.					■	■					▪	▪

Table 5 Contribution of GCAP actions towards Strategic Objectives

Primary benefit
Secondary benefit

	Transport		Energy and buildings		Water and Wastewater		Solid waste		Land Use		Cross cutting	
	SO 1.1 Sustainable transport	SO 1.2 Commuting & sustainable city	SO 2.1 Decarboni-sation of heat-ing system	SO 2.2 Commuting & sustainable city	SO 3.1 Efficient water system	SO 3.2 Capacity and awareness level increased	SO 4.1 Zero waste model	SO 4.2 Circular econ-omy capacity	SO 5.1 Green infrastructure	SO 5.2 Regeneration of urban sector	SO 6.1 KPIs and monitoring	SO 6.2 GCAP coordination
SOLID WASTE												
SW1 Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.							Primary	Primary			Secondary	Secondary
SW2 Feasibility assessment and landfill gas plant construction at Ilovac landfill post-closure.			Secondary				Primary	Secondary			Secondary	Secondary
SW3 Improving municipal solid waste separation at the source level.							Primary	Primary			Secondary	Secondary
LAND USE												
L1 Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.				Secondary					Primary	Primary	Secondary	Secondary
L2 Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.									Primary	Secondary	Secondary	Secondary
L3 Protection and revitalisation of urban forest Kozjača.									Primary	Secondary	Secondary	Secondary
L4 Innovative instruments for stimulating use of green infrastructure elements through spatial plans.									Primary	Primary	Secondary	Secondary
CROSS- SECTORAL												
CS1 Technical assistance for establishing a portfolio approach to project management "Smart Maturity".	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Primary	Secondary
CS2 Development of an Updated Smart City Strategy.	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Primary	Secondary
CS3 GCAP Web site for monitoring and implementation.	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Secondary	Primary	Primary

Source: Consultant

4.1 Transport

4.1.1 Introduction to sector and overview of key challenges

The sector

For centuries, Karlovac has been a pivotal junction for the major thoroughfares connecting Croatia's coast to its interior. Situated at the convergence of the critical A1 (Zagreb-Split highway) and D1 (the traditional Zagreb-Split Road), it also serves as a passage from Bosnia and Herzegovina to Northern areas and Western Europe. The urban area of Karlovac includes 1,432 unpaved roads, spanning a total distance of 600.3 kilometres, and 226 parking areas maintained by the City.

The Karlovac area is served by the RH2 corridor / M202 railway line (Zagreb-Rijeka), which is an essential artery for both passenger and freight services. Additionally, the L103 rail line (Karlovac-Kamanje-DG) plays a critical role in serving local commuters, covering 28.8 kilometres.

The region's bus system, centred in Karlovac, operates with a fleet of 103 buses across 32 routes, under the management of Autotransport d.d.

As for non-motorised travel, there is an urgent need to upgrade the existing cycling infrastructure. This encompasses constructing new cycle paths and bike storage facilities, as well as deploying proper signage and safety-oriented infrastructure enhancements.

Traffic rules are governed by the Decision on Traffic Regulation in Karlovac, which stipulates the guidelines and regulations for vehicular and pedestrian traffic on public thoroughfares, in addition to specifying the measures for enforcement.

Key challenges

The following are the key challenges identified within the transport sector:

1. Overall high GHG emissions from various sectors, including transport sector.

2. The Croatian Transport Development Strategy for 2017-2030 highlights the need for infrastructure improvements on the Zagreb-Karlovac corridor due to increased traffic. Proposals include adding lanes and implementing a closed drainage system. The inefficiency and toll expenses of current highways compel local commuters to seek alternatives, leading to frequent congestion on the D1 road. Furthermore, the heavy flow of trucks through City areas exacerbates traffic jams and environmental degradation, underlining the imperative for a bypass solution.

3. A pivotal requirement for this domain is a shift in transportation modes. Although private car usage is prevalent among residents, the compact nature of the City fosters cycling and walking, presenting an excellent chance to embrace sustainable transport methods.

4. To fully integrate with the City's public transportation system, enhancements are essential for the existing bike-sharing program. Moreover, the development of cycling infrastructure is critically needed; this includes constructing new bike paths, establishing bike stations, and ensuring adequate signage and safety-focused amenities.

5. However, there is a noticeable absence of comprehensive transport planning that prioritises public and non-motorised transit options. Alongside this, there is an evident scarcity of diverse transportation data at the municipal level.

4.1.2 City's current activities

A sound example of quality documentation providing data substantiated documentation framework for addressing some aspects of wider public and non-motorised transport use include the Technical Report on Transport Issues[13] done to aid the General Urban Plan development, and the Transport Study of Karlovac Cycling Infrastructure[14] both carried out in 2022 by the Faculty of Transport and Traffic Sciences Zagreb. These studies serve as an excellent sectoral overview and were instrumental for defining GCAP actions within this sector.

4.1.3 Sector's strategic objectives and targets

The following are the defined strategic objectives for Transport sector in Karlovac:

Strategic objective 1.1:
Ensure the highest quality of public transport, multimodal transport integration, and stationary traffic capacity through flexible organisation of the system, implementation of low carbon infrastructure, and digitalisation.

A wide-ranging, intersectoral strategy is necessary, with the City facilitating systems and infrastructure that promote alternative modes of transportation over reliance on vehicles powered by fossil fuels. The goal is to develop suitable regulatory measures that will extend the impact of crucial GCAP actions even after their scheduled end.

Strategic objective 1.2:
Leverage on opportunities of Karlovac as a commuting City and secure long terms sustainable development in this context.

Given Karlovac's strategic location, the City has an exceptional chance to sustainably capitalise on its close proximity to the capital and its role as a hub for the significant number of people traveling to the coast in the summer. It is vital for the City to establish itself as a commuter-friendly City and to implement a legislative framework with the accompanying infrastructure, focusing especially on transportation.

13 - Prometna stručna podloga Grada Karlovca, za potrebe IV. izmjena i dopuna GUP-a, Fakultet prometnih znanosti Zagreb, 2022

14 - Prometna studije biciklističke infrastrukture Grada Karlovca, Fakultet prometnih znanosti Zagreb, 2022.

4.1.4 Transport GCAP actions

4.1.4.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 1.1.– Ensure the highest quality of public transport, multimodal transport integration, and stationary traffic capacity through flexible organisation of the system, implementation of low carbon infrastructure, and digitalisation.			
SO 1.2.- Leverage on opportunities of Karlovac as a commuting City and secure long terms sustainable development in this context.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target (2032)	Final target (2039)
Transport modal share in commuting cars, motorcycles, taxi, bus, metro, tram, and bicycle.	89% private transport	50% private transport	30% private transport
Transport modal share in total trips.	41%	35%	30%
Kilometres of dedicated bicycle path per 100,000 population.	Approx. 10 km per 100,000 people	30 km per 100,000 people	50 km per 100,000 people

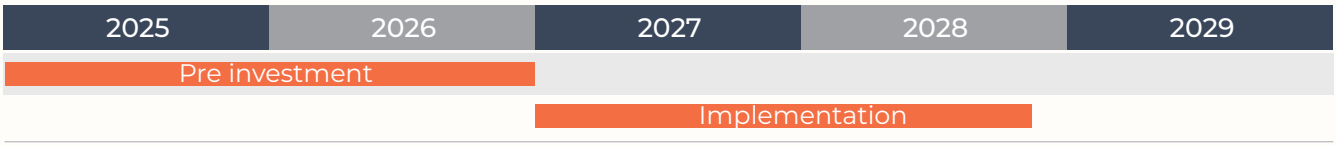
4.1.4.2 List of actions

ACTION CODE	ACTION TITLE	ACTION TYPE	MAIN IMPLEMENTING STAKEHOLDERS	ACTION REQUIRED BUDGET (EUR)	TIMEFRAME	GHG REDUCTION POTENTIAL – TOTAL OVER LIFETIME OF INVESTMENT
T1	Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	Investment	City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.	1,650,000	2025-2028	599 tCO_{2eq}
T2	Construction of primary and secondary cycling network and improving cycling infrastructure.	Investment	City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.	12,000,000	2025-2029	114,975 tCO_{2eq}
T3	Transport infrastructure development policies stimulating the use of non-motorised transport.	Policy	City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.	110,000	2025-2026	Undetermined at this stage
T4	Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.	Investment	City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government; PT providers.	4,500,000	2025 – 2028	1,998 tCO_{2eq}

T1: Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project

Type of action
INVESTMENT

Budget
1,650,000 EUR



Purpose

Conducting an analysis for better understanding of the needs of local transport system and the implementation of the Transit Oriented Approach (TOD).

Lead implementer

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action envisages the development of the Karlovac transport demand and supply study covering the entire sector and its aspects. The study will also ensure that the TOD approach is implemented into the Luščić action (EB1). That includes identification of high-traffic areas, design of pedestrian zones, and public transport and communal services Battery Electric Vehicles (BEVs). It is expected that around 30 of these vehicles will be procured.

Benefits

- Traffic data can highlight economic issues like vehicle idling.
- ICE vehicle stats improve CO2 estimates for better environmental measures.
- Reduction of congestion, pollution, and improve health, serving as a model for broader adoption.
- BEVs would benefit people with disabilities and would reduce GHG.

Financing needs

- Development of the Karlovac transport demand and supply study – including Luščić TOD strategy – 350,000 EUR.
- Investment into 30 light passenger and commercial BEVs – CAPEX: 1,300,000 EUR, OPEX: 30,000 EUR/y.

Outputs of the action

- Karlovac transport demand and supply study.
- 10 light passenger BEVs.
- 20 light commercial BEVs.

Baseline

The current level of transport data at the City level is very scarce. Furthermore, there are no transport development strategies such as TOD being introduced.

GCAP transformational change

The action will ensure the production of a comprehensive and full-fledged transport demand and supply study in the City of Karlovac. This will ensure understanding and will unlock future optimal and concise planning and investments into the sector. TOD pilot in Luščić project will serve as a demonstration and scalable project.

Synergies with other actions

T2, T3, T4, EB1, L1, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 1.1 and SO 1.2

GHG reduction potential

599 tCO_{2eq}

Action description

The action is aimed at providing an insight into the current and future transport needs in the City of Karlovac and pilot the TOD approach in a new greenfield development project. There is a need for a comprehensive understanding of the sector and therefore this analysis is required. On the other hand, Luščić project (action EB1), in the context of this action, poses a unique opportunity to introduce TOD system. There is a need for a comprehensive understanding of the sector and therefore this analysis is required.

The Karlovac transport demand and supply study

The action involves a comprehensive study of traffic demand and supply in Karlovac, aiming to identify current and future traffic sources while considering urban development goals and demographic changes. This analysis will enhance urban planning and improve transport infrastructure to better meet community needs. The study will also evaluate the impact of transport processes on the City's economy and strategic goals.

The study will address both Karlovac metropolitan, municipal/local and regional context. The key outcomes and indicators expected to be provided are the following:

- Data-substantiated indicators of the current state of transport (modal share breakdown, exact number of vehicles registered, vehicle types by powertrain, emission standard, vehicle category and age, indicators showing public transport use and utilisation etc.);
- Refined data-substantiated indicators of the local demographic trends;
- Correlation of the current indicators with the strategic development goals;
- Transport indicators extrapolated to showcase transport demand within a 10-year timeframe.

The analysis aims to offer a nuanced view of transportation requirements and act as an indicator for the clustering of population densities. TOD is an urban development strategy that prioritises public transport, pedestrian-friendly areas, and mixed-use spaces to reduce car dependency and improve overall accessibility. It promotes reduced travel times, enhanced lifestyles, and more effective City resource utilisation. In Karlovac, the implementation of TOD principles is anticipated to unify several initiatives suggested by this GCAP.

TOD pilot within the Luščić sustainable district (action EB1)

As already noted, under EB1 action Luščić project is explained in more detail. The study will define the implementation of the TOD pilot. That includes the identification of high-traffic areas, design of pedestrian zones, and public transport and communal services BEVs.

This approach includes introducing a public transport service using up to 10 light passenger BEVs to ensure that pedestrian zones are accessible to all, including people with disabilities and the elderly. Additionally, the proposal suggests using up to 20 light commercial BEVs for essential communal services like waste management, last-mile delivery, and facility maintenance. These measures aim to reduce traffic congestion, lower carbon emissions, and create a more inclusive and efficient urban environment. Related to the TOD approach, this pilot project introduces small electric vehicles as a service within the Luščić sustainable neighbourhood. Unlike car-sharing, it augments the

regular public transport service using light, compact electric passenger vehicles rather than cars. For a comparable model, see the Ljubljana Kavalir[15] service. This action will be closely coordinated with the EB1 and L1 actions.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of the Karlovac transport demand and supply study – including Luščić TOD strategy.	Pre-investment	Karlovac transport demand and supply study.	350,000	These costs are assumed as 2% of the value of the entire investments.
Investment into 30 light passenger and commercial BEVs.	CAPEX	10 light passenger BEVs 20 light commercial BEVs.	1,300,000	Estimated at 30,000 EUR per passenger light BEV; Estimated at 50,000 per commercial light BEV,
	OPEX	Annual operational costs.	30,000 /y	Estimated as 1,000 EUR per vehicle per year.
TOTAL	CAPEX		1,650,000	REVENUE GENERATING: NO

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Terms of Reference (ToR) development and contracting of service provider for the study development.						The study will provide understating of the sector that might unlock future investments into the sector. Especially TOD pilot that is expected to be scaled up.
Development of the transport demand and supply study.						
Development of the pilot TOD Luščić strategy – as part of the study.						
Coordination with the EB1 and L1 actions – integration of the T1 into those actions.						
Procurement of light BEVs.						

15 - https://www.lpp.si/en/informations-passensgers/electric-vehicle-kavalir-and-electric-train-urban

Implementing agencies and stakeholders

- City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.

Potential funding sources

- Own budget – City budget.
- National Governmental budget.
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- International Financial Institutions (IFIs) lending mechanisms (such as EBRD, EIB, and others), other financial institutions.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Key benefits

- Gathering specific data on the volume and efficiency of both local and through traffic can offer greater clarity into transportation issues that may be hampering economic development, notably the time vehicles spend idling in traffic.
- Accurate statistics regarding the prevalence of Internal Combustion Engine (**ICE**) vehicles in the Karlovac area will facilitate more precise estimations of CO2 emissions, laying the groundwork for the creation of effective environmental measures.
- Adopting a strategy centred on public transit could yield lasting advantages, such as decreased congestion, lower pollutant levels, and enhanced collective health. Moreover, this approach has the potential to act as a model initiative for the municipality, providing a robust platform for expanded application.

Enabling strategic framework

- Development Strategy of the City of Karlovac by 2020 and relevant national legislation.

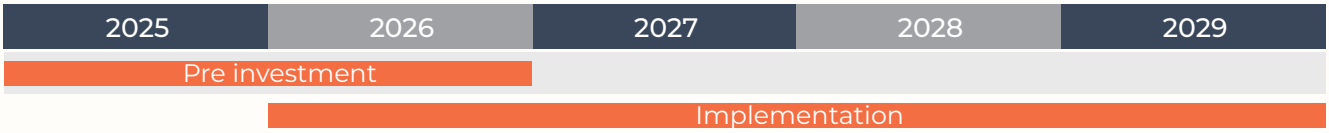
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Possibility to connect the project with smart traffic management systems (if introduced) and integrated transport platforms.
Gender and inclusion considerations	By collecting and evaluating data that captures a range of demographic aspects—age, gender, income, disability status, and ethnicity—transportation systems can be crafted to meet the requirements of all community members. This will be mandatory procurement output. Implementing light passenger vehicles enhances accessibility, safety, and economic opportunities for women and marginalised groups, contributing to a more equitable urban environment.	

T2: Construction of primary and secondary cycling network and improving cycling infrastructure

Type of action
INVESTMENT

Budget
12,000,000 EUR



Purpose

Development and investment into the City cycling infrastructure.

Lead implementer

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action includes the investment into primary and secondary cycling infrastructure in Karlovac. This involves the construction of 87 km of primary network, with 10 cycling parking lots, 30 km of secondary network, and improving of recreational cycling network. The action is based on the Traffic Study of Cycling Infrastructure of the City of Karlovac, developed by the Faculty of Transport and Traffic Sciences, University of Zagreb.

Benefits

- Reduced air pollution and decrease in GHG emissions.
- Health benefits due to use of cycling instead of other means of transport.
- Easy mobility throughout the City.
- Monetary savings.

Financing needs

- Preparation of engineering and construction documentation - 250,000 EUR.
- Investment into primary cycling infrastructure - 9,750,000 EUR.
- Investment into secondary and recreational cycling infrastructure – 2,000,000 EUR.
- Operational costs for the action – OPEX: 120,000 EUR.

Outputs of the action

- Set of engineering and construction projects documentation.
- 87 km of primary cycling network.
- 30 km of secondary cycling network.
- 10 cycling parking slots (10 spots each).

Baseline

The City already has 50 km of cycling lanes of which almost half does not complaint with national legislation. In 2022, the City received the designated cycling infrastructure study that is a firm basis for this action.

GCAP transformational change

This action will ensure that cycling potential defined in the Study is realised and implemented. Significant value added is that this action will be linked and synchronised with other transport actions.

Synergies with other actions

T1, T3, T4, EB1, L1, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 1.1

GHG reduction potential

114,975 tCO_{2eq}

Action description

The action is aimed at setting up a capacitated and modern cycling network to provide a sustainable alternative to passengers currently using private motorised transport as a key means of travelling. The network relies on the design proposed by the Transport Study of Karlovac Cycling Infrastructure which encompasses the so-called primary, secondary and recreational cycling network.

The primary network is designed to provide a viable sustainable link between residential areas, retail centres and other location generating larger volumes of traffic demand in the larger Karlovac area. The secondary network links local neighbourhoods and important urban locations with the key corridors of the primary network whereas the recreational network is intended to provide attractive cycling routes for leisure and tourism purposes.

In addition to primary, secondary and recreational-level cycle paths, the network also is expected to feature parking facilities for traditional bikes, charging stations for electric bikes and scooters, and the necessary components to support non-motorised Mobility-as-a-Service options.

The action will leverage upon and follow the Study and would unfold in three stages consistent with the categories identified as well as complexity of interventions, specifically the “Primary Network,” “Secondary Network,” and “Recreational Network.”

- A primary cycling network is a strategically planned system inking key areas such as residential neighbourhoods, commercial centres, and public amenities within a city or region.

- A secondary cycling network consists of supplementary cycling routes that connect to the primary network, providing access to less central areas, such as local neighbourhoods and smaller urban centres.

- A recreational cycling network is a system of cycling routes designed primarily for leisure and tourism.

Currently, the City already has around 50 km of already established cycling paths, however and according to the Study, almost half of it is not complaint with the relevant regulation. This action envisages development of the entire network to up to 140 km. This will involve the following:

- The construction of an 87 km primary cycling network, which includes 53 km of new cycling paths integrated into the existing traffic infrastructure and 34 km of additional cycling paths to be constructed alongside new traffic networks planned under the General Urban Plan.” Also, this will include the construction of at least 10 cycling parking lots (10 spots each) on most popular locations in the City such as “Zvijezda, Novi Centar, Luščić and Banija.

- The construction of an 18 km of secondary cycling network within existent traffic infrastructure, and additional 12km on traffic infrastructure envisaged by the GUP.

- Marking of cycling routes for 22 km of existing recreational lanes.

The initiative is also outlined in the Development Strategy for the Larger Urban Area of Karlovac 2021-2027.

The following figures present the locations of primary and secondary network to be built within this action.

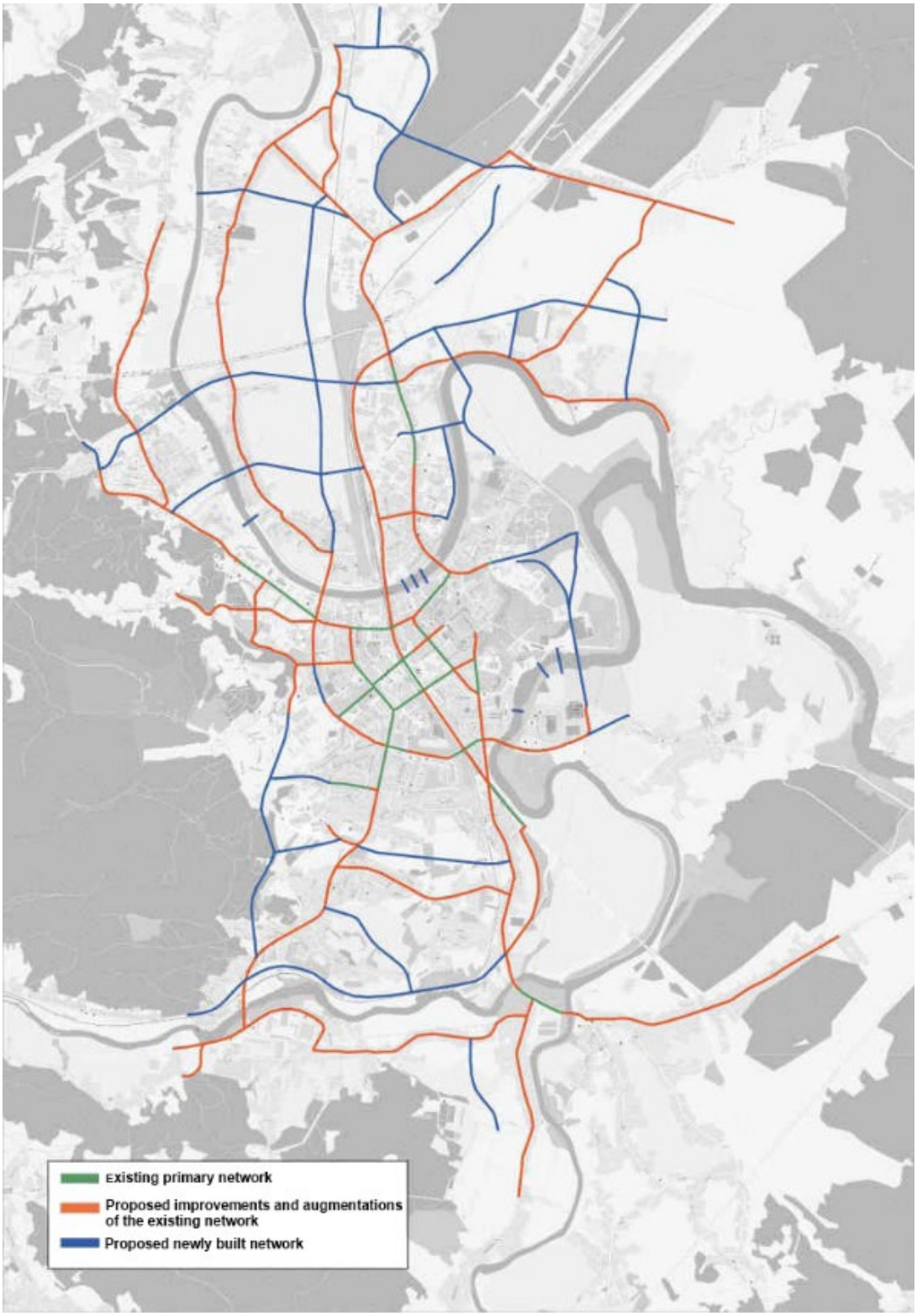


Figure 5
Karlovac primary cycling network

Source: Traffic Study of Cycling Infrastructure of the City of Karlovac, Faculty of Transport and Traffic Sciences Zagreb, 2022

Figure 6
Karlovac secondary cycling network

Source: Traffic Study of Cycling Infrastructure of the City of Karlovac, Faculty of Transport and Traffic Sciences Zagreb, 2022

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Preparation of engineering and construction documentation.	Pre-investment	Documentation package.	250,000	These costs are assumed as 2% of the value of the entire investments.
Investment into primary cycling infrastructure.	CAPEX	87 km of primary network and 10 cycling parking lots.	9,750,000	The CAPEX is based on the budget presented in the referent traffic study mentioned above.
Investment into secondary and recreational cycling infrastructure.	CAPEX	30 km of secondary network and 22 km upgrade of existing recreational network.	2,000,000	The CAPEX is based on the budget presented in the referent traffic study mentioned above.
Operational costs for the action.	OPEX	Annual operational costs.	120,000/y	Estimated as 1% of the CAPEX.
TOTAL	CAPEX		12,000,000	REVENUE GENERATING: NO

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Public procurement and preparation of the engineering documentation for construction.						Depending on the demand the network might be expanded. However, this action will cover entire current potential for this type of actions.
Phase 1 - Implementation of segments/ infrastructure elements characterised as simple with the principal aim of pure network expansion and cycling parking lots introduction.						
Phase 2 - Implementation of a shared pedestrian-bicycle path where possible as well as secondary cycling network.						
Phase 3 - Installation of cyclist navigation and cycling management solutions at traffic intersections.						

Implementing agencies and stakeholders

- City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own budget – City budget.
- National Governmental budget.
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions.

Key benefits

- Offering substitutes for private vehicular travel can culminate in notable diminishment of both airborne pollutants and emissions contributing to climate change.
- Encouraging means of travel that do not rely on engines, like bicycling and walking, benefits public health by fostering active lifestyles.
- Expanding the variety of transportation available mitigates vehicular overcrowding and improves the ease of moving through cities.
- Endorsing sustainable options for transit aids in the cultivation of cleaner, more habitable cityscapes.
- Lowering the dependence on individual car use fosters better community engagement and interpersonal exchange.

Enabling strategic framework

- Development Strategy of the City of Karlovac by 2020 and relevant national legislation.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Digital project management tools and cycling apps (not included in the CAPEX) for monitoring can enhance project implementation and evaluation. To be considered during the implementation.
Gender and inclusion considerations	The design of the network will take into account ensuring cycling infrastructure considered the needs of all users including women, elderly and people with disabilities.	

T3: Transport infrastructure development policies stimulating the use of non-motorised transport

Type of action
POLICY

Budget
110,000 EUR

Purpose

Strengthening local regulation in order to increase share of non-motorised transport and efficiency of road transport.

Lead implementer

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action includes the development of two sets of regulation related to management of stationery traffic and transport network development policy, respectively. The aim is to promote greater adoption of non-motorised transportation by requiring new developments to integrate non-motorised transport infrastructure in their projects/investments.

Benefits

- Promotes active travel and better health.
- Reduces traffic in the City centre.
- Lowers noise and air pollution.
- Improves the pedestrian environment.
- Boosts local commerce.

Financing needs

- Developed and enacted City regulations related to stationary traffic management – 60,000 EUR.
- Developed and enacted Transport network development policy – 50,000 EUR.

Outputs of the action

- Developed and enacted City regulations related to stationary traffic management.
- Developed and enacted Transport network development policy.

Baseline

The City currently has no similar regulation in place.

GCAP transformational change

This action will ensure that long term policies related to promotion of non-motorised transport are in place and support the overall sustainable development of the sector.

Synergies with other actions

T1, EB1, L1, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 1.1 and SO 1.2

GHG reduction potential

Undetermined at this stage

Action description

As it was presented in the baseline section, there is a high level of motorised transport within the City of Karlovac, this includes mostly personal cars. From the perspective of the sustainable development policies related to transport sector, there is a gap that City will address through this action. The aim of the action is to develop a set of policies related to promoting greater adoption of non-motorised transportation by requiring new developments to integrate non-motorised transport infrastructure, thereby offering a superior alternative to motorised vehicles. There are two policies envisaged in order to achieve this:

- Stationary Traffic Management Policy - policy to stimulate the increase of non-motorised travel and ensure the long-term viability of the cycling network and car parking provisions outlined in other initiatives of the GCAP. Specifically, this means that the policy will be designed in a way that all new commercial, business, educational, and similar developments will be mandated to provide a certain number of bicycle parking spaces relative to the size of the given development. Additionally, the policy will offer directions for creating optimised, eco-friendly car parking spaces that encourage the use of solar power among other energy sources. The policy is fully in line with the revision of Energy Performance of Buildings Directive (EPBD). The EPBD requires the inclusion of bicycle parking in new development projects and promotes eco-friendly parking solutions that support sustainable transportation. Even though there may be a national legislation transposing the EPBD, the City will ensure that the local regulation is tailored made according to findings in action T1 and overall City context.

- Transport Network Development Policy - aims to create a comprehensive list of intended improvements to the transport system, focusing specifically on those that support the development of the East Karlovac Bypass and a Park & Ride facility near the A1 Junction 3. It should be noted that both the East Karlovac Bypass and Park / Ride terminal are envisaged by the Spatial Plan of the Karlovac County stipulated in 2022.[16] These projects are not in jurisdiction of the City and as such are difficult to be directly influenced by undertakings of City administration. Nevertheless, given the influence of through traffic going northbound-southbound on D1 trunk road on Karlovac transport, building the bypass seems inevitable. In this regard, to make sure traffic to and from the City is routed through the future bypass as much as possible in order to minimise inner City travel time, the policy is intended to stimulate approach in which all new developments will consider making the physical connection to the bypass as direct as possible.

16 - Karlovac County (2022) Spatial Plan of the Karlovac County. Available at: https://www.kazup.hr/images/dokumenti/graditeljstvo/planski_poslovi_zastita_okolisa/VI._izmjene_i_dopuna_Prostornog_plana_K%C5%BD/VI_ID_PP_K%C5%BD_PP_za_PJR_02092022.pdf

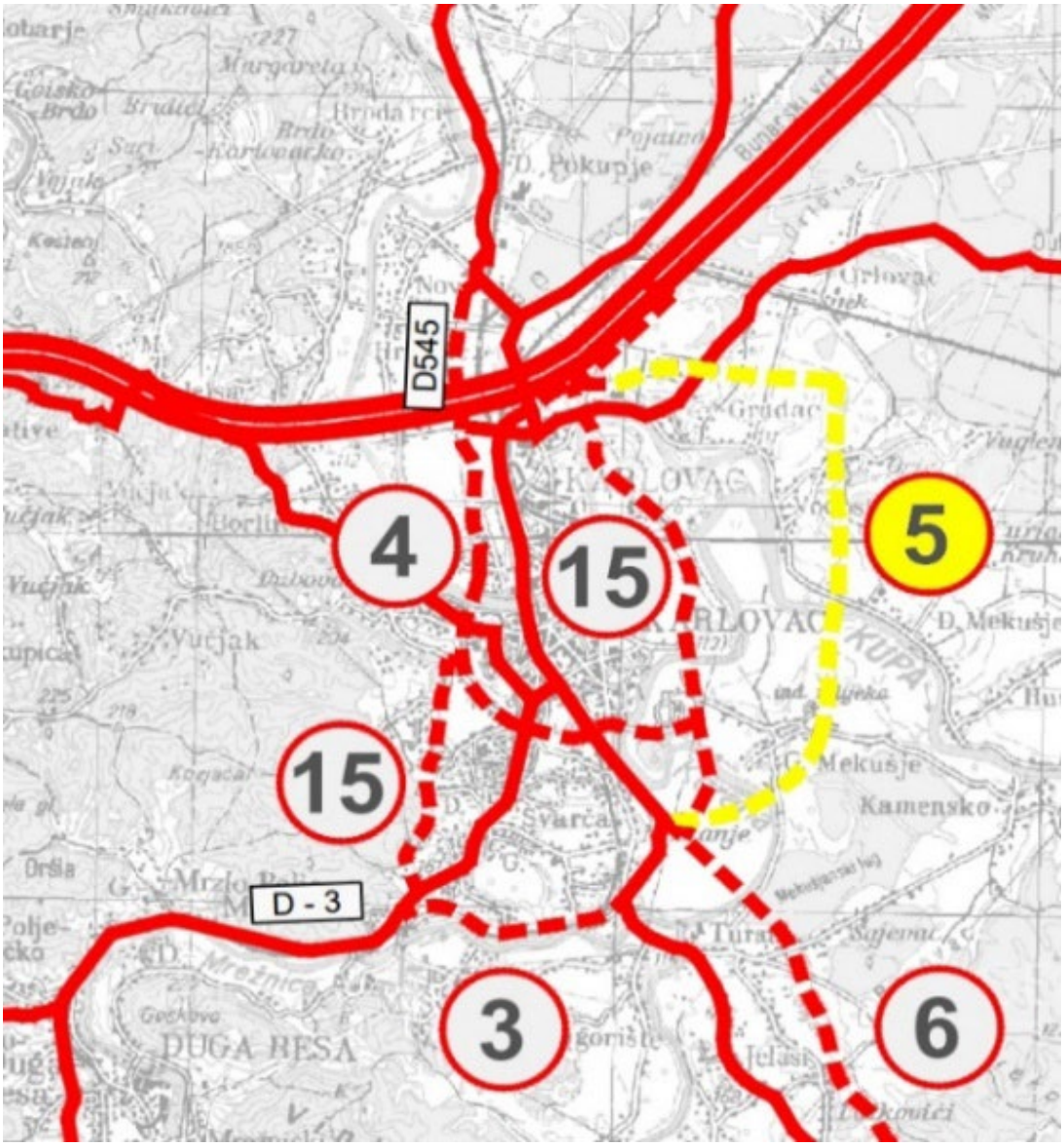


Figure 7
Close up overview of planned state roads within the City of Karlovac area – number 5 presents the East Karlovac Bypass

Source: Karlovac County Spatial Plan – Map of planned fast and state roads

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Developed and enacted City regulations related to stationary traffic management.	Policy development cost	1 Stationary traffic management regulation package.	60,000	Based on the estimate of approx. 100 expert man days – average level of effort needed to develop this kind of regulation.
Developed and enacted Transport network development policy.	Policy development cost	1 Transport network regulation package.	50,000	Based on the estimate of approx. 85 expert man days – average level of effort needed to develop this kind of regulation.
TOTAL	POLICY DEVELOPMENT COST		110,000	REVENUE GENERATING: NO

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Formalise the scope and project task of the policy development project.						Non time bound policies that might be reviewed according to needs and potential changes at the EU legislation level.
Prepare the Terms of Reference for hiring external technical assistance (TA) provider.						
Select the TA provider and generate policy proposals.						
Formally approve the policies.						
Inform the interested public.						
Set up internal institutional organisation and capacity for policy implementation and monitoring.						

Implementing agencies and stakeholders

- City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own budget – City budget.
- National Governmental budget.
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Encourages active travel like walking and biking, leading to better public health and lower emissions.
- Reduces traffic congestion in the City centre by redirecting transit traffic via a bypass.
- Lowers noise and air pollution, improving the overall quality of life for residents.
- Enhances the pedestrian environment and the cityscape, making the area more welcoming.
- Supports local commerce by creating a more attractive and accessible urban space.

Enabling strategic framework

- Development Strategy of the City of Karlovac by 2020 and relevant national legislation.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration
Smart City Potential	N/A
Gender and inclusion considerations	N/A

T4: Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet

Type of action
INVESTMENT

Budget
4,500,000 EUR

Purpose

Electrification of the public transport and City administrative fleet.

Lead implementer

Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action includes the modernisation and electrification of the public transport fleet as well as the fleet used by the City administration and City-owned utility companies. The action envisages the realisation of feasibility and implementation studies for the introduction of ZE buses servicing the entire PT network. During the GCAP period of implementation the City will introduce 3 ZE buses to service one chosen bus route and up to 40 electric vehicles within its own administrative and City companies' fleet.

Benefits

- Enhancement of modal share across various transportation modes.
- Reduction in CO2 emissions, contributing to environmental sustainability.
- Decrease in time spent in traffic queues, improving overall traffic efficiency.
- Increase in passenger kilometres travelled via public transport, indicating higher public transport usage.
- Improved utilisation of the City logistics fleet, optimising operational efficiency and resource management.

Financing needs

- Development of the Zero Emission Mobility (**ZEMO**) implementation and feasibility study for public transport – 350,000 EUR.
- Procurement of ZE buses – 1,650,000 EUR CAPEX, 36,000 EUR OPEX/y.
- Procurement of electrified fleet – 2,500,000 EUR CAPEX, 25,000 EUR OPEX/y.

Outputs of the action

- 1 Public transport feasibility study.
- 3 ZE buses.
- 3 overnight charging stations.

Baseline

The municipal public transport system is based on diesel powered buses. Furthermore, City administration and owned companies fleet is not electrified at all.

GCAP transformational change

The action will ensure the initiation of introduction of electric vehicles throughout public services within the City, based on the tailored made study. The action will ensure the demonstration effect of benefits resulting from it.

Synergies with other actions

T1, EB1, L1, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 1.1

GHG reduction potential

1,998 tCO_{2eq}

Action description

This action aims at the introduction of electrified bus related public transport services as well as the modernisation and electrification of City's administrative and City companies' vehicle fleet. Presented in the figure below, the local network consists of 21 routes, ranging from the shortest at 4.8 km round trip (Line 1: Tržnica-Gaza), to the longest at 62 km (Line 18: Autobusni kolodvor - Gornji Sjeničak). A recent contract has been secured with the local PT provider, Autotransport Karlovac LLC, to manage these services.

The action proposes a pilot project to of the inclusion of zero-emission (ZE) vehicles within Karlovac's PT framework. Additionally, it includes the implementation of a ZE shared mobility initiative for the City Administration and municipally run companies, aiming to expand the City's commitment to ZE transportation.

The expected outputs of the action are the following:

- Research and investment in ZE buses – a pilot project which aims to identify critical technological and financial details. Following the determination of these crucial ZE mobility criteria, a pilot project will be initiated on up to three public transport lines. It is anticipated that the public transport service will utilise BEVs, supported by overnight battery charging. Therefore, the initiative will not only supply essential technical data for integrating BEV buses into the Karlovac public transport system but also suggest amendments to the Public Service Obligation (PSO) contract to incorporate the deployment of ZE vehicles. Taking into account the estimated total yearly distance each bus travels, which is approximately 50,000 km (as specified in the PSO procurement documentation), and assuming the Autotransport Karlovac fleet mainly meets the Euro4 emission standard (as reported in the Karlovac Public Transport Study, 2021) . It is expected that 3 BEVs will be procured and introduced on three lines.

- The initiative will incorporate the procurement of electric cars and light commercial vehicles to facilitate a shared-mobility system servicing the City administration and City-owned utility companies. Alongside the purchase of BEVs, the action will also involve either developing a bespoke software solution or acquiring a commercially available solution to manage the shared-mobility system. It is estimated that 40 BEVs will be deployed as part of this scheme. Unlike the T1, the T4 features a car-sharing service, specifically with cars. This action will encourage city administration and city-owned utility companies to actively promote and utilize shared mobility within their daily operations to boost acceptance and usage.

17 - Prometna stručna podloga Grada Karlovca, za potrebe IV. izmjena i dopuna GUP-a, Fakultet prometnih znanosti Zagreb, 2022

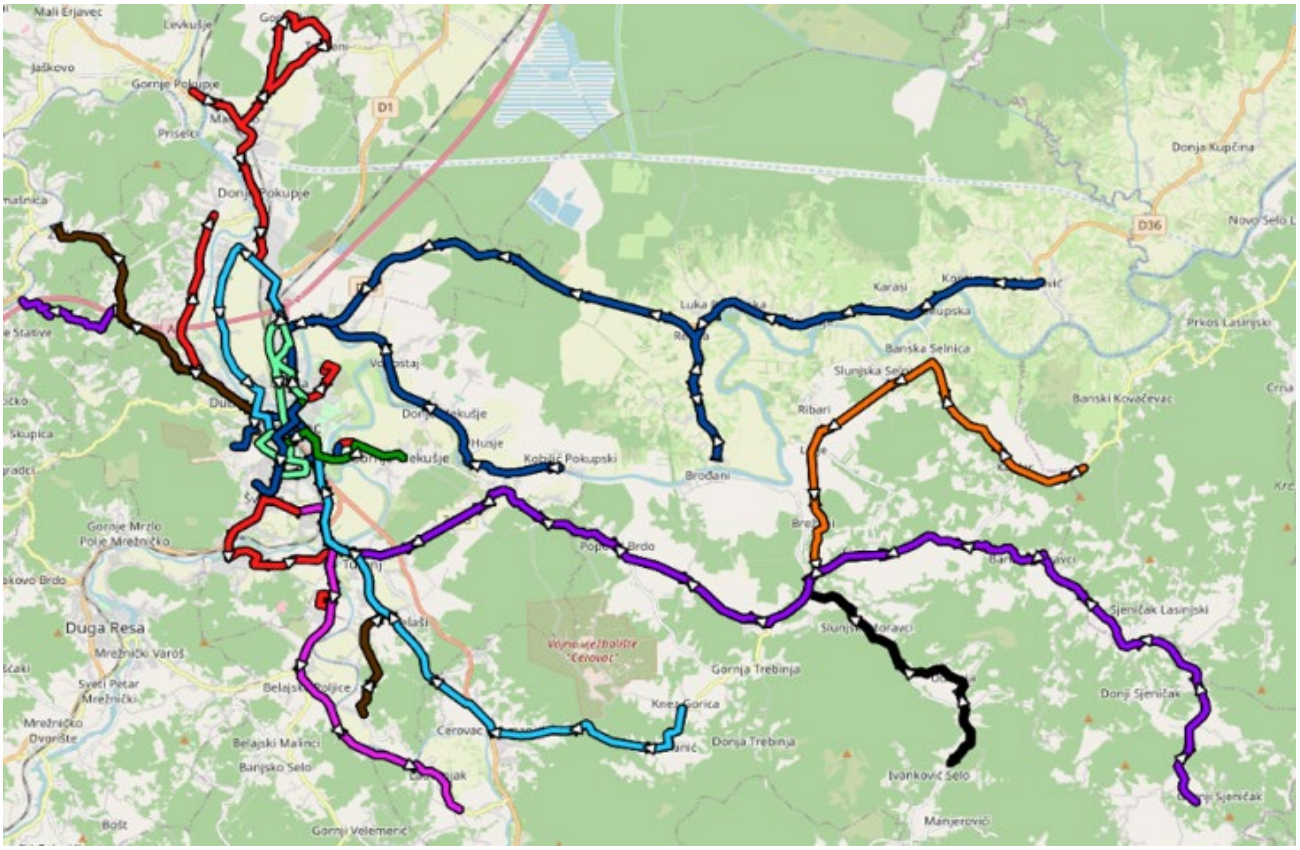


Figure 8
Overview of the PT bus routes.

Source: Karlovac GIS portal

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of the ZEMO implementation feasibility study – for public transport.	Pre-investment	1 Public transport feasibility study.	350,000	Based on the need for exert days as well as advanced tools and equipment.
Procurement of ZE buses.	CAPEX	3 ZE buses; 3 overnight charging stations.	1,650,000	Price per ZE bus is approximated at 450,000 EUR per bus – according to current market prices. Three charging stations – 100,000 EUR each.
	OPEX per year	OPEX for buses and charging stations.	36,000	Estimated at 10,000 EUR per year per bus and 2,000 for charging stations.
Procurement of electrified fleet.	CAPEX	40 BEVs.	2,500,000	Price per BEV is approximated at 62,500 EUR per vehicle – according to current market prices.
	OPEX per year	OPEX for 40 BEVs.	25,000	Estimated at 625 EUR per year per vehicle.
TOTAL	**CAPEX**		**4,500,000**	**Revenue generating: Yes, for buses, No, for municipal fleet.**

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Development of the study ToR and selection of the service provider.						There is a possibility to expand the electrification ambition within the GCAP timeframe and definitely afterwards – demonstration effect could ensure scaling up.
Development of the ZE feasibility study for the public transport sector.						
Identification of PT lines based on the study and confirmation with public transport provider.						
Procurement of 6 ZE buses.						
Run internal coordination and assess interest and needs for provision.						
Identification and procurement of specific EVs - approximately 40 BEVs.						

Implementing agencies and stakeholders

- City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.
- Autotransport Karlovac LLC.
- Alternative PT service operators operating with ZE vehicles.

Beneficiaries/partners

- Karlovac utility companies, Karlovac City administration.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own budget – City budget.
- National Governmental budget.
- Private sector – transport contractor.
- European Regional Development Fund (ERDF) / Cohesion Fund (CF) IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions.

Key benefits

- Enhancement of modal share across various transportation modes.
- Reduction in CO2 emissions, contributing to environmental sustainability.
- Decrease in time spent in traffic queues, improving overall traffic efficiency.
- Increase in passenger kilometres travelled via public transport, indicating higher public transport usage.
- Improved utilisation of the City logistics fleet, optimising operational efficiency and resource management.

Enabling strategic framework

- Development Strategy of the City of Karlovac by 2020 and relevant national legislation.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	The realisation of the action is expected to be underpinned by state-of-the-art tools and solutions. These include GIS-based network and spatial analysis tools, intelligent passenger and vehicle counting solutions, This were assumed under the cost of the feasibility study development. The shared mobility software is not included in the CAPEX, but it is a possibility on which will be decided during the action implementation.
Gender and inclusion considerations	The action will also provide more detailed data-substantiated approximations of the PT service accessibility to different social groups hence enabling refined purpose-built actions to be undertaken.	

4.2 Energy and buildings

4.2.1 Introduction to sector and overview of key challenges

The energy sector

Karlovac boasts a fully established electricity supply network. The Law on Renewable Energy Sources and High-Efficiency Cogeneration governs the electricity generation and integration into the national electric grid. Within the jurisdiction of Karlovac, there are 25 active projects (comprising solar, hydro, and biomass) with a collective capacity to generate 10,096 MW of electric power. Private entities have the opportunity to implement their own photovoltaic systems using a prosumer model. The City has issued public tenders for the co-financing of photovoltaic collector installations and other renewable energy sources technologies. Investments in renewable energy technologies come from both public funds and private sector engagement through Energy Service Companies (ESCO).

The district heating sector in Karlovac is steeped in nearly half a century of history, dating back to 1968. The city's central heating facility is situated right at the urban core. The aggregate nominal power of all units at this site amounts to 116 MW. A hot water boiler, powered by natural gas and with a capacity of 56 MW, serves as the primary heating source.

Karlovac's district heating system is a conventional District Heating System (**DHS**) suitable for smaller urban centres, featuring a distinctive star-shaped network extending 22.1 kilometres. This network encompasses five city districts—Banija, Grabrik, Luščić Jamadol, Novi Centar, and Rakovac—supplying thermal energy through 177 substations to approximately 8,000 end-users, which includes around 7,500 residential and 300 commercial properties. However, this DHS in the City of Karlovac does not support domestic hot water heating (DHW). Gradska toplana Karlovac d.o.o., entirely owned by the City of Karlovac, carries out the production, distribution, and provision of thermal energy, and since 2014 has also taken on the newly established role of thermal energy purchaser.

The City of Karlovac possesses notable potential for geothermal resources, and there are plans to harness this renewable energy within the district heating infrastructure. The elevated temperatures of the local waters also offer the possibility for cogeneration of both electricity and heat.

Photo 4.2
DH Construction works by the Karlovac DH plant.

Source: Gradska toplana d.o.o.

The buildings sector

Karlovac features a variety of residential structures, including stand-alone houses and multi-story residential buildings with height restrictions across categories P, P+1, P+2, along with collective housing units, predominantly P+4, with some even taller. The City boasts 27 high-rises, defined globally as structures with 10 or more stories. The highest structure in Karlovac is 11-floor building housing 44 apartments. The bulk of these collective residences were constructed from 1950 to1990 and have yet to receive substantial upgrades for better energy efficiency. These buildings demonstrate subpar thermal properties in their outer layers, which are influenced by the quality of thermal insulation used and the geometric and structural design of the existing constructions.

The City of Karlovac is notable for its array of historic structures, predominantly used for public or housing purposes, with a concentration in the Zvijezda district. Many are designated as culturally significant yet suffer from poor energy performance. For example, the municipal building has recently been updated, boosting its energy classification from the lowest category G to the top-tier A. Additionally, the earthquake in 2020 caused substantial damage to several buildings, necessitating repairs for energy conservation and seismic resistance. Meanwhile, more modern constructions demonstrate enhanced energy efficiency, and the latest projects comply with the contemporary nZEB (nearly zero-energy building) standards.

For heating solutions, residential properties primarily use a central heating system, heating oil, and firewood. The local heating utility, Gradska toplana Karlovac, services approximately 7,500 residential customers and operates 176 heating substations. As per data from the municipal heating provider, it is estimated that around 50% of the urbanised region within Karlovac receives heating through this centralised system.

Photo 4.3
View towards City centre

Source: City of Karlovac

Key challenges

The following are the key challenges identified within the energy and buildings sector:

1. Energy poverty remains one of the significant obstacles facing Karlovac. It is essential to consider that some flats within multi-dwelling structures are still dependent on wood for heating during the heating network's planning process. Weather patterns that include severe conditions like hail are also a factor.

2. Renovating existing buildings should focus on enhancing energy efficiency and resisting earthquakes and fires while promoting occupant health; this may involve integrating smart systems. There's also an imperative to increase connections to the DHS and to transition away from heating with firewood.

3. Moreover, the City often contends with regular river flooding and heavy rainfall, which can cause water to seep into and damage the foundations and lower levels of buildings, incurring repair expenses that the municipal budget only partly offsets.

4.2.2 City's current activities

A key initiative that has significantly aided in reducing the carbon footprint of Karlovac's building sector is the "Karlovac District Heating" project. This undertaking improved the efficiency of the local district heating system with assistance from a 5M EUR loan by the EBRD and the initial phase was successfully finalised in October 2023. Moreover, the ongoing research into harnessing thermal energy from renewable sources, specifically geothermal power, is poised to revolutionise the central heating systems across Croatia. GeotermiKA d.o.o., established by the City of Karlovac, is focused on utilising geothermal resources for heating and providing electricity to public buildings.

The municipality of Karlovac has embarked on various infrastructure projects aimed at mitigating climate change, aligning with the SECAP and the Smart City Development Strategy. These initiatives focus primarily on current energy consumption and utility upgrades. Despite the ambitious projects, there remains a need for their systematic integration across the comprehensive activities of stand-alone strategies and government branches. For instance, in the year 2021, the City authorities compiled the "Guidelines for the Integration of SECAP into the GUP of the City of Karlovac." Furthermore, Karlovac is currently witnessing several refurbishment initiatives. When upgrading the buildings, these developments often employ extensive renovation approaches that result in higher energy efficiency, as well as improved earthquake and fire safety features—significantly enhancing occupant comfort and applying digital technologies where appropriate.

4.2.3 Sector's strategic objectives and targets

The following are defined strategic objectives for Energy and buildings sector in Karlovac:

Strategic objective 2.1. Ensure the decarbonisation, efficiency, and resilience of current and future heating systems by introducing renewable energy and energy efficiency measures

Addressing this issue is a top priority for the City. Prominent stakeholders have emphasised the necessity to reduce carbon emissions from the DHS, with the GCAP being a pivotal element in attaining this goal. Moreover, the initiative aims to encompass not just the DHS but also other residential heating systems.

Strategic objective 2.2. Ensure decarbonisation of the city's building stock through the renovation, implementation of RES, introduction of smart metering, awareness raising, and building in an efficient, resilient, and sustainable way

The move towards decarbonisation in the building sector of Karlovac is regarded as a key factor to diminish local emissions of GHG. The goal is directed toward a long-term reversal of tendencies not just in the retrofitting of buildings for greater energy efficiency but also in constructing new infrastructures with energy-saving designs and circularity principles that considers life cycle analysis. This becomes increasingly critical as the updated Energy Performance of Buildings Directive (**EPBD**) will, at some stage, be mandatorily enforced, while simultaneously, European funding mechanisms are raising the standards/criteria for financing new constructions and renovating existing, such as the EU Taxonomy criteria that sets benchmarks surpassing those of national laws. The buildings sector, like residential, is particularly characterised by poor thermal performance. Therefore, the integration of energy-efficient solutions along with district energy strategies is often discussed as the pathway to substantial decarbonisation in an economically viable way.

4.2.4 Energy and Buildings GCAP actions

4.2.4.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 2.1.– Ensure the decarbonisation, efficiency, and resilience of current and future heating systems by introducing renewable energy and energy efficiency measures.			
SO 2.2.- Ensure decarbonisation of the city's building stock through the renovation, implementation of RES, introduction of smart metering, awareness raising, and building in an efficient, resilient, and sustainable way.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target	Final target
Share of households connected to district heating.	28%	30%	35%
Share of district heating from renewable sources.	0%	5%	10%
Share of renovated public buildings m^2.	No data available	15%	30%
m^2 renovated in multi-apartments buildings.	No data available	65.000 m^2	130.000 m^2

4.2.4.2 List of actions

Action code	Action title	Action type	Main implementing stakeholders	Action required budget (EUR)	Timeframe	GHG reduction potential – total over lifetime of investment
EB1	"15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.	Investment	City of Karlovac Administrative Department for Municipal Economy, Transport and Local Government.	50,170,000	2025-2029 and beyond	4,486 tCO_{2eq}
EB2	Utilisation of geothermal energy potential in the City of Karlovac.	Investment	GeotermiKA d.o.o. Gradska toplana d.o.o.	63,092,000	2025-2029 and beyond	780,000 tCO_{2eq}
EB3	Strengthening the DH system for sustainable, efficient, and innovative energy services.	Investment	Gradska toplana d.o.o. City of Karlovac – Administrative Department for Construction and Environmental Protection.	2,850,000	2025-2029 and beyond	14,999 tCO_{2eq}
EB4	Decarbonisation of multi-apartment buildings in the City of Karlovac.	Investment	Inkasator d.o.o. and other housing management companies. City of Karlovac – Administrative Department for Construction and Environmental Protection. Private sector – Multi apartment building owners.	340,000 40,000,000 investment mobilised	2025-2029 and beyond	47,940 tCO_{2eq}
EB5	Decarbonisation of public buildings in the City of Karlovac.	Investment	City of Karlovac.	10,000,000	2025-2029 and beyond	7,272 tCO_{2eq}
EB6	Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.	Policy	City of Karlovac.	300,000	2025-2029 and beyond	Undetermined at this stage

EB1: “15-minute city” Karlovac – Sustainable district Luščić and multifunctional garage systems

Type of action
INVESTMENT

Budget
50,170,000 EUR

Purpose

Brownfield investment with a purpose of integrating sustainable investments into the sustainable district.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The action envisages the realisation of the sustainable district Luščić project that includes infrastructural investments including garage systems that will ensure the integration with other relevant GCAP actions and overall, 15-minute City concept.

Benefits

- Accessibility: Optimises traffic, space, and mass transit.
- Economic growth: Enhances City centre access and boosts local commerce.
- Healthier environment: Reduces pollution and supports walking and cycling.
- Sustainability: Promotes alternative transport, conserves green districts, green buildings and improves living standards.

Financing needs

- Project preparation budget: 1,170,000 EUR.
- Buildings investment: CAPEX: 43,000,000, OPEX: 700,000 EUR/y.
- Garages Investment: CAPEX: 6,000,000 EUR, OPEX: 200,000 EUR/y.

Outputs of the action

- Updated Luščić project design.
- Technical investment documentation.
- Various public buildings such as school, kindergarten, elderly home, swimming pool.

Baseline

The sustainable district Luščić project implementation is in early stages and the GCAP is needed to fully realise its sustainable potential.

GCAP transformational change

The action will ensure that the project is realised and implemented in coordination with other actions within this plan in order to ensure its full potential.

Synergies with other actions

T1, T2, L1, EB5, EB6, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.1. and SO 2.2.

GHG reduction potential

4,486 tCO_{2eq}

Action description

The initiative "15-Minute City Karlovac" targets the transformation of the Luščić brownfield urban area to improve mobility and access, thus elevating the quality of life for its residents. It envisions repurposing a decommissioned military base into a dynamic neighbourhood with varied public amenities and infrastructure that adhere to eco-friendly certification standards like DGNB, LEED, and BREEAM.[18]

Within the scope of the GCAP, the Luščić project is distinct due to its integration of various GCAP actions, including T1 and L1, with a primary focus on the development of infrastructure.

The project encompasses two principal elements:

Development and construction of a low-energy – green City district with public facilities

The sustainable Luščić district is already in various planning and implementation phases. The action aims at securing the implementation of the project design with a caveat of improving it in its sustainable context and adding aspects of other relevant GCAP actions in its design. The investment strategy, based on the approved urban plan for Luščić district, encompasses several public structures, with a particular focus on educational buildings, as both a kindergarten and a school are presently being built. Additionally, an array of future projects is in the pipeline, which features: a pool complex, a residence for the elderly, a cluster of restaurants and bars, a business incubator, and a central park. The initiative will guarantee that all buildings adhere to recognised eco-friendly certification standards like DGNB, LEED, among others.

Currently, the project is in the phase of deconstruction of the decommissioned military base and securing construction permits for several initial buildings, such as kindergarten.

Construction of green certified garage systems

The implementation of the 15-minute City concept includes construction of green certified garages. These new developments will see one of the garages established within the Luščić district, with the another positioned strategically by the main railway station on Sarajevska street. These garages will house e-vehicle chargers and facilities for car sharing, alongside spaces designated for renting bicycles and scooters. Additionally, the project involves setting up charging stations specifically for electric vehicles, installing solar power plants to generate energy on-site, and renovating public lighting wherever necessary. Charging facilities for electric vehicles will also be located near municipal buildings in Karlovac. The garage systems will be constructed in line with the DGNB standards.

Garages as pivotal sustainability integrator

- To achieve DGNB certification, garages must meet several sustainability criteria, covering environmental, economic, sociocultural, technical, process, and site quality. Key requirements include using resource-efficient and low-emission materials, implementing energy-efficient technologies (like LED lighting and renewable energy systems), and ensuring accessibility and safety for all users. The design should support flexibility, adaptability, and integration with the surrounding community, while also promoting sustainable mobility options.

18 - DGNB, LEED, and BREEAM are internationally recognised green building certification standards that assess and promote sustainable building practices. DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), developed in Germany, focuses on a holistic approach to sustainability, emphasising environmental, economic, and sociocultural factors. LEED (Leadership in Energy and Environmental Design), originating in the United States, evaluates buildings based on energy efficiency, water usage, indoor environmental quality, and materials, aiming to reduce the overall environmental impact. BREEAM (Building Research Establishment Environmental Assessment Method), from the UK, assesses a building's performance across a range of sustainability categories, including energy, water, materials, waste, and ecology, promoting best practices for sustainable design and construction.

- The garages are in the close linkage to T1 action. Luščić district will serve as a pilot TOD project and BEVs purchased within that action will be stored and charged in these garages.

- This action is intrinsically linked to T2's initiatives, where the design of cycle routes will be intentionally inclusive of these efforts. Proposed structures will incorporate e-vehicle charging stations and car-sharing capabilities, as well as areas designated for bike and scooter rentals, to support diverse mobility options. The plan further includes the development and positioning of electric vehicle charging points—particularly near public buildings in Karlovac—as well as the installation of photovoltaic systems for localised energy generation and, if required, the retrofitting of existing public lighting.

- Action W4 envisages permeable surfaces that will be implemented as part of, among others, the garages investment.

- Garages will reduce motorised transport as it will offer an option to park vehicles and use transportation elements connected to this infrastructure.

To successfully execute this strategy, a synergy with transportation elements will be crucial. Currently, the developing Luščić project does not prioritise garages as key components of the "15-minute city" model. However, this measure will capitalise on the GCAP to ensure that the project lays the groundwork for this urban model. Detailed planning for the crafting and integration of such infrastructure will occur during the project design stage. The scheme of the district is presented in the figure below.

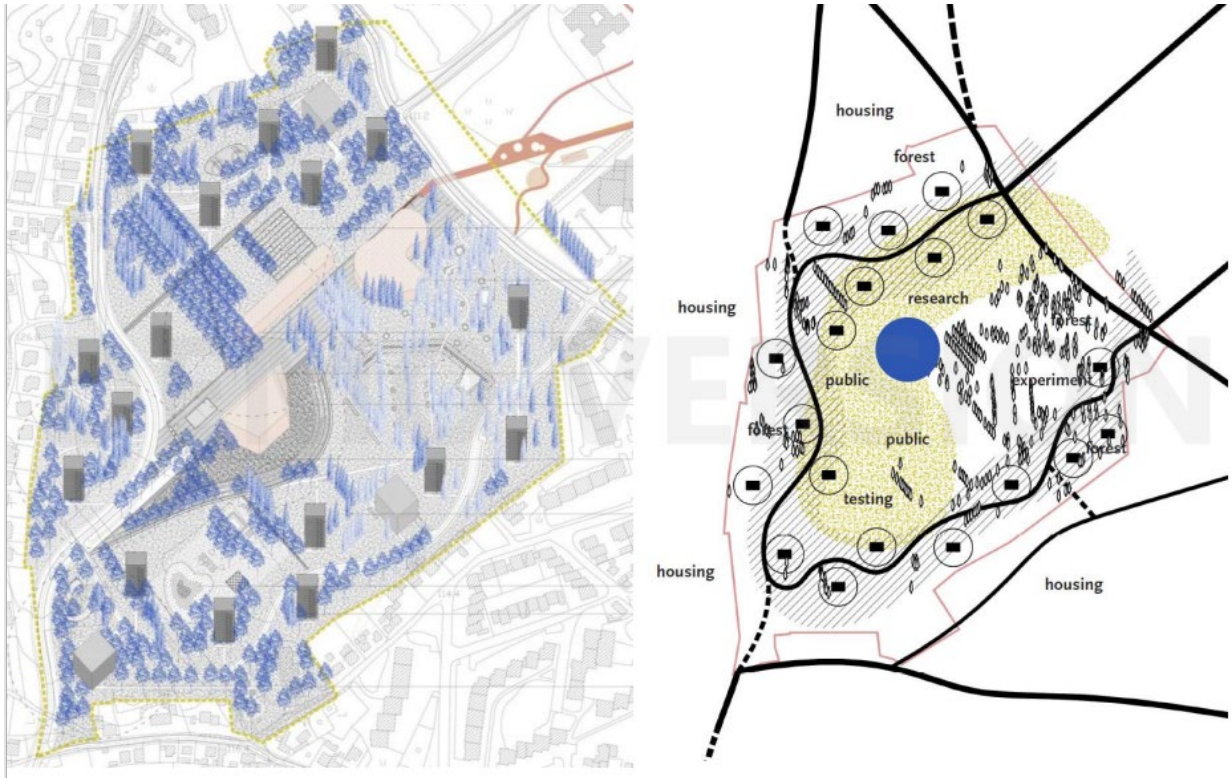


Figure 9
Schematic design of the sustainable Luščić district.

Source: https://www.karlovac.hr/prostorni_planovi/urbanisticki-plan-uredenja-luscic-centar/

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of GCAP context adjusted project design.	Pre-investment	Updated Luščić project design.	20,000	These costs are assumed for approximated in-kind contribution as the City would conduct this internally and in coordination with other GCAP actions.
Development of the technical project investment documentation – elderly home and restaurants and bars complex.	Pre-investment	Project documentation for two investments.	600,000	Estimated at average of 300,000 EUR per investment. Central road, kindergarten, and school have documentation developed.
Investment into kindergarten, school, and central road.	CAPEX	Kindergarten, school, and central road.	23,000,000	City documentation. 9.7M EUR kindergarten, 2.3M EUR central road, 11M EUR school.
Investment into elderly home and restaurant and bars.	CAPEX	Elderly home and restaurant and bars complex.	20,000,000	Provided by the City. 11M EUR elderly home and 9M EUR for restaurants and bars complex.
	OPEX/y	EUR/y.	700,000	Estimated based on the investments – approx. 5% of 1,000,000 CAPEX. Savings from restaurants and bars rent are envisaged at 30%.
Preparation of technical documentation for investment into garages.	Pre-investment	Technical documentation for garages.	550,000	Based on City documentation.
Investment into Luščić based garage.	CAPEX	2 floors, 240 parking spaces underground garage.	3,600,000	Based on City documentation.
Investment into Sarajevska garage.	CAPEX	Overground garage, 2 floors.	2,400,000	Based on City documentation.
OPEX for garages.	OPEX/y	OPEX for both garages.	200,000	Estimated at 100,000 EUR per garage.
TOTAL	**Direct costs**		**50,170,000**	**Revenue generating: Some potential**
Investment into business incubator is envisaged in the period 5-10 years from 2025.	CAPEX	Post GCAP investments envisaged.	27,000,000	Based on City documentation.

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Development of the project design to include integration of GCAP context – certified garages and linkage with other actions.						The action will continue post 2029. Through the implementation of further investments such as business incubator centre and pool complex.
Development of technical documentation for investments envisaged in 2027.						
Investment intro construction of kindergarten, central road, and school.						
Investment into elderly home and restaurant and bars complex.						
Further development planning for additional investments envisaged after 5 years period.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- The City of Karlovac budget and national budget.
- Private sector.

Key benefits

- City designed for accessibility: Eases traffic flow, optimises the use of City space, and prioritises mass transit systems.
- Economic growth and vitality: Parking structures contribute to economic development and help local commerce by increasing accessibility in City centres.
- Healthier air quality: Promotes pedestrian and cycling habits, thereby decreasing vehicular congestion and pollutants, which results in purer air quality.
- Reduced dependence on fossil fuels: Aids in combating climate change by lessening the need for fossil fuel consumption due to greater reliance on alternative transportation methods.
- Pedestrian-friendly urban environments: Develops spaces that cater to pedestrians and cyclists, which bolsters urban mobility.
- Improved cityscape: Conserves green spaces and minimises urban heat islands, enhancing both the aesthetic and the environmental condition of urban areas.
- Enhanced living standards: Ensures safer and more enjoyable streets for walking and biking, leading to an improved quality of life for community members.
- Climate change mitigation through green building construction.
- Improve occupant's satisfaction with better IEQ in green buildings.

Enabling strategic framework

- SECAP for the City of Karlovac.
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.

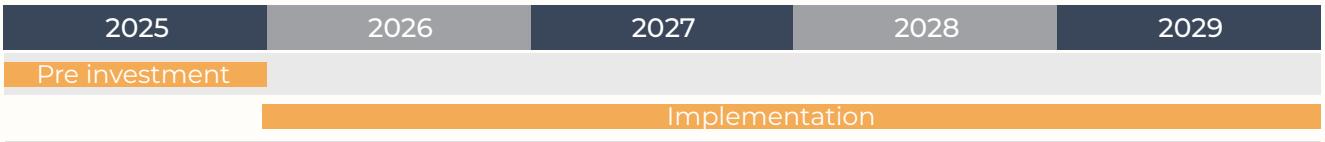
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Smart City platforms and data analytics can be used to significantly enhance the planning and operational efficiency of the 15-minute City concept. Due to the size of the action, digital aspect will be envisaged on a per investment basis.
Gender and inclusion considerations	This measure will guarantee that public buildings such as schools, kindergartens, and sports centres are accessible to all genders, ages, and abilities, inclusive of garages. It includes adding family-friendly features like childcare, secure play areas, and senior spaces. The plan is to offer a variety of affordable transport options, such as car sharing, bike and scooter hire, and EV charging for every income level. Both the EV chargers and solar power systems will be user-friendly for everyone, even those who have disabilities or are not tech-savvy. Ensuring well-lit, safe, and supervised parking and community areas is essential, especially to protect women and at-risk individuals. Pedestrian and bicycle paths will also be designed with safety and accessibility in mind.	

EB2: Utilisation of geothermal energy potential in the City of Karlovac

Type of action
INVESTMENT

Budget
63,092,000 EUR



Purpose

Utilisation of geothermal energy potential in the City of Karlovac.

Lead implementer

GeotermiKA d.o.o.

Description

The action envisages comprehensive investment into exploitation of the geothermal energy in Karlovac. It is divided into two phases aiming at exploitation of two wells. It envisages construction of 10 MW geothermal plant (and connecting hot water piping system) and two geothermal electricity plants of 2MW and 10 MW, respectively.

Benefits

- Reduces greenhouse gas emissions, mitigating climate change, and enhancing energy security.
- Increases profitability for Gradska toplana d.o.o., creates jobs, and stimulates local economic growth.
- Lowers energy costs, improves public health, and involves communities in the project.
- Establishes a model for other cities to adopt geothermal energy solutions.

Financing needs

- Phase 1 of the project: CAPEX: 24,537,000 EUR.
- Phase 2 of the project: CAPEX: 35,330,000 EUR.
- Other non CAPEX costs: 3,225,000 EUR, OPEX: 2,700,000 EUR/y.

Outputs of the action

- Exploratory well #1 and #2.
- Connecting hot water pipeline.
- 10 MW geothermal thermal plant.
- 2 MW geothermal electricity plant.
- 10 MW geothermal electricity plant.

Baseline

No renewable energy share of DH energy used. is The City has developed all the feasibility assessment for the geothermal energy exploitation and initiated first phase.

GCAP transformational change

This action will ensure the realisation of a comprehensive and complex geothermal potential and its development thus significantly decarbonising the energy sector and create numerous environmental and social benefits.

Synergies with other actions

EB3, EB4, EB6, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.1. and SO 2.2.

GHG reduction potential

780,000 tCO_{2eq}

Action description

The City of Karlovac has significant geothermal energy potential, and it is planned to use this energy in the district heating network as a major step toward the City's green transition. The public utility company GeotermiKA d.o.o., founded by the City of Karlovac with an objective of exploring geothermal energy, has developed a comprehensive exploration program and a detailed work plan for the exploitation of geothermal energy to produce thermal energy and electricity. For that purpose, the feasibility study, operational plan, and business plan are already developed.

The aim of the action is to secure realisation of the envisaged geothermal project. The action/project is divided into two main phases:

Phase 1

This phase includes the following:

- Construction of geothermal well #1 (exploratory-production and injection well). The estimated productivity of the geothermal well is projected to have a capacity of producing up to 6,000 m^3 of geothermal water per day, with the geothermal water temperature at the wellhead reaching 120°C;
- Construction of a connecting hot water pipeline;
- Construction of a geothermal power plant with a capacity of 10 MW thermal energy;
- Reception station for energy transfer with heat exchangers;
- Heat storage tanks (2 x 1,000 m^3) with handling facilities; and
- Construction of a container electricity power plant with a capacity of 2 MW. The proposed technological process for electricity production is based on the Organic Rankine Cycle (**ORC**).

The first step, construction of geothermal well, has already started in 2024 and its financing is secured.

Given that the extraction of geothermal water is planned for all 365 days of the year, it is expected that 2,190,000 m^3 of geothermal water will be extracted annually from the geothermal well. The estimated installed thermal capacity of the power plant will be 10 MW, and a key condition for its operational work is that water with a minimum temperature of 90-95°C is supplied to the heating system at the power plant's location. The main components of the power plant will include a reception station for receiving energy from the connecting pipeline and heat storage tanks for accumulating thermal energy, along with handling facilities. Finally, the construction of a geothermal power plant for electricity production is planned at the location of the first exploratory-production geothermal well.

Phase 2

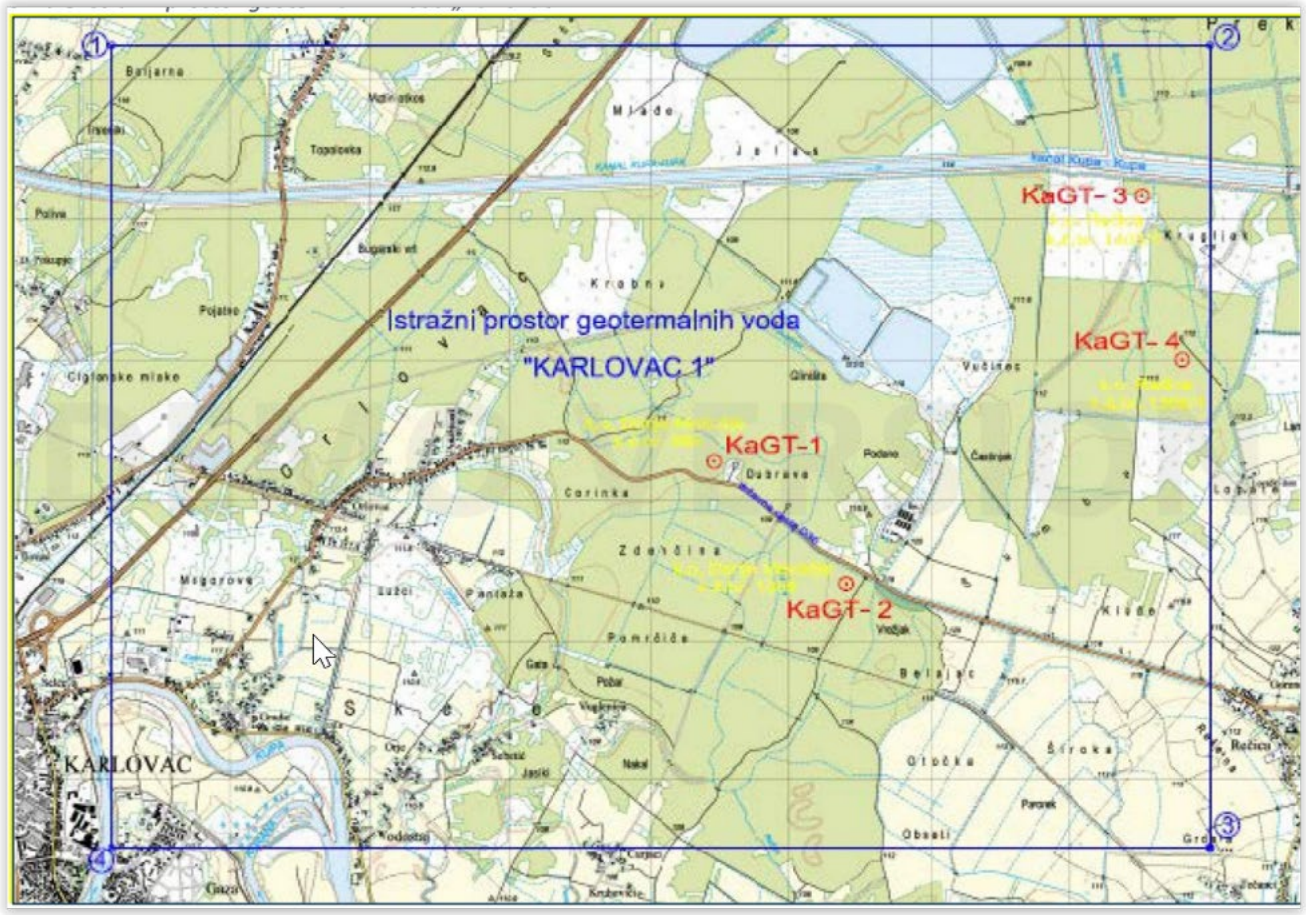
This phase includes the following:

- Construction of geothermal well #2;
- Construction of a container electricity power plant with a capacity of 10 MW.

As in the previous phase of the project, after the construction of the second exploratory production well, the assumed temperature regimes of the geothermal water, flow rates, and other characteristics of the water must be confirmed. Following this, the construction phase of the geothermal power plant will commence. The power plant will be built at the same location as the second exploratory production well, and the capacity of the well is estimated to be sufficient for the installation of a 10 MW electricity production capacity. There is a potential to scale up the system by exploitation of potential wells #3 and #4. The locations are presented on the figure below. All the data are provided by the feasibility study already developed by GeotermiKa d.o.o.[19]

19 - Grad Karlovac (2022) Studija izvedivosti s analizom troškova i koristi za projekt „Korištenje potencijala geotermalne energije ugradu Karlovcu - GEO4KA

Figure 10
Locations of geothermal wells (labelled as KaGTs).



Source: Feasibility study GEO4KA

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Phase 1: Investment into exploratory wells.	CAPEX	Exploratory well #1.	6,570,000	Feasibility study with cost benefit analysis for the project: "Using the potential of geothermal energy in the City of Karlovac - GEO4KA".
Phase 1: Technical documentation for the construction a connecting hot water pipeline.	Pre-investment	Technical documentation for connecting pipeline.	660,000	
Phase 1: Construction of the hot water pipeline.	CAPEX	Hot water pipeline.	13,340,000	
Phase 1: Construction of the geothermal thermal and electricity plants.	CAPEX	Technical documentation for plants – Phase 1. 10 MW geothermal thermal plant. 2 MW geothermal electricity plant.	4,627,000	
Phase 2: Technical documentation for geothermal well #2.	Pre-investment	Technical documentation for well #2.	565,000	
Phase 2: Investment into well #2.	CAPEX	Exploratory well #2.	8,330,000	
Phase 2: Construction of geothermal electricity plant.	CAPEX	10 MW geothermal electricity plant.	27,000,000	
Project management cost and project promotion (both phases).	Project management cost	EUR over implementation period.	2,000,000	
OPEX for all phases.	OPEX/y	EUR/y.	2,7000,000	
TOTAL	Direct costs		63,092,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Geothermal well #1: Construction of an exploration-exploitation and intrusion geothermal well at the location of the research area Karlovac 1.						The implementation of the action will almost certainly go beyond 2030. Furthermore, exploitation of well #3 and #4 will be evaluated.
Connecting hot water pipeline: Construction of connecting hot water pipeline from the research-exploitation well to the receiving station of the geothermal energy plant.						
Geothermal power plant and power plant: Construction of a geothermal power plant (10 MW) for the production of thermal energy and the construction of a power plant for the production of electricity (2 MW) at the location of the research area Karlovac. 1						
Geothermal well #2: Construction of an exploration-exploitation and intrusion geothermal well at the location of the research area Karlovac 1.						
Geothermal power plant: Construction of a power plant for the production of electricity (10 MW) at the location of the research area Karlovac 1.						
Project management and promotion.						

Implementing agencies and stakeholders

- GeotermiKA d.o.o.
- Gradska toplana d.o.o.
- City of Karlovac – Administrative Department for Construction and Environmental Protection

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- EU Modernisation Fund.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- Own budget and national budget.

Key benefits

- The decarbonisation of the district heating system and buildings, resulting in reduced greenhouse gas emissions and contributing to climate change mitigation.
- Enhancement of citizen comfort and bolstered energy security.
- Reduction in reliance on energy imports and mitigation of risks associated with fossil fuel price fluctuations.
- Increased profitability and financial sustainability for Gradska toplana d.o.o.
- Establishment of a replicable model for other cities to leverage geothermal energy.
- Creates new job opportunities in construction, operation, and maintenance while stimulating the local economy through investment attraction and enhanced energy security.
- Community and Environmental Impact: Reduces energy costs and air pollution, improving living standards and public health, while engaging local communities through consultations and fostering a sense of ownership.

Enabling strategic framework

- Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.
- Geothermal Potential Development Plan of the Republic of Croatia until 2030.
- Integrated National Energy and Climate Plan for the Republic of Croatia 2021. - 2030.

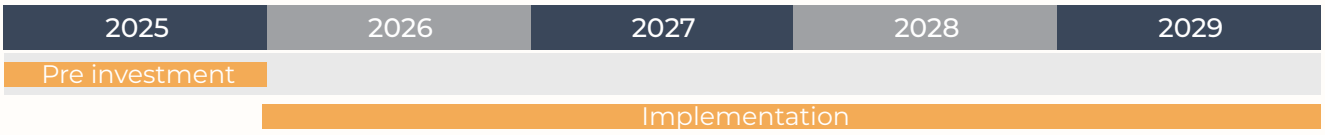
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	CAPEX envisages various sophisticated dedicated digital systems needed for operating plants.
Gender and inclusion considerations	The action will ensure equitable access to geothermal energy for low-income households by maintaining affordable pricing, implementing subsidy programs, and providing training and employment opportunities in the geothermal energy sector.	

EB3: Strengthening the DH system for sustainable, efficient, and innovative energy services

Type of action
INVESTMENT

Budget
2,850,000 EUR



Purpose

Increase overall energy efficiency of the Karlovac DH network.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The action will implement three components related to enhancing overall decarbonisation of DH system. It aims to improve EE in already connected buildings to DH, connecting additional buildings, and laying foundation for a ESCO operation model for Gradska toplana d.o.o.

Benefits

- Decarbonise district heating: Reduce greenhouse gas emissions.
- Mitigate climate change: Contribute to lowering climate change impacts.
- Reduce energy poverty: Lower household energy costs through efficiency.
- Improve citizen comfort: Enhance living conditions with better heating systems.

Financing needs

- Procurement and installation of EE equipment – CAPEX, 2,250,000.
- Technical assistance provided for connection to DH system – 300,000 EUR.
- Technical assistance for integration of ESCO business model into Gradska toplana d.o.o. – 300,000 EUR.

Outputs of the action

- Design solution for at least 50 buildings (10 per annum).
- EE equipment for at least 50 buildings (10 per annum).
- TA for 5 buildings per year.
- ESCO TA provided.

Baseline

While the district heating system has improved its distribution efficiency, it still requires upgrades. The potential for network expansion is clear with only 28% of households currently connected, and Gradska toplana d.o.o. There is an opportunity for development of innovative services or loyalty programme for customers.

GCAP transformational change

The action will ensure increased energy efficiency of the district heating system, expand the customer base, and support the development of a new business model.

Synergies with other actions

EB2, EB3, EB4, EB5, EB6, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.1. and SO 2.2.

GHG reduction potential

14,999 tCO_{2eq}

Action description

This comprehensive action aims to transform the DH system into a sustainable, efficient, and customer-centered energy service, advancing the City's ambitious decarbonisation goals. To achieve this, the project targets three critical areas: improving energy efficiency in the existing DH network, facilitating the connection of new buildings to the DH system, and developing an innovative loyalty program to foster customer engagement and new business models. By implementing energy efficiency measures across the DH system, including upgrades to the distribution, storage, and supply infrastructure, this initiative will reduce GHG emissions and enhance service reliability. Simultaneously, a technical assistance component will support the expansion of the DH network to additional buildings. Finally, a loyalty program anchored in an Energy Service Company (**ESCO**) model will empower Gradska toplana d.o.o. to introduce novel energy services that align with energy efficiency obligations, enhancing both the company's sustainability and revenue. Collectively, these components will ensure a future-ready DH system that reduces environmental impact while delivering cost-effective, customer-focused energy solutions in all its supply chain segments.

This action has three components:

Implementation of energy efficiency measures in the district heating system (EE improvements of already DH connected buildings): One of the key focuses and high priorities in the city's decarbonisation efforts is the decarbonisation of DH systems. In addition to integrating geothermal energy, other components ought to have its EE improved, including distribution and supply systems. Currently, the DHS is entirely powered by natural gas. At the end of 2023, Gradska toplana d.o.o. finalised the revitalisation of the heating network. However, it is also necessary to enhance the efficiency of energy production, storage, and other distribution system components to distribute the same amount of energy to more customers and reduce related GHG emissions.

This activity includes installing heat storage tanks, improving and replacing thermal substations in buildings (offered to building owners), integrating renewable energy sources (such as photovoltaic power plants), and installing smart metering. The objective is to ensure that the entire DH supply chain is energy efficient, with a particular focus on enhancing the efficiency for its customers. Gradska toplana will offer residents to design and implement EE solutions related to DH connection.

Technical assistance for connecting buildings to the DH system (connecting new buildings to DH system): Given that geothermal energy will be used in the future, it is essential to prioritise the DHS when considering the supply of thermal energy. To contribute to the decarbonisation of buildings, this action will analyse technical solutions for connecting these buildings to the DHS. The City's DH company, Gradska toplana d.o.o., will lead the effort to define these technical solutions for which external technical assistance is needed.

Technical assistance will span for 5 years and will result in the development of 50 projects, each detailing technical solution for connecting buildings to the central district heating system. Priority will be given to buildings that already have central heating piping and radiators installed. It is expected that 50 buildings can be connected to the DHS over the next 10 years. Based on the assumption that technical assistance will cover 5 buildings per annum at 20,000 EUR per building, the total CAPEX for 5 years is estimated at 500,000 EUR. This action is expected to remain operational for an additional 5 years, totalling 10 years.

The development of a loyalty program: Energy Efficiency Obligation (**EEO**) schemes, as defined by the Energy Efficiency Directive (2012/27/EU, 2018/2002, EU/2023/1791), are legislative mechanisms that require 'Obligated Parties' (OPs)

– energy utility companies – to meet quantitative energy savings targets across their customer portfolios. Gradska toplana d.o.o. Karlovac is an obligated party. EEOs are market-based instruments that give OPs the flexibility to choose the most cost-effective measures and delivery routes for achieving energy savings, within the scheme's constraints, without prescribing specific actions. The City sees EEO as an opportunity to develop new business models. EEOs encourage innovation by allowing energy companies to explore new revenue streams, such as the Energy Service Company (**ESCO**) model, while meeting savings targets.

The loyalty program will be developed as part of the technical support provided to Gradska toplana d.o.o., aimed at establishing a new service based on an innovative business model. The loyalty program and the introduction of the ESCO model will most likely include both energy performance contracting and/or energy supply contracting. "Energy as a service" model will enable Gradska toplana d.o.o. to undertake projects that contribute to the EEO Scheme. At the same time, this new service will generate additional revenue for the company.

More specifically this component will result in the following:

Technical assistance – defining ESCO model: Structured support, loyalty programme, that supports DH company in developing innovative services, particularly those that align with the ESCO model and so-called third-party financing with turn-key solutions. This will include analysing various legal and financial ESCO models, sources of financing, ownership of equipment, possible outsourcing partnerships option and typical energy efficiency measures including also integration of renewable energy sources that could be offered to customers. Models to be analysed are: ESCO model with "deemed" savings, Energy Performance Contracting (**EPC**) with or without shared savings, Energy supply contracting (**ESC**) and variation with all of them that. Special attention will be given to energy savings calculation, measurement, and verification protocols. As this requires an organisational unit with ESCO related skills, a capacity assessment will be conducted. The baseline report with a proposed ESCO business model will be developed. Finally, this activity will provide staff trainings that will ensure the DH company can integrate ESCO model in its operation.

ESCO model integration: The loyalty program supports the introduction of the ESCO model, This will include the establishment of the dedicated ESCO related organisational unit, operational procedure, and the development of a tailor-made template ESCO contract for multi-apartment buildings, public buildings, and private buildings.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Identification of buildings and project design of EE solutions.	Pre investment	Design solution for at least 50 buildings (annum).	-	Already accounted in for – standard procedure.
Procurement and installation of EE equipment.	CAPEX	EE equipment for at least 50 buildings (10 per annum).	2,250,000	45,000 EUR per building estimated for a 5-year period.
Technical assistance provided for connection to DH system.	Technical assistance	TA for 5 buildings per year.	300,000	100,000 EUR per annum (20,000 EUR per building).
Technical assistance for integration of ESCO model into Gradska toplana d.o.o.	Technical assistance	ESCO TA provided.	300,000	600-man days that includes baseline analysis, ESCO model and EPC contract development and training provided.
TOTAL	Direct costs		2,850,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025				2026				2027				2028				2029				Outlook after 5 years
Location Identification: Identify the buildings or sites where energy efficiency measures will be applied.																					All the components to remain operational after 5 years period.
Project Design Development: Create detailed designs for the installation of EE equipment.																					
Public Procurement: Conduct procurement processes for contractors and suppliers.																					
Investment: Allocate and invest the required capital for the implementation of the measures.																					
Preliminary Analysis: Assess potential buildings for connection to the district heating system.																					

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Project Assignment Development: Develop a project assignment outlining the scope, objectives, and deliverables.						All the components to remain operational after 5 years period.
Public Procurement: Procure consulting and design services.						
Elaborate Development: Create detailed documentation for evaluating the performance and costs of connecting buildings to the DH system, including technical solutions.						
Project Assignment Development: Draft the project assignment for developing the new business model.						
Public Procurement: Procure services for technical assistance, including consulting and development of the ESCO model.						
Project Team Nomination and development of the new business model.						
Training for the project team, encompassing all findings along with defined energy savings, measurement, and verification protocols.						

Implementing agencies and stakeholders

- Gradska toplana d.o.o.
- City of Karlovac – Administrative Department for the economy, City development and EU funds and Administrative Department for Construction and Environmental Protection.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions Own budget, company Gradska toplana ltd budget and national budget.

Key benefits

- Decarbonisation of the District Heating System: Reduction in greenhouse gas emissions.
- Climate Change Mitigation: Contributing to the overall reduction of climate change impacts.
- Reduction of Energy Poverty: Alleviating the economic burden on households by improving energy efficiency.
- Increased Comfort for Citizens: Enhancing living conditions through improved heating systems and indoor environmental quality.
- Boost in Investments for Energy Renovation: Encouraging investments in the renovation of multi-apartment buildings.
- Decarbonisation of Buildings: Reducing the carbon footprint of buildings through improved energy systems.

Enabling strategic framework

- Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac.
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.
- Geothermal Potential Development Plan of the Republic of Croatia until 2030.
- Energy Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Program of energy renovation of public sector buildings for the period until 2030.
- Program of energy renovation of multi-apartment buildings for the period until 2030.
- Energy renovation program of buildings that have the status of cultural property for the period until 2030.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Moderate	Existing digital platforms are used to streamline connection processes and support, but physical infrastructure is a major component.
Gender and inclusion considerations	Ensuring accessibility of energy efficiency upgrades for all customers, while prioritising safety and comfort in heating infrastructure design, installation, and maintenance.	

EB4: Decarbonisation of multi-apartment buildings in the City of Karlovac

Type of action
INVESTMENT

2025	2026	2027	2028	2029
Pre investment				
	Implementation			

Budget
340,000 EUR
40,000,000 EUR investment mobilised

Purpose

Provide technical assistance to apartment owners in order to increase the rate of renovation and decarbonisation of the sector.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The action envisages to secure investment mobilised into the deep energy efficiency renovation with prioritisation of RES utilisation of multi apartment buildings and investment into rooftop PVs. Facility management companies will provide active support to its members through financing proposal development towards various financing sources, most notably Environmental Protection and Energy Efficiency Fund (EPEEF).

Benefits

- Reduce emissions: Lower emissions and adopt low-carbon technologies.
- Improve living conditions: Enhance comfort and air quality.
- Boost resilience and savings: Strengthen buildings and cut energy costs.
- Drive economic growth: Create jobs through renovation projects.

Financing needs

- Implementing and operating the active assistance to multi apartment building owners– 30,000 EUR/y – 90.000 EUR.
- Potential investment mobilised from multi apartment building owners – EE renovation – CAPEX: 39.000.000 EUR.
- Technical assistance for the preparation of PV projects — 250.000 EUR.
- Potential investment mobilised for PV rooftop – 1.000.000 EUR.

Outputs of the action

- Project preparation facility – EE renovation.
- 65,000 m^2 renovated.
- Project preparation facility – PV rooftop installation.
- 85 PV rooftop units of approx. 10 kW per unit.

Baseline

Energy inefficient residential building sector, Available data show that energy consumption for heating and cooling in residential buildings exceeds 165 kWh/m^2.

GCAP transformational change

The action will provide TA to owners of multi-apartment buildings, enabling faster project preparation and larger investments, while supporting targeted investments and loan applications for energy renovation, improving tenants' quality of life and contributing to the decarbonisation of buildings.

Synergies with other actions

EB2, EB3, EB6, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.2.

GHG reduction potential

47,940 tCO_{2eq}

Action description

The City of Karlovac has a diverse range of residential buildings, including individual houses and residential buildings categorised by height limitations: P (ground floor), P+1 (ground floor + 1 floor), P+2 (ground floor + 2 floors), and collective buildings/blocks, mostly P+4 (ground floor + 4 floors), but also higher. Karlovac has 27 skyscrapers, with the tallest building having 11 floors and 44 apartments. Most collective buildings were constructed between 1950 and 1990 and have not undergone significant energy efficiency renovations. These buildings generally have poor thermal characteristics, with 57.2% of units rated D, E, F, or G for heating demand. Energy consumption for heating and cooling exceeds 165 kWh/m². The City also has numerous cultural heritage buildings, particularly in the Zvijezda district, which are energy inefficient and require significant renovation efforts.

Residential buildings are heated by district heating, heating oil, and firewood. Gradska toplana Karlovac, the DH company, serves around 7,500 residential end users with 176 substations installed. Approximately 50% of the urban area within the City is estimated to be supplied by district heating, considering households in the inner-city circle. In terms of electrical energy consumption, residential usage is primarily driven by domestic appliances and lighting rather than significant contributions from heating and cooling. The heated surface area of multi apartment buildings at the City level is 970,000 m². Inkasator d.o.o. is the largest facility management company.

In Karlovac County, there is more than 970,000 m² of heated area in multi-apartment buildings. Inkasator d.o.o., the largest housing management company founded by the City of Karlovac, manages 621 entities (building entrances) comprising a total living area of 522,394.62 m². This makes Inkasator d.o.o. the most impactful facility management company on residents in the City of Karlovac. In Croatia, facility management and energy companies are key stakeholders with legal ties to co-owners. These companies develop projects for co-owners, apply for EPEEF and other EU and national funding, and secure additional funds through commercial bank loans.

This action will ensure that the facility management companies act as a integrator of services and ensure investment mobilisation for buildings renovation. It will provide technical assistance to residents for preliminary analyses of energy renovations needs on a per case basis where utilisation of RES for heating and domestic hot water (**DHW**) will be maximised. For buildings already renovated or not needing renovation, a preliminary analysis for constructing a photovoltaic (**PV**) power plant will be conducted. Facility management companies will help residents prepare applications for EPEEF grants and other funding. The focus is on assisting residents with understanding the needs and support them with financing applications. The City will coordinate with facility management companies like Inkasator d.o.o. to promote renovation uptake, involving experts who will ensure that financing applications are developed and submitted to the relevant sources.

Depending on the scope of work and the duration of the project, current deep renovation prices are unknown due to inflation. In 2021, they were around EUR 330/m² and are now expected to be EUR 600/m². The action targets the renovation of 65,000 m² of area managed by Inkasator d.o.o. and other facility management companies over the next 5 years, at a cost of EUR 600/m², the investment might be approximately 39M EUR. It is envisaged that in the next 10 years this may double to 130,000 m² in total.

Apart from the renovation projects, this action would also involve the promotion and application development for utilising Flat Roofs for Photovoltaic (PV) Installation in multi apartment buildings for which there is a substantial potential.

The area of roofs on multi-apartment buildings is not readily available. However, the City envisages mobilisation for installing PV systems on 10-15% of roofs (65-85 roofs) with a 10 kW PV plant power, the estimated CAPEX is EUR 1 million. The current cost of photovoltaic systems is approximately EUR 1,200/kW. Additional technical assistance for project development and implementation is needed to encourage citizens to pursue this installation. For 85 PV plants, an estimated EUR 250,000 would be required for TA and 1M EUR for the actual rooftop PV systems.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Implementing and operating the active assistance to multi apartment building owners.	Technical assistance	Project preparation facility – EE renovation.	90,000	These costs are assumed for approx. 3 staff over 5 years who will provide technical assistance in project preparation.
Investment mobilised from multi apartment building owners – EE renovation.	CAPEX – potential investment mobilised	65,000 m^2 renovated.	39,000,000	The cost is based on the estimated cost for energy renovation of 65.000 m^2.
Technical assistance for the preparation of PV projects.	Technical assistance	Project preparation facility – PV rooftop installation.	250,000	The costs are estimated based on 85 preliminary studies with unit costs of app. 3000 EUR.
Investment mobilised from multi apartment building owners – PV rooftop.	CAPEX – potential investment mobilised	85 10kW rooftop PVs.	1,000,000	The cost is estimated for 85 PV with average power of 10 kW and unit price of EUR 1,200/kW.
TOTAL	Direct costs		40.340,000	Revenue generating: Yes (residents perspective)

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Internal approach on project preparation facility development and communication with the facility management companies.						Depending on the available financial sources technical assistance will be continued. It is expected that in the next 5 years the investment mobilised might double.
The development of the project preparation facility operational plan– the facility is operational.						
Project identification and technical assistance for EE and RES project development.						
Assistance in funding arrangement.						
Mobilising investment - project facility to track progress.						

Implementing agencies and stakeholders

- Inkasator d.o.o. and other facility management companies.
- City of Karlovac – Administrative Department for Construction and Environmental Protection.
- Private sector – Multi apartment building owners.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Environmental Protection and Energy Efficiency Fund (EPEEF).
- Other concessional financing and commercial bank lending.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions EU Renovation Wave[20] based sources - European Structural and Investment Funds (ESIF) and Croatia's National Recovery and Resilience Plan (NRRP).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- The City of Karlovac budget and national budget.

20 - The EU Renovation Wave is an initiative under the European Green Deal to double the rate of energy-efficient renovations by 2030, focusing on decarbonising buildings, reducing energy use, and tackling energy poverty across the EU.

Key benefits

Economic and environmental benefits:

- Climate change mitigation: reduction in greenhouse gas emissions through improved energy efficiency and the use of renewable energy sources.
- Decarbonisation of multi apartment buildings: transitioning multi apartment buildings to low-carbon technologies, contributing to the city's overall decarbonisation goals.
- Higher utilisation of renewable energy sources: increased integration of renewable energy technologies, such as photovoltaic systems, in renovated buildings.
- Increased comfort and indoor environmental quality (**IEQ**): enhanced living and working conditions through better insulation, ventilation, and modern building systems.
- Health and Wellbeing of Occupants: Improved indoor air quality and thermal comfort leading to better health outcomes for building occupants.
- Climate Change Adaptation: Strengthening the resilience of buildings to extreme weather events and other climate-related challenges.
- Decrease in Energy Costs: Lower energy consumption and reduced utility bills as a result of energy-efficient renovations.
- Enhancing Economic Growth: Increased investment in renovation projects leading to job creation and economic development within the City.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	**High**	High. Online platforms such as ISGE[21] that City use for public buildings can be used for smart metering and verification of energy savings in multi apartment buildings.
Gender and inclusion considerations	The technical assistance facility will embed into its project identification outreach activities a special emphasis on ensuring that the support for energy renovations is accessible to all building owners, including low-income households and marginalised groups – the support will be specifically offered to those groups (it is part of the CAPEX).	

21 - The ISGE (Information System for Energy Management) is Croatia's national energy management information system designed to support efficient energy management and data monitoring across public buildings and institutions..

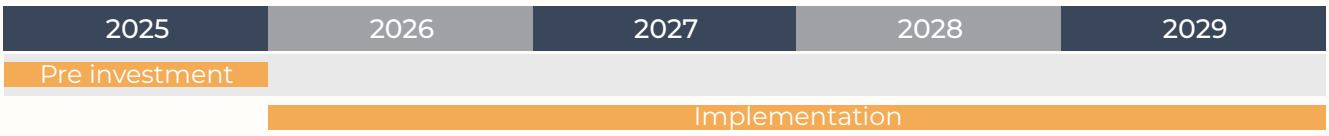
Enabling strategic framework

- Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac.
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.
- Integrated National Energy and Climate Plan for the Republic of Croatia 2021 - 2030.
- Geothermal Potential Development Plan of the Republic of Croatia until 2030.
- Energy Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Integrated National Energy and Climate Plan for the Republic of Croatia 2021. - 2030.
- Program of energy renovation of multi-apartment buildings for the period until 2030.
- Energy renovation program of buildings that have the status of cultural property for the period until 2030.

EB5: Decarbonisation of public buildings in the City of Karlovac

Type of action
INVESTMENT

Budget
10,000,000 EUR



Purpose

Comprehensive renovation of public buildings stock in order to achieve high level of energy efficiency.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The action will ensure continuation of the public building's renovation process. In accordance with the EPBD, at least 3% of the area used by the public sector will be renovated annually. For the City of Karlovac, this translates to a minimum of 3,000 m² per year, requiring an estimated budget of €1.8 – 3 million annually.

Benefits

- Climate action: Reduce greenhouse gas emissions and increase the use of renewable energy in public buildings.
- Enhanced building performance: Improve comfort, air quality, earthquake resistance, through energy-efficient renovations.
- Climate adaptation: Strengthen buildings' resilience to extreme weather and climate challenges.
- Economic benefits: Lower energy costs, create jobs, and promote economic growth through investment in renovations.

Financing needs

- Investment into the renovation of public buildings – technical documentation costs are included - CAPEX: 10,000,000 EUR until the end of 2029.

Outputs of the action

- Report on prioritised public buildings.
- 12,000 m² renovated over 4 years period.

Baseline

Several activities have been planned and implemented to decarbonise the public building sector. Additional investment and efforts are needed to continue public building renovation.

GCAP transformational change

The action will ensure the continuation of the programme through investment identification.

Synergies with other actions

EB2, EB3, EB6, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.2

GHG reduction potential

7,272 tCO_{2eq}

Action description

Several activities have been planned and implemented to decarbonise the building sector, including replacing heating oil boilers with biomass boilers in public institutions; energy renovation of public buildings; promotion of renewable energy systems in residential homes; co-financing heat allocators and calorimeters in residential buildings. Investments in public buildings within the City are managed by the City of Karlovac, Karlovac County, and the relevant Ministries with facilities in the City. In March 2022, the Government of the Republic of Croatia adopted a new Program for the Energy Renovation of Public Sector Buildings, which is planned to extend up to 2030. However, the allocated funds are insufficient to cover all public buildings, necessitating additional efforts from the City to achieve energy renovations for its publicly owned buildings. A significant challenge in the energy renovation of public buildings is that over 16% of the buildings listed in the Integrated Sustainable Governance Evaluation (**ISGE**) database are categorised as cultural heritage sites. Special regulations apply to the energy renovation of these protected buildings. To address this, the Government has also developed and adopted a Program for the Energy Renovation of Cultural Heritage Buildings for the period up to 2030 (December 2021).

Most of the building stock dates from 1950-1990 and has not undergone major energy efficiency renovations. With energy consumption for heating exceeding 200 kWh/m², this sector is characterised as not energy efficient. To utilise grant funds for necessary energy renovations through these programs, the City of Karlovac must prioritise buildings and begin preparing project documentation. The City has approximately 90 public facilities/ buildings, covering about 87,000 m², with approximately 85% of this area used by public institutions such as schools, kindergartens, libraries, and museums.

In the City of Karlovac, the primary challenges in building reconstruction are ensuring high energy efficiency, earthquake and fire resistance, and user well-being, while also integrating digital systems where needed.

These challenges result in higher renovation costs per square meter and necessitate additional expertise and comprehensive project documentation. The objective of this action is to support the City of Karlovac's systematic decarbonisation goals, which include utilising geothermal energy in the district heating system. Therefore, the objectives of deep energy renovation besides measures on building envelope and HVAC systems include:

- Connecting Buildings to the District Heating Network: Where feasible, existing buildings should be integrated into the district heating system to phase out gas and firewood heating systems;
- Installation of Photovoltaic Plants: In the prosumer model, photovoltaic systems should be installed where possible;
- Smart Metering and Automation: Buildings should be equipped with smart metering and automated technical systems to enhance flexibility and integration with the electricity network; and
- Where possible and feasible natural based solutions such as green roofs and walls, rainwater harvesting systems, natural ventilation and cooling systems and similar should be analysed and implemented leverage benefits in energy efficiency, climate resilience, biodiversity support, air quality improvement, and community well-being.

Several buildings have been prioritised by the Development Strategy of the Larger Urban Area Karlovac 2021-2027. Additionally, all other public buildings will be analysed, and a pipeline of projects will be continuously updated. The prioritised projects include:

- Revitalisation of the Croatian House;
- Revitalisation of the City Museum.

In accordance with the recast EPBD[22] (which ought to be transposed into Croatian legislation system by 2026), at least 3% of the area used by the public sector must be renovated annually. For the City of Karlovac, this translates to a minimum of 3,000 m² per year, requiring an estimated budget of 1.8 – 3M EUR annually.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Public buildings prioritisation.	Pre-investment	Report on prioritised public buildings.	-	Regular and ongoing City activities – already budgeted.
Investment into the renovation of public buildings – technical documentation costs are included.	CAPEX	65,000 m² renovated over 4 years period.	10,000,000	The cost is based on the estimated cost for energy renovation of 3,000 m² per year (3%) with the cost of 800 EUR/m² (per year = 2,400,000 EUR Capex, 100,000 technical documentation).
TOTAL	Direct costs		10,000,000	Revenue generating: Yes (energy savings)

22 - The revised Energy Efficiency Directive (EU/2023/1791) extends the obligation to renovate 3% of central government buildings to all public buildings, at local, regional and national level which have a total useful floor area of more than 250 m².

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Buildings Prioritisation: Identify and prioritise public buildings for renovation.						It is expected that in the next 5 years at least same amount will be spend on the renovation of buildings Targets are defined in EPBD directive.
Development of Project Design: Create detailed project designs that address energy efficiency improvements.						
Public Procurement: Conduct public procurement processes to select contractors, consultants, and suppliers for the renovation projects.						
Investment: Allocate and manage funds for the renovation projects, including securing additional financing if necessary.						
Monitoring and verification.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own budget – the City of Karlovac including the national budget.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions EU Renovation Wave based sources - European Structural and Investment Funds (ESIF) and Croatia's National Recovery and Resilience Plan (NRRP).
- Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

Economic and environmental benefits:

- Climate Change Mitigation: Reduction in greenhouse gas emissions through improved energy efficiency and the use of renewable energy sources.
- Decarbonisation of Public Buildings: Transitioning public buildings to low-carbon technologies, contributing to the city's overall decarbonisation goals.
- Higher Utilisation of Renewable Energy Sources: Increased integration of renewable energy technologies, such as photovoltaic systems, in renovated buildings.
- Increased Comfort and IEQ: Enhanced living and working conditions through better insulation, ventilation, and advanced building technical systems.
- Health and Wellbeing of Occupants: Improved indoor air quality and thermal comfort leading to better health outcomes for building occupants.
- Improvement of Productivity: Enhanced work environments that can lead to increased productivity and performance in public sector buildings.
- Climate Change Adaptation: Strengthening the resilience of buildings to extreme weather events and other climate-related challenges.
- Increasing earthquake resistance.
- Decrease in Energy Costs: Lower energy consumption and reduced utility bills as a result of energy-efficient renovations.
- Enhancing Economic Growth: Increased investment in renovation projects leading to job creation and economic development within the City.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	The use of Building Information Modelling (BIM) and energy management systems optimises the planning, implementation, and energy use of construction projects, ensuring more efficient project execution and sustainable energy consumption. Online energy management platform that City already use (ISGE) should be used for integration of smart metering and verification of energy savings in public buildings. This is to be considered, not included in the CAPEX.
Gender and inclusion considerations	Renovated public buildings and spaces will be made accessible to all, ensuring affordability, incorporating universal design principles for diverse needs, and including gender-sensitive features such as safety measures and inclusive facilities. Implement effective communication strategies to inform all demographic groups about the benefits and opportunities of the renovation projects, ensuring broad community engagement.	

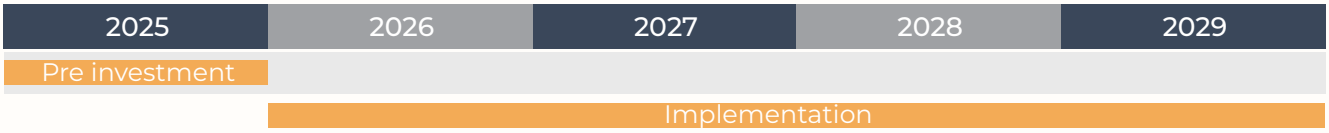
Enabling strategic framework

- Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac.
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.
- Geothermal Potential Development Plan of the Republic of Croatia until 2030.
- Energy Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a View to 2050.

EB6: Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation

Type of action
POLICY

Budget
300,000 EUR



Purpose

Encourage investing into green certified buildings, ensure strong energy planning policy and raise awareness among citizens related to decarbonisation.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The action aims at increasing the investment into green certified buildings by introducing mechanism such as reducing utility and communal fees. Furthermore, it will assess the need for adopting local regulations on energy planning in relation to urban planning. Finally, it envisages the awareness raising campaign in order to promote investments intro decarbonisation of the building sector.

Benefits

- Promote sustainability and circular economy in the built environment.
- Improve citizens' health, well-being, and biodiversity.
- Decarbonise buildings and the energy sector in Karlovac.
- Increase understanding and investments in energy efficiency and renewable energy.

Financing needs

- Green building policy preparation and budget cost for the incentives applied – 100,000 EUR.
- Energy planning policy development – 100,000 EUR.
- Awareness raising campaign on benefits of decarbonisation for the sector – 100,000 EUR.

Outputs of the action

- 1 policy on green building.
- 1 Energy planning policy.
- Set of workshops and informative materials.

Baseline

Currently, no buildings in Karlovac have green certification, and local regulations on energy planning are needed to support integrating future buildings and those undergoing retrofits into the district heating system, aligning with the City's 2050 decarbonisation goals. Further awareness is needed to enhance the implementation of energy efficiency and renewable energy measures.

GCAP transformational change

The action will ensure creation and adoption of regulatory documents that will encourage a greater number of newly constructed buildings with green certificates and a greater number of buildings that will use RES after energy renovation. That more citizens initiate their private investments for energy renovation of buildings.

Synergies with other actions

EB1, EB2, EB3, EB4, EB5, L1, W2, SW2, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 2.1 and SO 2.2

GHG reduction potential

Undetermined at this stage

Action description

This action consolidates regulatory objectives to create a sustainable, low-carbon future for Karlovac, integrating green building incentives, energy-focused regulations, and citizen engagement. At its core, this is a regulatory initiative: local legislation will mandate energy planning in urban development, ensuring that new construction and renovations align with stringent energy efficiency and renewable energy targets set by the EU Green Deal. Incentivising green building certifications through fee reductions supports these regulations, encouraging developers to meet high environmental standards. Complementing these regulatory steps, citizen awareness campaigns will foster energy-efficient practices and renewable adoption, ensuring broad public alignment with the city's sustainability goals. Together, these components form a unified regulatory approach that aligns standards, policy, and community engagement to achieve Karlovac's decarbonisation objectives.

The following action has three main components:

1. Encouraging green building and green building certification

At the national level, the Green Building Council Croatia (GBCC) promotes and encourages the construction of green buildings with green certificates. Additionally, the GBCC has established a certification system based on the DGNB international green certificate, which is currently being translated into Croatian and will serve as the national green building certification scheme (still voluntary, like others). More than 150 building professionals have been educated through the GBCC and are certified consultants. The City of Karlovac has been a member of the GBCC since 2011 and actively promotes green building principles. To increase the rate of green building certifications, the City of Karlovac will encourage investors to develop, design, and build green buildings by reducing utility and communal fees when applying for building permits. Buildings pursuing other green building certification schemes, such as LEED, BREEAM, or equivalent, will also be eligible. The City previously offered similar incentives for nZEB buildings before they became a legal obligation.

It is expected that in the next five years, five to seven buildings will apply for a reduction in City utility fees and will achieve green certification.

2. Draft and implementation of local regulations related to energy planning

The aim is to analyse the current state and assess the need for adopting local regulations on energy planning in relation to urban planning. This includes drafting recommendations, formulating legislation, and implementing it. The regulation would mandate the City to integrate energy considerations into planning procedures (energy planning and urban planning) and instruments, clearly specifying how it aims to achieve its energy goals. This should apply to both new building construction and renovation. Actions should focus on achieving mid- and long-term Green Deal targets, which include a 55% reduction in emissions by 2030 and a 90% reduction by 2050.

This component would involve a comprehensive analysis of energy sources and potential retrofit solutions across different sectors to achieve the 90% decarbonisation target by 2050. Based on the results of this analysis, a local energy policy should be developed and proposed.

3. Citizens awareness raising on the importance of energy efficiency and renewable energy sources

This component involves organising workshops and producing educational publications or brochures to encourage

residents about the importance of energy efficient renovation and the implementation of renewable energy sources, as well as promoting behaviour changes to save energy. Additionally, it is important to educate citizens which natural based solutions might contribute to decreased need for energy consumption for both heating and cooling and how they might cope with climate change and temperature rise in the future. It includes a promotional campaign targeting owners and residents of single-family houses and multi-apartment buildings, as well as the general public, through local media, City websites, and other City companies. This component will also involve the development of specification of digital tools such as interactive webpages or mobile applications that will be additionally finance when scope of work will be known. Exact indicators and specific targets will be determined during the design of the component.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Green building policy preparation and budget cost for the incentives applied.	Policy preparation and Incentive cost to the City	1 policy on green building.	100,000	The cost is estimated to include cost of policy preparation but are mainly related to loss of income towards the City due to incentive mechanism applied.
Energy planning policy development.	Policy development cost	1 energy planning policy cost.	100,000	The cost is based on the estimated cost for energy renovation of 65.000 m^2.
Awareness raising campaign on benefits of decarbonisation for the sector.	Technical assistance	Set of workshops and informative materials.	100,000	The cost is estimated for two-year activities based of human resource capacity of the City to implement measure.
TOTAL	Direct costs		300,000	Revenue generating: No

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
City's internal policy decision for communal utility fee reduction for the new buildings pursuing green energy certification.						Policy might be reviewed based on the monitoring results. The same is valid for the awareness campaign.
Promote the new policy and establish a monitoring system.						
Develop the project assignment, decide on the budget and sources of financing.						
Public procurement of documentation.						
Documentation development.						
Implementation of energy planning policy. Ensure monitoring of implementation process.						
Develop the project assignment, decide on the budget and sources of financing.						
Public procurement.						
Development of awareness raising campaign.						
Implementation of awareness raising campaign activities and establishment of monitoring system.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own budget – City budget.
- National Governmental budget.
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Promotion of sustainable principles in the built environment.
- Enhanced health and well-being for citizens.
- Decarbonisation of building stock in Karlovac.
- Implementation of circular economy principles.
- Enhancement of biodiversity.
- Reduction of the urban heat island effect.
- Improved understanding of the causes and actions required for energy efficiency and renewable energy source (RES) measures in the residential sector.
- Increased investments in multi-apartment buildings for energy renovation.
- Decarbonisation of buildings.
- Decarbonisation of the energy sector in the City of Karlovac.

Enabling strategic framework

- Sustainable Energy and Climate Action Plan (SECAP) for the City of Karlovac.
- Development Strategy of the Karlovac Urban Area for the period 2021-2027.
- Development Plan of the City of Karlovac 2021–2030.
- Energy Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a View to 2050.
- Integrated National Energy and Climate Plan for the Republic of Croatia 2021. - 2030.
- Program of energy renovation of public sector buildings for the period until 2030.
- Program of energy renovation of multi-apartment buildings for the period until 2030.
- Energy renovation program of buildings that have the status of cultural property for the period until 2030.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Data about energy planning and possible energy sources and RES planed/implemented should be digitalised. Digital project management tools can enhance project implementation and evaluation. To be considered during the implementation. Mobile apps for the promotion of the decarbonisation will be considered (not part of the CAPEX). The App could be a "One-stop-shop" on EE for citizens and businesses.
Gender and inclusion consider-ations	The action will develop awareness campaigns, educational materials, and workshops to ensure accessible information on green building incentives and fee exemptions for all community members, including minority groups and vulnerable populations. It will also engage diverse stakeholders in refining policies and ensuring transparent, straightforward application processes.	

4.3 Water and Wastewater

4.3.1 Introduction to sector and overview of key challenges

The sector

Karlovac, located at the confluence of four rivers, is prone to flooding, with notable occurrences in 1939 and 1966. After 1966, efforts were made to build flood defences along the Korana and Kupa rivers by constructing embankments; however, this initiative is still incomplete.

The City of Karlovac's water supply network also serves the administrative area of the City, alongside the municipality of Draganić, portions of the municipalities of Netretić and Barilović, and a section of the City of Ozalj. Drinkable water is sourced from subterranean aquifers through six operational pump stations, then distributed via the network or stored in 12 storage reservoirs. The water network pipelines in Karlovac stretch close to 640 kilometres and have an average lifespan of approximately 32 years.

In 2011, Karlovac introduced a sophisticated water management system that incorporates advanced wastewater for improving water quality and safeguarding the environment both within its own region and farther downstream. The wastewater treatment plant in Karlovac is notable for being the first municipal infrastructure project co-financed by the European Union. Moreover, it is the pioneering facility in Croatia that can perform tertiary treatment, successfully removing nitrogen and phosphorus. Over the past 12 years, the plant has proficiently processed upwards of 77 million cubic meters of water. The water, once purified, is released into the Kupa river. The sewage network of the City includes a sprawling 180 kilometres of piping and drainage systems, which are presently being extended via the Agglomeration project. The local utility company, Vodovod i kanalizacija d.o.o., takes charge of strategic planning and upkeep of the water network.

Photo 4.4
Wastewater treatment plant of cities of Karlovac and Duga Resa

Source: ViK. https://www.vik-ka.hr/odvodnja/uredaj-za-prociscavanje-otpadnih-voda.html

23 - Trend (2023) Newspaper article. https://trend.com.hr/2023/06/01/u-12-godina-koliko-postoji-procistac-otpadnih-voda-iz-rijeka-je-izvadeno-preko-26-500-tona-krupnog-i-sitnog-otpda-i-22-000-tona-mulja/

Key challenges

The following are the key challenges identified within the water and wastewater sector:

- The City of Karlovac, along with its surrounding region, is continually confronted with challenges in managing flood defences, which incurs significant financial costs for repairs following flood events. Current endeavours to build and renovate water defence and regulation infrastructure are facing delays;
- One critical issue is the high rate of non-revenue water, with network losses amounting to approximately 58%. Tackling this loss is a pivotal concern in the water sector. The current "Improvement of the water utility infrastructure of the Karlovac-Duga Resa agglomeration" project does not cover the whole area of Karlovac and will not entirely address the problem of water loss;
- There is an urgent need to enhance the water usage management system, which could be facilitated by campaigns that increase public awareness;
- Implementing water meters equipped with modules for remote readings can enhance the effectiveness of the billing process. A significant concern in metering is the absence of individual meters in many multi-tenant properties, leading to the practice of allocating water bills according to the size of an apartment instead of actual consumption due to a single meter installed for the entire building; and
- Furthermore, there are opportunities to enhance the energy efficiency of the machinery and infrastructure used in the water industry, particularly the energy consumed in water treatment and pumping. Future initiatives could build on the existing PV project undertaken by ViK d.o.o. at the water treatment facility.

4.3.2 City's current activities

Presently, there is an ongoing project "Improvement of the water utility infrastructure of the agglomeration Karlovac-Duga Resa", with an estimated value of around 56M EUR. The objective of this initiative is to extensively enlarge the sewage system, partially renew the water distribution network, and establish a solar-powered sludge drying facility.

In 2022, a provisional flood defence system consisting of 2 kilometres of sandbag barriers was put in place. The national water authority has indicated a requirement for 34 kilometres of additional levees and concrete barriers within the City of Karlovac, of which half have already been constructed. The project is still under implementation and its worth around 47M EUR, almost all of which is financed by EU grants.[24]

24 - Index.hr (2022) Newspaper article. https://www.kazup.hr/index.php/aktualno/projekt-obrane-od-poplava-u-cijelosti-ce-biti-izgraden-u-iducih-pet-godina

4.3.3 Sector's strategic objectives and targets

The following are defined strategic objectives for Water and Wastewater sector in Karlovac:

Strategic objective 3.1.
Ensure efficiency of water systems and preservation of water resources while achieving high level of climate resilience.

It has been noted that over half of the water within network systems is lost, highlighting a critical need for enhancements in system efficiency, reliability, and sustainability. Although efforts are already being made to tackle this challenge, the GCAP offers an opportunity to expand these initiatives, integrate acquired insights, and incorporate digital technology into the sector. In addition, it is imperative to deploy remote smart metering devices across all buildings and homes.

With regards to climate resilience against flooding, achieving this goal is imperative by any means necessary. Decision-making processes are primarily at the national level; nevertheless, cities must guarantee the appropriate application of national strategies. The GCAP is strategically positioned to facilitate effective coordination and communication between City and national levels, ensuring the implementation of impactful actions such as nature-based solutions, green infrastructure, and rainwater management to further reduce flood risks.

Strategic objective 3.2.
Enhance capacity of key stakeholders and achieve satisfactory awareness level on water sustainability among citizens and stakeholders.

It is essential to foster awareness of water conservation measures within the community. Also, because achieving a sustainable transformation in the sector typically requires complex and innovative approaches, enhancing the knowledge base of various pivotal stakeholders is necessary.

Korana river, Karlovac

4.3.4 Water and Wastewater GCAP actions

4.3.4.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 3.1.– Ensure efficiency of water systems and preservation of water resources while achieving high level of climate resilience.			
SO 3.2. - Enhance capacity of key stakeholders and achieve satisfactory awareness level on water sustainability among citizens and stakeholders.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target	Final target
Non-revenue water.	58%	45%	30%
Energy used for urban water production and supply.	2.51 kwh/m^3	0.5 kwh/m^3	0.3 kwh/m^3
Water consumption per capita.	117 l / day / capita	100 l / day / capita	80 l / day / capita

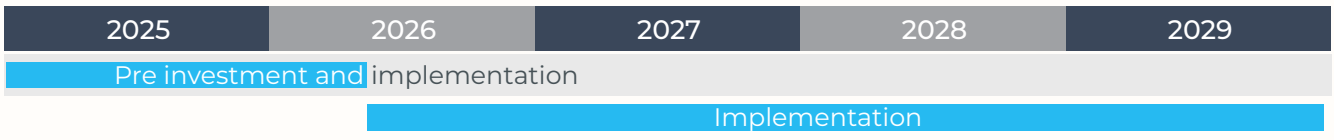
4.3.4.2 List of actions

Action code	Action title	Action type	Main implementing stakeholders	Action required budget (EUR)	Timeframe	GHG reduction potential - total over lifetime of investment
W1	Reduction of water consumption and water network losses.	Investment	Vodovod i kanalizacija d.o.o.	16,300,000	2025-2029 and beyond	19,316 tCO2eq
W2	Increase of water storage capacity and installation of solar-powered pump systems.	Investment	Vodovod i kanalizacija d.o.o.	6,050,000	2025-2029 and beyond	32,318 tCO2eq
W3	Introduction of heat pump and CHP systems into Karlovac Wastewater Treatment Plant.	Investment	Vodovod i kanalizacija d.o.o.	11,580,000	2025-2028	20,247 tCO2eq
W4	Increase climate resilience against flooding in the City of Karlovac.	Investment	Gradska toplana d.o.o.	5,450,000	2025-2029	N/A

W1: Reduction of water consumption and water network losses

Type of action
INVESTMENT

Budget
16,300,000 EUR



Purpose

Further reduction of water losses and overall water efficiency increase.

Lead implementer

Vodovod i kanalizacija Karlovac - ViK.

Description

The water supply network losses are still substantial, and Agglomeration project needs to be scaled up. The action envisages scale up of works around water supply network (apprx.30 km of rehabilitation network and 5 km of new network) during the GCAP phase. This will be accompanied with roll out of 9,000 smart metering devices and by conducting water efficiency related awareness campaign – user consumption decrease oriented.

Benefits

- Reducing water losses increases the availability of water and decreases expenses.
- Improved efficiency of the supply system due to digitalisation component.
- Reduced water consumption lowers the need for energy so less GHG emitted.
- Reduced risk of water contamination in the supply system.
- Fair billing of water consumption.

Financing needs

- Preparation of the investment documentation for water supply network enhancement - 200,000 EUR.
- Investment into the rehabilitation and construction of water supply network - CAPEX 15,000,000 EUR, OPEX: 300,000 EUR/y.
- Distribution of smart metering devices – CAPEX 1,000,000 EUR.
- Awareness raising campaign – 100,000 EUR.

Outputs of the action

- Technical project documentation.
- Approx. 30 km of rehabilitated network and 5 km of new network.
- OPEX for 35 km of the network.
- 9,000 meters.
- Social media and leaflets related campaign.

Baseline

Current Agglomeration project set up the basis for the scaling up which is needed due to substantial water losses in the network. Smart metering has started but also needs a scale up, accompanied with the awareness raising campaign.

GCAP transformational change

The action will ensure continuous path toward achieving acceptable water losses level and overall water efficiency in the City of Karlovac.

Synergies with other actions

W2, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 3.1 and SO 3.2

GHG reduction potential

19,316 tCO_{2eq}

Action description

The water supply network in Karlovac is primarily composed of aging pipelines, with sections dating back to as early as 1913. The network includes 709 km of pipelines, with materials ranging from cast iron and asbestos cement, reflecting the various phases of expansion over the decades. Despite recent upgrades, much of the infrastructure consists of older pipes, particularly cast iron, which date from the early 20th century through the 1940s.[25]

Addressing the reduction of non-revenue water is identified as a top priority in the water sector. The "Improvement of the Water Utility Infrastructure of the Karlovac-Duga Resa Agglomeration" project is limited and does not cover all of Karlovac, nor will it fully address the water loss problems. This initiative will directly contribute to the agglomeration efforts. The action consists of three main components: will encompass the refurbishment and enhancement of current infrastructure (rehabilitation of pipelines and targeted remediation when cost-effective) as well as the deployment of sophisticated analytical tools, like pressure management systems and leak detection software. Currently, there is a 58% loss in water which needs to be cut down to 30% or below. Finally, action envisages awareness raising campaign.

This action has following components:

1. Scaling up of the current Agglomeration project to increase the impact on reducing of water network losses.

   The ongoing Agglomeration project focuses on the rehabilitation of 28.1 kilometres of existing piping infrastructure and the construction of an additional 5.8 kilometres of new pipes. The action envisages the scaling up of the ongoing project by investing additional 15M EUR for the water supply system enhancement. This will include approx. 30 km of rehabilitated pipeline and up to 5 km of new pipeline.

2. Incorporating enhanced actions related to the water metering and invoicing process.

   Traditionally, water meters are mounted per building in residential areas, not per apartment, which does not promote the conservation of water. Additionally, billing is often calculated based on the size of the dwelling rather than actual usage of water. Thus, the recommendation is to install individual water meters equipped with remote reading capabilities for each household. It is expected that about 9,000 metering units will be deployed as part of this plan.

3. Awareness raising to improve water efficiency.

   A campaign to educate residents on water conservation is planned to ensure long-term resource stewardship. It will emphasise the importance of mindful water use, provide tips for reducing consumption indoors and outdoors, highlight the benefits of technology, and support community initiatives like the GCAP. Campaign will be disseminated through social media and leaflets to be sent with bills.

Photo 4.5
Works on the current Agglomeration project

Source: City of Karlovac

25 - ViK (2016) Strateigc Plan 2016-2020.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Preparation of the investment documentation for water supply network enhancement.	Pre investment costs	Technical project documentation.	200,000	The amount is based on costs of similar activities as presented in ViKs strategic documentation.
Investment into the rehabilitation and construction of water supply network.	CAPEX	Approx. 30 km of rehabilitated network and 5 km of new network.	15,000,000	The costing is based on data from Agglomeration project. Approx. 400,000 EUR per km of rehabilitated, and 500,000 of new pipeline.
	OPEX per year	OPEX for 35 km of the network.	300,000	Estimated as 2% of the CAPEX.
Distribution of smart metering devices.	CAPEX	9,000 meters.	1,000,000	Approximated at 110 EUR per metering device – aligned with market prices.
Awareness raising campaign.	Awareness raising campaign cost	Social media and leaflets related campaign.	100,000	Estimated as 20,000 EUR per year over 25 years.
TOTAL	CAPEX		16,300,000	REVENUE GENERATING: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Preparation of the investment technical documentation.						The action ought to be scaled up further after the GCAP lifespan in order to achieve targets set. Therefore, it is expected that the action will be further scaled up.
Implementation of water supply network construction works.						
Procurement and distribution of smart metering devices.						
Preparation of awareness raising materials.						
Conducting of awareness raising campaign.						

Implementing agencies and stakeholders

- City of Karlovac.
- Vodovod i kanalizacija(ViK) d.o.o. - City-owned water management company.

Fit with Funding sources

- Good fit
- Possible fit
- Poor fit

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

Potential funding sources

- The City of Karlovac budget.
- State budget – through Croatian Waters.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Reducing water losses increases the availability of water and decreases expenses.
- Improved efficiency of the supply system due to digitalisation component.
- Reduced water consumption lowers the need for energy so less GHG emitted.
- Reduced risk of water contamination in the supply system.
- Fair billing of water consumption.

Enabling strategic framework

- ViK Strategic Plan 2021-2025.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.
- National relevant regulation framework.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Digitisation enhances water network management by reducing losses, implementing smart metering, and raising awareness through digital campaigns. Sensors enable precise leak detection and proactive maintenance, while smart meters offer real-time monitoring, accurate billing, and consumer engagement.
Gender and inclusion considerations	This initiative guarantees that enhancements will focus on underserved populations, without regard to gender or economic standing. In the strategic development and financial choices for water infrastructure, give precedence to the requirements of disadvantaged and marginalised demographics. The awareness campaign will also include the awareness raising of the role and leadership of women in the water sector – included in the CAPEX.	

W2: Increase of water storage capacity and installation of solar-powered pump systems

Type of action
INVESTMENT

Budget
6,050,000 EUR

Purpose

Increase in the drinking water capacity and the introduction of the renewable energy powered systems into the supply infrastructure.

Lead implementer

Vodovod i kanalizacija Karlovac - ViK.

Description

The action aims at improvements of the drinking water storage capacity by almost 40% through expanding current capacity. Also, this action envisaged the introduction of an efficient solar pumping systems into all water storage tanks and within the WWTP Karlovac.

Benefits

- Reduction in water losses and increased flexibility of the system during drought and heat waves.
- Energy conservation and reduction of GHG emissions.
- Prolonged lifetime of tanks.

Outputs of the action

- Technical project documentation - storage tanks.
- 12 water storage tanks refurbished.
- 6,000 m^3 of additional water storage capacity.
- Technical project documentation – solar pumps.
- 5 high-capacity solar pumps.
- 7 low-capacity solar pumps.
- 9 WWTP solar pumps.

Financing needs

- Preparation of the technical documentation for the refurbishment and water storage expansion – 50,000 EUR.
- Investment into refurbishment of 12 tanks and expansion of Strmac, Švarča, and Vučjak storage facilities – CAPEX: 3,000,000 EUR, OPEX: 30,000 EUR/y.
- Preparation of technical documentation for solar pumps – 30,000 EUR.
- Investment into solar pumping systems - CAPEX: 1,970,000, OPEX: 50,000 EUR/y.

Baseline

A significant number of water storage facilities are nearing the end of their service life, presenting issues with maintenance. The existing capacity for storing drinking water is merely 0.19 days' worth of supply. Finally, the urban water production and supply system requires 2.51 kWh m^3, which is a considerable amount.

GCAP transformational change

This action will ensure the refurbishment of the entire current water storage capacity in the City of Karlovac. Also, it will ensure that drinking water tank capacity is increased and thereby securing water supply during drought periods. Finally, introduction of efficient solar powered pumps will ensure the reliability of supply and overall decarbonisation of the sector.

Synergies with other actions

W2, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 3.1

GHG reduction potential

32,318 tCO_{2eq}

Action description

A significant number of water storage facilities are nearing the end of their service life, presenting issues with maintenance that can lead to leaks, potential contamination, and inefficiency in both storing and distributing water. As these tanks age, they may experience material degradation, causing cracks and corrosion which result in leaks. Furthermore, existing coatings and linings might be outdated, failing to inhibit bacterial and algae growth. The absence of contemporary monitoring and management technologies also hinders these tanks from functioning efficiently. Furthermore, regarding energy consumption, the urban water production and supply system requires 2.51 kWh/m³, which is a considerable amount.

This action envisages two components:

1. Development and improvement of infrastructure to increase drinking water storage capacity

This action aims to improve drinking water storage capacity to ensure sufficient supply for the needs of the population. The existing capacity for storing drinking water is merely 0.19 days' worth of supply. This indicates the volume of potable water in reserve that can be immediately utilised. In essence, if the storage does not receive any new water additions, the current potable water supply would be depleted in less than five hours. Improvements in water storage capacity will be done by expanding the capacity of existing tanks where feasible and economically viable. This action envisages refurbishment of 12 water tanks is envisaged.

The 12 tanks have a total volume of 14,730 m³. The water storage capacities in Karlovac include Strmac with 6,700 m³, Švarča with 4,000 m³, Borlin with 1,000 m³, Jelsa with 1,000 m³, Budrovci with 1,200 m³, Vučjak with 100 m³, Vukmanić with 300 m³, Mel with 60 m³, Rečica with 300 m³, Ljubenki with 10 m³, Skupica with 60 m³, and Slunjska brda with 800 m³.[26] The action plans to increase the volume capacity by 6,000 m³ by expanding the existing storages (mainly Strmac and Švarča). This is aligned with the ViK's strategic plan 2021-2025. Expansion of existing tanks that will also include structural reinforcement, of all the mentioned tanks, increase of tank height, tank lining, and coating. Finally, this component includes the installation of modern control systems that will include level sensors and automation. Remote monitoring system Supervisory Control and Data Acquisition (SCADA) will be introduced. In water supply systems, SCADA (Supervisory Control and Data Acquisition) is used to monitor and control the distribution and treatment processes. It enables real-time data collection, remote control of pumps and valves, and alerts for any anomalies, ensuring efficient, reliable, and safe water delivery to consumers.

2. Use of energy efficiency and renewable energy sources in the operation of the water supply and wastewater system

This initiative will enhance the energy efficiency and integration of renewable energy within water and wastewater infrastructure. This involves the deployment of more efficient equipment and software-managed pump operation to lower energy use. Moreover, the plan includes implementing renewable energy solutions, like solar panels at water production and wastewater treatment facilities to supply power for pumps and systems in the distribution network. Water storages of more than 1,000 m³ will require high-capacity solar pumps (5 in total), the remaining 7 will require low-capacity solar pumps (7 in total). The Karlovac Wastewater Treatment Plant might require up to 9 pumps. Detailed requirements will be determined through preparation of technical documentation.

26 - ViK (2021) ViK Strategic Plan 2021-2025

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Preparation of the technical documentation for the refurbishment and water storage expansion.	Pre investment costs	Technical project documentation - storage tanks.	50,000	The amount is based on costs of similar activities as presented in ViKs strategic documentation.
Investment into refurbishment of 12 water tanks.	CAPEX	12 water tanks refurbished.	1,000,000	Cost per tank vary significantly due to different sizes and state. This cost may range from 300,000 EUR for large tanks and 3,000 for small tanks.
Investment into expansion of Strmac, Švarča, and Vučjak storage facilities.	CAPEX	6,000 m^3 of additional water storage capacity.	3,000,000	The costing is based on a 500 EUR per m^3 of the new storage – in line with similar projects.
	OPEX per year	OPEX for 6,000 m^3.	30,000	Assumption that the OPEX is 5 EUR/m^3/year.
Preparation of technical documentation for solar pumps.	Pre investment costs	Technical project documentation – solar pumps.	30,000	The amount is based on costs of similar activities as presented in ViK's strategic documentation.
Investment into solar pumping systems.	CAPEX	5 high-capacity solar pumps; 7 low-capacity solar pumps; 9 WWTP solar pumps.	1,970,000	100,000 EUR/high-capacity pump; 50,000 EUR/low-capacity pump; 130,000 EUR/WWTP pumps.
	OPEX per year	OPEX for 21 solar pumps.	50,000	Assumption based on similar activities.
TOTAL	CAPEX		6,050,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Preparation of the technical documentation for water storage expansion.						Croatian Waters may invest into additional water supply network that might include City of Karlovac.
Investment into refurbishment of water tanks and expansion of drinking water capacity.						
Preparation of the technical documentation for solar pumping.						
Investment into solar pumps within 12 water tanks and WWTP Karlovac.						

Implementing agencies and stakeholders

- Vodovod i kanalizacija(ViK) d.o.o. – City-owned water management company.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City budget.
- State budget – through Croatian Waters.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Reduction in water losses and increased flexibility of the system during drought and heat waves.
- Energy conservation and reduction of GHG emissions.
- Prolonged lifetime of tanks and availability of data due to modern monitoring systems.

Enabling strategic framework

- ViK Strategic Plan 2021-2025.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.
- National relevant regulation framework.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Retrofitting existing drinking water storage infrastructure and adopting solar-powered pumps hold great promise for digital transformation. The action envisages inclusion of the SCADA system – included in the project budget.
Gender and inclusion considerations	N/A	

W3: Introduction of heat pump and CHP systems into Karlovac Wastewater Treatment Plant

Type of action
INVESTMENT

Budget
11,580,000 EUR

Purpose

Utilisation of WWTP waste heat and biogas potential for the production of thermal energy.

Lead implementer

ViK d.o.o.
Gradska toplana d.o.o.

Description

This action will upgrade the current Wastewater Treatment Plant (WWTP) in Karlovac by introducing waste heat recovery system with a capacity of 7.4 MW of heat pumps and the implementation of 500 kW Combined Heat and Power (CHP) system. This will ensure that waste heat and biogas potential are fully utilised and will reduce overall GHG from the sector.

Benefits

- Utilisation of waste heat and consumption within the DH.
- Reduced energy consumption and GHG emission reductions.
- Cost savings due to waste heat recovery.
- Cost savings on sludge removal and turning it into revenue generating feedstock.

Financing needs

- Preparation and the development of feasibility study - 100,000 EUR.
- Investment into heat pumps for heat recovery system – CAPEX: 3,000,000 OPEX: EUR, 60,000 EUR/y.
- Preparation of the technical investment documentation for the WWTP CHP system - 30,000 EUR.
- Investment into the CHP WWTP system - CAPEX: 1,500,000 EUR, OPEX: 50,000 EUR/y.

Outputs of the action

- Feasibility study for the WWTP heat pumps.
- 2 heat pumps – 3.7 MW each, 7.4 MW in total, 10 km of pipeline connecting WWTP and DH plant, and 3 MW electric boiler at DH plant.
- Technical project documentation – CHP system.
- Approx. 500 kW CHP system.

Baseline

The Karlovac WWTP is a modern treatment facility. However, there is a room to improve it even more. The WWTP has substantial potential to utilise waste heat and sludge biogas potential.

GCAP transformational change

This action will ensure that the WWTP is upgraded with additional systems that would make it even more sustainable and would unlock the potential to use waste heat and biogas potential for its own consumption and thus reducing its carbon footprint.

Synergies with other actions

W1, EB3, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 3.1 and SO 3.2, SO 2.1

GHG reduction potential

20,247 tCO_{2eq}

Action description

This action envisages two components:

1. Integration of heat pumps on wastewater from the WWTP with 2,000 m³ storage tanks - Conducting a feasibility study and investment

This action involves carrying out a feasibility study, followed by investing in a waste heat recovery system at the wastewater treatment facility. This technology will involve the implementation of heat pumps designed to reclaim residual heat from the wastewater, which will then be integrated into the central DH network.

In July 2024, Gradska toplana d.o.o. has developed a conceptual study for this component. The availability of treated wastewater from the Karlovac WWTP enables the integration of a water-to-water heat pump, which will utilise the heat from the treated/processed water to produce thermal energy for the DH system of the City of Karlovac. During the heating season, wastewater temperature is around 13°C with a flow rate of 200 to 238 l/s—data used for selecting the heat pumps. The action envisages two heat pumps - compression-type water-to-water heat pumps, each with a capacity of 3,700 kW (totalling 7,400 kW) at a treated wastewater flow rate of 105 l/s and an inlet temperature of 13°C. The outlet temperature of the heating water (for distribution in the district heating system) under these conditions is 75°C. Treated wastewater at around 13°C will be piped underground to heat pumps. After heat exchange, the cooler water will be discharged into the canal towards the Kupa River. In the heat pump system, the water remains in a closed loop, preventing contamination. The system water is heated to 55/75°C and distributed via an underground pipeline to the DH plant and finally its network.[27]

Additionally, to enable the connection of the heat pump facility, located on the cadastral plot of WTP, with the existing DH system, it is necessary to plan an underground connecting pipeline from the new facility to the heating plant. This pipeline will allow the distribution of thermal energy produced by the proposed heat pumps, which utilise heat from treated wastewater, a renewable energy source. The route length from the new facility to the heating plant is approximately 5 kilometres (10 kilometres of pipeline – supply and return). Finally, an electric boiler with a capacity of 3 MW is planned to be installed in the existing boiler room at the DH plant location and connected to the existing system. The electric boiler will operate in parallel with heat pumps using treated wastewater for district heating in the City of Karlovac.

2. Modernisation of wastewater collection and treatment plants through the implementation of the CHP system

The WWTP in Karlovac incorporates a range of sludge treatment technologies. It features both biogas generation and solar sludge drying facilities. The plant manages approximately 2,500 tonnes of sludge annually. This sludge is subjected to aerobic stabilisation for up to 25 days, followed by an anaerobic stabilisation period of 21 days which generates about 500 m³ of biogas each day. Subsequent mechanical dehydration yields a dry matter content of 25%. A solar dryer further reduces moisture, reaching up to 90% dry matter content. The action envisages further upgrade of the system with the introduction of CHP system in the WWTP sludge development. The already mentioned Agglomeration project (in W1) will generate around 11,000 people connected to the wastewater system. This will increase the biogas potential of

27 - SttS d.o.o. (2024) Conceptual study for heat pumps in WWTP Karlovac.

more than 700 m^3 of biogas per day. This unlocks the potential to introduce CHP system. Technical documentation preparation phase will determine the size and power of the CHP system, expected to be approx. 500 kW system.

Photo 4.6
Example of the CHP unit within the WWTP

Source: https://guascor-energy.com/2023/09/19/biogas-chp-generators-with-fuel-blending-system-for-wwtp-in-grandville-usa/

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Preparation and the development of feasibility study.	Pre investment costs	Feasibility study for the WWTP heat pumps.	100,000	Based on the estimate of 200 expert days.
Investment into heat pumps for heat recovery system.	CAPEX	2 heat pumps – 3.7 MW each, 7.4 MW in total.	4,500,000	Estimated as 600 EUR per kW of installed capacity.
		10 km of the pipeline connecting WWTP and DH plant.	5,000,000	Estimated as 500 EUR per m of the pipeline.
		3 MW electric boiler in DH plant.	450,000	Estimated at 15 EUR per kW.
	OPEX per year	OPEX EUR/y.	200,000	Estimated as 2% of the CAPEX.
Preparation of the technical investment documentation for the WWTP CHP system.	Pre investment costs	Technical project documentation – CHP system.	30,000	Estimation based on similar studies undertaken – Gradska toplana annual reports.
Investment into the CHP WWTP system.	CAPEX	Approx. 500 kW CHP system.	1,500,000	Estimated based on 3,000 EUR per kW CAPEX.
	OPEX per year	CHP OPEX/y.	50,000	Estimated based on similar projects.
TOTAL	CAPEX		11,580,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development and selection of the service provider for feasibility study – heat recovery.						The scale up of the system is not envisaged as the current WWTP capacity can serve approx. 100,000 people.
Development of the heat recovery feasibility study and technical documentation.						
Implementation of heat pumps and the heat recovery system into the Karlovac WWTP and DH plant.						
Development of technical documentation for investment into the CHP.						
Investment into the WWTP CHP system.						

Implementing agencies and stakeholders

- Vodovod i kanalizacija(ViK) d.o.o. – City-owned water management company.
- Gradska toplana d.o.o. – City-owned DH company.
- City of Karlovac – various departments.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City budget.
- State budget – through Croatian Waters.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Utilisation of waste heat and consumption within the DH.
- Reduced energy consumption and GHG emission reductions.
- Cost savings due to waste heat recovery.
- Cost savings on sludge removal and turning it into revenue generating feedstock.

Enabling strategic framework

- ViK Strategic Plan 2021-2025.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.
- National relevant regulation framework.

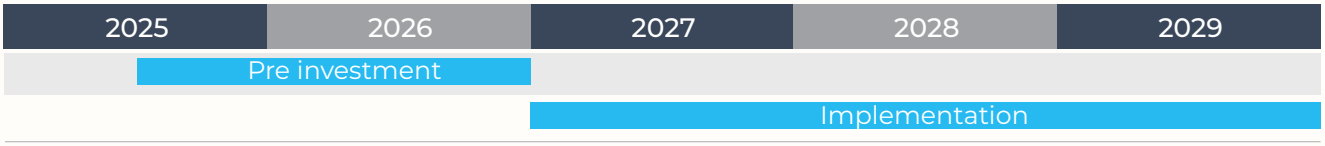
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Medium	WWTP has digitalisation aspects integrated already such as Intelligent control mechanisms and live tracking. Opportunity to integrate new systems into the system and overall City's digitalisation efforts will be investigated through the study development.
Gender and inclusion considerations	N/A	

W4: Increase climate resilience against flooding in the City of Karlovac

Type of action
INVESTMENT

Budget
5,450,000 EUR



Purpose

Increase capacity for response to climate resilience and ensuring the sewage system has capacity for current and future climate profile.

Lead implementer

ViK d.o.o.

Description

The action includes the introduction of the Early Warning System (EWS) vigilant tracking of water levels and swift reaction when there is a threat of flooding and investment in the modernisation and expansion of the drainage infrastructure (6 spillways and approx. 15,000 m^2) of permeable surfaces. The EWS system will be promoted through awareness raising campaign.

Benefits

- Avoided losses due to timely given information and climate resilience capacity increase.
- Less vulnerability to stormwater.
- Groundwater and overall water quality protection.
- Data gathering and data management.

Outputs of the action

- Technical EWS documentation.
- EWS implemented.
- 1 Awareness raising campaign.
- Feasibility assessment – technical documentation for spillover mitigation.
- 6 spillways.
- 15,000 m^2 of permeable surfaces.

Financing needs

- Development of the technical documentation for the EWS system implementation – 30,000 EUR.
- Implementation of the EWS – CAPEX: 2,000,000 EUR, OPEX: 100,000 EUR/y.
- EWS awareness raising campaign – EUR: 100,000.
- Feasibility assessment of the drainage systems and location determination for spillways and permeable surfaces – 20,000 EUR.
- Implementation of the rainwater water spillways and permeable surfaces – CAPEX: 3,300,000, OPEX: 60,000 EUR/y.

Baseline

Given its proximity to four rivers (the Kupa, Korana, Mrežnica, and Dobra), Karlovac is particularly susceptible to fluvial flooding and sewage spillovers.

GCAP transformational change

The action will ensure that the EWS implemented provides timely information and guidance on actions to be undertaken in case of a risk. Furthermore, this action will ensure that the spillover is mitigated with more resilience.

Synergies with other actions

W2, L2. CS1, CS2, CS3

Contribution to Strategic Objectives

SO 3.1 and SO 3.2.

GHG reduction potential

N/A

Action description

This action boosts Karlovac's climate resilience through a coordinated approach combining early warning, community awareness, and infrastructure upgrades. The Early Warning System (**EWS**) enables real-time monitoring and swift response to rising water levels, working seamlessly with drainage upgrades to manage excess rainwater via remote-operated spillways. A public awareness campaign further strengthens this system by equipping residents with essential information to respond to flood alerts.

This action envisages two components:

1. Reducing the risk of flooding in municipal water systems through introduction of EWS.

- Systematic monitoring of weather conditions using stations and prediction software.
- Installing sensors to track groundwater, surface water, and stream flows for early detection of rising levels. To maximise the smart potential of this initiative, the action will include the development of a combined hydraulic model that accurately simulates the interaction between the river system/watershed and the city's drainage infrastructure. This model would integrate real-time data from the deployed sensors and other sources to predict flood events more accurately.
- Development of communication pathways for alerts in partnership with the National Meteorological and Hydrological Service (**DHMZ**) and Croatian Water Authority, aiming to design systems capable of sending out warnings through various mediums, including text messages, emails, and digital platforms.

As indicated, deploying the EWS will necessitate collaboration with DHMZ and the Croatian Waters A. The municipality will set up consistent coordination meetings and establish reporting protocols related to flood management with these national agencies. This is particularly vital with the national water authority, which has oversight over such issues. The goal is to embrace a data-driven methodology in interactions with these national entities.

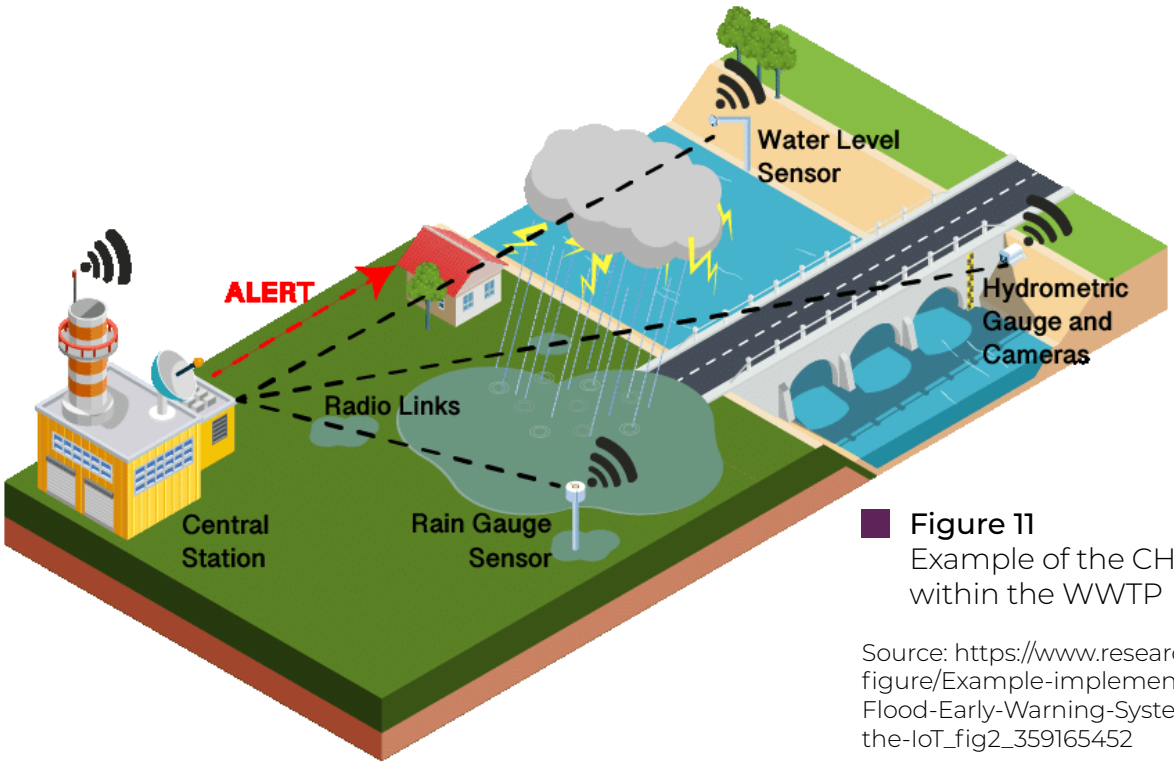


Figure 11
Example of the CHP unit within the WWTP

Source: https://www.researchgate.net/figure/Example-implementation-of-a-Flood-Early-Warning-System-based-on-the-IoT_fig2_359165452

This action will also include a targeted public awareness campaign. Its objective is to disseminate essential information regarding flood risk, EWS, and response practices through leaflets included with monthly water utility statements. The materials provided will cover:

- In-depth explanations of flood risks, covering potential consequences for property, infrastructure, and individual safety;
- Comprehensive insights into the EWS, detailing its functions and the steps taken during alerts; and
- A thorough, sequential manual on the actions to take upon receiving a flood warning, which encompasses evacuation pathways, preparation of emergency supplies, and safeguarding of assets.

2. Investments in the modernisation and expansion of the drainage system to increase capacity and reduce the risk of spillover.

This element of the action involves investment in the modernisation and expansion of the drainage infrastructure, which is intended to enhance capacity and decrease overflow potential. This initiative includes developing and setting up 6 spillways for rainwater that feature remote operation capabilities. The cost for each system is projected to be approximately 500,000 EUR. The action will also involve the implementation of permeable surfaces where applicable. Locations are to be determined through the L1 action. It is expected that 15,000 m^2 will be covered during the period of the GCAP.

Spillways are engineered to regulate and channel the surplus of rainwater to avert flooding and soil erosion. They play a key role in safely directing excess rainwater from urban surfaces to downstream locations.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of the technical documentation for the EWS system implementation.	Pre investment costs	Technical EWS documentation.	30,000	Estimated at 60 expert days.
Implementation of the EWS.	CAPEX	EWS.	2,000,000	Assumption based on similar projects.
	OPEX	OPEX EUR/y.	100,000	Estimated as 5% of the CAPEX.
EWS awareness raising campaign.	Awareness raising campaign	1 Awareness raising campaign.	100,000	Estimated as 25,000 EUR over the period of 4 years.
Feasibility assessment of the drainage systems and location determination for spillways and permeable surfaces.	Pre investment cost	Feasibility assessment – technical documentation for spillover mitigation.	20,000	Estimated at 40 expert days.
Implementation of the rainwater water spillways and permeable surfaces.	CAPEX	6 spillways; 15,000 m^2 of permeable surfaces.	3,300,000	Estimated as 500,000 EUR each spillway and 20 EUR m^2 of permeable surfaces.
	OPEX per year	EUR/y.	60,000	Estimated as 2% of the investment.
TOTAL	CAPEX		4,630,000	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development and selection of the service provider for feasibility study – EWS.						There is a potential for continuation of investing into spillways and permeable surfaces after the GCAP implementation period. Feasibility assessments will define the potential and workplan.
Development of the feasibility study and technical investing data - EWS.						
ToR development and selection of the service provider for feasibility study – Spillways and permeable surfaces.						
Development of the feasibility study and technical investing data - Spillways and permeable surfaces.						
Implementation of the EWS system.						
Investing into spillways and permeable surfaces.						
Development of EWS public awareness materials.						
Conducting ESW public awareness campaign.						

Implementing agencies and stakeholders

- ViK d.o.o. – City-owned water management company.
- City of Karlovac.
- DHMZ.
- Croatian Waters.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City budget.
- State budget – through Croatian Waters.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Avoided losses due to timely given information and climate resilience capacity increase.
- Less vulnerability to stormwater.
- Groundwater and overall water quality protection.
- Data gathering and data management.

Enabling strategic framework

- ViK Strategic Plan 2021-2025.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.
- National relevant regulation framework.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Medium	The action includes the deployment of critical monitoring infrastructure and the establishment of an advanced EWS, with recommendations for the integration of a combined hydraulic model and the sharing of data on an open platform to fully realise the smart potential of this initiative included in the CAPEX.
Gender and inclusion considerations	This initiative will guarantee that every member of the community, especially those from underrepresented groups and women, will have access to up-to-date and reliable information about flood risks and the EWS.	

4.4 Solid Waste

4.4.1 Introduction to sector and overview of key challenges

The sector

In the area of the City of Karlovac, the collection of municipal waste is entrusted to the company Čistoća d.o.o. Karlovac, located at Gažanski trg no. 8. The public service of municipal waste collection includes the collection of waste at the user's billing location (doorstep) and encompasses the collection of mixed municipal waste, biowaste, recyclable waste (waste paper and cardboard, waste plastic, waste metal, and waste glass), and bulky waste. The municipal waste collection service also includes waste disposal at recycling centers or mobile recycling centers, as well as the transportation and handover of waste to an authorized entity.

The municipal waste collection system in the area of the City of Karlovac consists of:

- A "door-to-door" municipal waste collection system;
- A waste collection system on public surfaces;
- A waste collection system through recycling centers and mobile recycling centers; and
- A system for the collection of bulky waste.

The waste collection system based on the "door-to-door" model requires each user to act more responsibly, as waste collection is conducted according to a precise schedule, and each user is responsible for the contents of their waste container and its cleanliness. Containers for mixed municipal waste have been distributed to all users. Residents of multi-apartment buildings are provided with containers for paper and cardboard, plastic, metal, glass, and biowaste. For users in suburban areas of the City of Karlovac, composters (home composting) are provided for the disposal of biowaste. Composters have been made available to more than 4,000 users.

In public areas, there are containers for collecting waste glass (glass bells), waste metal, waste plastic, and waste paper. In the City of Karlovac, there are glass bells located at 80 sites, while waste metal can be disposed of in 53 metal containers. Containers for paper/cardboard packaging and containers for waste plastic are located at the billing locations of service users.

The City of Karlovac has two recycling centers: one at the "Ilovac" landfill under rehabilitation and another in the industrial zone Jug-Mala Švarča. The company Čistoća d.o.o. Karlovac also operates one mobile recycling center. The recycling center at Ilovac, Zagrebačka 17d (registered in the registry of recycling centers under number REC-72-G-1), began operations in November 2016. The Mala Švarča recycling center, at Ulica dr. Slavka Rozgaja 5a (registered under number REC-72-G-2), started operations in October 2019. The mobile recycling center (registered under number REC-72-M-1) visits each settlement in the Karlovac area three times a year, except for the Karlovac settlement itself.

Users (citizens) can bring bulky waste to the recycling center and, once a year, request the removal of bulky waste from their billing location free of charge.

The WMC for the Karlovac County "Babina Gora" is currently under construction. This WMC is based on the principles outlined in the Waste Management Plan of the Republic of Croatia for the period 2017-2022. This project will establish an organised and economically viable means of waste disposal across the entire area of Karlovac County.

While waiting for the WMC to become operational, the City of Karlovac uses Ilovac landfill for disposing MSW. In operation since 1978, the landfill has seen the disposal of over 800,000 m^3 of municipal solid waste and various inert materials. Remediation efforts have been applied to part of the site, along with the implementation of an active gas extraction system that includes a high-temperature flare for gas combustion. The landfill is presently in the process of remediation and closure, but it will remain functional until the Waste Management Centre is projected to commence operations in 2027. Also, the landfill area has a mobile recycling yard that citizens may use.

Key challenges

The identified key challenges are as follows:

1. Total municipal solid waste generation per capita is relatively high;
2. Proportion of organic waste separated is too low;
3. Proportion of dry recyclables separated is too low; and
4. The construction of the WMC is expected to address sectoral challenges. However, there is potential to improve waste policies at the City level, particularly focusing on measures to encourage waste separation and reduce waste.

4.4.2 City's current activities

The City of Karlovac has adopted a Waste Management Plan covering the period from 2017 to 2022, in accordance with national waste management strategies and legislative requirements. This plan remains effective until January 1, 2024, or until the adoption of a subsequent Waste Management Plan for Karlovac County. The current plan outlines key initiatives aimed at minimising and preventing waste, including:

- Execution of actions within the Waste Prevention Program;
- Implementation of educational and informational activities; and
- Organisation of community waste collection events.

The City is also engaged in ongoing awareness-raising drives to enhance public knowledge regarding waste minimisation and preventative practices.

It is worth reiterating that the regional Waste Management Centre (WMC) Babina Gora will play a pivotal role in resolving pressing waste-related challenges within Karlovac. Intended to cater to the needs of Karlovac County (encompassing 5 cities and 17 municipalities), the northeast segment of Lika-Senj County (1 City and 3 municipalities), as well as the western sector of Sisak-Moslavina County (1 City and 2 municipalities), the WMC is anticipated to process upwards of 30,000 tons of assorted municipal solid waste per annum. The WMC is being built over a 30-hectare area and includes several key components: storage area for bulky and other recyclable waste; a mechanical-biological waste treatment facility with halls for mechanical processing, composting, and odour control; a processing area for construction and demolition waste; a landfill for non-hazardous waste (Subcategory 2)

for stabilised waste fractions; a landfill for inert waste from construction debris; a system for stormwater and wastewater collection and purification; a gas collection and treatment system; and a dedicated space for bulky waste processing.

4.4.3 Sector's strategic objectives and targets

The following are strategic objectives for the solid waste sector in Karlovac:

Strategic objective 4.1.
Develop and strengthen a modern system for waste management based on a "zero-waste" model.

The goal is to fully leverage the upcoming establishment and operation of the Waste Management Centre in the forthcoming years. Concurrently, the City intends to prime the entire waste management process for this development. This involves a strong focus on adopting a "zero-waste" approach.

Currently, the City possesses recycling facilities and practices household waste segregation according to waste categories. Yet, it is critical to guarantee that this existing infrastructure and its procedures are expanded, improved, and integrated into a coherent and effective system that embodies the concepts of a circular economy.

Strategic objective 4.2.
Accelerate, encourage, build capacity, and monitor circular economy related solutions, especially recycling and reuse of materials and waste.

This objective is designed to implement circular economy strategies that will result in a highly efficient waste management system. The focus is on implementing solutions that facilitate the reuse and recycling of materials and waste.

Likewise, in the water sector, it is essential to strengthen and develop the capabilities of the main actors associated with the circular economy and to foster awareness to minimise waste production at its source.

4.4.4 Solid Waste GCAP actions

4.4.4.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 4.1 – Develop and strengthen a modern system for waste management based on a "zero-waste" model.			
SO 4.2. - Accelerate, encourage, build capacity, and monitor circular economy related solutions, especially recycling and reuse of materials and waste.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target	Final target
Total solid waste generation.	346 kg/year/capita	250 kg/year/capita	200 kg/year/capita
Proportion of dry recyclables.	13%	40%	65%

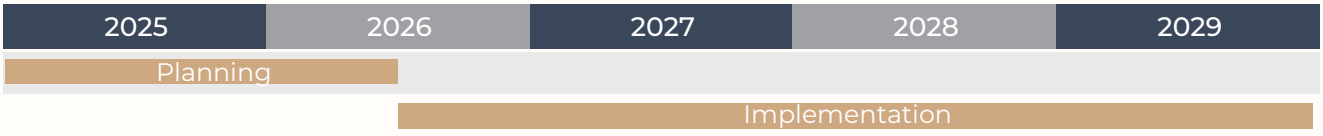
4.4.4.2 List of actions

Action code	Action title	Action type	Main implementing stakeholders	Action required budget (EUR)	Timeframe	GHG reduction potential - total over lifetime of investment
SW1	Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.	Investment (TA only)	Čistoća d.o.o.	350,000	2025-2029	Undetermined at this stage
SW2	Feasibility assessment and landfill gas plant construction at Ilovac post-closure.	Investment	Čistoća d.o.o.	5,100,000	2025-2028	40,366 tCO2eq
SW3	Improving municipal solid waste separation at the source level.	Policy and Investment	Čistoća d.o.o.	1,000,000	2025-2028	Undetermined at this stage

SW1: Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.

Type of action
INVESTMENT

Budget
350,000 EUR (TA only)



Purpose

Organising and conducting series of public awareness related initiatives in order to decrease waste generation and capacity development of Čistoća d.o.o.

Lead implementer

Čistoća d.o.o.

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

Conducting a comprehensive variety of awareness raising initiatives that include repair and reuse related fairs, thematic workshops on reduction of waste generation, and finally, circular economy related capacity development of Čistoća d.o.o. staff.

Benefits

- Reduction of waste generation and landfill disposal.
- Increase in waste reuse and recycling.
- Enhanced public awareness,
- Improved access to services like repair and recycling.
- Potential for local market stimulation and job creation.

Financing needs

- Fairs on reuse and reduction of waste generation for citizens – 150,000 EUR.
- Thematic workshops on reusing materials and minimisation of waste creation – 80,000 EUR.
- WMC Informative tours – 20,000 EUR.
- Capacity building of Čistoća d.o.o. staff – 100,000 EUR.

Outputs of the action

- 8 fairs in total (2 per year).
- 4 thematic workshops.
- 2 WMC informative tours.
- Capacity assessment and training programme.

Baseline

The City of Karlovac has engaged in numerous educational and informational initiatives aimed at the public, running them on an ongoing basis. Regardless of these endeavours, there has been no significant decrease in the volume of municipal solid waste, and the levels of separately collected recyclable materials remain inadequate. Furthermore, there is a gap in the capacity of Čistoća d.o.o.

GCAP transformational change

This action will ensure that circular economy related information are disseminated in the efficient way and that the behavioural based waste generation is achieved. Also, the circular economy related capacity of Čistoća d.o.o. will be increased which may lead towards the identification and implementation of additional relevant projects, after GCAP implementation period.

Synergies with other actions

SW3, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 4.1 and So 4.2

GHG reduction potential

Undetermined at this stage

Action description

The City of Karlovac has engaged in numerous educational and informational initiatives aimed at the public, running them on an ongoing basis. Regardless of these endeavours, there has been no significant decrease in the volume of municipal solid waste, and the levels of separately collected recyclable materials remain inadequate. Consequently, it is imperative for the City of Karlovac to bolster public consciousness and enhance its own internal capabilities to carry out GCAP measures within the framework of a circular economy.

The circular economy is a sustainable model centred around minimising waste and pollutants, extending the lifespan of materials, and safeguarding natural ecosystems. This approach encompasses activities like repurposing products, repairing items, sharing, donating unwanted items, and recycling existing products and resources to maximise value and minimise new raw material consumption. To apply the circular economy principles in waste management, a holistic strategy that integrates waste prevention, recycling, composting, energy recovery, and reuse is necessary. It is vital to educate both corporations and individuals for the effective implementation of this model. Utilising a mix of information campaigns, education programs, training sessions, incentives, and digital solutions can greatly aid in fulfilling the objectives of the circular economy and promoting sustainability.

This action is divided into multiple elements:

- Throughout the calendar year, two comprehensive three-day fairs should be held in different City districts, orchestrated in collaboration with local services, businesses, and non-governmental organisations centred on the themes of waste reduction and reuse.
- In addition, a series of four specialised workshops aimed at residents will take place, focusing on the principles of reusing materials and minimisation of waste creation. These sessions will inform attendees on how to repurpose pre-owned items, including the restoration of antique furniture, finding alternate uses for common objects, and crafting new garments or other useful items from discarded textile materials. These awareness raising events will be organised alongside nonprofits, local tradespeople, and private sector companies.
- In partnership with KODOS Ltd., conduct two informative tours during and subsequent to the pilot phase of the Babina Gora Waste Management Centre's launch. These tours are intended to inform citizens about the significance of responsible waste sorting, with an overarching goal of fostering greater community awareness regarding effective waste management practices.
- Ultimately, the initiative anticipates an evaluation of the existing capacities within the City of Karlovac and Čistoća d.o.o. regarding their circular economy practices. Following this analysis, a customised training program will be developed, drawing from the best methods within the sphere of the circular economy.

The purpose of these activities is to strengthen the capacity of staff and enable them to promote, raise awareness, and conduct campaigns that advocate for the circular economy. The training program aims to equip staff with the necessary expertise and resources to implement informational and awareness raising campaigns targeting individuals and organisations around the project area.

The focus will be on fundamental tenets of the circular economy and imparting practical knowledge in areas such as:

- Minimising waste production, particularly through product reuse.
- Strategies for decreasing waste associated with packaging, plastics, food, electronics, and textiles (How to empower consumers and the consumer society as a whole).
- Promoting use of recyclable or reusable products.
- Advancing the sorting and separate collection of waste by categories (plastics, paper, glass, metal).
- Instruction on appropriate sorting techniques to enhance recycling rates, ensure cleaner recyclables, and improve the quality of recycled materials.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Fairs on reuse and reduction of waste generation for citizens.	Technical Assistance	8 fairs in total (2 per year).	150,000	Estimated at 18,750 EUR per fair – over the period of four years.
Thematic workshops on reusing materials and minimisation of waste creation.	Technical Assistance	4 thematic workshops.	80,000	Estimated at 20,000 EUR per thematic workshop.
WMC Informative tours.	Awareness raising	2 WMC informative tours.	20,000	Estimated at 10,000 per tour.
Capacity building of Čistoća d.o.o. staff.	Technical Assistance	Capacity assessment and training programme.	100,000	Approx. 200 expert days – based on similar initiatives.
TOTAL	CAPEX		350,000	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Development of the fair plan and programme.						There is a possibility to continue similar activities after GCAP timeframe – depending on the needs. The need for electronic equipment repair centre will be gauged once the action is completed.
Contracting fair service providers.						
Conducting fairs.						
ToR development, and contracting workshop service providers, development of workshop materials.						
Conducting of thematic workshops – decreasing of waste generation.						
Coordination with KODOS d.o.o. and informative tours plan development.						
Conducting of informative tours at WMC.						
ToR development and service provider contracting – Čistoća capacity development.						
Capacity assessment and training materials development.						
Conducting of staff capacity development.						

Implementing agencies and stakeholders

- City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.
- Čistoća d.o.o. – City-owned waste management company.
- KODOS Ltd. – WMC management company (Partner of the project).
- NGOs (Partners of the project).

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City of Karlovac.
- Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).

Key benefits

- Reduction of waste generation.
- Reduction of the amount of waste disposed at the ''Ilovac'' landfill.
- Increase of the reuse of waste.
- Increase in the quantity of the separately collected recyclable waste.
- Increased awareness of residents about the economic and environmental benefits of reuse and waste segregation.
- Improves residents' access to basic services such as repair of household appliances / bicycle service, etc.
- Residents' will acquire practical knowledge how to reuse existing items.
- There is a potential for the action to stimulate the local markets to encourage private investors or NGOs to start waste recovery centres.
- A moderate level of job creation may be possible.
- Implementing digital platforms for tracking and managing material use and waste generation will significantly reduce waste and improve resource efficiency.

Enabling strategic framework

- Waste Management Plan of the City of Karlovac for the period 2017 – 2022.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.

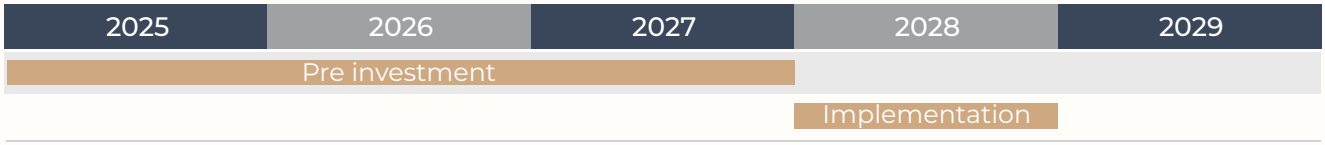
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Possible implementation of digital platforms for tracking and managing material use and waste generation will be explored – currently not part of the CAPEX.
Gender and inclusion considerations	By implementing this measure, every community member, irrespective of gender or economic status, will have an equitable chance to engage in waste minimisation activities and learning opportunities, enhancing inclusivity and diversity, in the local area. Moreover, this approach will cultivate collective participation and cooperation as it brings together local services, artisans, organisations, and corporate stakeholders at events like waste reduction markets, workshops, and instructional excursions, instilling a communal sense of duty and collective stewardship over waste management processes.	

SW2: Feasibility assessment and landfill gas plant construction at Ilovac post-closure

Type of action
INVESTMENT

Budget
5,100,000 EUR



Purpose

Utilisation of the waste to energy potential from the Ilovac landfill and thus reducing GHG emissions from the sector.

Lead implementer

Čistoća d.o.o.

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action aims at utilising the landfill gas potential of Ilovac landfill after its closure. There is a potential to exploit landfill gas for energy production over the next several decades. The action will develop feasibility study and will result in investing into 1.2 MW landfill gas energy recovery CHP plant, based on the study findings.

Benefits

- Utilisation of landfill gas and producing energy from wate. Reduction in GHG emissions as the landfill gas would not emit into atmosphere.
- Involvement of private sector and job creation opportunity.
- Increase of renewable energy capacity within the City.
- Potential to use heat and electricity directly from the plant.

Financing needs

- Feasibility Assessment of introducing Ilovac landfill gas energy recovery plant – 100,000 EUR.
- Construction of a landfill gas recovery plant at Ilovac landfill – CAPEX: 5,000,000 EUR, OPEX: 100,000 EUR/y.

Outputs of the action

- 1 feasibility study - landfill gas energy production.
- 1.2 MW capacity of CHP landfill gas powered system.

Baseline

Ilovac landfill has been accumulating waste for almost a half a century and is planned for closure in 2027. Landfill gas energy potential might be substantial. Currently, this gas is used burned for safety reasons only.

GCAP transformational change

This action will unlock the full understanding of the Ilovac landfill gas energy potential and will ensure investment into the CHP plant that will utilise landfill gas and produce energy thus securing GHG emission reduction and increased safety.

Synergies with other actions	Contribution to Strategic Objectives	GHG reduction potential
EB4, W3, CS1, CS2, CS3	SO 4.1	40,366 tCO_{2eq}

Action description

Discarded materials in landfills are a major source of methane, a potent greenhouse gas with 28 times the global warming potential of carbon dioxide. The Ilovac landfill is set to close upon the start-up of the WMC. Owing to the considerable volume of organic discards, the site is likely to emit methane for decades to come. The planned measure is designed to harness this potential by capturing the methane emitted, thereby creating valuable energy from waste and simultaneously slashing greenhouse gas emissions by preventing the direct release of methane into the atmosphere. Ilovac landfill in Karlovac is already equipped with a flare gas facility. This means that this facility manages and reduces its emissions of landfill gas, primarily methane, which is produced as organic waste decomposes under anaerobic conditions in the landfill. The flare system is primarily used for safe combustion of the gas, not for a production of energy nor it has such possibility.

Feasibility study

This action aims at upgrading the system in order to introduce energy producing facility. It includes a detailed evaluation of the potential to harness biogas from Ilovac. The feasibility study will be tailored to assess both the technical and economic viability, including an examination of participation by the private sector. Primarily, the study will investigate the practicality of establishing a biogas facility at the Ilovac landfill after its closure.

Investment – landfill gas energy production facility

Upon finalising the feasibility assessment, plans involve converting the Ilovac landfill site into a landfill gas recovery plant. Following its shutdown, it is proposed to construct a facility dedicated to landfill gas conversion with a capacity of approx. 1.2 MW, initially. Depending on the study's findings, this could potentially lead to a multi-year, private-sector-led concession.

The energy content of the produced landfill gas in similar installations ranges between 5.2 to 6.5 kWh per m^3. This amount of biogas is sufficient to provide electricity for approximately 1,000 homes and heat for about 150 homes each year. Within this

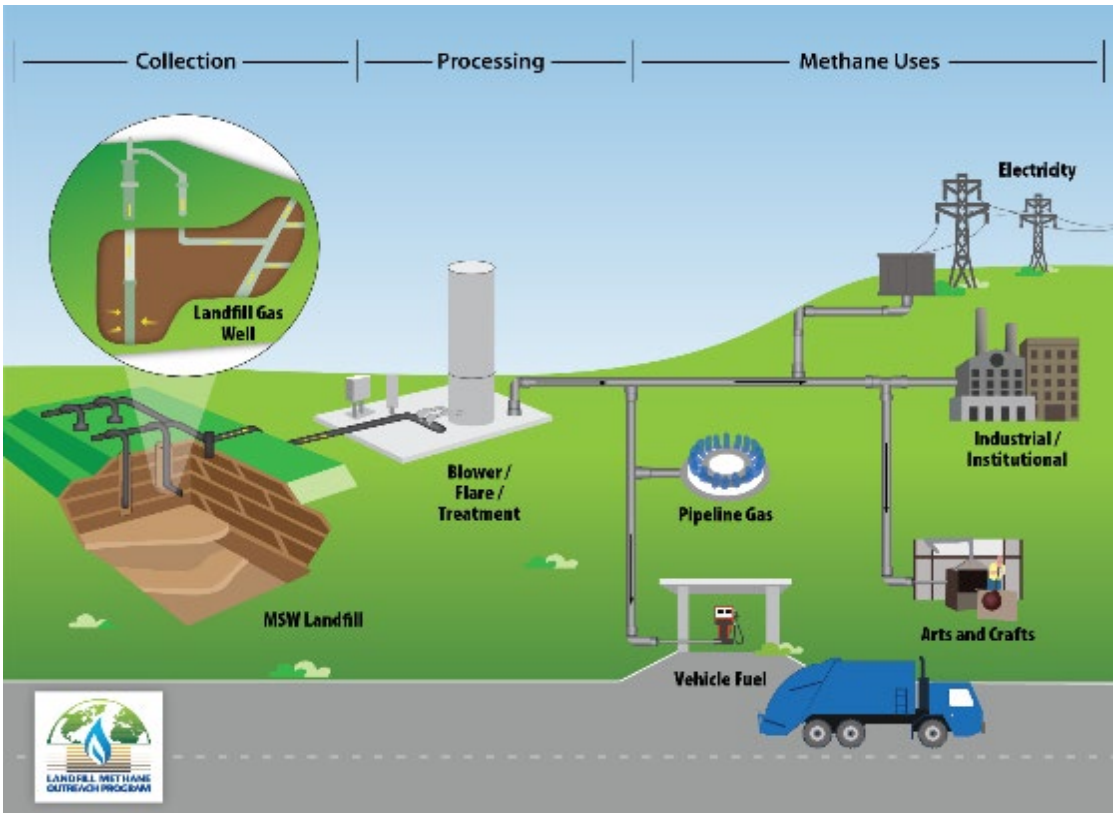


Figure 12 Landfill biogas production scheme

Source: https://www.epa.gov/lmop/basic-information-about-landfill-gas

process, a total of 83.8% of the energy can be effectively utilised through CHP. From this energy generation, an estimated 42.1% contributes to electricity while 41.7% goes to thermal energy. The generated electricity can then be supplied to the electrical grid, and the resultant heat is used in the raw material treatment for landfill gas production. The concrete objective and purpose will be defined via feasibility assessment.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Feasibility Assessment of introducing Ilovac landfill gas energy recovery plant.	Pre investment	1 feasibility study -landfill gas energy production.	100,000	Estimated at 200 expert days.
Construction of a landfill gas recovery plant at Ilovac landfill.	CAPEX	1.2 MW capacity of CHP landfill gas powered system.	5,000,000	Estimation is approx. 4,100 EUR per kW of installed capacity.
	OPEX/y	OPEX for a 1.2 MW CHP system.	100,000	Approx. 2% of the CAPEX – based on similar projects.
TOTAL	CAPEX		5,100,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development and service provider contracting for feasibility assessment.						Not applicable
Conducting of feasibility assessment - study developed.						
Securing project finance and investors.						
Preparation of the construction related technical documentation.						
Construction of the landfill gas CHP recovery system.						

Implementing agencies and stakeholders

- City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.
- Čistoća d.o.o. – City-owned waste management company.
- Private sector investors.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City budget.
- Private investors equity.
- Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions.

Key benefits

- Utilisation of landfill gas and producing energy from wate. Reduction in GHG emissions as the landfill gas would not emit into atmosphere.
- Involvement of private sector and job creation opportunity.
- Increase of renewable energy capacity within the City.
- Potential to use heat and electricity directly from the plant.

Enabling strategic framework

- Waste Management Plan of the City of Karlovac for the period 2017 – 2022.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.

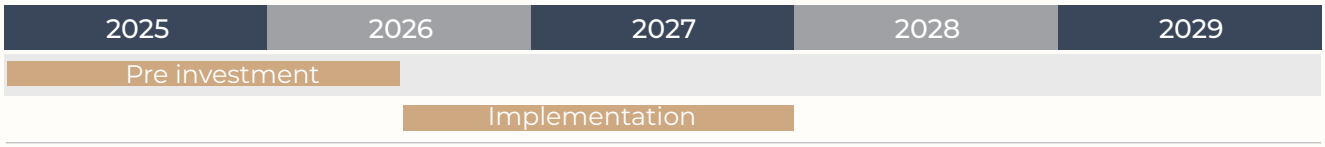
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Medium	Standard digitalisation equipment needed for modern landfill plants. There is potential to share production data with the City.
Gender and inclusion considerations	This initiative will guarantee that women have an equal opportunity to contribute to the feasibility assessment and the decision-making process. It will take into account the specific needs and viewpoints of marginalised populations, such as low-income sectors or ethnic minorities, throughout the planning and execution phases of energy projects – mandatory procurement terms.	

SW3: Improving municipal solid waste separation at the source level

Type of action
INVESTMENT
POLICY

Budget
1,000,000 EUR



Purpose

Implementation of a model that will increase the separation of the municipal solid waste (MSW) at the household level.

Lead implementer

Čistoća d.o.o.

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

This action will implement more efficient MSW separation at the household level in order to increase the share of dry recyclables separation rate. This will be achieved through the implementation of the designated model identified by the feasibility assessment. The model will very likely include procurement of additional waste trucks and other equipment such as bins and containers, including the designated mobile application.

Benefits

- Increase in the quantity of the separately collected dry recyclables.
- Reduction of waste generation.
- Reduction of the amount of waste disposed at the ''Ilovac'' landfill.
- Implementing digital platforms for tracking materials and waste will reduce waste and boost resource efficiency.

Financing needs

- The source MSW separation model feasibility assessment - 50,000 EUR.
- Investment into separation equipment that include collection trucks and designated waste containers/bins – CAPEX: 900,000 EUR, OPEX: 20,000 EUR/y.
- Development of the Čistoća d.o.o. mobile digital application – CAPEX: 50,000 EUR.

Outputs of the action

- Feasibility study on the MSW separation model.
- At least 4 waste trucks.
- Bins and containers.
- OPEX for 4 trucks.
- Designated MSW source separation mobile app.

Baseline

The city uses a segregated collection system for dry recyclables, including “green islands” for apartment residents, dedicated containers for private households, and two recycling centres for pre-sorted recyclables. However, the system’s effectiveness is low, with only a 13% separation rate for dry recyclables.

GCAP transformational change

The action will ensure that the separation model is significantly improved by introducing motivational system for residents. This action will ensure the effectiveness of the entire value chain, once WMC becomes operational.

Synergies with other actions

SW1, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 4.1 and SO 4.2

GHG reduction potential

Undetermined at this stage

Action description

The City currently operates a segregated collection system for dry recyclables, which consists of "green islands" serving apartment residents, dedicated containers for private households, and two recycling centres where individuals can dispose their pre-sorted dry recyclables. Nevertheless, the effectiveness is relatively modest, with only a 13% separation rate for dry recyclables. Thus, to enhance results, the City of Karlovac is looking into implementing a new municipal service targeted at households.

This action is designed to enhance the volume of dry recyclables collected separately by implementing a household level waste separation and collection system for materials like paper and plastic. The project involves conducting a feasibility study which, upon completion, will inform the development of an effective household level waste separation and collection strategy. Part of this initiative's execution includes building the necessary infrastructure through acquisition of vehicles, containers, and bags. Moreover, a digital platform and mobile application will be created to increase public awareness regarding the procedure and timing of waste collection and to track the initiative's success. The action has three components.

1. Feasibility study

The feasibility study will evaluate different models for dry recyclable waste separation and collection, assessing curbside pickup and placement of collection points appropriateness (both are applicable based on various location characteristics). It will assess the financial viability of models specifically for dry recyclables, including which types should be collected, and examine the capacity and efficiency of the system. The objective is to identify the most optimal collection model for various parts of the City.

2. The waste separation model

The action will implement the separation model based on the results of the study. It is expected that this will include implementing a Pay-As-You-Throw (PAYT) scheme for unsorted waste which could lead to reduced fees for residents who generate less non-recyclable trash. The fee savings can be reduced by the appropriate City regulation. For example, monetary savings can be achieved by making it mandatory for residents to purchase designated bags for MSW which include higher cost of disposing non separated waste. For all the other types of waste, Čistoća d.o.o. will provide designated bags and curbside bins/collection points at the normal price included in a monthly bill. The more waste is separated the less demand is for more expensive mandatory bags. The model will include separation of the following waste: plastic, metal, paper, and organic waste.

The final model will be identified during the study development process.

3. Designated digital application

The action will also design and implement designated mobile application. I will serve as a key tool in the waste separation and collection initiative, providing users with real-time information on waste collection schedules, guidelines for proper waste separation, and updates on the action progress. The application will also feature reminders, notifications, and tracking capabilities, allowing users to easily manage their waste disposal and contribute to the success of the initiative.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
The source MSW separation model feasibility assessment.	Pre investment	Feasibility study on the MSW separation model.	50,000	Approx. 100 expert days.
Investment into separation equipment that include collection trucks and designated waste containers/bins.	CAPEX	At least 4 waste trucks. Bins and containers.	900,000	Estimated at 150,000 EUR per truck. Bins and containers worth approx. 300,000 EUR.
	OPEX/y	OPEX for 4 trucks.	20,000	Estimated at 5,000 EUR per truck.
Development of the Čistoća d.o.o. mobile digital application.	CAPEX	Designated MSW source separation mobile app.	50,000	Estimated based on the application development market prices.
TOTAL	CAPEX		1,000,000	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR preparation and contracting of service provider for feasibility assessment.						Potential to improve the system based on the lessons learned during the GCAP implementation and through initial operation of the WMC Babina Gora.
Conducting waste separation feasibility assessment.						
Identification and implementation of the waste separation model – regulation decision.						
Procurement of equipment such as trucks and bins/ containers.						
ToR development and contracting of service provider – mobile application.						
Development and finalisation of the mobile application.						

Implementing agencies and stakeholders

- City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.
- Čistoća d.o.o. – City-owned waste management company.
- General public.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City of Karlovac.
- Environmental Protection and Energy Efficiency Fund (EPEEF).
- European Regional Development Fund (ERDF) / Cohesion Fund (CF).
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions.

Key benefits

- Increase in the quantity of the separately collected dry recyclables and improve the local environment by improving waste management.
- Reduction of waste generation.
- Reduction of the amount of waste disposed at the ''Ilovac'' landfill.
- Implementing digital platforms for tracking and managing material use and waste generation will significantly reduce waste and improve resource efficiency.

Enabling strategic framework

- Waste Management Plan of the City of Karlovac for the period 2017 – 2022.
- Environmental protection program of the City of Karlovac for the period from 2022 to 2025.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Karlovac's proposed waste management system leverages cutting-edge digital tech to boost efficiency and engage citizens. A straightforward app and website provide instant updates on waste pickup, recycling tips, and drop-off locations – included in the CAPEX.
Gender and inclusion considerations	The initiative will prioritise the implementation of a "doorstep" waste separation system that is fully accessible to everyone, encompassing residents with disabilities, the elderly, and households that face mobility challenges. The design of both the physical infrastructure and the associated digital platform will be tailored to serve the varied requirements of all users, ensuring simple operation. Moreover, it will actively involve local residents, community groups, and stakeholders in shaping the waste separation system, to accurately reflect the needs and concerns of the neighbourhood.	

4.5 Land Use

4.5.1 Introduction to sector and overview of key challenges

The sector

Karlovac is famed for its Zvijezda district, the historic core established in the 16th century with its unique star-like layout designed as a Renaissance fortification. Despite being of significant typological and historical value, Zvijezda confronts various issues including an aging demographic and deteriorating architecture. As Karlovac grew over time, it incorporated elements from different eras, leading to a cityscape with diverse historical layers. Presently, the City exhibits a notably low population density while simultaneously expanding the built-up area through greenfield investments, mainly including individual houses, residential complexes and commercial facilities situated in the peri-urban and suburban zones of the City.

There is considerable potential for capitalising on Karlovac's heritage core, Zvijezda, by way of urban revitalisation. The City's GUP promotes the integration of mixed-use developments, dedicating at least 32% of building zones for such purposes.

In terms of density, Karlovac has a relatively sparse population within its limits. Moreover, the urban area covered by the GUP typically maintains a satisfactory balance of green spaces, reflecting the commitment to land use planning that ensures the prevalence of these natural areas. The National Program for the Development of Green Infrastructure in Urban Areas, which runs from 2021 to 2030, plays a pivotal role in enhancing the integration of green infrastructure across the City.

There are potential heat island issues during summer months. On the territory of the City of Karlovac there is a part of the ecological network area important for birds (POP 1000001 Pokupski bazen) with an area of about 140 km^2.

Key challenges

The identified key challenges are as follows:

1. While data regarding brownfield potential are not yet available, there are mentions of larger urban regeneration projects in the preparation stages. City officials and stakeholders concur on the need to capitalise on the prospects of brownfield sites. The significant

amount of unoccupied residential spaces also suggests an emphasis on refurbishing existing structures rather than constructing new developments.

2. Karlovac's current sparse population density, along with impractical urban planning, is attributable to extensive depopulation. Additionally, the low density translates into a higher-than-average urban land usage per resident.

3. It is crucial to equalise access to public amenities across Karlovac. The lack of public services in sparsely populated areas contributes to an increased reliance on automobiles for transportation.

4.5.2 City's current activities

Croatia has established a modern and comprehensive already mentioned program for the development of green infrastructure, which defines the typology of green infrastructure in alignment with EU best practices. Consequently, all green spaces within Croatian cities, including Karlovac, are recognized as part of the green infrastructure network, despite their diverse typologies and benefits. In Karlovac, data on green infrastructure exists and has been used in defining GCAP actions. It is noteworthy that there is limited data on green infrastructure's role in climate change adaptation. This gap is expected to be addressed through the forthcoming Green Urban Renewal Strategy for Karlovac.

The municipality is diligently pursuing the transformation of former industrial (brownfield) sites by implementing redevelopment plans for areas like Gaza, Luščić, and ŠRC Korana. In conjunction with these efforts, there is an initiative to create green spaces that will not only enhance the environment but also promote active lifestyles through the development of biking and walking paths.

This strategy is especially critical in light of current challenges such as demographic shifts towards an aging population, escalating costs associated with upkeeping urban infrastructure, and the anticipated decline in European Union funding. These factors underscore the necessity of sustainable urban planning to preserve the established standards of living, which could be compromised by the unchecked development of undeveloped land.

Karlovac emerges as a leader in this domain, pioneering in the integration of SECAPs into the GUP. These guidelines represent an exhaustive framework that evaluates the existing scenario, predicts future demands in energy, and proposes a comprehensive energy-climate strategy, paving the way for holistic energy policy-making in Karlovac's jurisdiction. The methodology for integral energy-climate planning involves a tri-step process: starting with an assessment of spatial-energy needs, followed by crafting SECAP guidelines within Karlovac's GUP, and concluding with thorough consultation and the implementation stages.

4.5.3 Sector's strategic objectives and targets

The following are defined strategic objectives for Land Use sector in Karlovac:

Strategic objective 5.1.
Maintain existing and develop new green infrastructure to ensure environmental, social and economic benefits and improve the city's resilience to the impacts of climate change.

The primary focus of this strategic objective is to underscore the significance of preserving and fully capitalising on the City's extensive green infrastructure that is already in place. Moreover, it highlights the crucial role of strategizing and introducing additional green infrastructure components, particularly with the consideration of climate change effects.

Strategic objective 5.2.
Intensify use and regeneration of existing underutilised urban structures with the aim of achieving higher urban quality and limit the expansion of urban and other construction land.

The strategic goal is to tackle the City's growth requirements through the transformation of underdeveloped City areas. It seeks to incorporate widespread urban greening efforts, aiming to improve the vibrancy and quality of City environments. This includes minimising the consumption of natural spaces during urban expansion, encouraging compact urban development, and supporting sustainable facilities via regulatory measures and City design. The strategy also emphasises safeguarding key landscapes and natural City zones, especially near urban woodlands.

4.5.4 Land Use GCAP actions

4.5..4.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 5.1.– Maintain existing and develop new green infrastructure to ensure environmental, social and economic benefits and improve the city's resilience to the impacts of climate change.			
SO 5.2.-Intensify use and regeneration of existing underutilised urban structures with the aim of achieving higher urban quality and limit the expansion of urban and other construction land.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target	Final target
Population density on urban land.	1,592 inhabitants/km^2	1,500	1,600
Urban construction land area (within GUP limits).	2,450 ha	remains the same	remains the same
Planned urban green infrastructure.	to be calculated (L1)	increase 5 ha	increase 15 ha

4.5.4.2 List of actions

Action code	Action title	Action type	Main implementing stakeholders	Action required budget (EUR)	Timeframe	GHG reduction potential – total over lifetime of investment
L1	Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.	Policy and investment	City of Karlovac – multiple departments.	3,000,000	2025-2029	Undetermined at this stage
L2	Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.	Investment	City of Karlovac – multiple departments.	10,600,000	2025-2029	Undetermined at this stage
L3	Protection and revitalisation of urban forest Kozjača.	Investment	City of Karlovac – multiple departments; Croatian Forests; NGOs.	500,000	2025-2029 and beyond	Undetermined at this stage
L4	Innovative instruments for stimulating use of green infrastructure elements through spatial plans.	Policy	City of Karlovac – A multiple departments.	City's standard procedures budget	2025 - 2026	N/A

L1: Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register

Type of action
INVESTMENT
POLICY

Budget
3,000,000 EUR

Purpose

Supporting systematic green urban renewal in the City of Karlovac with the realisation of the Luščić urban park as part of the large Luščić urban regeneration project.

Lead implementer

City of Karlovac - Administrative Department for Municipal Economy, Traffic, and Local Self-Government.

Description

The action is based on the development of the City brownfield and green infrastructure investment register with the main investment into the Luščić 3 ha urban park within the large new 20ha mixed-use green urban neighbourhood.

Benefits

- Efficient land use with no greenfield land take.
- Creation of green spaces as a part of a new green urban neighbourhood regeneration project.
- Increased property values and improved urban environment.
- Enhanced well-being through access to green spaces and sustainable stormwater management.

Financing needs

- The development of the brownfield and green infrastructure City register – policy component – already contracted by the City.
- Development of Luščić park project documentation – 180,000 EUR.
- Construction of the Luščić park – investment component – CAPEX 2,820,000 EUR.

Outputs of the action

- 1 brownfield and green infrastructure register as a part of Green Urban Renewal Strategy which is separately contracted by the City.
- 1 technical construction project completed.
- 3 ha of a new City park.

Baseline

Recently, the City started the development of Green Urban Renewal Strategy and has existing Landscape Study and the Study of Green Infrastructure Elements. Also, the Luščić project is developed with master planning stage completed. However, no significant investments in this context were undertaken.

GCAP transformational change

The action will ensure that the brownfield and green infrastructure register is developed in order to showcase the benefits and potential of investments into this context, with a goal of securing investment mobilisation. Luščić park will ensure the demonstration effect and will have a significant impact onto the City green area capacity.

Synergies with other actions

T1, EB1, L2, L3, L4, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 5.1 and SO 5.2

GHG reduction potential

Undetermined at this stage

Action description

The action consists of two main components:

1. Policy component

The policy component refers to the analysis of the entire urban area with the aim of identifying the most important and potential locations for brownfield redevelopment projects and the network of green infrastructure projects. As part of this activity, a city register will be created and will include, among other things, property rights aspects, site rehabilitation needs and spatial planning conditions). The same will be done for existing and planned green infrastructure elements within the urban area, having in mind vulnerability to heat islands formation and urban floods due to extreme rainfall events. The basic input for this activity will be the Green Urban Renewal Strategy recently contracted by the City, as well as the existing Landscape Study with the Study of Green Infrastructure Elements. The City will ensure that Green Urban Renewal Strategy is developed in the context of this plan. This component will unlock the understanding of the brownfield and green infrastructure potential, including the pipeline of potential investments. Due to the complex nature of the sector, it is not possible to estimate the potential and amount for mobilised investments.

2. The investment component

The investment component will facilitate the creation of an urban park forest, spanning 3 ha, within the Luščić mixed-use urban regeneration area. The area of this entire strategic project is about 20 ha of very valuable space of the former Luščić barracks on the central axis of the City of Karlovac. The project was developed through several stages, including an urbanistic architectural competition (EUROPAN 2015). This investment has already been conceptually identified and will serve as a demonstration investment and basis for the pipeline of investment being identified in the first component.

The Luščić project, action EB1, includes the construction of a various infrastructure such as kindergarten and elementary school, retirement home, swimming pool, business incubator, hotel with congress centre as well as commercial housing projects in the form of several residential towers. The urban park that is the subject of this action is the central element of the green infrastructure of the future new urban neighbourhood.

The public city park with an area of approximately 3 ha was conceived as a complex system that includes different plant species and the creation of different forest microenvironments. The park is the central area of the Luščić project, which connects all social facilities and forms the backbone of the public space of this part of the City. At the same time, the park represents the final section of an important City axis, whose unbuilt, natural elements tend to connect with the area of Luščić and, in the longer term, with the area of the Kozjača park-forest on the west. Inside the park, areas of bioretention and rain gardens will be realised, as part of the storm water drainage system.

The detailed technical documentation will look at the whole of the Luščić urban regeneration zone in terms of overall phasing, dynamics of construction and logical sequence of works. This especially applies to traffic areas (roads and pedestrians) that border the park and neighbouring land uses as well as utility infrastructure lines.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
The development of the brownfield and green infrastructure city register – policy component.	Policy development costs	1 brownfield and green infrastructure register.	Already contracted	Contracted by the City.
Development of Luščić park project documentation.	Pre-investment	1 technical construction project completed.	180,000	Based on the usual share of the cost of project documentation of this type (roughly 6%), All according to the price list of the architectural and landscape design services issued by the relevant national chambers of engineers.
Construction of the Luščić park – investment component.	CAPEX	3 ha of a new city park.	2,820,000	Approximated at 100 EUR per m^2 which is a typical cost for these type of investments (used in calculations in the National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030).
	OPEX per year	OPEX for 3 ha of city park.	100,000	Estimated by taking into account average costs for groundskeeping, waste management, utilities and similar.
TOTAL	CAPEX		3,000,000	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Development of the city brownfield and green infrastructure register.						The action will result in the register which basically serves as the potential pipeline of future investments. It is expected that those investments will be mobilised in the later phases of the GCAP and afterwards.
ToR development, public procurement, and service provider identification – Luščić park project.						
Development of detailed technical project documentation for the construction of Luščić park.						
Construction of the Luščić park.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.
- City of Karlovac - Administrative Department for Spatial Planning and Implementation of Urban Development Documents.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- National Program for the Development of Circular Management of Space and Buildings 2021-20230.
- National Program for the Development of Green Infrastructure in Urban Areas 2021 to 2030.
- Environmental Protection and Energy Efficiency Fund.
- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions.
- Own funds – City budget.
- Commercial loans.

Key benefits

- More rational use of urban land and lower construction costs (without the need to purchase private land).
- Compact urban form also means lower investment costs and operational costs of maintaining urban infrastructure.
- Urban development with less consumption of greenfield land and preservation of natural green peri-urban areas.
- Proximity to quality green area with recreational facilities can increase the value of surrounding real estate.
- Higher quality of the urban environment with higher air quality and greater climate resilience.

Enabling strategic framework

- Physical Planning Act and Spatial Development Strategy of the Republic of Croatia (2017).
- National Recovery and Resilience Plan 2021-2026.
- National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030.
- National Program for Development of Circular Management of Space and Buildings for the Period 2021 to 2030.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	Karlovac Citywide GIS for wider site analyses and planning, along with digital project management tools, would optimise described project implementation and monitoring of the park (in particular vegetation).
Gender and inclusion considerations	The initiative will prioritise the involvement of all community members, including women, the elderly, youth, and individuals with disabilities, in designing and planning the Luščić Urban Park to reflect a wide array of needs and preferences. This will be required by the procurement calls.	

L2: Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre

Type of action
INVESTMENT

Budget
10,600,000 EUR

2025	2026	2027	2028	2029
Pre investment				
		Implementation		

Purpose

Introduction of green infrastructure and nature-based elements into the already planned SRC project.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

The aim of the action is to mainstream elements of green infrastructure (**GI**) and nature-based solutions (**NbS**) in an already planned SRC Korana project. This GCAP action will ensure the integration of green infrastructure and nature-based elements into the planned project over the area of 8-10 ha, out of total project area of 55 ha. The location within the City allows easy accessibility to many residents and users. Currently, less than 20% of the zone (football stadium and freshwater aquarium) has been realised, all in line with urban plans in power.

Benefits

- Modern, very green sports and recreation centre in an attractive natural environment with additional educational and cultural offer.
- Enhances urban growth, investments and job creation.
- Increases local biodiversity.
- Boosts sustainable tourism.
- Strengthens climate resilience.
- Nature based solutions for stormwater management.

Financing needs

- Development of SRC Korana project documentation – 600,000 EUR.
- Construction works – investment component estimate – CAPEX 10,000,000 EUR.

Outputs of the action

- Project documentation for implementation (without architectural design documentation for facility buildings on green islands).
- Construction works including groundworks, infrastructure and construction of network of walkways with initial landscaping on an area of approx. 8-10 ha.

Baseline

The City has completed the SRC Korana master planning phase (after EUROPAN and master plan architectural competitions) with a strong commitment to apply available environmentally friendly and nature-based solutions in further development of the project, in particular taking care to the resilience to floods and the protection of the sensitive riverine environment.

GCAP transformational change

This action will ensure and support realisation of main green components of the SRC Korana project.

Synergies with other actions

W4, L1, L3, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 5.1

GHG reduction potential

Undetermined at this stage

Action description

The aim of the action is to mainstream elements of GI and NbS in an already planned SRC Korana project. This project covers an area of 55ha on the right bank of the Korana River which is partly developed with existing stadium and freshwater aquarium. Within the 55 ha that this project covers, a number of facilities will be realised, most of them in the form of 15 green islands ranging in size from 0.5 to 4.4 ha.

This action will ensure that the project coverage area includes investments that would result in protection from flooding. This will be ensured through construction of embankments and a network of elevated walkways/bikeways and landscape structures. Raising the level of the walkways to the height above the elevation flooded in the inundation zone, a solution that fully regulates the floodplain, offering safety to future structures throughout the year and offering a panoramic view of the Korana River.

As already mentioned, the project envisaged green islands formed in a way that will carry various facilities, including a fluvial botanical and butterfly garden, as well as diverse sports and recreational facilities. A bathing area is planned on part of the Korana riverbank. The entire area is devoid of cars, as parking takes place along in the southern and eastern access roads.

The local botanical diversity includes over 100 species and cultivars, primarily native species like willow, linden, oak, and ash planned to be planted within the area, Additionally, well-adapted foreign species such as ginkgo and black walnut will be introduced. The variety of species and micro-landscape compositions create diverse spaces, environments, and views. As already mentioned, the SRC project will cover the 55-ha area that includes various investments as presented below:

This GCAP action will integrate green infrastructure and nature-based elements into the planned project over the area of 8-10 ha including the 4 islands which are completely green, without thematic facilities. It is assumed that this would include the internal communication system areas (pedestrian and bicycles) with necessary communal infrastructure. The infrastructure will include use of nature-based solutions for storm water drainage system (bioretention areas and rain gardens). The pedestrian traffic areas are made up of a network of walkways and cycling paths that connect 15 green islands and the facilities that are planned on 11 of them, all surrounded by rich landscaping as described before. The primary task of this GCAP action is the realisation of this phase.

The final choice of project elements that will be realised also depends on land ownership and the process of purchasing privately owned land that has only been partially purchased so far. In addition, the western part of the project area where the existing facilities are located (football stadium and freshwater aquarium) is closer to existing infrastructure lines and better candidate for earlier realisation. Finally, the stages and speed of project implementation will be affected by the construction of a transversal road with a bridge over the SRC to the north towards Korana River. As part of the first step which is the preparation of the project documentation, the detailed phasing of the project implementation will be elaborated.

Figure 13
Korana SRC project illustration
Source: Urbanistic Plan SRC Korana

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of detailed technical documentation based on the architectural competition designs and urbanistic plan in power.	Pre investment	1 set of technical documentation including all GI and NBs.	600,000	Based on the usual share of the cost of project documentation of this type (roughly 6%), all according to the price list of the architectural and landscape design services issued by the relevant national chambers of engineers.
Groundworks including infrastructure construction and construction of network of walkways with initial landscaping (facility buildings not included) on an area of approx. 8-10 ha.	CAPEX	8-10 ha.	10,000,000	Approximated at 100 EUR per m^2 which is a typical cost for these type of investments (used in calculations in the National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030).
	OPEX/y	OPEX for 8-10 ha.	100,000	Estimated at 1% of the CAPEX.
TOTAL	CAPEX		10,600,000	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Coordination on the implementation of the NbS and GI elements into the SRC Korana project.						Depending on the project implementation phasing, construction of facilities on green islands while completed SRC facilities may be operational.
Preparation of detailed project documentation for implementation including the identification and development of NbS and GI elements to be implemented and detailed phasing.						
Implementation / construction of the identified elements within the SRC Korana project.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.
- City of Karlovac - Administrative Department for Spatial Planning and Implementation of Urban Development Documents.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030.
- ITI mechanism.
- Environmental Protection and Energy Efficiency Fund.
- Own funds – City budget.


Karlovac Gradska uprava

Key benefits

- The construction of the centre provides short-term job growth, while its long-term operations will sustain ongoing employment.
- A contemporary urban sports and recreation facility enhances the neighbourhood's appeal to prospective inhabitants and enterprises, fostering urban growth and investment.
- The introduction of a new, state-of-the-art sports and recreation facility set amidst striking natural scenery and supplemented by educational and cultural offerings will greatly enrich the sustainable tourism prospects of the City.
- Implementing green and blue infrastructure within an area prone to flooding will fortify the region's resilience to climate change.

- Local biodiversity will be augmented by varied planting schemes (including ground cover, shrubbery, and trees) and the incorporation of indigenous species to support different local wildlife populations.
- Innovative nature-based methodologies are utilised in the stormwater management system, including bioretention zones and rain gardens.
- National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030.
- This GCAP action contributes to the realisation of the SRC Korana project which was planned through all valid strategic and spatial planning documents of the City of Karlovac.

Enabling strategic framework

- Physical Planning Act and Spatial Development Strategy of the Republic of Croatia (2017).
- National Recovery and Resilience Plan 2021-2026.

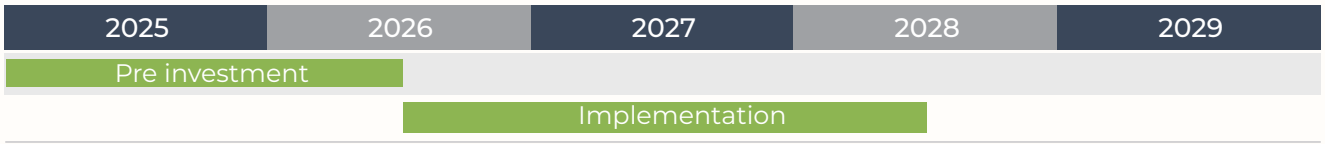
Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	BIM and digital collaboration tools can be leveraged to streamline project documentation and management.
Gender and inclusion considerations	This initiative will offer a range of leisure activities catering to various genders and age demographics, encompassing sports competitions, workout sessions, and public gatherings, while adhering to inclusive design principles to guarantee access for individuals with disabilities and senior citizens. Additionally, it will foster engagement among assorted community groups, such as women's clubs, youth associations, and local constituents, to solicit their views on the facilities and features of the SRC. The plan includes enhancing illumination across the SRC to improve security during nighttime and to cultivate an inviting atmosphere for all patrons.	

L3: Protection and revitalisation of urban forest Kozjača

Type of action
INVESTMENT

Budget
500,000 EUR



Purpose

Protection of the valuable nature locationand implementation of visitors' trail system.

Lead implementer

City of Karlovac – Administrative Department for Construction and Environmental Protection.

Description

Formalisation of revitalising and protection of urban forest Kozjača through conducting baseline studies which will be used in the process of establishing formal protection status and preparation of the project documentation for the revitalisation works. The action will involve investments into educational trail systems in the scale of 8-10 km of forest paths and other visitors' infrastructure. Finally, action will undertake public awareness campaign on the importance of Kozjača forest but also on Karlovac GI system in general.

Benefits

- The forest improves the local microclimate, reducing air conditioning use and saving energy.
- Trees capture pollutants, enhancing air quality.
- Urban vegetation cools the area, reducing the urban heat island effect, especially in dense neighbourhoods.
- Well-planned green spaces can significantly enhance Karlovac's climate change resilience.

Financing needs

- Development of park forest baseline studies and implementation project documentation – 80,000 EUR.
- Realisation of visitors' infrastructure and forestry works (closer-to-nature forest management) – CAPEX: 370,000 EUR.
- Raising public awareness on the GI in Karlovac – 50,000 EUR.

Outputs of the action

- 1 set of studies and investment documentation.
- 8-10 km of maintained paths.
- 6-8 educational boards.
- 8-10 rest points.
- Awareness raising campaign.

Baseline

Kozjača forest has not been formally protected and its recreational and educational potential has not been fully utilised and sustainably managed.

GCAP transformational change

This action will ensure formal protection and provide basis for sustainable forest and visitor system management. In addition, awareness raising campaign in order to achieve promotion of the GI system within the City of Karlovac will be implemented.

Synergies with other actions

L1, L2, L4, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 5.1

GHG reduction potential

Undetermined at this stage

Action description

Kozjača forest today is dominantly a forest of mulberry oak (Quercus petraea) and sweet chestnut (Castanea sativa). In addition, the forest has a significant recreational potential, which was previously recognised through the construction of an educational path, which is neglected today. Some parts, in particular the edges of the forest, are threatened by the construction of houses and roads, waste disposal and insufficiently controlled felling.

The protection and revitalisation of the Kozjača urban forest together with the protection of other peri-urban forests (Dubovac, Ilovac, Mogorovo, Kostanjevac) is an important part of the concept of the City's green infrastructure system, especially the formation of the City's green belt.

Kozjača forest, covering over 6 km^2 and located just a 20-minute walk from the City centre, plays a crucial role in mitigating climate change impacts, particularly by providing fresh air to nearby neighbourhoods during warmer months. Recognised for its importance since 1959 when it was designated as a protective forest for Karlovac, this action will ensure to formally protect it as an urban park forest under the national nature protection system.

The objective of this action is to ensure the Kozjača forest is protected and revitalised through the following activities:

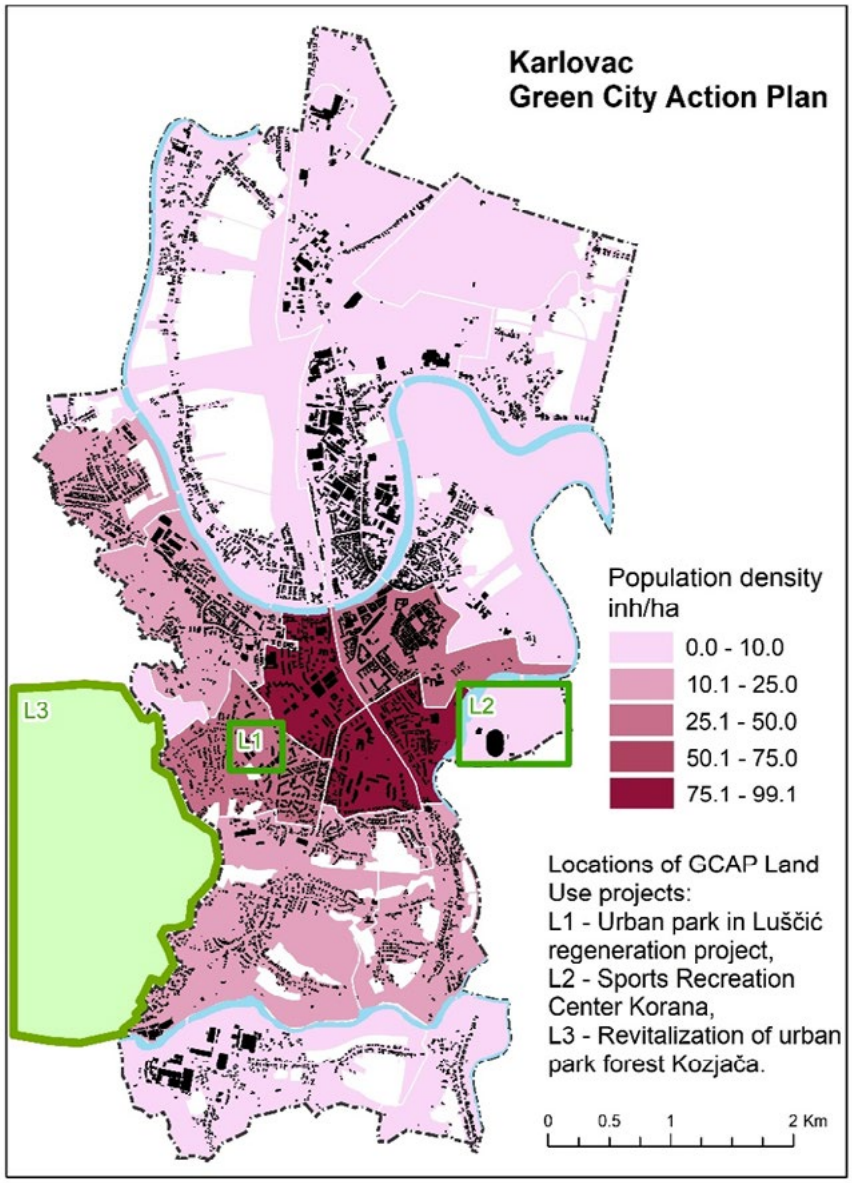
- The first step is the creation of project documentation, which will contain two main parts. The first is a baseline study of the valorisation of the entire park forest area and all its natural values, according to the current state, as a basis for future protection status and sustainable forest management. In this part, for example, the threats will be analysed including construction of houses and roads on the edges of the forest, waste disposal and insufficiently controlled felling. The second part is a revitalisation project that will analyse the visitor system and propose future visitor infrastructure. The starting point is the existing visitor infrastructure, i.e. the renovation of the Kozjača educational trail, which is neglected today. The educational trail is circular and in a longer version 4.5 km long, and 2.3 km in the shorter one. The elevation of the trail ranges from 120 m to 191 m. New educational boards at the beginning and along the trail will be provided with historical overview and general information about Kozjača forest, plant communities and biodiversity that can be found in the forest and on the map paths. Participatory design and management practices will include local communities, stakeholders, and interest groups in planning and maintaining the Kozjača urban park forest. This ensures that the solutions identified align with community needs and values, promoting sustainable and inclusive development.

- The second step is, based on the analysis, the implementation and realisation of the park forest Kozjača revitalisation project including the trail system with installation of educational boards, interpretive signage and rest areas equipment.

A parallel activity will be an on-going process of raising public awareness of the multiple importance of urban park forest Kozjača and, in general, the green infrastructure system in Karlovac and its multiple benefits (environmental, social, economic) for the City. The main messages will be tailored for different groups such as residents, businesses, schools, and local government officials. Depending on the target groups the best communication

channels will be chosen including traditional media (press releases, newspapers, radio, and television), digital media (websites, social media platforms, newsletters) and more direct community engagement (workshops, public meetings, school programs). The content to be communicated include easy-to-understand infographics and visuals, educational materials (brochures, flyers, and fact sheets that explain the benefits and importance of green infrastructure) and possibly interactive tools. The choice of topics for educational materials will be adapted to current activities in the City, for example, the preparation of statutory spatial plans for Karlovac area and/or development planning acts. The area of the Kozjača urban forest is about 630 ha. The length of planned maintained trails and paths is 8 to10 km. In addition, 6 to 8 educational boards and 8 to 10 rest points are planned.

Figure 14
Locations of the L1, L2, L3 and the population density map



Source: Consultant

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of park forest baseline studies and implementation project documentation.	Pre investment	1 set of studies and investment documentation.	80,000	Estimated at 300 expert days.
Realisation of visitors' infrastructure and forestry works (closer-to-nature forest management).	CAPEX	8-10 km of maintained paths; 6-8 educational boards; 8-10 rest points .	370,000	Based on the data for similar projects.
	OPEX/y	OPEX for planned infrastructure.	20,000	Estimated as approx. 5% of the CAPEX.
Raising public awareness on the green infrastructure system in Karlovac.	Raising awareness costs	Awareness raising campaign over 4 years.	50,000	Based on the data for similar projects.
TOTAL	CAPEX		500,000	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development, public procurement, and service provider.						N/A
Development of baseline studies and preparation of investment technical documentation.						
Implementation of identified investment – trail system and forestry works.						
Public awareness campaign on the green infrastructure system in Karlovac.						

Implementing agencies and stakeholders

- City of Karlovac – Administrative Department for Construction and Environmental Protection.
- City of Karlovac - Administrative Department for Spatial Planning and Implementation of Urban Development Documents.
- Croatian Forests.

- IFIs lending mechanisms (such as EBRD, EIB, and others), other financial institutions
- NGOs – focusing on green investments

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Croatian Forests through their regular activities
- EU and national grant programmes, in particular the National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030
- International financial institutions such as the EBRD, EIB and others.
- Own funds – City budget

Key benefits

- Strategically situated, the well-maintained urban park forest of Kozjača has the potential to attract tourists and visitors, consequently supporting local enterprises and stimulating economic growth.
- With its strategic location, the Kozjača forest enhances the local urban microclimate during periods of heat, decreasing the reliance on air conditioning in the warmer months and thus contributing to energy savings.
- The trees within Kozjača are capable of capturing pollutants such as nitrogen oxides, ammonia, sulphur dioxide, and particulate matter, leading to an improvement in air quality.
- Furthermore, the urban vegetation offers shade and releases moisture via transpiration, diminishing the urban heat island effect and cooling the surrounding air, especially beneficial for nearby densely populated areas.
- Thoughtful planning of urban green spaces could greatly increase Karlovac's adaptive capacity to climate change phenomena.

Enabling strategic framework

- Physical Planning Act and Spatial Development Strategy of the Republic of Croatia (2017)
- National Recovery and Resilience Plan 2021-2026
- National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Medium	GIS can facilitate the development of comprehensive urban forest maps, pinpointing the precise location, type, dimensions, and condition of the forest.
Gender and inclusion considerations	This action will guarantee, by procurement call, that measures for the redevelopment and revitalisation of urban areas prioritise accessibility for all citizens, including those with disabilities and seniors, and will include gender-neutral structures and services to meet a variety of necessities. Equally important is the stakeholder engagement of local inhabitants, community organisations, and interested parties in the collaborative planning and governance of the Kozjača urban forest – will be conducted as part of the baseline studies.	

L4: Innovative instruments for stimulating use of green infrastructure elements through spatial plans

Type of action
POLICY

Budget
Regular City budget activities

2025	2026	2027	2028	2029
Policy development				
	Finalisation			

Purpose

Providing incentives for use of green infrastructure elements in spatial planning.

Lead implementer

City of Karlovac –Administrative Department for Spatial Planning and Implementation of Spatial Planning Documents.

Description

This action aims at encouraging and incentivising urban developers to implement measures related to the use of green infrastructure elements on private plots that the urban plan only recommends.

Benefits

- Improved urban landscape with better air quality and climate resilience.
- Proximity to greenery boosts property values and attracts investment.
- Trees absorb and filter rainwater, reducing runoff, erosion, and flood risk.

Financing needs

- Regular City budget activities.

Outputs of the action

- Development of GI incentive scheme regulation.

Baseline

Urban plans often only recommend the use of elements of green infrastructure, such as planting trees along streets and footpaths or in parking lots, leaving it up to developers to follow the recommendation.

GCAP transformational change

This action will offer incentives to developers to follow recommendations from urban plans and plan the use of elements of green infrastructure in their projects.

Synergies with other actions

L1, L2, L3, CS1, CS2, CS3

Contribution to Strategic Objectives

SO 5.1 and SO 5.2

GHG reduction potential

N/A

Action description

Karlovac's urban region is marked by a relatively low population density and some areas experience a lack of public green spaces. The struggle to acquire space for green infrastructure endeavours is a common issue across Croatian cities, stemming from inadequacies within the national spatial planning framework. A prime illustration lies in the provisioning for rows of street trees that necessitate more land due to broader street profiles, leading not only to initial investment surges but also to ongoing maintenance costs. Consequently, City strategies often involve outlining portions of future green spaces on private properties within spatial plans, but only as suggestions rather than firm requirements. This approach effectively leaves the execution of green infrastructure components at certain sites to the discretion of property developers.

Compounded by concerns such as escalating instances of urban flash flooding and the emergence of heat islands, the need to address climate change impacts in Karlovac is critical. The immediate solution appears to be enforcing regulations that mandate a higher calibre of green space and infrastructure standards. In tandem, enhancing public awareness about the benefits of green infrastructure for climate resilience is paramount. Until such mandates come into effect, there is an undeniable call for additional measures to encourage private sector participation in integrating green infrastructure elements which fall outside the scope of compulsory urban planning requirements but are merely advised as best practices.

Cities impose an annual communal charge on properties, which is determined based on factors such as the location and urban utilities standard. Should a developer implement green infrastructure components recommended in the GUP, it could alleviate stress on the stormwater system, enhance the local microenvironment, and provide additional benefits associated with green infrastructure. This supports the proposal to vary the communal fees based on the number of recommended green infrastructure measures enacted.

Encouraging developers to embrace green infrastructure initiatives on their private properties that the urban plan suggests, through such financial incentives, could result in increased implementation of environmentally friendly measures.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of GI incentive scheme regulation.	Policy development costs.	1 set of regulation.	Regular City budget activities.	N/A
TOTAL	CAPEX		N/A	Revenue generating: Yes

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Develop draft regulation in consultation with various stakeholders.						To revise the implementation period and identify potential changes to be implemented to the policy.
Revision and adoption of the regulation.						

Implementing agencies and stakeholders

- City of Karlovac –Administrative Department for Spatial Planning and Implementation of Spatial Planning Documents.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds – City budget.

Key benefits

- Enhancement of the urban landscape, evident through better air quality and increased resilience to climate change.
- Closeness to any form of greenery can boost the value of adjacent properties and draw investments to these zones.
- Trees, along with their roots, play a crucial role in soaking up and purifying rainwater, which diminishes runoff, curbs erosion, and lowers the likelihood of floods.

Enabling strategic framework

- Physical Planning Act and Spatial Development Strategy of the Republic of Croatia (2017).
- National Recovery and Resilience Plan 2021-2026.
- National Program for the Development of Green Infrastructure in Urban Areas for the period from 2021 to 2030.
- However, ensuring the planned green infrastructure system in cities requires systemic implementation instruments that the spatial planning system does not currently provide. This is why additional instruments like the one proposed as an incentive for the realisation of the planned system of urban green infrastructure are needed.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	Medium	Potential to introduce online platforms for managing obligations and data analytics for tracking compliance for biodiversity preservation. Currently, not envisaged within the action.
Gender and inclusion considerations	The initiative is designed to foster the growth of urban GI in a way that ensures equitable access for all, including underrepresented communities and women. Moreover, it entails engaging various sectors of society—women, the youth, and community groups—in shaping and governing the rollout of GI through spatial strategies. All of which will be consulted during the draft phase.	

4.6 Cross sectoral actions

A variety of factors could yield advantages throughout the several areas covered by the GCAP. To prevent redundancy within each sector, this segment has been designed to address those intersectoral concerns.

The initiatives highlighted are aimed at advancing the digitalisation components of the GCAP. This strategy greatly supports not only the oversight and execution of the GCAP but also enhances the broader functions within the City's procedures. A well-organised and detailed monitoring and reporting system is essential. Consequently, there are various strategic goals pertaining to the overarching elements of this GCAP.

Key challenges

The following present some of the key challenges related to digitalisation and data management area in the City of Karlovac:

1. The absence of a unified national strategy for Smart cities has resulted in disjointed initiatives and a lack of unified direction. Moreover, the City is moving from a spontaneous to a structured strategic approach in Smart City leadership and governance, necessitating changes in procedures and mindset.
2. Engaging different participants (City administration, municipal enterprises, private sector, citizens, educational institutions, civil society organisations) with their diverse priorities and objectives poses coordination challenges. Promoting transparency and accountability in the creation and execution of Smart City efforts remain difficult.
3. At present, the City is laying the groundwork for an integrated ICT infrastructure, a complicated yet vital step toward realising Smart City ambitions. Additionally, resources and capabilities for data analysis, as well as investing in essential hardware and software plus upskilling staff in data application, are limited.
4. Presently, the City's capacity to leverage data is inadequate, suffering from siloed and obsolete systems. The captured data is mostly proprietary to the collecting entities and not openly shared or disclosed. Also, there is not a consistent dedication to open data practices, resulting in infrequent updates to any data that is published.

The following are defined cross sectoral strategic objectives:

Strategic objective 6.1.

Establishment of relevant KPIs, monitoring, and coordination of activities needed for achieving strategic objectives.

Enhancing the service by focusing on the development of proficient, low-emission, and climate-adaptive infrastructure and services is necessary. Additionally, optimising the system through intelligent digitisation and functional organisation is essential. This objective is intended to achieve precisely that.

Strategic objective 6.2.

Have an effective and efficient Green Cities coordination, monitoring, and management system in place to drive and coordinate the implementation of KPIs and the Karlovac GCAP successfully.

Creating a robust organisational framework in the City is crucial, comprising adequate, skilled, consistent, and driven personnel to oversee the Karlovac GCAP effectively, supported by sufficient capacity-building assistance. This objective will guarantee that effective engagement with stakeholders is sustained throughout the development of the GCAP, preserving an active exchange with various stakeholder groups and associations as the Plan progresses into its execution stage.

4.6.1 Cross sectoral GCAP actions

4.6.1.1 Strategic objectives and midterm and final targets

Strategic objectives			
SO 6.1.– Establishment of relevant KPIs, monitoring, and coordination of activities needed for achieving strategic objectives.			
SO 6.2.- Have an effective and efficient Green Cities coordination, monitoring, and management system in place to drive and coordinate the implementation of KPIs and the Karlovac GCAP successfully.			
Relevant indicators/ variables	**Targets and values**		
	Current value	Mid-term target	Final target
Portfolio Approach to Project Management "Smart Maturity" is established.	Not established	Fully established	Fully established
Updated Smart City Strategy is developed and active.	No updated strategy	Strategy fully developed and active	N/A

4.6.3.2 List of actions

Action code	Action title	Action type	Main implementing stakeholders	Action required budget (EUR)	Timeframe	GHG reduction potential
CS1	Technical assistance for establishing a portfolio approach to project management "Smart Maturity".	Investment	City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.	50,000	2025-2027	N/A
CS2	Development of an Updated Smart City Strategy.	Policy	City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.	30,000	2025-2028	N/A
CS3	GCAP Web site for monitoring and implementation.	Investment	City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.	50,000	2025-2026	N/A

CS1: Technical assistance for establishing a portfolio approach to project management "Smart Maturity"

Type of action
INVESTMENT

Budget
50,000 EUR

2025	2026	2027	2028	2029
Pre investment				
	Implementation			

Purpose

Improvement of the City's digital management through the implementation of the portfolio approach.

Lead implementer

City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.

Description

The main objective of this action is to implement a portfolio management model for overseeing digital solutions in the City of Karlovac. This will include establishing guidelines for adding and removing projects from the portfolio, reflective of true needs, strategic importance, and budgetary limitations. By embracing a portfolio approach, the City seeks to optimise IT project planning and resource distribution, cut down on upkeep expenditures, and phase out superfluous or obsolete technologies.

Benefits

- Improved efficiency in managing digital resources, reduced maintenance costs, elimination of redundant projects.

Financing needs

- Development of portfolio approach needs assessment with the implementation guidance – 40,000 EUR.
- Training on implementing the portfolio approach – 10,000 EUR.

Outputs of the action

- 1 portfolio management report.
- 2 sets of trainings conducted.

Baseline

At present, despite its significant smart City related improvements, City of Karlovac is overseeing its digital endeavours in a still somewhat fragmented fashion. Individual departments and municipally owned entities conduct their operations autonomously, which has resulted in disjointed efforts and a piecemeal approach to digitisation.

GCAP transformational change

The action will ensure to implement a portfolio management model for overseeing digital solutions in the City of Karlovac. This will significantly improve the efficiency of the managing digital resources.

Synergies with other actions

All the actions

Contribution to Strategic Objectives

SO 6.1

GHG reduction potential

N/A

Action description

At present, despite its significant smart City related improvements, City of Karlovac is overseeing its digital endeavours in a still somewhat fragmented fashion. Individual departments and municipally owned entities conduct their operations autonomously, which has resulted in disjointed efforts and a piecemeal approach to digitisation. This situation has led to inefficiencies that include duplicate undertakings, unnecessary repetition, and an absence of collaborative benefit across different projects. Additionally, the lack of an overarching digital strategy might result in activities that do not align with the City's larger objectives, thus failing to capitalise on the potential of digitalisation to improve municipal services and infrastructure.

The main objective of this action is to implement a portfolio management model for overseeing digital solutions in the City of Karlovac. This will include establishing guidelines for adding and removing projects from the portfolio, reflective of true needs, strategic importance, and budgetary limitations. By embracing a portfolio approach, the City seeks to optimise IT project planning and resource distribution, cut down on upkeep expenditures, and phase out superfluous or obsolete technologies. This orderly process will permit systematic assessment and ranking of digital endeavours to guarantee alignment with the City's strategic objectives and value optimisation.

Moreover, it will promote enhanced interdepartmental and intercompany harmony within City operations, enhancing cooperative efforts in the execution of digital strategies. The technical assistance provided will assist the City in creating necessary methodologies and tools for proficient portfolio management, as well as staff training and establishment of a solid governance structure to guide portfolio oversight and maintenance.

The undertaking calls for the creation of a unified portfolio management framework for the City of Karlovac's digital initiatives. This infrastructure will be instrumental in guiding the City's digital transformation, offering an aggregated perspective on all current and prospective projects. The extent of the project encompasses formulating a governance system, applying portfolio management software, and educating municipal personnel for efficient employment of this infrastructure. The consolidated management platform will permit consistent tracking of each initiative's development, evaluation of its effectiveness, and facilitation of judicious investment decisions. The remit also involves integrating current digital measures into the new arrangement and discontinuing those that are redundant or ineffective. Centralisation of digital project oversight aims to enhance operational efficiency, decrease costs, and make certain that every venture contributes to the overarching aim of improving City services and the quality of life for inhabitants.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Development of portfolio approach needs assessment with the implementation guidance.	Technical assistance	1 portfolio management report.	40,000 EUR	Estimated on the basis of undertaking similar activities.
Training on implementing the portfolio approach.	Technical assistance	2 sets of trainings conducted.	10,000 EUR	Price for two short workshops.
TOTAL	CAPEX		50,000 EUR	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
Assess ongoing and planned digital projects, including those by partially owned companies, to identify overlaps, gaps, and opportunities for improvement.						The portfolio management system might be upgraded based on the needs and availability of the budget/ funding sources.
Develop criteria for selecting projects based on strategic alignment, impact, resources, and financial viability, including guidelines for phasing out projects that no longer meet the city's needs.						
Create standardised processes for adding new projects to the portfolio and retiring those that are no longer relevant, ensuring a dynamic and responsive portfolio.						
Train City staff on the new portfolio management system through 2 workshops.						
Implement the portfolio management system, configure software, migrate data – in the current City system.						

Implementing agencies and stakeholders

- City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds - City budget.
- Urban Innovative Actions[28].
- CIVITAS[29].

Key benefits

- Improved efficiency in managing digital resources, reduced maintenance costs, elimination of redundant projects.

Enabling strategic framework

- Croatian Smart Specialisation Strategy S3 2021-2029.
- Croatian National Development Strategy 2030.
- Digital Croatia Strategy 2032.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	This is completely Smart City related action.
Gender and inclusion considerations	The action will ensure inclusive participation in digital projects, ensuring all groups benefit from digital initiatives.	

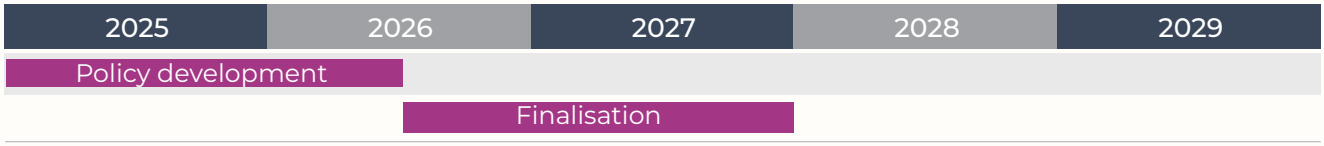
28 - Provides EU funding for pilot projects in urban areas to test innovative solutions addressing issues like poverty, climate change, and housing, encouraging experimentation and knowledge sharing.

29 - An EU initiative that funds and supports cities in implementing innovative and sustainable urban mobility solutions to improve transport systems and reduce traffic congestion.

CS2: Development of an Updated Smart City Strategy

Type of action
POLICY

Budget
30,000 EUR



Purpose

To develop the updated Smart City Strategy built upon previous strategy and its learnings.

Lead implementer

City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.

Description

The initiative is centred around crafting a modern and comprehensive Smart City Strategy for Karlovac. This revamped strategy will supersede the former outdated plan, assimilating knowledge and feedback garnered from previous efforts to align more closely with the municipality's present and prospective needs.

Benefits

- Clear strategic framework that will ensure operational efficiency, promote sustainable urban development, improve public service delivery that will ensure high citizens satisfaction, and foster economic growth.

Financing needs

- Updated Karlovac Smart City Strategy – 30,000 EUR.

Outputs of the action

- Updated Strategy document.

Baseline

Five years ago, the City launched its Smart City Strategy to implement digital solutions for improving life in the City and its operational effectiveness. Since its inception, a number of initiatives have been successfully completed. An updated strategy is now critical to recalibrate the city's ambitions for digital modernisation based on current demands and recent technological progress.

GCAP transformational change

This action will collect insights gained from past efforts, tackling concerns like overlapping projects, the dynamic needs of citizens, and the ever-changing tech sphere. The revised strategy promises a more synchronised and successful deployment of smart City endeavours, encouraging synergy among all sectors and participants in pursuing a collective goal of digital innovation and lasting sustainability.

Synergies with other actions

All the actions

Contribution to Strategic Objectives

SO 6.1

GHG reduction potential

N/A

Action description

Five years ago, the City launched its Smart City Strategy to implement digital solutions for improving life in the City and its operational effectiveness. Since its inception, initiatives have been successfully completed; however, some are still underway, while others have been discontinued due to shifts in priorities. An updated strategy is now critical to recalibrate the city's ambitions for digital modernisation based on current demands and recent technological progress. This update will take into account the insights gained from past efforts, tackling concerns like overlapping projects, the dynamic needs of citizens, and the ever-changing tech sphere. The revised strategy promises a more synchronised and successful deployment of smart City endeavours, encouraging synergy among all sectors and participants in pursuing a collective goal of digital innovation and lasting sustainability.

The initiative is centred around crafting a modern and comprehensive Smart City Strategy for Karlovac. This revamped strategy will supersede the former outdated plan, assimilating knowledge and feedback garnered from previous efforts to align more closely with the municipality's present and prospective needs. Through the integration of actions from GCAP, it aims to provide a unified and systematic framework for the city's smart development. The plan will set definitive goals, articulate meticulous action plans, and establish stringent tracking systems to monitor advancements and adjust as needed. This strategy document will direct all digital undertakings, fostering collaboration between different municipal sectors and optimising resource allocation to enhance outcomes for citizens.

The task involves formulating and applying an evolved strategic guide that outlines the trajectory for Karlovac's smart City campaigns. From inception to implementation and appraisal, this in-depth strategy will govern every facet of smart City evolution. The project's breadth encompasses broad-based stakeholder involvement, comprehensive evaluations of ongoing and historical endeavours, and formulating a precise agenda aligned with local and national objectives for digital progress. With a centralised strategic approach, Karlovac is poised to forge a more cohesive and efficacious digital infrastructure, improving its efficacy and longevity. The forward-thinking strategy will set explicit parameters and benchmarks for choosing projects, guaranteeing each contributes meaningfully to transforming Karlovac into a more interconnected, efficient, and habitable urban space.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Updated Karlovac Smart City Strategy.	Technical assistance	Updated Strategy document.	30,000 EUR	Estimated based on similar activities
TOTAL	CAPEX		30,000 EUR	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development and contracting service provider.						The Strategy itself will provide information on this aspect.
Conduct a comprehensive review of the current Smart City Strategy, evaluating project status, progress, challenges, and effectiveness.						
Facilitate consultations with key stakeholders, including municipal departments, partially owned companies, external consultants, and the public, to gather input on needs and expectations.						
Draft an updated Smart City Strategy based on the review and stakeholder input, outlining clear objectives, priorities, and implementation plans, integrating best practices and lessons learned.						
Revision period and approval of the Smart City Strategy.						

Implementing agencies and stakeholders

- City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds - City budget.
- Urban Innovative Actions[30].
- CIVITAS[31].

Key benefits

- Clear strategic framework that will ensure operational efficiency, promote sustainable urban development, improve public service delivery that will ensure high citizens satisfaction, and foster economic growth.

Enabling strategic framework

- Croatian Smart Specialisation Strategy S3 2021-2029.

Evaluation of Smart City and social inclusion opportunities

Dimension	Elaboration	
Smart City Potential	High	This is completely Smart City related action.
Gender and inclusion considerations	The action will ensure inclusive participation in digital projects, ensuring all groups benefit from digital initiatives.	

30 - Provides EU funding for pilot projects in urban areas to test innovative solutions addressing issues like poverty, climate change, and housing, encouraging experimentation and knowledge sharing.

31 - An EU initiative that funds and supports cities in implementing innovative and sustainable urban mobility solutions to improve transport systems and reduce traffic congestion.

CS3: GCAP Web site for monitoring and implementation

Type of action
INVESTMENT

Budget
50,000 EUR

Purpose

To have a clear, informative, and transparent platform for the implementation of the Karlovac GCAP.

Lead implementer

City of Karlovac – Administrative Department for Economy, City Development, and EU Funds.

Description

The central aim of this initiative is the creation of a web portal that will act as the key platform for the observation and management of GCAP initiatives. This online gateway will provide instantaneous insights into project status, cost efficiency, and the environmental benefits achieved.

Benefits

- Provides comprehensive information and resources on GCAP initiatives, strategies, and sustainability efforts.
- Enhances public awareness, engagement, and education while promoting transparency and accountability.
- Facilitates access to data, reports, progress tracking, and success stories, supporting community and stakeholder collaboration.
- Offers tools and platforms for individuals and organisations to contribute to GCAP projects and sustainable policies.

Financing needs

- Designing and setting up of the GCAP website – CAPEX: 50,000 EUR, OPEX: 10,000 EUR/y.

Outputs of the action

- GCAP related website designed and operational.

Baseline

N/A

GCAP transformational change

Informative GCAP website for monitoring reporting and information dissemination.

Synergies with other actions

All the actions

Contribution to Strategic Objectives

SO 6.1, SO 6.2.

GHG reduction potential

N/A

Action description

Karlovac is committed to improving openness and ease of access regarding its digital endeavours, especially those associated with the GCAP. At present, the absence of a unified platform accessible to the public impedes citizens and interested parties from effectively tracking the development and outcomes of different programs, notably in terms of decarbonisation. The introduction of a specialised online portal will tackle these challenges by offering a transparent and detailed perspective on all current and future projects. This effort is pivotal in building public trust and participation, guaranteeing that everyone in the community can stay informed about Karlovac's actions to lower carbon emissions and encourage environmental responsibility.

The central aim of this initiative is the creation of a web portal that will act as the key platform for the observation and management of GCAP initiatives. This online gateway will provide instantaneous insights into project status, cost efficiency, and the environmental benefits achieved. The site will prioritise ease of use and public interaction through its intuitive design and interactive capabilities. It is set to amalgamate inputs from diverse sources such as IoT devices, administrative tools for project oversight, and financial reporting systems, offering a comprehensive perspective on the city's reduction of carbon emissions. In the spirit of fostering an inclusive community, the portal will be accessible to every individual, accounting for those with varying abilities. To build this informative platform, there will be joint efforts between the City's IT division, third-party web development consultants, and the communications team, to confirm its functionality and user experience.

This venture encompasses establishing and continuously updating a detailed web portal for the City of Karlovac, from constructing the foundational infrastructure to integrating current data streams and supervising apparatuses, constantly refining the site in response to user input. The magnitude of this project demands both substantial technical proficiency and methodical planning. It includes developing a sturdy back-end framework able to manage extensive data sets, implementing a front-end platform that prioritises accessibility, and adopting meticulous privacy measures to safeguard personal data. As a locus for all details about GCAP activities, the portal will foster enhanced accountability and transparency. Its implementation and upkeep will hinge on perpetual collaboration amongst municipal entities, expert external advisors, and communication specialists to ensure its enduring relevancy and operational viability.

Investment Costs

OUTPUT	TYPE OF COST	UNITS	COST AMOUNT (EUR)	COST ELABORATION
Designing and setting up of the GCAP website.	CAPEX	GCAP related website designed and operational.	50,000 EUR	Estimated based on similar activities.
	OPEX/y	EUR/y.	10,000 EUR	At least 1 permanent staff and other costs of running the website.
TOTAL	CAPEX		60,000 EUR	Revenue generating: No

Implementation steps and timeline

Implementation steps	2025	2026	2027	2028	2029	Outlook after 5 years
ToR development and contracting service provider.						It is expected that the website remains operational after the GCAP implementation period.
Conduct a needs assessment to define requirements for the web portal, including data, user interface, accessibility, and security, with stakeholder input.						
Design and develop the technical infrastructure, including back-end systems, databases, and front-end interfaces, ensuring scalability and security, and set up real-time data integration.						
Integrate the portal with existing data sources like IoT sensors and project management tools, and include monitoring tools for data visualisation.						
Perform comprehensive testing for functionality, usability, and security, adjust as needed, and launch with a public communication campaign.						
Implement a promotional strategy to increase awareness via social media, local media, public events, and community outreach.						
Conduct a needs assessment to define requirements for the web portal, including data, user interface, accessibility, and security, with stakeholder input.						

Implementing agencies and stakeholders

- City of Karlovac –Administrative Department for Economy, City Development, and EU Funds.

Fit with Funding sources

City Budget

National or regional funds

IFIs – reimbursable

Donors

Private sector / PPPs

General Public/Other

- Good fit
- Possible fit
- Poor fit

Potential funding sources

- Own funds - City budget.
- Urban Innovative Actions[32].
- CIVITAS[33].

Key benefits

- Provides comprehensive information on GCAP initiatives and strategies.
- Enhances public awareness and education about GCAP and sustainability efforts.
- Facilitates easy access to GCAP-related data, reports, and resources.
- Offers a platform for tracking progress on actions goals and targets.
- Encourages community engagement and participation in GCAP projects.
- Promotes transparency and accountability in GCAP planning and implementation.
- Supports collaboration and information sharing among stakeholders, including governments, businesses, and NGOs.
- Showcases best practices and success stories.
- Provides tools and resources for individuals and organisations to contribute to GCAP implementation.
- Enhances communication and outreach efforts related to sustainable policies and initiatives.

Enabling strategic framework

- Croatian Smart Specialisation Strategy S3 2021-2029.
- Croatian National Development Strategy 2030.
- Digital Croatia Strategy 2032.

Dimension	Elaboration	
Smart City Potential	High	This is completely Smart City related action.
Gender and inclusion considerations	The action will ensure the portal is accessible to all community members, including those with disabilities, and provide information relevant to diverse social groups.	

32 - Provides EU funding for pilot projects in urban areas to test innovative solutions addressing issues like poverty, climate change, and housing, encouraging experimentation and knowledge sharing.

33 - An EU initiative that funds and supports cities in implementing innovative and sustainable urban mobility solutions to improve transport systems and reduce traffic congestion.

5. SUMMARY OF FUNDING REQUIREMENTS FOR GCAP ACTIONS

5.1 Sources of Potential Finances

The table below outlines several potential funding sources for GCAP Actions. During the GCAP development process, each action was assessed for its potential to secure suitable financing from either municipal or external sources.

Financing mechanism	Description
City funding.	This can include direct funding through mechanisms such as municipal budgets, encompassing both future capital project budgets and in-kind contributions like land or staff time.
National or regional funds.	Certain actions may also involve finance (typically non-reimbursable) in the form of direct fiscal transfers or serve as a distribution channel for other financing mechanisms. Various EU funding mechanisms for each action are also included here.
International Financial Institutions (IFIs) – reimbursable.	Examples under this mechanism include entities like the EBRD and EIB. Funding is typically provided via debt instruments where banks lend funds to cities either through national governments with sovereign loans or directly to the City. Different development banks have unique policies on lending practices; in some cases, equity finance is also an option. This mechanism often requires repayment of the investment and may include guarantee mechanisms.
Donor funds – non-reimbursable.	This could also encompass sources like the EU structural funds and other donor sources that are non-reimbursable, usually in the form of grants. These funds are frequently used to cover funding gaps enabling other investments and loans. Technical assistance or donor funds mobilised by IFIs may also be included.
Private sector finance / Public-Private Partnerships (PPPs).	Certain actions may involve City policies or investments attracting private sector finance for initiatives such as new energy production methods. Others might relate to joint ventures or public-private partnerships with private investors or third parties, as seen in waste management, district heating, or energy efficiency in public buildings. Private sector involvement helps reduce financial liabilities for the City, shares risk between the City and private investors, and retains some degree of control over investment activities for the City. Some capital projects might be financed, built, operated, and controlled by private organisations. This could include private companies working under services contracts with the City, such as utility concessions for specific periods (e.g., 25 years).
General public and other sources.	This includes financing from the general public (e.g., residential sector renovations) or other decentralised fundraising models like service user payments and crowdfunding.

Similar to other GCAPs, a colour-coded scoring system (**Red**, **Amber**, **Green**) was implemented to evaluate the suitability of financing mechanisms and sources for each action:

Fit	Description
Good fit	Prioritised for further investigation due to a strong alignment between the finance source and the scale of the intervention, or because the activity is typical for that type of mechanism/source.
Possible fit	Worth exploring, but not an ideal match. Required financing scale does not perfectly align with the mechanism, or the action is not commonly financed through this source, though exceptions exist.
Poor fit	The project's scale significantly exceeds or falls short of the capacity of the financing mechanism, or the mechanism is generally inapplicable (e.g., funding meant for capital investments).

The table below provides a summary of the funding requirements for implementing the Karlovac GCAP over the next five years. It shows a total needed investment of **CAPEX 236,177,000 EUR**, with almost 98% allocated to investment actions.

Table 6
Assessment of benefits against GCAP actions

Action	Total investment without OPEX (EUR)	Infrastructural CAPEX (EUR)	Other direct costs (TA, awareness raising) (EUR)	OPEX per annum in year 2030 (EUR)	City Budget	National or regional funds	IFIs – re-imbursable	Donors	Private sector / PPPs	General public / other
Transport										
T1 Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	1,650,000	1,300,000	350,000	30,000						
T2 Construction of primary and secondary cycling network and improving cycling infrastructure.	12,000,000	11,750,000	250,000	120,000						
T3 Transport infrastructure development policies stimulating the use of non-motorised transport.	110,000	-	110,000	-						
T4 Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.	4,500,000	4,150,000	350,000	61,000						
Total Transport	18,260,000	17,200,000	1,060,000	211,000						

* - Does not include OPEX

Action	Total investment without OPEX (EUR	Infrastructural CAPEX (EUR)	Other direct costs (TA, awareness raising) (EUR)	OPEX per annum in year 2030 (EUR)	City Budget	National or regional funds	IFIs – re-imbursable	Donors	Private sector / PPPs	General public / other
Energy and buildings										
EB1: “15-minute city” Karlovac – Sustainable district Luščić and multifunctional garage systems.	50.170.000	49,000,000	1,170.000	900.000						
EB2 Utilisation of geothermal energy potential in the City of Karlovac.	63.092.000	59,867,000	3,225,000	2.700.000						
EB3 Strengthening the DH system for sustainable, efficient, and innovative energy services.	2,850,000	2,250,000	600,000	0						
EB4 Decarbonisation of multi-apartment buildings in the City of Karlovac.	40,340,000	40,000,000	340,000	0						
EB5 Decarbonisation of public buildings in the City of Karlovac.	10,000,000	10,000,000	0	0						
EB6 Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.	300,000	0	300,000	0						
Total Energy and Buildings	166,752,000	161,117,000	5,635,000	3,600,000						

Action	Total investment without OPEX (EUR	Infrastructural CAPEX (EUR)	Other direct costs (TA, awareness raising) (EUR)	OPEX per annum in year 2030 (EUR)	City Budget	National or regional funds	IFIs – re-imbursable	Donors	Private sector / PPPs	General public / other
Water and Wastewater										
W1 Reduction of water consumption and water network losses.	16,300,000	16,000,000	300,000	300,000						
W2 Increase of water storage capacity and installation of solar-powered pump systems.	6,050,000	5,970,000	80,000	80,000						
W3 Introduction of heat pump and CHP systems into Karlovac Wastewater Treatment Plant.	11,580,000	11,450,000	130,000	250,000						
W4 Increase climate resilience against flooding in the City of Karlovac.	5,450,000	5,300,000	150,000	160,000						
Total Water and Wastewater	39,380,000	38,720,000	660,000	790,000						
Solid Waste										
SW1 Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.	350,000	-	350,000	-						
SW2 Feasibility assessment and landfill gas plant construction at Ilovac post-closure.	5,100,000	5,000,000	100,000	100,000						
SW3 Improving municipal solid waste separation at the source level.	1,000,000	950,000	50,000	20,000						
Total Solid Waste	6,450,000	5,950,000	500,000	120,000						

Action	Total investment without OPEX (EUR)	Infrastructural CAPEX (EUR)	Other direct costs (TA, awareness raising) (EUR)	OPEX per annum in year 2030 (EUR)	City Budget	National or regional funds	IFIs – re-imbursable	Donors	Private sector / PPPs	General public / other
Land Use										
L1 Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.	3,000,000	2,820,000	180,000	100,000						
L2 Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.	10,600,000	10,000,000	600,000	100,000						
L3 Protection and revitalisation of urban forest Kozjača.	500,000	370,000	130,000	20,000						
L4 Innovative instruments for stimulating use of green infrastructure elements through spatial plans.	N/A	N/A	N/A	N/A						
Total Land Use	**14,100,000**	**13,190,000**	**910,000**	**220,000**						
Cross sectoral actions										
CS1 Technical assistance for establishing a portfolio approach to project management "Smart Maturity".	50,000	-	50,000	-						
CS2 Development of an Updated Smart City Strategy.	30,000	-	30,000	-						
CS3 GCAP Web site for monitoring and implementation.	50,000	-	50,000	-						
Total Cross sectoral actions	**130,000**	**-**	**130,000**	**-**						
Total Karlovac GCAP	**245,072,000**	**236,177,000**	**8,595,300**	**4,941,000**						

Source: Consultant

6. SUMMARY OF BENEFITS

6.1 Introduction

This Green City Action Plan aims to enhance the environmental and climate performance of our City. The benefits of each action were evaluated against a variety of typical advantages outlined in the EBRD Green Cities Methodology. These not only encompass environmental benefits but also include social and economic co-benefits, such as gender and inclusion benefits, which should be realised through the implementation of the action plan.

Each action possesses the potential to positively impact several areas identified within this framework, and a matrix approach has been employed to determine which actions will support which benefit areas. Benefits have been categorised into three levels:

Fit	Description
3	Significant benefit: The action has considerable potential benefits.
2	Secondary benefit: While not the main reason for choosing the option, there is likely to be some material benefit.
1	Marginal benefit: Benefits are minimal and were not significant factors in the decision-making process.

The benefits analysis for each project is outlined below. Given the strategic nature of this plan, these benefits have been evaluated primarily in qualitative terms and should be viewed as indicative. Nonetheless, they offer implementing agencies a useful guide to the potential advantages of each action.

Each detailed description of actions in the main report includes a summary of benefits. This summary is derived from the assessment detailed below:

Table 7
Assessment of benefits against GCAP actions

Ref. number	Action	Air Quality	Water quality	Soil quality	Biodiversity	Water use	Energy use	Land use	Material use	Climate change mitigation	Climate change adaptation	Economic returns for investor	Economic growth	Employment	Economic inclusion	Public health	Access to basic services	Safety	Gender equality	Green behaviour and awareness	Community involvement
T1	Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	2	0	0	0	0	2	2	0	2	1	1	1	1	1	1	2	2	2	2	1
T2	Construction of primary and secondary cycling network and improving cycling infrastructure.	3	0	0	0	0	2	2	0	3	0	2	1	0	1	1	3	1	2	3	2
T3	Transport infrastructure development policies stimulating the use of non-motorised transport.	2	0	0	0	0	2	2	0	2	1	1	1	1	1	2	2	3	1	0	0
T4	Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.	3	0	0	0	0	3	0	0	3	0	2	1	0	1	2	2	1	1	3	0

Ref. number	Action	Air Quality	Water quality	Soil quality	Biodiversity	Water use	Energy use	Land use	Material use	Climate change mitigation	Climate change adaptation	Economic returns for investor	Economic growth	Employment	Economic inclusion	Public health	Access to basic services	Safety	Gender equality	Green behaviour and awareness	Community involvement
EB1	"15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.	3	1	2	2	1	3	2	0	3	1	2	2	2	2	1	1	0	1	1	2
EB2	Utilisation of geothermal energy potential in the City of Karlovac.	3	1	1	1	1	3	0	0	3	0	3	3	2	2	2	3	1	1	1	0
EB3	Strengthening the DH system for sustainable, efficient, and innovative energy services.	3	0	0	0	0	3	0	0	3	0	2	1	1	1	1	3	1	1	3	3
EB4	Decarbonisation of multi-apartment buildings in the City of Karlovac.	3	0	0	0	0	3	0	1	3	0	3	2	1	1	1	0	2	1	2	3
EB5	Decarbonisation of public buildings in the City of Karlovac.	3	0	0	0	1	3	0	0	3	0	3	0	0	1	1	2	2	1	1	0
EB6	Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.	1	0	0	1	0	3	0	1	3	1	2	1	0	2	1	0	2	1	3	3

Ref. number	Action	Air Quality	Water quality	Soil quality	Biodiversity	Water use	Energy use	Land use	Material use	Climate change mitigation	Climate change adaptation	Economic returns for investor	Economic growth	Employment	Economic inclusion	Public health	Access to basic services	Safety	Gender equality	Green behaviour and awareness	Community involvement
W1	Reduction of water consumption and water network losses.	1	2	1	1	3	1	0	1	2	1	3	1	1	0	3	3	3	1	3	2
W2	Increase of water storage capacity and installation of solar-powered pump systems.	1	3	0	0	3	2	0	0	1	2	2	0	0	1	2	3	3	2	0	1
W3	Introduction of heat pump and CHP systems into Karlovac Wastewater Treatment Plant.	2	1	2	1	1	3	0	1	3	0	3	1	2	1	2	1	2	1	1	1
W4	Increase climate resilience against flooding in the city of Karlovac.	0	1	2	1	1	0	2	0	0	3	3	2	1	1	3	0	3	1	3	3
SW1	Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.	1	1	1	0	0	0	0	3	0	0	0	1	1	1	2	1	1	1	3	3
SW2	Feasibility assessment and landfill gas plant construction at Ilovac post-closure.	3	2	2	1	0	3	1	3	3	0	3	2	2	1	2	1	1	1	2	1
SW3	Improving municipal solid waste separation at the source level.	1	1	1	0	0	0	0	3	1	0	2	2	1	1	2	1	1	1	3	3

Ref. number	Action	Air Quality	Water quality	Soil quality	Biodiversity	Water use	Energy use	Land use	Material use	Climate change mitigation	Climate change adaptation	Economic returns for investor	Economic growth	Employment	Economic inclusion	Public health	Access to basic services	Safety	Gender equality	Green behaviour and awareness	Community involvement
L1	Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.	1	1	2	3	1	0	3	0	0	3	2	2	2	2	1	0	3	1	1	2
L2	Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.	0	1	2	3	0	0	3	1	0	3	2	2	2	2	1	1	3	1	1	1
L3	Protection and revitalisation of urban forest Kozjača.	0	0	1	3	0	0	3	0	0	1	1	0	1	1	1	0	0	0	1	3
L4	Innovative instruments for stimulating use of green infrastructure elements through spatial plans.	0	0	1	2	0	0	3	0	0	2	0	1	1	1	1	0	0	1	2	2
CS1	Technical assistance for establishing a portfolio approach to project management "Smart Maturity".	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3	1	2	0	1
CS2	Development of an updated Smart City Strategy.	0	0	0	0	0	1	0	0	0	0	0	2	1	2	0	3	1	2	0	1
CS3	GCAP Web site for monitoring and implementation.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	2	2	3

Source: Consultant

6.2 Key Environmental Benefits

The following section provides a summary of the key environmental benefits which are likely to be achieved through the implementation of the Karlovac GCAP.

6.2.1 Air Quality

The GCAP details several strategies aimed at reducing reliance on private vehicles and boosting the use of public transportation by improving bus services. It also focuses on encouraging walking and cycling in the City by proposing improved cycling infrastructure and concentrated initiatives for developing multiple green projects, alongside optimising the transport sector.

Additionally, the plan underscores incorporating renewable energy across various sectors, particularly DH, and improving energy efficiency within the building sector. These mitigation measures are anticipated to enhance air quality.

6.2.2 Biodiversity

Land use actions aim to build on the Municipality's significant progress in promoting the development and marketing of brownfield sites and green infrastructure projects. The objective is to create an interconnected network of green spaces that traverse communities, with green corridors enhancing the urban environment by incorporating more trees and vegetation, thereby increasing the City's ecological assets. By accelerating the implementation of green infrastructure projects, incorporating nature-based solutions, and protecting the Kozjača forest, we can maximise opportunities for preserving biodiversity.

6.2.3 Water Use

The water supply in Karlovac is celebrated for its high quality and easy access, yet there is potential to reduce usage by raising awareness about water conservation.

These campaigns aim to foster a culture that values saving water and using it responsibly. A significant advantage of adopting these measures within the GCAP is the decrease in non-revenue water losses, currently standing at 58%.

6.2.4 Energy Use

A key focus for reducing energy consumption in the City of Karlovac revolves around enhancing the DH system. The plan includes integrating geothermal energy into the system, which would significantly lower GHG emissions, promote partial self-sufficiency, and set a precedent for similar initiatives on a national scale.

Another crucial area for boosting energy efficiency involves residential and public buildings. As highlighted earlier in this document, there is a substantial need to enhance the energy performance of the City's building inventory. Consequently, the plan outlines various actions aimed at driving the sector toward more sustainable energy practices.

6.2.5 Land Use

Actions like L4 aim to promote sustainable land use for the long term. This regulation integrates green infrastructure into future investment projects. With the EB1, Luščić project, the City demonstrates its commitment to addressing land use considerations and providing multiple benefits.

6.2.6 Climate Change Mitigation

Significant opportunities for reducing GHG emissions include enhancing energy efficiency in buildings, especially in residential areas, upgrading the District Heating network, and decreasing emissions from transportation by promoting a shift from private vehicle use to more environmentally friendly alternatives.

Opportunities for Buildings

The greatest potential for reducing GHG emissions lies in ensuring new buildings meet green energy performance standards. This is followed by the thermal rehabilitation of existing building stocks, particularly residential ones. The GCAP suggests various actions to lower GHG emissions from the building sector.

Opportunities for Sustainable Mobility

In the transport sector, multiple measures encourage a shift from private car use to more sustainable transport modes. Emission reductions can be further achieved by replacing old diesel buses with modern electric ones and incorporating electric vehicles into public services.

Other Areas

Several actions will also support climate mitigation efforts in Karlovac. These include decarbonisation initiatives within the district heating and building sectors. Additionally, other measures such as W3 and SW2 are closely linked to the energy sector and directly aim to reduce GHG emissions.

Action	Estimated GHG savings in year 2030 (tonnes CO2eq / year)
T1 Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.	60
T2 Construction of primary and secondary cycling network and improving cycling infrastructure.	3,833
T4 Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet (administration and City's owned companies).	120
EB1 "15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.	150
EB2 Utilisation of geothermal energy potential in the City of Karlovac.	39,000
EB3 Strengthening the DH system for sustainable, efficient, and innovative energy services.	500
EB4 Decarbonisation of multi-apartment buildings in the city of Karlovac.	1,598
EB5 Decarbonisation of public buildings in the City of Karlovac.	242
W1 Reduction of water consumption and water network losses.	644
W2 Increase of water storage capacity and installation of solar-powered pump systems.	1,077
W3 Introduction of heat pump and CHP systems into Karlovac Wastewater Treatment Plant.	675
SW2 Feasibility Assessment and Landfill Gas Plant Construction at Ilovac Post-Closure.	1,346
Total	**49,245**

Table 7
Assessment of benefits against GCAP actions

Source: Consultant

A dedicated GCAP GHG methodology estimates that Karlovac's emissions will decrease from 4 tCO_2e per capita in 2019 to 3.1 tCO_2e per capita by 2050 under a business-as-usual scenario. With a Steady Decrease Paris-aligned trajectory, the City aims for a 60% reduction in baseline emissions by 2030 and full decarbonization by 2050. Fully implementing GCAP actions is projected to save approx.50,000 tCO_2e annually.

6.2.7 Climate Change Adaptation

As noted in the baseline section, the City of Karlovac faces ongoing challenges from flooding, heat islands, and increasingly severe climate impacts like storms. Several actions will enhance the adaptive capacity and resilience of vulnerable areas. Most notably, W4 - Increase climate resilience against flooding in the City of Karlovac will significantly improve flood protection by providing timely information and procedural steps. This action includes the introduction of an EWS for flood monitoring and rapid response, along with upgrades to drainage infrastructure, including spillways and permeable surfaces. Additionally, actions targeting buildings will ensure that new construction and renovations account for both current and future climate risks. Finally, land use actions will further strengthen resilience through NbS and green infrastructure, particularly in L2, which will introduce embankments and a network of elevated walkways, bikeways, and landscape structures.

6.3 Key Economic and Social Co-Benefits

The GCAP process has concentrated on creating measures aimed at achieving environmental benefits. However, it is important to acknowledge the various economic and social co-benefits that may arise from implementing GCAP actions.

6.3.1 Financial Benefits for Potential Investors

Numerous actions outlined in the GCAP offer potential advantages for investors, including both the Municipality and private sector stakeholders. These benefits arise from efficiency enhancements like lower operating costs or heightened revenue due to greater service utilisation. This is pertinent to energy efficiency initiatives (in buildings and the district heating system) and a more adaptive transport network. Certain actions within the GCAP, such as EB1, SW2, W4, L1, are specifically targeting private sector participation.

6.3.2 Employment

Investments may create both short term employment opportunities (for example in the delivery of infrastructure projects) but also create longer term "green jobs" such as installation, servicing and maintenance of small-scale renewables technologies or insulation products for buildings, additional jobs in public transport to service additional routes, and management of the cycling network. However, there are infrastructural actions, such as EB1 (Luščić project), SW2 (Landfill biogas), EB2 (Geothermal energy) and similar, that can open new jobs at various levels and expertise.

6.3.3 Economic Inclusion

Enhanced public services and infrastructure, such as an expanded cycling network, are likely to positively

impact all societal segments. This development means that individuals with lower incomes can utilise transportation options that are accessible, efficient, and highly attractive. Additionally, various other inclusion benefits will emerge from this GCAP, as detailed for each action.

6.3.4 Public Health

The Green City Action Plan has identified three main areas of public health benefits:

- Reduced dependence on private car use through enhanced walking and cycling infrastructure. This not only offers affordable, sustainable transportation options but also markedly improves physical health and mental well-being.

- Urban green spaces enhance both physical and mental health by reducing morbidity and mortality rates. They offer physical relaxation, alleviate stress, boost social cohesion, encourage physical activities, and diminish exposure to noise, poor air quality, and excessive heat.

- Increasing the rate of DH connections aims to phase out remaining wood-fired heating systems, thereby significantly improving air quality levels.

6.3.5 Safety

The introduction of new infrastructure, encompassing neighbourhood areas, transport networks, adherence to building standards, and public transport vehicles and facilities, can enhance user safety through the adoption of secure design and operational practices. Cycling infrastructure, in particular, offers distinct road safety advantages. When well-conceived, these plans not only shield cyclists from motorised traffic but also foster a safer environment by reducing crime risks, ensuring that pedestrian and cycling paths are placed in areas with ample natural surveillance. Furthermore, initiatives such as landfill biogas recovery systems and climate adaptation measures could lead to marked improvements in overall safety within the City.

6.3.6 Gender Equality

During the development of each action, gender issues must be carefully considered to ensure that schemes account for the distinct needs of both men and women. The GCAP focuses on several key aspects in this context:

- Ensure cycling infrastructure is designed to meet the needs of all users, including women, children, the elderly, and individuals with disabilities, by incorporating wide lanes, gentle gradients, and rest areas.

- Conduct community consultations with a diverse range of groups to collect input on safety and accessibility features.

- Incorporate comprehensive safety measures such as well-lit paths, clearly marked and color-coded lanes, safe crossing points with pedestrian signals, and barriers separating cycling lanes from vehicle traffic.

- Design routes that link various neighbourhoods and provide equal access to cycling facilities for all socio-economic groups. Implement child-friendly, elderly-friendly, and disability-accessible design elements like lower speed limits near schools, protected cycle tracks, and educational signage to foster safe cycling habits among young riders.

- Include features for elderly cyclists, such as smooth surfaces, gentle slopes, frequent resting spots with benches, and clear, large-print signage. Ensure cycling infrastructure is accessible to individuals with disabilities by offering adaptive cycle parking, ramps, and tactile paving for visually impaired cyclists.

- The GCAP is also ensuring that the development of urban green infrastructure benefits all residents, particularly marginalised groups and women, by prioritising the inclusion of green infrastructure elements in central and built-up urban areas where access to green spaces may be limited.

- Additionally, it will involve diverse stakeholders, including women, youth, and community organisations, in the planning and decision-making processes related to the implementation of green infrastructure elements through spatial plans.

- Finally, it will take into account gendered mobility patterns and transportation needs when designing and locating green infrastructure elements within urban areas to ensure accessibility for all residents, especially women who may depend on walking or public transportation. Furthermore, green infrastructure projects will be designed with safety and inclusivity in mind, incorporating features such as well-lit pathways, accessible amenities, and seating areas to accommodate diverse users, including women, children, and elderly individuals.

7. GCAP IMPLEMENTATION AND MONITORING

7.1 Introduction

Regular monitoring of GCAP measures and projects is crucial to its implementation, as it allows the City to assess whether progress aligns with the initial plans and strategic objectives are being achieved. A monitoring framework has been developed for the GCAP, serving several key purposes:

- To support planning, the process of figuring out where the City wants to go and how they can get there;
- To enhance decision-making through a better understanding of current conditions and trends;
- To enable benchmarking of conditions and performance across the different environmental sectors; and
- To ensure accountability for actions and outcomes set out in the GCAP.

Routine monitoring of the GCAP action plan will help evaluate whether the environmental challenges outlined in the Plan are being addressed or if new issues are arising. The Karlovac GCAP monitoring framework relies on agreed strategic objectives related indicators. GCAP Governance & Institutional Structure.

To ensure the successful delivery of the GCAP, it is crucial to set up effective implementation arrangements. A new governance structure has been formed to coordinate, manage, and supervise the effective execution of the GCAP. This structure emphasises the significance of political decision-making and technical input to foster progress in scheme development and implementation. It also involves evaluating the impact of actions and monitoring progress towards achieving GCAP targets and strategic goals. The proposed roles and responsibilities are outlined below:

Mayor (Political Champion)

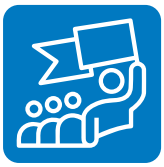
A political champion will be designated as having overall responsibility for the driving the GCAP. The political champion will Chair the GCAP Coordination Board and champion the relevant administrative motions to progress the actions within the GCAP (noting that the preparation of such documents are likely to be delegated).

GCAP Coordination Board

A GCAP coordination board will be formed to ensure a joined-up approach to implementing the GCAP and to understanding the ongoing environmental performance in the City. This will be chaired by the Political Champion with support from the GCO and will bring together senior representatives from the key directorates within the municipality. This will include the Public Services Directorate, Finance Directorate, Project Implementation Directorate, Urbanism Directorate and the Public Relations team. The coordination group will meet at least 6 monthly and will a) Confirm projects to be progressed (subject to the appropriate approvals of the council) b) monitor progress of projects c) review environmental performance monitoring data d) validate and approve GCAP reporting e) initiate further rounds of GCAP planning when appropriate.

GCAP Green City Officer (GCO)

The GCO is principally accountable for overseeing the implementation and subsequent monitoring of the plan. They possess the authority to collaborate with all pertinent municipal departments to ensure the effective execution of all GCAP initiatives. Additionally, the Green City Coordinator will strive to align the monitoring and evaluation processes with other municipal operations and strategic objectives. This alignment will be achieved through regular communication with the GCAP Sector Leaders during the implementation phase. The GCO plays an essential role in supporting the overall coordination efforts and fostering effective collaboration with the GCAP Project and Sector Leaders.



GCAP Project Leaders

Within City Hall, dedicated project leaders must be appointed to actively manage the development and implementation of GCAP schemes and initiatives. These appointed officers will supervise the completion of specific actions, provide progress reports, and gather necessary impact data. Annually, City Hall departments will establish budgets and timelines for their designated actions. Quarterly progress and environmental impact updates will be submitted to

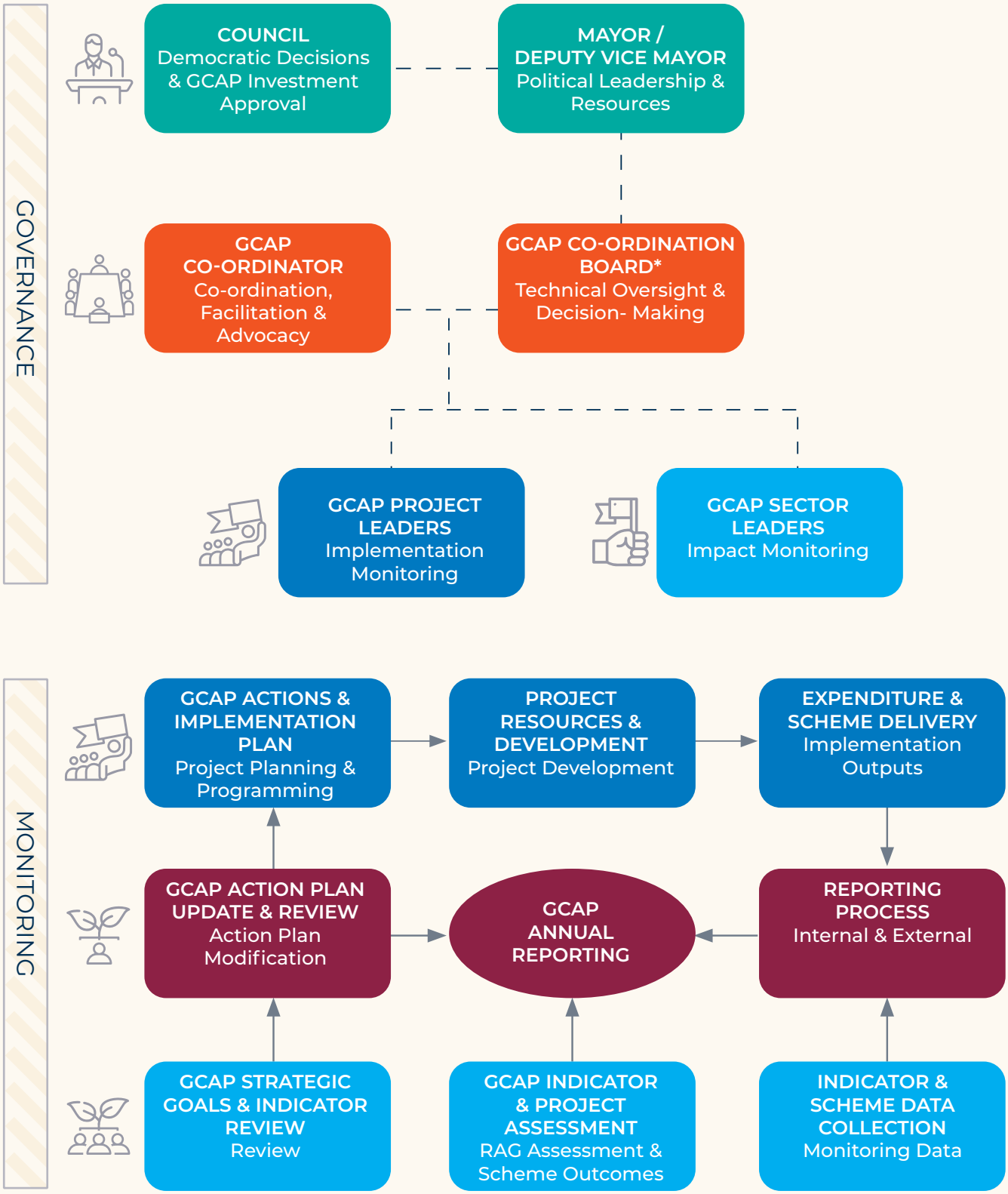
the City's Coordination Group. The findings from these reports will guide the planning of subsequent stages, including adjustments to timelines, resources, and budgets as needed.

GCAP Sector Leaders

Sector Leaders will function on an operational level, collaborating closely with the GCO to gather and assess data on sector performance targets. This information is routinely collected to evaluate overall performance and contribution towards achieving targets and benchmarks. The results of this analysis will be included in an annual report, which will also review City investment and implementation progress. Working directly with the Sector Leaders, the GCAP City Coordinator will compile the data and prepare the corresponding reports.

The complete governance structure, which will be established to coordinate, manage, and oversee the successful implementation of the GCAP, is depicted in the figure below.

Figure 16
Karlovac GCAP Governance structure scheme



Source: GCAP Methodology 2.1

* - GCAP Co-Ordination Board to include
Deputy Mayor (Political Champion), GCAP Co-ordinator, Public Services Directorate, Finance Directorate, Project Implementation Dir. Urbanism Directorate, Public Relations Team

Individual actions may be executed by any entity approved by the GCAP Coordination Board, which can include a City department, enterprise, or an external party such as a state entity or a private sector organisation. Agencies responsible for implementing a GCAP action must coordinate with the GCAP Coordination Team through direct liaison with the GCO.

To assist project leaders in managing data effectively, the GCO will collaborate closely with Sector Leaders to ensure that relevant data is collected and analysed. This process aims to assess the performance regarding (i) the impact of individual schemes and (ii) the overall evaluation of GCAP performance against baselines and targets. When new baselines are needed, fresh data will be gathered, which will subsequently feed into future annual reports detailing progress against set targets.

7.2 GCAP Implementation and Monitoring

The City has developed a list of actions to be implemented and identified a governance structure for project delivery. Additionally, the City has established a preliminary programme for these projects, outlined on the following page. This programme specifies proposed timeframes for executing projects over the GCAP period (5 years), usually divided into a preparatory phase—which includes studies preparation, coordination with delivery partners, and finance applications—followed by a delivery phase. The delivery could either be annual, where actions are repetitive, or a single phase, when appropriate. These schedules are based on estimates of the project's scale and complexity. However, this programme is preliminary, as detailed planning during the initial implementation period will refine resourcing needs, budget availability, lead times for financing processes, and requirements from potential delivery partners.


Planning
Implementation
2024
2025
2026
2027
2028
2029
Year 0
Year 1
Year 2
Year 3
Year 4
Year 5 and beyond
GCAP MANAGEMENT
Mobilisation Phase.
Monitoring.
Reporting.
TRANSPORT
T1 Karlovac transport demand and supply analysis and implementation of Transit Oriented Development approach in Luščić development project.
T2 Construction of primary and secondary cycling network and improving cycling infrastructure.
T3 Transport infrastructure development policies stimulating the use of non-motorised transport.
T4 Modernisation and electrification of City's Public Transport (PT) and City's vehicle fleet.
ENERGY AND BUILDINGS
EB1 "15-minute city" Karlovac – Sustainable district Luščić and multifunctional garage systems.
EB2 Utilisation of geothermal energy potential in the City of Karlovac.
EB3 Strengthening the DH system for sustainable, efficient, and innovative energy services.
EB4 Decarbonisation of multi-apartment buildings in the City of Karlovac.
EB5 Decarbonisation of public buildings in the City of Karlovac.
EB6 Development of local policies and implementation of awareness raising initiatives on buildings decarbonisation.
WATER AND WASTEWATER
W1 Reduction of water consumption and water network losses.
W2 Increase of water storage capacity and installation of solar-powered pump systems.
W3 Introduction of heat pump and CHP Systems into Karlovac Wastewater Treatment Plant.
W4 Increase climate resilience against flooding in the City of Karlovac.


Planning
Implementation
2024
2025
2026
2027
2028
2029
Year 0
Year 1
Year 2
Year 3
Year 4
Year 5 and beyond
SOLID WASTE
SW1 Reducing material consumption / solid waste generation and capacity building of Čistoća d.o.o.
SW2 Feasibility assessment and landfill gas plant construction at Ilovac landfill post-closure.
SW3 Improving municipal solid waste separation at the source level.
LAND USE
L1 Realisation of Luščić urban park and development of Karlovac urban area brownfield and green infrastructure projects register.
L2 Integration of green infrastructure and nature-based solutions in the Korana Sports and Recreation Centre.
L3 Protection and revitalisation of urban forest Kozjača.
L4 Innovative instruments for stimulating use of green infrastructure elements through spatial plans.
CROSS- SECTORAL
CS1 Technical assistance for establishing a portfolio approach to project management "Smart Maturity".
CS2 Development of an Updated Smart City Strategy.
CS3 GCAP Web site for monitoring and implementation.

7.3 Mobilisation

This phase of the GCAP emphasises outlining and identifying a phased methodology for executing and organising GCAP initiatives and measures. Key elements of this stage will include:

1. Institutional and governance structures setup:

   During this period, the current GCAP CGO and the Mayor will designate resources to the roles specified in the governance structure mentioned earlier. Particular emphasis is placed on the GCO and the GCAP Coordination Board.

2. Capacity building workshops:

   The consultants will offer Capacity Building workshops to selected members of the Coordination Board and other essential staff to support the effective implementation, monitoring, and reporting of the GCAP.

3. Engagement with Project Leaders and budget allocation:

   The GCAP Coordination Board will identify team members within delivery partners (both internal and external) assigned to each "Action," appoint a Project Leader to oversee project progression, and ensure suitable resources are devoted to the project's execution.

4. Detailed terms of reference:

   Project Leaders will further develop the high-level information in this plan into encompassing terms of reference for executing their respective projects. This will encompass:

   - Programme - The consideration of the extended lead times associated with constructing particular projects, especially significant infrastructure proposals. Realistic delivery timelines are essential here.
   - Outcomes – Detailed outcomes, including project-specific monitoring criteria developed as part of this GCAP.
   - Delivery Risks - It is crucial to identify any potential risks to delivery and establish contingency plans, taking into account possible barriers to implementation.
   - Funding options – Identifying relevant funding organisations (both internal and external) that should be engaged to gauge interest in the projects.
   - Alignment – Reviewing the current policy context, particularly in light of potential changes in City leadership following the September elections, to ensure actions are synchronised with complementary activities.
   - Budget and Value for Money – Developing an outline business case to determine project-specific budgets for the forthcoming period to advance the action.

5. Agreed budgets:

   The Coordination Board will compile the budgets to be submitted through the appropriate municipal channels, ensuring formal adoption into the City's budgeting process for progressive action.

6. Finalisation of a phased implementation plan:

It is crucial that the implementation programme maintains enough flexibility to adapt to specific changes in the Plan (due to stakeholder engagement or feasibility study outcomes) and the development of schemes. This includes planning for potentially accelerated or slower than expected delivery. In developing these phased programmes, interventions will be prioritised to:

- Implement a transparent, policy-driven process that guides GCAP expenditures and showcases the expected impacts as the Plan progresses; and
- Emphasise proactive forward planning, exploring opportunities to execute packages of schemes when feasible and advantageous.
- Monitoring of implementation must occur on both short-term and long-term bases, detailing all Green City actions and initiatives, including project status and progress against milestones. As part of the overall GCAP action planning, a series of steps will be followed to establish realistic scheme programmes and timelines. Initially, suitable projects and timelines will be selected, many based on further feasibility studies and development work. Once ready for implementation, resources and budgets will be allocated, and milestones for project programmes will be set.

Partnership Delivery

The success of many GCAP actions relies on the involvement of various partners and agencies, making their engagement crucial during the creation of the implementation plan. Several key issues related to implementation will be examined, including:

1. Strategies to ensure a constructive approach to execution, guaranteeing that GCAP proposals are actively adopted by implementing agencies as part of a coordinated effort to deliver interventions.
2. An assessment of relevant partnerships and responsibilities, particularly identifying lead agencies for specific interventions, identifying key organisations and agencies involved in initiatives, and identifying opportunities for pooling and coordinating resources; and
3. Innovative methods for developing scheme financing and contributions.

7.4 GCAP Impact Monitoring

In addition to monitoring the progress of the Actions included in this plan, the City will also track our progress against the Strategic Goals and Mid Term Targets to assess the GCAP's impact on Karlovac's Environmental Performance. Each target to be tracked will have an assigned municipal department or external agency responsible for providing the necessary data. It is essential for the GCO to maintain regular contact with these target owners during the Plan's implementation to ensure a comprehensive understanding of performance.

The City will consistently review the GCAP sector targets to monitor progress towards the Strategic Goals and targets. Based on the performance assessment of actions in meeting GCAP targets and strategic objectives, the action plan may need adjustments. Unforeseen events, such as City flooding, may require the City to prioritise infrastructure repairs over other planned investments. As part of the overall GCAP monitoring plan, appropriate quality management processes will be developed and implemented to record and store data centrally and consistently, ensuring validity with Sector and Project Leaders. An annual GCAP Monitoring Report will be published, accessible to both external stakeholders and the general public, presenting a clear and user-friendly summary of sector performance and action implementation progress.

If corrective action is needed based on the progress of GCAP scheme delivery, it will first be considered by the GCAP Coordination Board. Any required changes to the GCAP action and investment plan will be escalated to the Mayor for a final decision, followed by Full Council approval of the updated Plan and any adjusted timescales and financial resources. The GCAP Coordination Group is responsible for engaging with relevant Project Officers/ Leaders and Sector Leaders to ensure proper approvals for any updates to the monitoring plans. Effective collaboration with numerous external agencies in Karlovac is also crucial to collect target data across multiple sectors and foster cross-departmental cooperation within the City, aligning actions with other planned activities outside the Karlovac GCAP.

KARLOVAC

Green City Action Plan

With the support of

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