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Foster Research Excellence for Green Transition in the Western Balkans

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List of Abbreviations

ACT IP	Accelerated Coal Transition Investment Plan
AF	Alternative Fuel
ALL	Albanian currency
ANPR	Automatic Number Plate Recognition
AVs	Autonomous Vehicles
BCR	benefits-to-costs ratio
BT	Biological Treatment
CBA	Cost Benefit Analysis
CEN	European Standardization Commission
CKD	City of Kragujevac
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO2	Carbon Dioxide
CRD	Center for Regional Development
CRFs	Concentration-Response Functions
CSO	Civil Society Organizations
CV	Calorific Value
DEU	Donor and External Relations Unit
EC	European Commission
EE	Electronic Engineering
ENPV	Environmental Net Present Value
EnC	Energy Community
EPA	Environmental Protection Agency
EPR	Extended Producer's Responsibility
ERC	Energy Regulatory Commission
ESM	National state-owned electricity producer
ESRA	E-Survey of Road Users' Attitudes
EU	European Union
EUR	Euro
EWL	European Waste List
FTE	Full time employment equivalent
GAWB	Green Agenda for the Western Balkans
GDP	Gross Domestic Product
GH	Greenhouse Gas
GS	Garage Spaces
GUP	General Urban Plan
HC	Hydrocarbon
HBS	Household Budget Surveys
HGV	Heavy Goods Vehicle
ICFTU	International Confederation of Free Trade Unions
IED	Industrial Emissions Directive
INECP	Integrated National Climate and Energy Plan
IRR	Internal Rate of Return
JGT	Just Green Transition
JT	Just Transition

KII Key informant interviews
kWh Kilowatt-hour
LFP Lithium Iron Phosphate
LSGU Local Self-Government Unit

MDD Minimum Detectable Difference
MKD North Macedonia currency
MLSP Ministry of Labour and Social Policy
MoE Ministry of Environment
MoEPP Ministry of Environment and Physical Planning
MONSTAT The national statistical office of Montenegro
MSW Municipal Solid Waste
NACE Nomenclature of Economic Activities
NBS National Bank of Serbia
NCCC National Climate Change Committee
NCSD National Council for Sustainable Development
NEPA National Environmental Protection Agency
NGO Non-Governmental Organization
NOx Nitrogen Oxides
NPV Net Present Value
NWMP National Waste Management Plan
OECD Organisation for Economic Co-operation and Development
PES Public employment service
PM Particulate Matter
PS Parking Spaces
PUC Public Utility Company
PV Photovoltaics
RAPI Public information act requests
RBD River Basin Directorate
RDF Refuse-Derived Fuel
RES Renewable Energy Sources
RNM Republic of North Macedonia
RS Republic of Srpska
SAA Stabilization and Association Agreement
SDGs Sustainable Development Goals
SE-CBA Socio-Economic Cost Benefit Analysis
SNA System of National Accounts
SSO State Statistical Office
SRF Solid Recovered Fuel
SSL Safety Living Labs
SWPR Southwest planning region
UB-GEF University of Belgrade, Faculty of Geography
UNDP United Nations Development Programme
VAT Value-added tax
VRUs Vulnerable Road Users
WB Western Balkans
WFD Waste Framework Directive
WP Work Package
W2E Waste to Energy

Executive Summary

This deliverable presents the interim findings of the comprehensive assessment of the costs, benefits, and impacts of (just) green transition in the Western Balkans (WB), designed in the framework of the GreenFORCE project. The report is a compilation of 5 case studies meticulously selected case studies in Albania, North Macedonia, Serbia, Montenegro, and Bosnia and Herzegovina. Developed through an in-depth co-design process involving diverse stakeholders, these studies aim to provide first glimpse into the regional implementation of JGT policies and practices, as well as responding to the project's objective of strengthening research capacities of WB research performing organizations, i.e Co-PLAN (lead partner); Faculty of Geography within the University of Belgrade (UB-GEF) and Center for Economic Analyses (CEA). The criteria for selecting the case studies included:

- Coverage of at least three components out of the three pillars of the green agenda for the WB.
- Selection based on workshop results and stakeholder willingness to participate in further co-assessment workshops.
- Evidence of transition potential, data availability, and feasibility for meaningful cost-benefit analysis.

Moreover, these case studies are meant to establish contextual knowledge and methodologies for continuous monitoring and assessment of JGT impacts in the WB. In this regard, this research capitalizes on previous work done for identifying specific territories, sectors, policy gaps and networks of quadruple helix stakeholders engaged in Green Transition in WB.[1] The research methodology, as well as the case studies, were conceived as part of the initial 'Conceptualization and Contextualization' report of the Western Balkans just green transition[2].

This report will be followed by a final research study report, which summarizes key findings upon validation with regional and local stakeholders through a series of co-assessment processes.

The aim of these reports is **not to achieve full comparison** but to identify common elements at the regional level and list key aspects to formulate policy recommendations for each sector addressed by the cases. Each case study responded to the following research questions from various sectorial and country perspectives:

- How did place-specificity and spatial scale influence JGT processes in the Western Balkans? The study explored socio-economic structures, climate vulnerability, infrastructure distribution, political processes, post-socialism effects, resource distribution, smart specialization potential, and development of JGT policies.
- What were the potential implications and impacts (costs and benefits) of JGT pathways for WB societies and territories? The study used scenario-based analysis to derive holistic costs and benefits, including quantifiable and non-quantifiable impacts.
- Did geographical proximity between diverse local and regional territories play a role in joint progress in transition? The study explored potential social networks within the region and between local territories that advanced JGT.
- What role did territorial stakeholders play in advancing JGT in the WB? The study argued that successful JGT required whole-of-society involvement to ensure the justice dimension and avoid potential pitfalls of top-down transitions.
- Potential for Innovation Transition: At least one case (Serbia) showed promise for a potential niche for innovation transition. Albania's case, while more premature, could establish grounds for urban innovation.

The research cases observed the interrelation between JGT and place specificity, focusing on the Western Balkans at both country and regional levels. Methods included case study approaches, desk/literature reviews**, scenario development**, observation, surveys, **cost and benefit analysis**, and in some cases, territorial analysis. The case studies are representative of regime dynamics imposed mostly top-down by governments or higher inter-

[1] See Deliverable 4.2 Regional mapping report
[2] See Deliverable 4.1 Report on WB Just Green Transition Conceptualization

governmental policies. The transitions in Serbia and Albania, for instance, were proposed within broader urban development and resilience policies for decarbonization and depollution.

The implementation of the research activities was conducted in accordance with the Data Management Plan and ethical guidelines adopted by GreenFORCE. Each research case followed guidelines regarding data confidentiality, integrity, and availability. Participants were informed about the purpose, benefits, risks, and funding of the research and had the option to participate voluntarily. Anonymity was guaranteed, and personal data was collected only when necessary.

Acknowledging great potential in instrumentalising this research work for effective policymaking is crucial. Our scope is for governments to take steps in creating knowledge about the expected impacts of just green transition as a way to correct actions in dynamic way, and to prepare the society for the transition. Through a combined forecasting - back casting method, similar to the scenario-based method used in these research cases, actions may be assessed prior to being implemented, along with implementation or right after it. Because the transitions are gradual processes of change (Rotmans et al., 2001), this path of iterative cycles of learning, doing, evaluating, learning and doing again should facilitate the just green transition achieve its end result in the Western Balkans and beyond.

Case studies

The five case studies were chosen based on their potential to provide diverse and insightful perspectives on green transitions in the WB, focusing on key sectors and territories, with the only conditionality – covering at least 3 out of the 5 Green Agenda Pillars (decarbonization; depollution; circular economy;

Indeed, each case study addresses critical aspects of the green transition, including energy efficiency, waste management, and sustainable mobility, tailored to the unique socio-economic and environmental contexts of the respective territories.

The broad topics for each territory were identified in a co-design process with multiple quadruple helix stakeholders. The first co-design workshop of the GreenFORCE project, held on November 8, 2022, aimed to conceptualize the Green Transition in the Western Balkans from policy, socio-economic, spatial, scientific, and technological perspectives through a back-casting scenario analysis. Approximately 50 societal actors from policy, civil society, industry, and academia participated, contributing to an interactive visioning process. The workshop was structured on group discussions focusing on five core thematic dimensions—Climate, Depollution, Circular Economy, Energy Efficiency, and Territorial Planning. Within these discussions a few potential research targets were identified. For example, the discussion on energy focused very highly on the importance of renewable energy transitions, and on improvement of energy efficiency in the residential sector. The circular economy discussion stressed the importance of designing effective waste management systems. The Territorial Planning group underscored the significance of integrated territorial policies, sustainable urban transport, and nature-based solutions.

Taking into account the raised issues, the availability of data, the time and resource constraints, as well as the expertise of each of the WB partner institutions, Co-PLAN, CEA and UB-GEF designed their research case studies based in Albania, North Macedonia and Serbia respectively. These research concepts were subsequently co-validated in a second co-design process with quadruple helix stakeholders. A summary of the findings from these workshops can be found here. With the aim to cover at least 5 out of the 6 WB territories, a call for expertise was issued for the 3 remaining WB territories (BiH; Kosovo; Montenegro), ultimately concluding in development of research cases in BiH and Montenegro.

A brief summary of the Cases is shown below:

ALBANIA	BOSNIA & HERZEGOVINA	MONTENEGRO	NORTH MACEDONIA	SERBIA
Net-Zero transition for Post-Communist Urban Neighborhoods	**Assessing local economic and employment impact of JGT**	**Waste management sector transformation and its impact towards JGT**	**Implications of Transition in the Energy Sector at the Regional Level**	**Sustainable Mobility – Transitioning Public Transportation at Local Level**
Decarbonization (Energy Efficiency); Depollution	Decarbonization (RES)	Circular Economy	Decarbonization (RES)	Decarbonization (Sustainable Mobility); Depollution

Albania: The focus here is on decarbonizing post-communist urban neighborhoods. This case study examines the transition towards zero-emission buildings in Tirana, addressing both technical and socio-economic challenges. The selection was driven by the city's high energy consumption and outdated infrastructure, making it a crucial area for demonstrating the benefits and feasibility of sustainable urban development.

Bosnia and Herzegovina: This case study assesses the local economic and employment impacts of green transition initiatives. By focusing on specific sectors and regions within the country, the study aims to highlight the potential for job creation and economic resilience through green transition efforts.

Montenegro: This study examines the transformation of the waste management sector, a critical component of the circular economy. Montenegro's efforts to modernize waste management practices and reduce pollution provide valuable insights into the practicalities and impacts of adopting circular economy principles in the WB.

North Macedonia: This case study explores the implications of transitioning the energy sector in the Southwest planning region, home to one of the oldest and most polluting thermoelectric power plants. The region's heavy reliance on coal presents significant socio-economic and governance challenges, making it a pivotal area for understanding the broader impacts of energy sector reforms.

Serbia: Focused on sustainable mobility, this case study assesses the transition of public transportation in Kragujevac. The city's current public transport system and urban planning offer a unique opportunity to explore the benefits and challenges of implementing sustainable and smart mobility solutions in a mid-sized urban area.

Albania

Net-Zero transition for Post-Communist Urban Neighbourhoods in Tirana

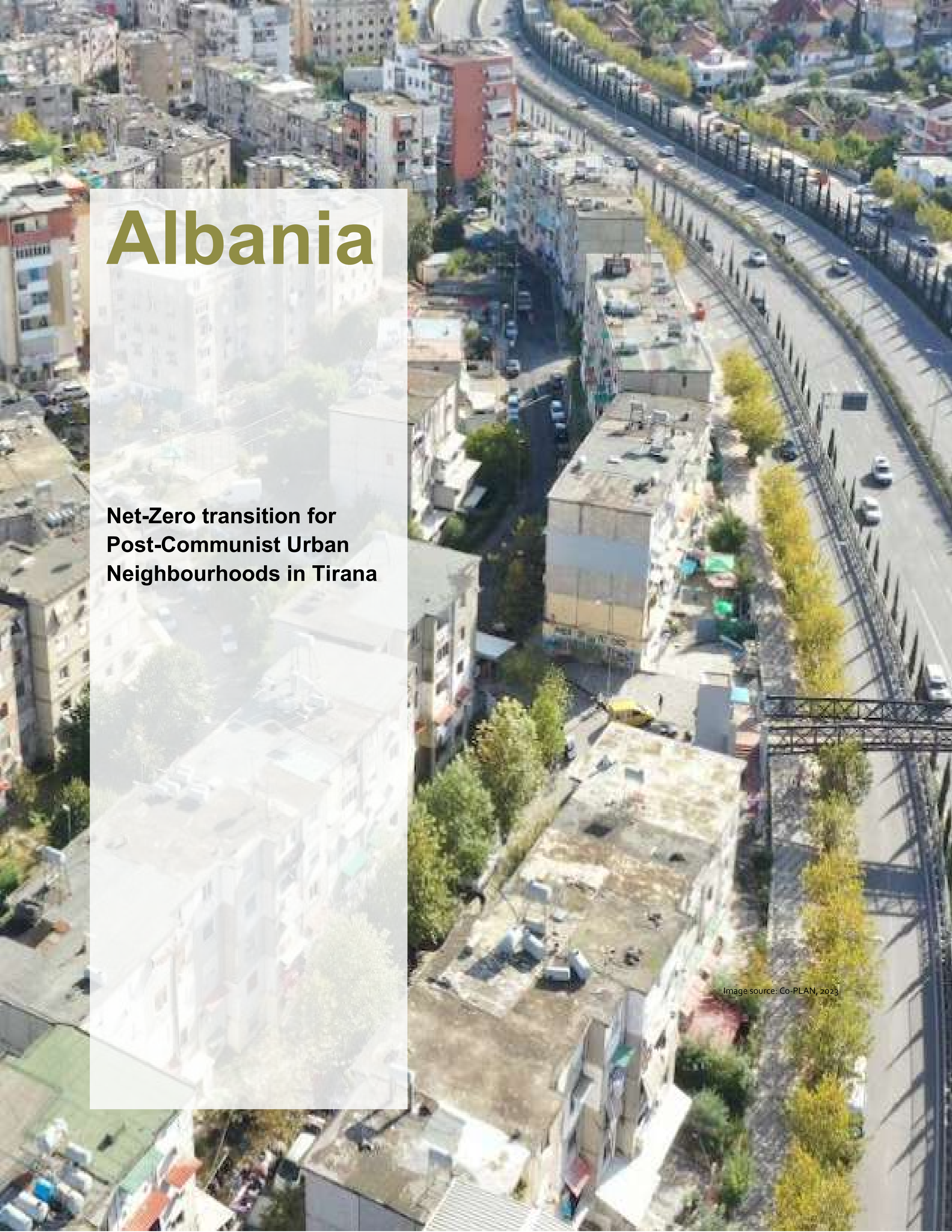


Image source: Co-PLAN, 2023

Albania

Net-Zero transition for Post-Communist Urban Neighbourhoods in Tirana

1.1. Introduction

In recent years, Albania has increasingly recognized the urgent need for sustainable development strategies, particularly in response to the challenges posed by climate change. The European Green Deal, endorsed through the Berlin Process since November 10, 2020, represents a pivotal shift towards a modern, climate-neutral, and resource-efficient economy. The commitment of Western Balkans (WB) countries, as outlined in the joint declaration in Sofia, underscores a collective effort towards addressing key pillars including climate, energy, mobility, circular economy, depollution, sustainable agriculture, and biodiversity.

This research addresses the urgent need to examine the socio-economic and environmental implications of transitioning towards **net-zero-emission buildings (NZEB)** in post-communist urban neighbourhoods, with a focus on large panel apartment blocks constructed during the 1960s to 1980s.

The research contributes to the Climate, Energy, and Depollution pillars of the WB Green Transition Agenda by providing evidence-based insights into the challenges and opportunities of transitioning towards NZEB. Moreover, it directly aligns with national strategies and initiatives aimed at enhancing energy efficiency, reducing carbon emissions, and promoting sustainable urban development.

The findings of this research can inform policy-making at the national, regional, and local levels by highlighting the socio-economic and environmental benefits of transitioning towards NZEB. While focused on Albania, the research results have broader implications for the Western Balkans region within the framework of GreenFORCE. By examining the challenges and opportunities of transitioning towards NZEB in post-communist urban neighbourhoods, the research provides valuable insights that can be generalized and applied to similar contexts across the region.

The main objective of the research is to identify and assess the expected benefits and costs of transitioning towards NZEB in post-communist urban neighbourhoods in Tirana, Albania. Through a combination of qualitative and quantitative analyses, the research aims to address the following research questions and sub-questions:

- What are the socio-economic and environmental expected benefits and costs of transitioning to zero-emission buildings in post-communist urban neighbourhoods in Tirana, Albania?
- What are the economic, social, and environmental impacts and implications of transitioning towards NZEB through energy efficiency measures?
- How can the research results contribute to improved policy-making at the national, regional, and local levels in Albania?
- What lessons and recommendations can be drawn from the research findings for Albania and other Western Balkans cities within the GreenFORCE framework?

1.2. Methodology

The research employs a predominantly qualitative approach, supplemented by quantitative data analysis. This mixed-methods design was chosen to provide a comprehensive understanding of the costs and benefits of energy efficiency interventions in the target areas. An ex-ante scenario-based approach was used to explore different pathways for achieving sustainable urban mobility and improved environmental performance up until year 2040.

Data was collected through a combination of surveys, interviews, observations, and document analysis. Surveys and interviews provided direct insights from stakeholders, while observations and document analysis offered additional context and background information. These methods were chosen to ensure comprehensive coverage of perspectives and data sources, contributing to the research objectives and scenario development. To ensure data reliability and validity, measures were taken to minimize bias, such as pilot testing survey questionnaires and training field surveyors on data collection protocols.

The research instruments included survey questionnaires, semi-structured interview guides, and observation protocols. These instruments were co-designed with stakeholder input and refined based on feedback from co-design workshops. Reliability and validity were ensured through rigorous data collection and archiving, following the Data Management Plan. The instruments were pilot-tested for reliability, and expert reviews ensured content validity.

The study focused on three areas with typical residential buildings representing Tirana's urban population. The selected areas—Ali Demi, 21 Dhjetori, and Ish-Teknologjiku—cover about 1-2 hectares each, comprising 7-10 buildings or approximately 250 apartments. These areas have a diverse residential mix, predominantly elders, consolidated families, and some young renters, making them representative of Tirana's socio-economic profile.

Analytical techniques applied included thematic analysis for qualitative data and statistical analysis for quantitative data. Data were processed, coded, and interpreted to derive meaningful insights, following the guidelines in the Data Management Plan. Software tools used for data analysis included SPSS for statistical analysis, ArcGIS for spatial data processing and mapping, and EnviMET for environmental performance assessment.

Table 1. Scenario Development

	Scenario 0 – Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	**Scenario 1 – Enhance Energy Performance of Prefabricated Buildings in Tirana**	**Scenario 2 – Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhood**	**Scenario 3- Build anew: Implement value capture instruments for redevelopment of entire area**
Description of the transition scenario	No action on addressing reduction targets for household and public services energy efficiency and consumption.	Initial assessment of energy performance and further design proposals for a complete renovation required to align energy consumption indicators of prefabricated buildings with class A energy performance.	S1 + substitution of energy production with RES / PV and harvesting of rain-water for sanitary and management purposes required to achieve net-zero objectives of the prefabricated buildings.	Redevelop all the area from scratch, taking into consideration the wider structural unit, as per General Local Plan
Underlying assumptions	There are no local policies and support measures for transition in the next 7 years. Increased energy price combined with building and appliances amortization leading to energy poverty. No strategic measures to tackle JGT will take place until the demolition option is presented (considering the lack of information and strategic support) or taken on board by the private sector (developers)	Community representatives, stakeholders and local/national authorities are open to: - Sharing sensitive information with regard to their socio-economic data - Sharing information upon household energy consumption and list of appliances. - Co-projecting and participate for JGT at a community level. Existing support scheme applied by Municipality of Tirana and Energy Efficiency Agency are	Note: Underling assumptions of S1 are all applicable to S2. The following assumptions are only applicable for S2 Local and Central agencies supporting community initiatives leading to auto-supply with what previously were public services. Besides the foreseen investments, there are co-financing and co-ownership modalities between community and local authorities. Legal and regulatory aspects and strategic documents are aligned and	There is interest from developers to redevelop the whole neighborhoods; Community representatives, stakeholders and local/national authorities are open to redevelopment and to discuss the proposed masterplan as shareholders of new development value

		prone to further alignment with NZEB as per the EU Directive on EE. Legal and regulatory aspects, strategic documents are aligned and in compliance with the Energy Community (EnC) acquis.	in compliance with the Energy Community (EnC) acquis. Regulatory framework and support of relevant public institutions for new investments in RES for auto consumption is in place.	

Methodological Highlights per Activity Plan

A1: Screening national and local legal and policy frameworks through **desk research** and **semi-structured interviews**.

A2: Conducting air pollution monitoring at seven stations across the study areas to establish a baseline.

The air quality monitoring practices involves measurements of pollutants at designated 7 stations in 3 areas through Aeroqual. The methodology is built based on sectors with the highest emissions in these areas such as transportation, urban development, the current state of pollutants (CO_2, NO_2, PM2.5 and PM10). and their impact on health. Measurements took place from 24.10.2023 to 21.03.2024.

A3: Conducting energy audits for five households to determine baseline energy performance.

Energy efficiency is measured by the ratio between the benefit obtained and the energy used. This methodology follows Regulation No. 5 dated 12.01.2021 for the energy audit. The audit report contains detailed elements described in the buildings under audit, including building envelope systems, technical systems, energy management systems, and the use of alternative high-efficiency systems. An accredited energy audit company conducted thorough energy audits and simulations for three different apartments in the 21-Dhjetori prefabricated blocks, covering three typologies: 1+1, 2+1, and 3+1. The audits included the physical construction of buildings, heating systems, interviews with managers, discussions with beneficiaries, and the use of local climate data.

A4: Assessing baseline urban environmental performance using Envi-MET for microclimate modelling.

ENVI-met software was used to study the microclimate situation of three areas. The model allows for the calculation of shortwave and longwave radiation fluxes, transpiration, evaporation, sensible heat flux, dynamic surface and wall temperatures, and the dispersion of gases and particles such as NO_2, CO_2, PM2.5, and PM10. Data for the model was collected through field surveys, including information on surface materials, construction materials, types of plants, and pollutant presence. Simulations were run for specific dates across a 20-day monitoring period, covering one date at the beginning, middle, and end of each month for each area. These simulations helped to analyze the urban heat island effect by observing interactions between potential air temperature, relative humidity, and diffused shortwave radiation with the urban environment.

A5: Assessing societal costs and benefits of NBS for environmental performance through workshops and toolkit development.

This activity is planned for the next phase, emphasizing the need to validate current proposals with local households

A6: Designing energy efficiency renovation scenarios to increase energy performance up to or close to Class A

By examining the energy audits, solutions were designed to approximate energy performance for each apartment to Class C and Class B, thus developing two sets of technical solutions

A7: Designing rooftop PV systems for self-consumption and interchange with the transmission network.

The designed PV system, simulated using PV SOL Premium 2021 software, considers 78% of the available rooftop space, leaving room for maintenance and potential future systems. The system is based on a full feed-in concept, with energy produced being directly discharged into the local grid. A bi-annual calculation determines each family's billable amount based on their consumption minus their share of PV-generated energy. Technical specifications include a PV generator output of 342.36 kWp, covering a surface of 1,650.5 m², with 634 PV modules and 12 inverters, utilizing climate data from Meteonorm 8.2 for Tirana (2001-2020).

A8: Designing rooftop rainwater harvesting systems for sanitary use and neighborhood sanitation.

From a technical standpoint, the system was designed taking into consideration the roof surface for collection, gutters for water transport, storage tanks for holding the collected water, and an extraction device for use. The research employed a combination of intermittent and full regimes for rainwater harvesting, considering the meteorological patterns of a prolonged dry summer season and the peak demand for water during this period.

A9: Conducting a cost-benefit analysis to determine the impacts and implications of transition scenarios.

A Social-Economic CBA (SE-CBA) approach was used, identifying project outcomes through desk reviews, surveys, expert assessments, and international practices, followed by quantifying and monetizing these outcomes. The analysis compares the "with project" scenario against the "without project" counterfactual to determine net impacts. It evaluates the behavior of costs and benefits over a reference period, applies discounting to obtain present values, and calculates key economic indicators such as the Economic Net Present Value (ENPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (BCR). Publicly available data, survey results, technical project data, expert assessments, and national and international sources were utilized. Assumptions include a 16-year reference period, the use of social discount rates, and the exclusion of VAT.

A10: Assessing the demolish and redevelop scenario using Value Capture Instruments.

The assessment considered the full redevelopment of the structural units where the target areas are part of, using a revised proposed FAR; the carrying capacity calculation of the area; and a calculation of the residual land value to be used for public investment within the redeveloped area. The work conducted for this scenario was integrated with the regulatory planning course within the curricula of Urban Planning and Management Master's Program; Polis University.

1.3. Policy and legal context

Albania is in the process of establishing the energy efficiency obligation scheme as mandated by the Energy Efficiency Law. The Ministry of Infrastructure and Energy has drafted an order for the approval of this scheme, but it has yet to be adopted.

Regarding funding mechanisms for energy efficiency, no dedicated fund has been created. Currently, investments in energy efficiency are primarily supported through the state budget and foreign financial aid, with a significant focus on the buildings sector. Additionally, local banks are promoting energy efficiency by offering credit lines for various measures, especially for enhancing the thermal insulation of building envelopes in private buildings. These initiatives receive subsidies covering up to 50% of the costs, financed by the Municipality of Tirana.

The development of the energy service company (ESCO) market model is still ongoing. The necessary regulations and model contracts for energy performance contracting have not yet been adopted.

Albania has made progress toward energy efficiency and climate action by introducing its 2030 energy efficiency targets and related policies, as outlined in the NECP adopted in February 2022. However, these measures do not fully align with the 2030 targets established by the Energy Community.

Although the Energy Efficiency Law established a legal foundation for a comprehensive assessment of the potential for efficient heating and cooling in 2021, Albania has yet to conduct these assessments as required by Article 14 of the Energy Efficiency Directive. Additionally, the implementation of provisions for inspecting heating and air-conditioning systems remains incomplete. Recently, Albania subsidized solar water heating systems for 2,000 families. Ministry of Infrastructure and Energy introduced new by-laws to implement the Energy Efficiency Law, addressing local energy efficiency action plans and building requirements. The drafting of additional by-laws covering key areas such as monitoring and verification, energy efficiency obligations, and public procurement criteria is ongoing, with their adoption still pending.

To encourage energy demand reduction within public institutions, the Government has mandated a 15% reduction in electricity consumption. Designated energy managers are tasked with monitoring and reporting progress. Penalties have been instituted for non-compliance.

According to the 2011 census, Albania had a total of 598,267 residential buildings for a population of 2,821,977 people, with 53.5% living in urban areas and 46.5% in rural areas. The total number of households was 1,012,062, of which 722,262 were private houses. However, only 709,865 households were occupied at the time of the census (Instat, 2011).

The building stock has been categorized into 20 different types. The largest group comprises individual houses built between 1991 and 2010, totalling 108,752 buildings. Other significant groups include apartments constructed between 1961-1980 and 1981-1990.

Since 1960, residential buildings in Albania have often been constructed using prefabricated technology with "sandwich" type insulation incorporated into the construction panels. Buildings erected during the peak construction years of the 1990s frequently had partial or inadequate insulation. Precast buildings consist of various prefabricated elements that are manufactured off-site and then connected together on-site using simple connections. The ease of assembly and the short time required for prefabricating and assembling the panels have made these structures highly popular in Albania, the region, and globally. Even in the 2000s, building codes were not stringent, resulting in many structures failing to meet the necessary insulation criteria. Consequently, thermal insulation is generally poor, leading to high energy consumption. Some buildings have undergone renovations, with common interventions including the addition of thermal insulation, roof hydro-insulation, and the replacement of old windows and doors with double-glazed alternatives.

A long-term building renovation strategy has not yet been adopted in Albania. However, following the adoption of relevant by-laws to implement the 2016 Law on Energy Performance of Buildings, the country has established an operational energy performance certification system. The Energy Efficiency Agency is responsible for supporting the issuance of energy performance certificates for buildings and overseeing the scheme. Since its inception, more than 40,000 audit reports have been issued and more than 9800 units have undergone an basic energy performance enhancement through envelope insulation (either co-financed with various grant schemes or totally private financing)

1.4. Energy efficiency in target area – key findings from energy audit

This component served as basis for scenario 1. A full energy audit was performed for 3 residential units in the 21-Dhjetori area. Some technical solutions were introduced to improve the energy performance of these aging buildings, which are known for their poor energy efficiency. Subsequently, the findings were generalized for the 3 study areas.

The methodology follows Albania's Regulation No. 5 (12.01.2021) for energy audits, supplemented by the German ENEV standard due to the lack of specific Albanian energy performance standards. The audit process was thorough, involving detailed examinations of building construction, heating systems, and interviews with both managers and residents. Local climate data was also incorporated to ensure accuracy.

The block consists of three apartment types: 38 units of 1+1 (55m2), 75 units of 2+1 (71.7m2), and 30 units of 3+1 (90m2). The three detailed audits covered different apartment types and locations within the building (ground floor, top floor, and south-facing) to account for varying thermal behaviors.

The research scenario aims to enhance the energy performance class of these buildings from their current E or D ratings to as close to A by 2040. To achieve this, a range of interventions were proposed, including:

- Wall and roof insulation using 11cm EIFS plaster and insulation board
- Replacement of windows and doors with 18cm double glazing
- Blockage of thermal nodes with 8cm glass wool
- Upgrade of HVAC systems to Class A++ with COP > 3.6
- Replacement of lighting with LED systems
- Upgrade of appliances to Class A++

The results of the audits were promising. For example, the 55m2 apartment could reduce its annual energy consumption from 140 kWh/m2 to 79.5 kWh/m2, resulting in savings of 3,327 kWh or 31,606 ALL per year, with an investment of 6,332 Euro. Similar improvements were observed in the other audited apartments.

Table 2. Findings from Energy Audit –baseline

Pre Energy Efficiency					
Unit Typology	**Total No Units**	**Energy Demand (kwh/m2)**	**Class**	**Yearly Consumtion (kwh)**	**Annual Energy Cost (Lek)**
1+1	38	140	E	292600	2.779.700,00
2+1	75	136	E	577500	5.486.250,00
3+1	30	155	D	418500	3.975.750,00

total	**131**	**E**	**1288600**	**12.241.700,00**

Source: Authors' calculations based on independent Energy Audit assessment

Table 3. Findings from Energy Audit after measures have been set up

Post Energy Efficiency						
Unit Typology	**Total No Units**	**Investment (Lek)**	**Energy Demand (kwh/m2)**	**Class**	**Annual Energy Savings (kwh)**	**Annual Financia Savings**
1+1	38	24.061.600,00	79,5	C	126426	1.201.047,00
2+1	75	47.490.000,00	81	C	249525	2.370.487,50
3+1	30	18.996.000,00	81	C	99810	948.195,00
Total		**90.547.600,00**	**80,00**	**C**	**475761**	**4.519.729,50**

Source: Authors' calculations based on independent Energy Audit assessment

The current condition shows that water absorption in the facade is relatively high, thus negatively impacting the actual thermal performance of all prefabricated blocks at 21 Dhejtori study area. Excessive water presence increases the thermal performance coefficient (U value), exceeding acceptable limits. Windows, being one of the elements with the highest heat flow, require significant intervention to enhance the building's thermal performance, as their current thermal efficiency is very poor.

Only one of the buildings has already implemented energy efficiency measures by applying a thermal insulation on the facade but no further changes in appliances or windows.

On the other hand, for some of the buildings, it is recommended to requalify the foundation, exterior walls, terrace, and windows in terms of thermal performance before applying the thermal insulation system. This includes insulating all joints between prefabricated panels and surface treatment with concrete primer like web-prim.

Addressing only the external walls results in minimal improvement in heat flow from inside to outside, making terrace insulation necessary. Reducing the U-value of the windows can significantly enhance the building's thermal performance, so their immediate improvement is strongly recommended.

The baseline analysis reveals that the old apartments consume a substantial amount of energy for heating and cooling due to inadequate insulation. Without proper insulation in the walls, windows, and roof, the building suffers significant heat loss in winter and heat gain in summer, leading to increased energy demands to maintain comfortable indoor temperatures.

Consequently, the old apartment incurs high energy costs for heating and cooling throughout the year. The poor insulation and high U-values contribute to thermal inefficiencies, causing the HVAC systems to operate more frequently and at higher capacities, leading to elevated energy bills for the occupants or property owner.

The occupants likely experience discomfort due to temperature variations, drafts, and uneven heating or cooling distribution. The inadequate thermal insulation and inefficient building envelope exacerbate indoor comfort issues, affecting the quality of life and productivity of residents, especially during extreme weather conditions.

The baseline analysis also highlights the lack of regular maintenance practices for the apartment's building envelope and HVAC systems. Deferred maintenance worsens energy inefficiencies, as deteriorating components such as weather seals, insulation materials, and HVAC equipment degrade over time, further compromising the building's energy performance and comfort levels.

Given these findings, the old apartment urgently needs retrofitting measures to improve its energy efficiency and thermal comfort. Retrofitting interventions such as insulation upgrades, window replacements, sealing air leaks, and HVAC system optimizations are essential to mitigate heat loss, enhance thermal performance, and reduce energy consumption. Investing in energy efficiency upgrades and maintenance for the old apartment can yield significant long-term benefits, including reduced energy costs, improved occupant comfort and health, increased property value, and a lower environmental impact. Implementing energy-efficient measures aligns with sustainability goals, enhances the building's resilience, and ensures a more sustainable and cost-effective operation in the long run.

It is estimated that a total of **1287000 kwh** electricity is consumed each year by all 143 householders and small businesses resident within the study area. Therefore, the actual investments **900,000 euro** for the thermal insulation, lightning, appliances and HVAC system generates an overall annual energy saving of **475761 kwh.**

On a comparative note, if also Ali Demi and Teknologjike areas were to be invested into a B class energy performance the following results would be expected:

Ali Demi:

Annual Energy Savings: 1,101,600 kwh

Annual Financial Savings: 10,465,205 ALL

Investment: 456,504,275 ALL

Ish-Teknologjiku:

Annual Energy Savings: 855,124 kwh

Annual Financial Savings: 8,123,656 ALL

Investment: 354,364,050 ALL

1.5. Environmental performance in target area

Environmental performance in the target area was focused on 2 dimensions: pollution and urban greenery.

1.5.1. Air quality monitoring

All three selected study areas represent significant similarities with regard to construction period with over 55 years of age. Featuring an urban form composed of linear and parallel and closed edge residential buildings ranging from five to six floors, oriented mainly from the Northwest. Such an arrangement is ideally suited for the natural dispersion of air pollutants and facilitates natural ventilation, leveraging the most prevalent wind directions in Tirana.

Ish-Teknologjiku and Ali Demi areas stand out for their natural ventilation efficacy, attributable to their linear residential structures as well as to presence of main roads that do facilitate the creation of urban canyon effect. Despite the proximity to construction activities, congestion 21 Dhejtor exhibited lower pollution levels, particularly due to the distance from these sources of pollution.

Table 4. Summary table of key findings from environmental survey

Area	21 Dhjetori			Teknologjiku			Ali Dem		
Pollutant	PM 2.5	PM 10	NO2	PM 2.5	PM 10	NO2	PM 2.5	PM 10	NO2
Monitored Concentration	12,8	21,3	70	10	18	134	27	36	142
Difference with WHO std	7,8	1,3	60	5	-2	124	22	16	132
Difference with EU std	-7,2	-18,7	30	-10	-22	94	7	-4	102
Annual health cost of PM air	31,2	5,2		20	0		214	64	

pollution exposure per family (70Eur and 280 Eur)									
Annual health cost of NO_2 air pollution exposure per family (70Eur and 280 Eur)			360			1000			1080
Number of families	143			170			219		
Total Public Health Cost	4.461,60	743,60	51.480,00	3.400,00	-	170.000,00	46.866,00	14.016,00	236.520,00
Overall cost per areas	**56.685,20**			**173.400,00**			**297.402,00**		
Total annual Public Health impact in all 3 areas	**527.487,20**								

Source: Co-PLAN, 2023-2024

The assessment of air quality across the Ali Demi, 21 Dhjetori, and ish-Shkolla Teknolognike zones reveals significant variations in pollutant levels, highlighting distinct challenges and areas of concern. Based on the air quality data for each zone, it is concluded that proximity to traffic and roads increases exposure to pollutants, while the presence of urban greenery and its ecosystem services significantly improves air quality. The prominence of these locations along major thoroughfares serves as a critical indicator of pollution levels, predominantly stemming from vehicular traffic and poorly maintained roadways.

Observations indicate that the urban form play a significant role in determining the infiltration of pollutants into interior spaces and further the dispersal of pollution through natural ventilation. Structures situated close to roadsides and stretching along them are particularly susceptible to heightened exposure to pollutants whilst 21 Dhjetori stands out as an area with less concentration due to distance with source but with a higher retention rate due to its urban form and deprived natural ventilation.

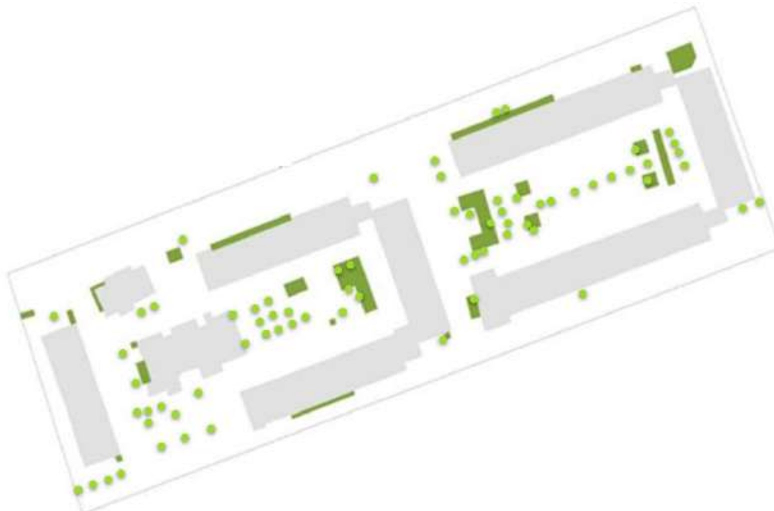
1.5.2. Urban Greenery

The 21 Dhjetori area in Tirana, characterized by prefabricated blocks, has largely maintained its original urban layout since its design phase. The public spaces, although intact, are predominantly occupied by informal car parking and large underground refugee settlements. Only 6% of the total study area is considered green space, with low and high vegetation allowing for water infiltration. The inner part of the block features approximately 20-25-year-old plane trees (Platanus species), providing various ecosystem services that enhance environmental health and offer economic benefits.

Urban plane trees contribute significantly to the urban ecosystem by improving air quality, sequestering carbon, regulating temperatures, managing stormwater, and supporting biodiversity. These trees effectively absorb pollutants such as ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM_{10} and $PM_{2.5}$), with a single mature plane tree capable of absorbing up to 21.77 kg of pollutants annually (Nowak et al., 2006). Through photosynthesis, they produce substantial amounts of oxygen, with one tree generating up to 1500 kg of oxygen each year (McPherson et al., 1997). Additionally, plane trees sequester carbon dioxide in their biomass, storing around 1 ton of CO_2 over their lifetime, thereby mitigating climate change impacts (Nowak & Crane, 2002).

The plane trees also play a crucial role in temperature regulation. They provide substantial shade, which can reduce surface temperatures by 11-25°C (Akbari et al., 2001), thus mitigating the urban heat island (UHI) effect. Their evapotranspiration process releases water vapor, further aiding in cooling the urban environment. In terms of water management, these trees intercept rainfall, reducing runoff and easing the burden on urban drainage systems, which helps mitigate flooding and improve water quality by decreasing the amount of pollutants reaching water bodies (Xiao et al., 1998). Moreover, plane trees provide habitat and food for various urban wildlife, including birds, insects, and small mammals, supporting urban biodiversity (Davies et al., 2011).

Figure 1. Mapped green areas and tree vegetation in 21 Dhjetori



Source: Author's elaboration based on field investigation

In addition to plane trees, the 21 Dhjetori area includes 28 linden trees (Tilia species), with the potential to plant 52 more, completing the area with 80 linden trees. Linden trees offer similar ecosystem services, with notable contributions to air quality, carbon sequestration, temperature regulation, water management, and biodiversity support. A single mature linden tree can absorb up to 21.77 kg of pollutants and produce approximately 1500 kg of oxygen annually (Nowak et al., 2006; McPherson et al., 1997). They also store around 1 ton of CO_2 over their lifetime (Nowak & Crane, 2002).

Linden trees aid in cooling the air through evapotranspiration. In terms of water management, mature linden trees intercept thousands of gallons of stormwater annually, reducing runoff and improving water quality (Xiao et al., 1998). Additionally, linden trees support urban biodiversity by providing habitat and food for various wildlife. Notably, linden tree flowers are used for curative tea, with a single mature tree generating 7-10 kg of flowers each season, valued at 5 euros per kilogram.

Monetary valuations of these ecosystem services show that the **annual benefits of a single urban linden tree can range from 80 to 120 euros**, depending on its location and age (McPherson et al., 1997). Tools like i-Tree, developed by the USDA Forest Service, quantify these benefits, providing detailed reports on the ecosystem services provided by trees, including linden trees.

1.5.3. Environmental performance

Within the environmental performance study, the general microclimate condition and potential for nature-based solutions (NbS) was assessed for the three prefabricated residential areas: 21 Dhjetori, Ali Demi, and Ish-Teknologjiku. The study employs ENVI-met, a 3D microclimate modeling software, to simulate surface-plant-air interactions and assess the effects of urban design on local environmental conditions.

The methodology involved collecting detailed data on surface materials, construction types, vegetation, and pollutants through field surveys. This data was then integrated into the ENVI-met model to run 24-hour simulations for specific dates across a monitoring period spanning several months. The key parameters analyzed were potential air temperature, relative humidity, diffuse short-wave radiation, and particle trajectory.

In 21 Dhjetori, simulations showed that the block typology was more effective at retaining cooler temperatures during peak sun hours compared to linear building arrangements. However, these blocks also tended to retain higher humidity levels, potentially offsetting the comfort benefits of cooler temperatures. The area experienced significant changes in diffuse radiation throughout the day, with asphalt and paved surfaces retaining more heat than buildings.

Ali Demi's urban composition, featuring a mix of villas, medium-density, and high-density buildings, created small urban pockets with cooler temperatures due to building shadows. However, these pockets also retained higher humidity levels. The area's fragmented morphology affected air circulation, with the largest corridors between buildings allowing for better airflow.

Ish-Teknologjiku demonstrated the most significant temperature changes over the three-hour peak sun period, with both linear and block typologies experiencing distinct temperature variations. The area's wind patterns, influenced by its urban layout, created three major corridors that affected particle dispersion and air quality.

Across all three areas, asphalted surfaces like roads consistently showed the highest heat retention, followed by paved surfaces and then buildings. This highlights the significant role of urban surface materials in contributing to the urban heat island effect.

The research underscores the complex interplay between urban design, building typology, and microclimate factors. Block typologies, while often cooler, may create less comfortable conditions due to higher humidity and potential air quality issues from wind vortices. Linear typologies generally allow for better air circulation but may be more susceptible to heat retention depending on building orientation and length.

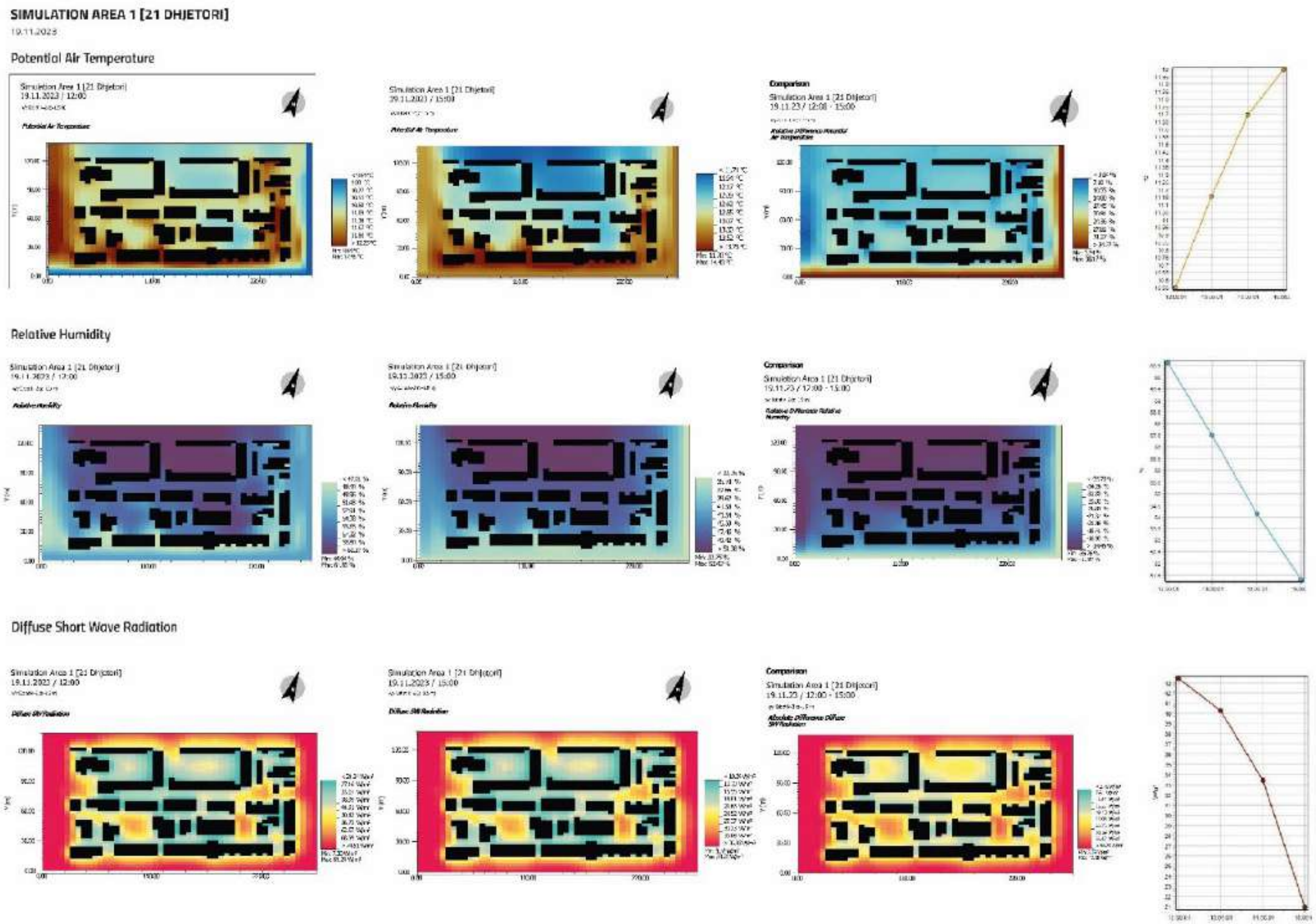
Based on these findings, the study recommends several nature-based solutions and urban planning strategies:

1. Prioritize green infrastructure, such as parks and urban forests, to improve cooling, air quality, and reduce urban heat islands.
2. Use high-albedo and light-coloured materials for pavements and buildings to decrease heat absorption.
3. Design urban layouts that incorporate prevailing wind patterns to enhance air circulation and prevent wind vortices.
4. Integrate water features to help regulate humidity and temperature.
5. Implement regular climate and air quality monitoring for informed decision-making.
6. Enforce stricter regulations on industrial and vehicular emissions to reduce pollutants.
7. Launch public awareness campaigns about the benefits of urban greenery and sustainable practices.

NbS are presented as adaptable, context-specific strategies that can address multiple urban challenges simultaneously, including climate change mitigation, biodiversity loss, and disaster risk reduction. Examples include green roofs, carbon-sequestering urban forests, wildlife-friendly urban design, and permeable pavements for stormwater management.

However, the research cautions against viewing NbS as a universal panacea. Their effectiveness is highly dependent on local climate and ecosystem characteristics, and their implementation can involve complex trade-offs between ecological benefits and socio-economic needs. The study emphasizes the importance of considering potential drawbacks, such as unequal benefit distribution and the need for continuous funding and maintenance.

Figure 2. **Summary findings from environmental performance simulation, 21 Dhjetori neighbourhood**



Source: EnviMet, author's interpretation

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1.6. Potential to use renewable energy and rainwater harvesting in target area

For development of scenario 2, a thorough assessment of the feasibility of instalment of photovoltaic panels and thermal solar panels was developed, including the potential to store rainwater for non-drinkable use. The research was focused in the '21 dhjetori' area and results were generalized for the other ones.

1.6.1. Designing rooftop PV systems (scenario) for self-consumption purposes, interchange with transmission network

The photovoltaic (PV) system design proposed for the 21 Dhjetori prefabricated blocks in Tirana is part of a broader initiative to increase renewable energy use, reduce carbon emissions, and enhance energy efficiency. The focus is on generating renewable electricity to offset a significant portion of the area's electricity consumption, thereby reducing reliance on the national grid and promoting energy self-sufficiency.

A: Albania's Energy Profile and Renewable Energy Potential

Albania's energy production relies heavily on renewable sources, primarily hydropower, which accounted for 89% of its electricity generation in 2019. However, the country's energy sector faces challenges, including vulnerability to variable rainfall and the need to diversify its renewable energy sources. The government has introduced the National Action Plan on Renewable Energy Sources, aiming to add 740 MW of photovoltaic and wind energy. This shift towards renewable energy is crucial given Albania's status as a net energy importer and the high energy consumption in the residential sector, which accounts for 49% of total electricity use.

Technical Specifications and Design

The PV system for the 21 Dhjetori area is designed using PV SOL Premium 2021 software, which considers 78% of the rooftop surface (approximately 1650 m²) as feasible for installation. This area allows for the integration of maintenance operations and future HVAC rooftop systems. The system includes 634 PV modules (SunPower SPR-P6-540-COM-M-BF-V2) and 12 inverters (Fronius ECO 27.0-3-S), configured for efficient direct grid connection. The installed capacity of the PV system is 343 kWp, with an expected annual production of 408,415 kWh.

The total investment for the PV system is estimated at 240,000 Euros, with a projected payback period of approximately six years. The system's electricity production cost is 0.026 Euros/kWh, significantly lower than the current retail price of 0.09 Euros/kWh. Over a 25-year period, the PV system is expected to generate substantial economic benefits, including approximately 1 million Euros in electricity revenues. Additionally, the system will avoid 193,917 kg of CO_2 emissions annually, contributing to Albania's climate goals.

Table 5. PV System Energy Balance

Parameter	Value	Unit
Global radiation - horizontal	1558.47	kWh/m²
Deviation from standard spectrum	-109.09	kWh/m²
Ground Reflection (Albedo)	2.2	kWh/m²
Irradiance on the rear side of the module	0	kWh/m²
Global Radiation at the Module	1433.1	kWh/m²
Global PV Radiation	2,365,349	kWh
PV energy (DC)	429,372.22	kWh
PV Generator Energy (AC grid)	412,662.01	kWh

Source: Author's calculations based on desk review**Error! Not a valid link.**The PV system's performance is characterized by a high specific annual yield of 1205.13 kWh/kWp and a performance ratio of 84.10%. The system is designed to minimize yield reduction due to shading, estimated at only 1.2%. The technical simulation forecasts

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a grid export of 412,660 kWh per year, with an initial grid export of 408,415 kWh, accounting for module degradation.

Cash Flow and Financial Indicators

The financial analysis of the PV system includes an internal rate of return (IRR) of 17.21% and an amortization period of 5.7 years. The electricity production costs are calculated at 0.0264 Euros/kWh. The system's cash flow is projected over a 25-year period, with annual feed-in/export tariff revenues starting at 44,926 Euros and decreasing slightly due to module degradation. The accrued cash flow is expected to reach 662,099 Euros by the end of the assessment period.

Table 6. Financial Analysis

Parameter	Value	Unit
Total investment costs	239,652	Euros
Internal Rate of Return (IRR)	17.21	%
Amortization Period	5.7	Years
Electricity Production Costs	0.0264	€/kWh
Accrued Cash Flow (Cash Balance)	662,099	Euros
Total Payment from Utility in First Year	44,925	€/Year

Source: Author's calculations

The study also considers the integration of green roofs with PV systems to enhance urban resilience and sustainability. While green roofs provide ecological benefits such as improved air quality, reduced stormwater runoff, and enhanced biodiversity, PV systems offer direct renewable energy generation and significant economic savings. A hybrid approach, combining both solutions, may maximize energy efficiency and environmental benefits for Tirana's prefabricated buildings.

1.6.2. Designing rainwater harvesting systems

Rooftop rainwater harvesting (RTRWH) is an efficient and sustainable method for collecting and using rainwater for domestic and neighborhood sanitation purposes. This technique captures rainwater from building roofs, directs it through gutters to storage reservoirs, and uses it directly or for groundwater recharge. RTRWH is valued for its simplicity, cost-effectiveness, and scalability, making it suitable for both individual households and large housing developments. One of the primary advantages of RTRWH is its cost-effectiveness. The initial installation and maintenance costs are relatively low compared to other water supply systems. Maintenance primarily involves occasional cleaning of gutters and storage tanks. Additionally, RTRWH provides a supplementary water source during times when conventional supplies are scarce or contaminated, which is particularly beneficial in arid regions or areas with brackish groundwater. From an environmental perspective, RTRWH reduces dependence on municipal water supplies, conserves groundwater resources, and helps mitigate urban flooding by capturing and storing rainwater.

However, RTRWH also presents certain challenges that need to be addressed to ensure the quality and safety of the harvested water. Collected rainwater can be contaminated by pollutants from the air, animal or bird droppings, insects, and organic matter that accumulate on the roof. Regular maintenance is crucial to prevent the build-up of contaminants, which includes cleaning gutters, downspouts, and storage tanks, as well as repairing any damages. Appropriate water treatment methods such as filtration and disinfection are essential to ensure the harvested rainwater is safe for consumption. Filtration systems can remove particulate matter, while disinfection methods such as chlorination or UV treatment can eliminate harmful pathogens.

Implementing RTRWH involves installing gutters along the edges of the roof to channel rainwater into downspouts, which direct the water to a storage reservoir. The storage tank, which can be above ground or underground depending on space and aesthetic considerations, should be equipped with a filtration system to remove debris and a cover to prevent contamination. Regular maintenance tasks include cleaning the gutters and downspouts to prevent blockages and debris accumulation, inspecting and cleaning the storage tank periodically to ensure it remains free of contaminants, and checking for and repairing any leaks or damages to the system promptly.

In Albania, although detailed information about specific RWH projects is sparse, the practice is increasingly recognized as a viable solution for addressing water scarcity and managing water resources sustainably. Notable initiatives have been undertaken mainly by private entrepreneurs or historically by families living in remote areas. However, there is no specific regulation or law in Albania that mandates or regulates RWH. Efforts to develop regulatory frameworks for sustainable water management, including RWH, are part of broader strategies to enhance water security and mitigate the impacts of climate change.Local people can be easily trained to construct RWH systems themselves, which lowers costs and fosters greater participation, ownership, and sustainability at the community level. Rainwater is often superior to other available or traditional water sources, which may be unusable due to issues like fluoride, salinity, or arsenic contamination in groundwater. This method can also save money on purchasing water and reduce the time spent extracting water from city supplies. Furthermore, RWH provides water directly at the point of consumption and is not influenced by local geology or topography.

Additionally, RTRWH helps reduce the volume of rainwater entering sewers and drains, mitigating flooding and preventing clogging of water channels and uptakes. Rooftop rainwater harvesting stands out as a practical and sustainable solution to water scarcity and quality issues, offering significant environmental, economic, and social benefits. While it requires regular maintenance and appropriate water treatment to ensure safety, its versatility and scalability make it an attractive option for a wide range of applications.

As climate change and population growth continue to strain traditional water resources, RTRWH can play a crucial role in achieving water sustainability and resilience for communities around the world. In Tirana, the variability and intensity of rainfall underscore the need for efficient water management strategies. Implementing RTRWH systems can help mitigate the effects of irregular precipitation patterns and provide a reliable supplementary water source.

Rooftop rainwater harvesting involves collecting rainwater from rooftops, transporting it via gutters to a storage reservoir, and either using it directly at the point of consumption or for groundwater recharge. This method can supplement water sources, especially when traditional sources become scarce or are of low quality, such as brackish groundwater or polluted surface water. However, the quality of harvested rainwater can be affected by various factors, including air pollution, animal droppings, insects, and organic matter. Therefore, regular maintenance, such as cleaning and repairs, along with appropriate treatment methods like filtration and disinfection, are crucial to ensure the safety and usability of the collected water.

A: Findings for the study area

In the study area of 21 Dhjetori in Tirana, the total rooftop surface available for RTRWH is 1800m². With an average annual precipitation of 1250mm, approximately 2250m³ of rainwater can be harvested annually. Additionally, 180m³ can be collected from cooling system discharge water. The stored rainwater will be used for public space washing, cleaning household items, and creating water bodies to mitigate the urban heat island effect.

Table 7. Typical water consumtion of one individ per day.

Water Consumption	**individual water demand per day**	**%**
Drinking, Cooking	22,5	18%
Cleaning	21,25	17%
Bathing	20	16%
House Item & Car Washing	31,25	25%
House Cleaning / Gardening	12,5	10%
Toiles / Sanitary	17,5	14%
Total	**125**	**100%**

Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_statistics

The proposed interventions include roof levelling, installing a new gutter system, filtration systems, storage tanks, pumps, and water supply systems. Two surface water ponds with integrated fountains will be created to ease the

UHI effect. The cooling effect of these water bodies is expected to decrease temperatures by up to 7.5°C within a 100m buffer area. The harvested rainwater will also be used for secondary purposes such as washing household items and cars, contributing to a 6% reduction in overall water demand and annual savings of 2000 Euros for the study area.

By implementing RTRWH, the 21 Dhjetori area aims to become the first neighborhood in Tirana to achieve significant reductions in public water system burdens, mitigate the UHI effect, lower flooding risks, and promote sustainable practices. Such interventions are expected to increase property values by approximately 10%. Similar investments in the Ali Demi and Ish-Teknologjiku areas could yield annual rainwater volumes of 3645m³ and 2845m³, respectively, with higher investment costs due to additional ground works required for storage tank installations.

Table 8. Proposed intervention

	unit	price per unit	Cost Euro
roof levelling works	1800	2,5	4500
new gutter system	345	10	3450
first filter	14	25	350
particulate filter	14	70	980
400m³ storage tanks	2	1500	3000
ground works	2	800	1600
pumps	2	300	600
water supply system	300	22	6600
fountains	2	450	900
ponds	2	600	1200
public water inlet (for washing and gardening)	8	120	960
Fire hydrants	2	150	300
Total Investment			**24440**

Source: Author's calculations

1.7. Redevelopment scenario

1.7.1. State of the art

The planning legislation in Albania, revised in 2014, outlines specific conditions and rules to be integrated at the area level for development purposes. According to DCM No. 686, dated 22.11.2017, titled "On the Approval of the Territorial Planning Regulation," any areas undergoing redevelopment, typological changes, or changes in intensity/density must be planned based on a detailed local plan. This regulation ensures that all landowners within the structural unit slated for redevelopment are considered shareholders in the new development, thereby fostering inclusive and equitable urban transformation.

The density parameters for each structural unit are delineated in the General Local Plan, approved in 2015, which remains valid until 2030 for the municipality of Tirana. While the plan provides a robust framework for urban development, it is designed with the flexibility to accommodate changes throughout its implementation, ensuring that it remains responsive to evolving urban needs and conditions.

1.7.2. Construction sector in Tirana

Albania's residential sector has undergone significant transformation since the fall of communism in the early 1990s. The shift from a centrally planned economy to a market-based system has led to rapid urbanization and substantial changes in housing patterns. The legacy of prefabricated buildings from the communist era presents a challenge, as these structures often lack modern amenities, proper insulation, and energy efficiency, resulting in high energy consumption and poor living conditions (INSTAT, 2020). The demand for residential spaces in urban areas, particularly in Tirana, has surged due to increased urbanization, population growth, and rising living standards. The market, supported by local government, has responded with a mix of new developments, either plot-based, tower typologies, or area-based large-scale investments. However, affordability remains a critical issue, with significant disparities between income levels and housing prices (World Bank, 2021).

Indeed, compared to the region, the Albanian economy is most dependent on the construction sector. In 2022, the added value of construction in GDP was 12%, twice as high as the average in Southeast European countries. Kosovo follows closely behind with nearly 11% (Central Bank of Austria, 2023). According to CBA (2023) Albania tops the ranking for investment in housing, accounting for 12% of GDP, indicating that they are seen as a form of investment with quick returns. As for prices, Albania has the strongest growth since 2019, with a 90% increase according to the Fischer index of the Bank of Albania. To put it on a comparison viewpoint, in Serbia, the growth was 58%, while in North Macedonia, it was around 40%.

In terms of building permits, it is recognisable that Tirana has experienced a significant surge in construction activity since 2019. The built area has increased dramatically, more than doubling from 2020 to 2021 (Instat, 2021). The per capita construction area remains substantially higher than pre-2021 levels. However, they seem to be disproportionate to the rate of population growth, where in the period 2021-2023 the new built area averages to 200 m2/person (Instat, 2024). Not all this area is for residential purposes, given that 30% or more of the permits are issued for non-residential uses, such as hotels, office spaces, etc. Given the increase in housing and service demand, the municipality of Tirana has rapidly increased the density and intensity (FAR) for residential and other purposes. This has developed a relatively high building stock, which will create potentially vacant housing in the future.

Tirana's development model has been the subject of criticism from experts, urban planners, and activists. They argue that the city is facing excessive concrete development at the expense of historical sites and green spaces. A study conducted by Co-PLAN and Milieukontakt in 2020 reveals a significant environmental change in Tirana over the last decade. The research shows that 52.6 hectares of natural surfaces, with a rainwater infiltration coefficient of 0.77mm/m^2, have been converted into hardened, impermeable surfaces. This transformation has dramatically reduced the city's capacity to absorb rainwater naturally. As a result, approximately 530,000m^3 of rainwater can no longer be absorbed by the soil, significantly increasing the risk of localized flooding. This change not only strains the city's drainage systems but also highlights the urgent need for sustainable urban planning practices that balance development with environmental preservation.

Plot-based development prevails to area-based redevelopment projects. Even though the density at plot-based level may reach a FAR of up to 10, with buildings reaching 30-40 floors, in general this typology of development is more endorsed and supported by the local government. Permits for this typology of development can only be issued if the development proves to have strategic importance for the city/country, thus superseding requirements from the general local plan and other local regulations. Currently within the administrative unit of Tirana (central part of the Municipality of Tirana) there are 60 approved detailed local plans, where area-based development has been, or is in the process of implementation, following the regulations from the General local plan (NTPA , 2024). This makes up only 1/8 of all planned areas for redevelopment for the period 2016-2030. However, the number of building permits for strategic investments (plot-based) is close to 20 (National Agency for Territorial Development, 2024) . This suggests that the process of detailed local planning with full participation of owners is less favoured in comparison to the plot-based strategic development, and sometimes less feasible, because of the owners behaviour towards their property or the new redevelopment.

1.7.3. Concept of residual land value and land value capture instruments

Residual land value is a fundamental principle in real estate economics and urban planning, that refers to the value of land that remains after accounting for all other costs associated with a property development project. As Ingram and Hong (2012) explain in their comprehensive work on value capture and land policies, residual land value is essentially the maximum price a developer would be willing to pay for a piece of land while still achieving their desired profit margin.

The calculation of residual land value can be expressed as:

Residual Land Value = Gross Development Value - (Construction Costs + Land Purchase Costs + Taxation Costs + Developer's Profit)

This concept is crucial in understanding how urban development decisions are made and how land markets function. In cases where local taxation towards land (i.e. property taxes) are not so high, it is possible that the residual land value supersedes the developers profit by many times. Therefore, in order to capitalize from this development value that is generated, municipalities may implement land value capture instruments.

Land value capture (LVC) refers to the process by which public entities recover and reinvest land value increases that result from public investment and government actions. Smolka (2013), in his work on implementing value capture in Latin America, emphasizes that the underlying principle is that public actions often lead to increases in private land values, and that the public should share in these "unearned" gains.Peterson (2009), in his World Bank publication on financing urban infrastructure, outlines several common land value capture instruments:

- Betterment Levies: One-time taxes or fees imposed on property owners who benefit from public improvements.
- Tax Increment Financing (TIF): Earmarking future property tax increases in a designated area to finance current improvements.
- Special Assessment Districts: Designated areas where property owners pay an additional tax or fee to fund specific local improvements.
- Development Impact Fees: One-time charges imposed on developers to help fund public infrastructure required to serve new development.
- Land Value Taxation: Taxing the value of land itself, rather than improvements on the land.

Alterman (2012) discusses another important instrument in her analysis of land use regulations and property values: Inclusionary Zoning. While not strictly a value capture tool, this requires developers to include a certain percentage of affordable housing units in new developments. Medda (2012), in her review of land value capture finance for transport accessibility, highlights the potential for Partnerships between public entities and private developers to develop land around public infrastructure.

The effectiveness and appropriateness of these instruments can vary depending on local conditions, legal frameworks, and policy objectives. It's worth noting that while land value capture has gained increasing attention in recent years, particularly in the context of sustainable urban development, the concept is not new. Ingram and Hong (2012) trace the idea back to Henry George, a 19th-century American economist who was one of the early proponents of capturing land value for public benefit through his proposed "single tax" on land values.

In Albania land value capture instruments are not fully implemented, yet there are some efforts to pilot or include them in national legislation. Bonus FAR may be implemented (if preceded by a local program), as stated in the law on territorial planning and development[3]. Moreover, the law on social housing[4] mandates that private entities seeking development and construction permits for residential buildings exceeding 2,000 square meters must allocate at least 3 percent of the functional area for the public social housing fund. This means that the inclusionary housing concept is also being implemented, albeit with no real effectiveness.

However, there is immense potential in redistributing development value among the developer, land owners and the general public, if the instruments are used in innovative, flexible and accountable way. The data from this research supports this statement.

[3] Law No. 107/2014 on Territorial Planning and Development, as amended
[4] Law No. 22/2018 "On Social Housing"

1.7.4. The case studies

Discussing on the potential for redevelopment in the 3 case studies, first it is necessary to extend the focus area of them, covering at least the whole structural units. For the cost-benefit analysis data projections from the whole structural units have been adapted for the target areas. However, the efforts in mobilizing larger scale redevelopment is higher and may hinder the implementation of scenario 3, albeit more preferable and economically feasible (See chapter 1.10)

Figure 3. Structural Units area for selected case studies

Source: ASIG, 2024; NTPA, 2024, own elaboration

The data on proposed development indicators for the target areas suggests that no increase in FAR is envisaged. This means that the redevelopment scenario would not be realized, given the current development conditions from the General Local Plan. However, since the redevelopment is foreseen to be achieved by 2040, and the current plan is valid until 2030, while also being revised frequently, the redevelopment of the areas was studied based on a 'moderate' increase in density, calculating based on proposed FAR in adjacent units, and taking into consideration the carrying capacity. The table below shows the proposed indicators for each area and the calculations for carrying capacity, taking into consideration a medium of 25sqm/ inhabitant of gross built area; and the public space standards[5] as follows:

-2,5 sqm/person green area

-2 sqm/person public space or public-use building

-3 sqm/person public parking space

- 1,6 sqm/person sport terrain

Total: 9,1 sqm/person of public space

The carrying capacity is hence calculated following the formula[6]:

25 X = FAR*{Total area - (Road area + 9,1 X) - Non-residential private area}

Table 9. Calculations for the target structural units for the redevelopment scenario

	Structural Unit: TR/232	**Structural Unit: TR/85; TR/540; TR/88; TR/89**	**Structural Unit: TR/223**
Zone	Ish-Teknologjiku	Ali Demi	21 Dhjetori
Gross Plot Coverage Ratio (KSHT)	36%	53.10%	56%
Existing FAR	1.8	2.3	3
Proposed FAR	4.5	3.2	
Existing Public Space Ratio (KSHP)	5%	7.20%	10%
Existing Road Area Ratio (KSHR)	40%	28%	40%
Total Unit Area	69,598 m²	201,457 m²	82,824 m²
Total current Built Area	80,162 m²	298,700 m²	128,435 m²
Existing Public Space	3,655 m²	14,540 m²	8,313.32 m²
Carrying Capacity	**4,737 Residents**	**9,790 Residents**	**4,038 Residents**
Proposed Built Area	**4,737 * 25 = 118,425 m²**	**9,790 * 25 = 244,750 m²**	**4,038 * 25 = 100,950 m²**
Total proposed Public Space	**4,737 * 9.1 = 43,106 m²**	**9,790 * 9.1 = 89,089 m²**	**4,038 * 9.1 = 36,745 m²**

Source: Author's calculations, based on general local plan

Subsequently the researchers developed masterplans[7] for redevelopment of the 3 areas, considering full redevelopment, aside from buildings with height of +5 floors, where owners would be more reluctant to be subjected to the redevelopment scheme. A summary of Residual Land Value calculations can be found in Table 10.

[5] Based on DCM No. 671 dated 29.07.2015 "On the Approval of the Territorial Planning Regulation" which has been repealed.Current DCM on planning regulation does not indicate any standards

[6] FAR = Built area / buildable plot area; and built area = 25 sqm/person, therefore the formula reflects two forms of calculating proposed built area

[7] Masterplans and redevelopment schemes were designed in the framework of the Regulatory Planning Laboratory course, Polis University. Credits awarded to Irisa Kalo, Megi Dajko, Ersi Rryci, Alba Gora, under the supervision of main lecturer, dr.Kejt Dhrami.

1.8. Key findings from socio-economic survey

This section includes the main results from the households and businesses survey carried out in three targeted areas in the municipality of Tiranë. The results will be presented separately for the two categories of stakeholders: businesses and households. In addition, the database and related documentation are available in Zenodo[8].

1.8.1. Households survey results

The response rate to the household survey registered 42% (with 136 valid questionnaires filled at a minimum of 80% out of an estimated total of 324 units). Based on the information collected by interviewers, several apartments were empty/closed (not in use). In some cases, households refused to collaborate in the survey. Nevertheless, the response rate is satisfactory and adequate to inform the survey objectives.

The majority of respondents (63%) are originally from Tiranë, while 38% have moved from other locations, including Vlorë (17%), Sarandë (12%), and Përmet (10%). Women constitute 63% of the respondents, and men 35%. Most respondents are married (74%), with singles making up 15% and divorced or widowed individuals accounting for 11%.

General data

The average age of respondents is 59 years, with 46% in the 45-69 age group and 23% in the 30-44 age group. Educationally, 53% have completed university, 35% have a high school education, and 2% have post-graduate qualifications.

Employment distribution shows that 38% work in the private sector, 20% in the public sector, and 8% are self-employed. Retirees represent 30% of respondents, while 4% are unemployed or students. Primary income sources are salaries (58%) and pensions (32%), with monthly household incomes up to 75,000 ALL for 36% of respondents, up to 100,000 ALL for 26%, and above 100,000 ALL for 21%. Notably, 18% declined to disclose their income.

Living Conditions

Most respondents (74%) own their apartments, while 26% rent. The average apartment size is 71.5 square meters. On average, respondents have lived in their apartments for 19 years, with a range from 1 to 50 years. In Tiranë, the average duration of residence is 41 years, ranging from 1 to 76 years.

The survey also gathered information on renovations, with 74 respondents reporting renovations conducted between 1996 and 2024, likely influenced by recent earthquake events. Renovation expenses varied, with significant spending on internal adjustments, electrical, and hydraulic installations.

Households reported a high prevalence of common appliances such as televisions (96%), washing machines (98%), water boilers (98%), and refrigerators/freezers (90%). Less common appliances include computers (62%), LED lighting (50%), and dishwashers (32%). Traditional heating methods like wood stoves and fireplaces are absent, reflecting a reliance on modern electrical appliances.

Energy Consumption

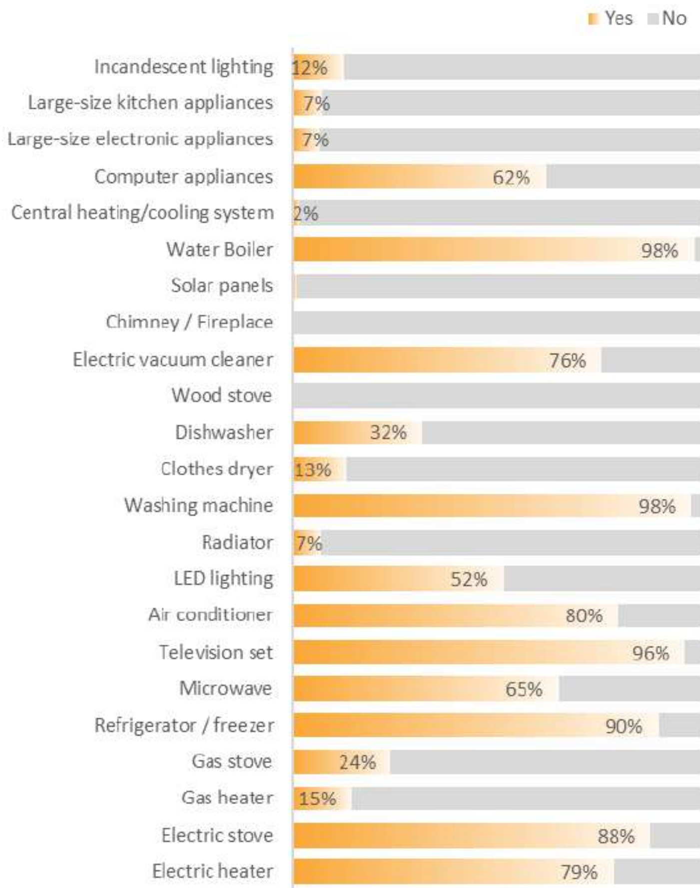
Households primarily rely on electric power for most needs, including lighting, cooking, hot water, and cooling. Gas is used by a minority mainly for cooking (20%) and heating (7%). The average electricity bill is significantly higher in the cold season (7,198 ALL/month) compared to the warm season (4,484 ALL/month), indicating increased

[8] Household survey: https://zenodo.org/records/12818546
Business survey: https://zenodo.org/records/12818546

heating costs. Over the past five years, 53% of households reported an increase in energy consumption, and 80% noted higher energy bills.

Only 11% of buildings have an administrator, and 24% of respondents pay an administration fee, primarily for cleaning and maintenance. Informal collaboration among neighbors is common for tasks like painting and general maintenance. There is potential for improving community engagement and structured building management practices.

Figure 4. Household appliances and utilities, frequencies in %



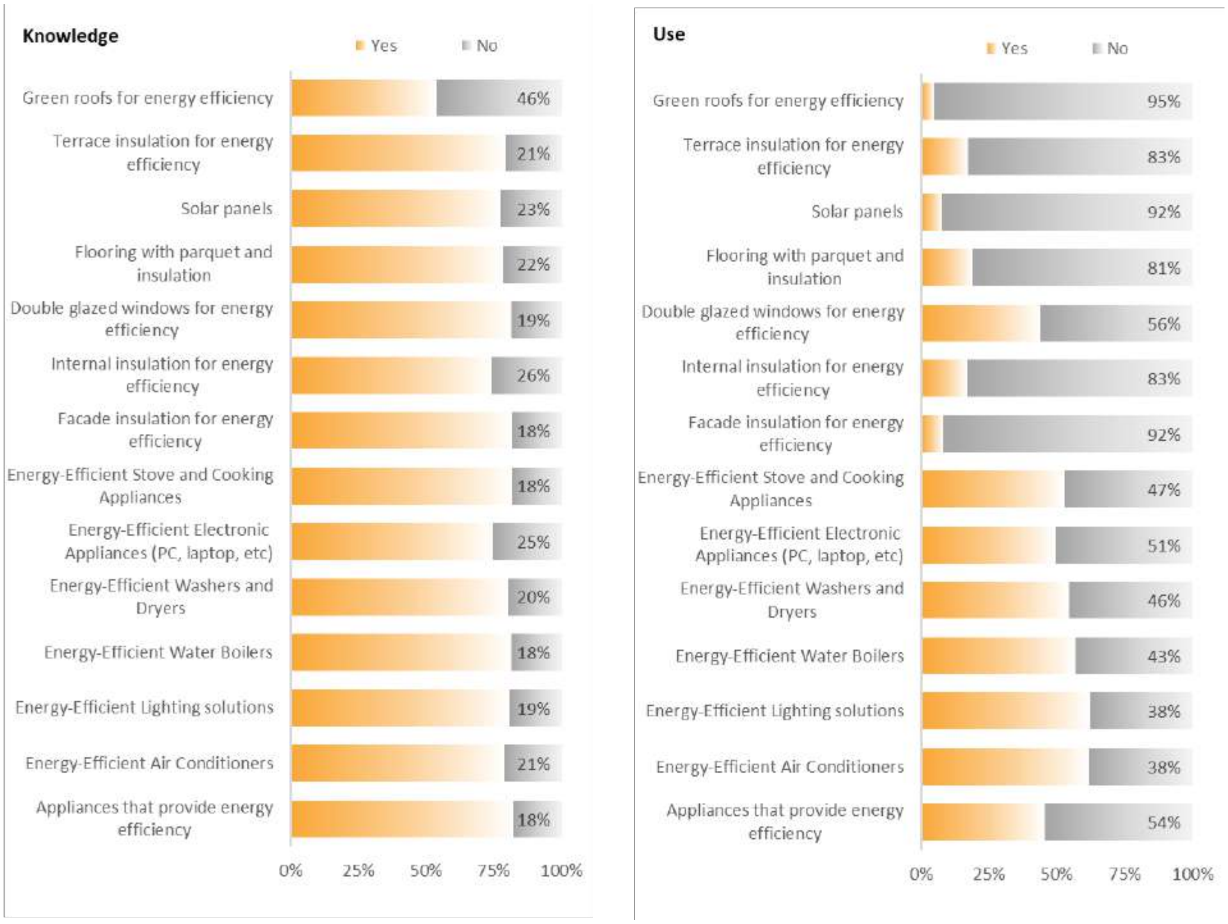
Source: Authors' processing based on survey data

Perception

Most respondents find their apartments livable and are generally reluctant to move. However, there is a recognition of the need for investment to improve living conditions. While 72% disagree with the statement that their apartment is not livable, 41% agree that significant investment is needed.

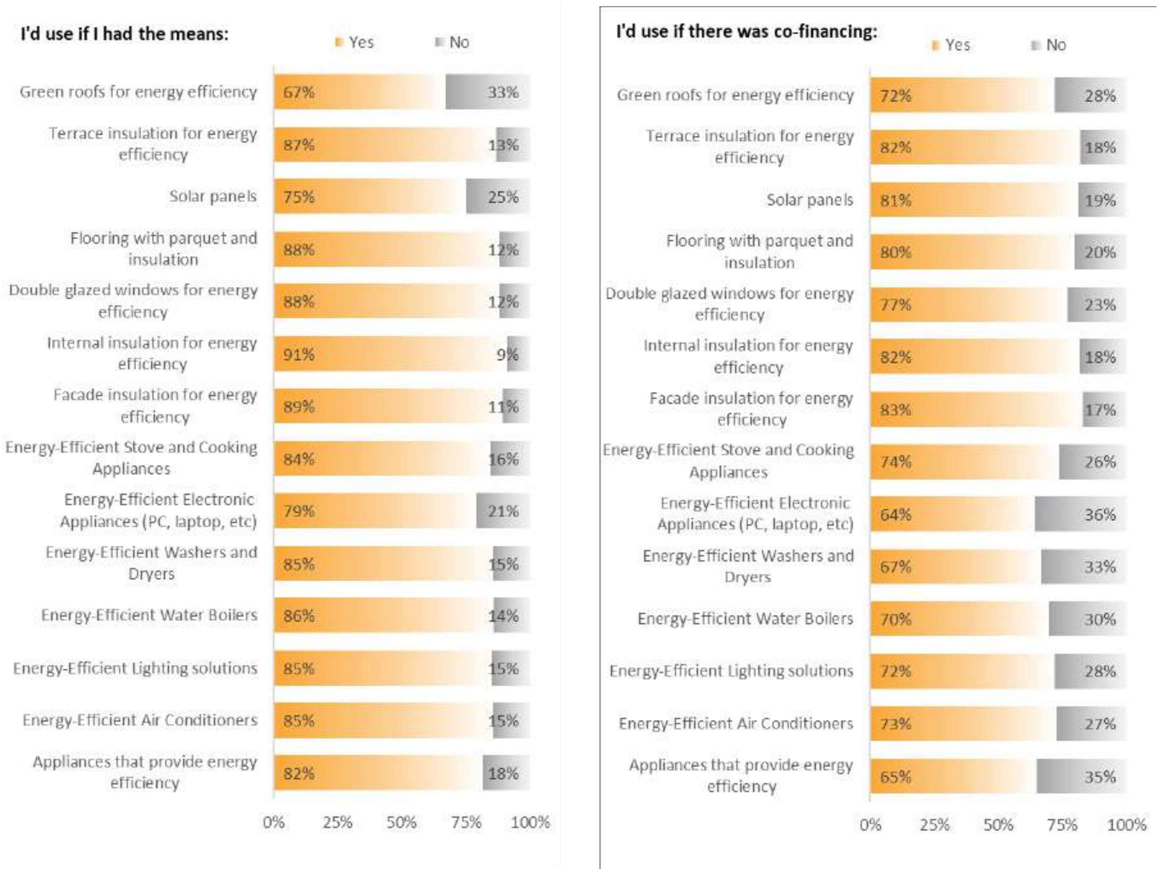
Respondents perceive the quality of life in their neighborhoods as average, with safety, education, and access to services rated positively. However, there are concerns about green spaces, air quality, and certain infrastructure aspects like parks and sports facilities. Water retention during storms is generally low, with 63% reporting retention times of less than 8 minutes.

Figure 5. Households knowledge and use of energy-efficient solutions



Source: Authors' processing based on survey data

Figure 6. Households willingness to use if means allow and if co-financing available



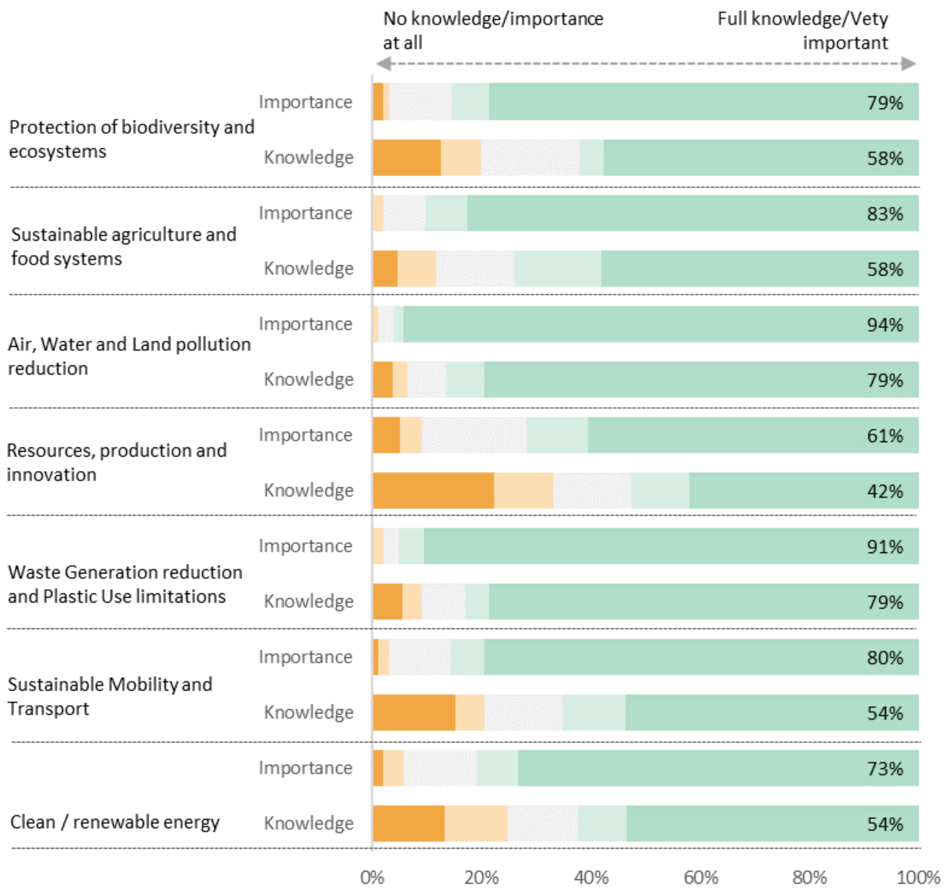
Source: Authors' processing based on survey data

Environmental Awareness and Green Transition

A majority of respondents (61%) are aware of the Green Transition, although 34% have not heard of it, and 5% are unsure. Information availability on the Green Transition is seen as adequate by 30% of respondents, but 27% are unsure if enough information is available. Households recognize the environmental benefits of public transport, greenery, and energy-saving measures, but there is a need for greater awareness and implementation of energy-efficient solutions.

Respondents support various sustainable interventions, with high support for thermal insulation of facades and apartments and replacing asphalt with permeable pavements. However, willingness to co-finance these interventions is lower, particularly for green roofs and urban gardens. The average willingness to pay is 18% of the cost, indicating moderate financial support for sustainability measures.

Figure 7. Household knowledge and importance of green transition pillars



Source: Authors' processing based on survey data

1.8.2. Businesses survey results

The response rate to the business survey[9] registered was 30% (with 17 valid questionnaires filled at a minimum of 80% out of an estimated total of 56 units preliminarily identified). Many businesses in the area refused to collaborate and participate in the survey. Nevertheless, the response rate is satisfactory and adequate to inform the survey objectives. The gender distribution of respondents shows that 69% are women and 31% are men. The largest share of respondents belongs to the 18-29 age group, while the remaining two age groups each account for 31% of the respondents. The average age of respondents is 35.4 years old and varies from 19, the youngest, to 55.

The data on educational attainment among respondents reveals diverse backgrounds. A small portion, 6%, have no formal education. Those with a junior high school education (8/9 years) make up 13% of the respondents. A significant share, 31%, hold a high school diploma or an equivalent qualification. Half of the respondents, 50%, have obtained a university degree. Notably, none of the respondents possess a post-graduate degree. The data on the residency status of respondents indicates that a majority, 54%, live in the area (and this is the reason for choosing the location). Conversely, 46% of the respondents do not live in the area where they exercise their business activity.

[9] A more complete overview can be found in the Extended Report

The data on the premises where activities are conducted reveals that the majority of respondents, 81%, operate in rented spaces. A smaller portion, 13%, own the premises where they conduct their activities. About 38% of the respondents affirm that they have been exercising their activity in the area for less than three years. Businesses operating in the area for 4-6 years account for 31%, and those for 7-9 years make up 13%. Only 19% of the businesses have been in the area for over ten years. The duration of stay presents some relative volatility, which might be linked somehow to the nature of the business's activities. Direct observation of interviewers suggests that most of the businesses in the areas object of study operate in bars – restaurants, financial institutions, dental clinics, flower shops, travel agencies, hairdressers, pharmacies, etc. The data on business typology and size indicates that the vast majority of businesses, 94%, are classified as small (with one employee). A small portion, 6%, are medium-sized businesses.

On average, the premises registered 21 sqm (ranging from a minimum of 10 sqm to 35 sqm) and have a height of 3 meters. Information on the condition of premises used for business activities shows that 21% of the respondents operated in spaces that were ready to be used for business purposes. A majority, 64%, had newly invested premises (investment carried out by the proprietor). Investments in the premises are reported to be carried out following 2019, with an average expense of 462,500 ALL (minimum 100,000 and maximum 900,000 ALL), mainly on internal works and hydraulic installations. Short–term yearly expenses for the regular maintenance of the premises average 23,752 ALL (minimum 10,000 and maximum 40,000 ALL).

Business representatives in the survey provided information regarding endowment with a list of appliances and utilities. The most commonly present appliances in the business premises are the refrigerator/freezer (100%), electric heater (56%), chimney/fireplace (56%), large-size appliances (63%), and other types of appliances such as bread cutter and refrigerator rooms.

The business respondents were presented with a list of statements and required to provide a rating of their agreement level on a scale from 1 – strongly disagree to 5 strongly agree. Survey results indicate a mixed perception of the premises, with notable disagreement on statements related to suitability and quality, while also showing strong agreement on the premises' good structure and potential for improvement with small investments.

Respondents broadly disagree with statements like " This premise presents a low quality " and "If I had the possibility, I'd move out to another place " (100% of respondents selected the strongly disagree and disagree options). Similarly, more than 85% of respondents do not agree with statements like "This premise is not suitable", "This premise needs high investments to become suitable for the activity", and "If I owned the place and a construction company would ask for it, I'd exchange the premise for a new construction in a different place." Regarding exchange willingness, responses vary among respondents: about 54% do not agree, and about 46% agree that " If I owned the place and a construction company would ask for it, I'd exchange the premise for a new construction in the same place". Similarly, for the statement, "I would not exchange the premise for a new construction, " 42% of respondents disagreed, and about 58% agreed.

Business representatives provided insights into the area's commercial spaces' perceived sale and rent prices and the specific commercial space in use. For sale prices, the area's minimum price per square meter (sqm) is 100,000 ALL. At the same time, the business premises have a minimum price of 120,000 ALL (20% higher, which might be related to the investments carried out to adapt the premises for commercial uses). The maximum sale price is 600,000 for the area and business premises. On average, the sale price in the area is 300,000 ALL per sqm, whereas, for business premises, the average is 390,000 ALL per sqm.

Regarding rent prices, the minimum rent for commercial spaces in the area is 30,000 ALL per sqm, and for the business premises in use, it is slightly lower at 20,000 ALL per sqm. The maximum rent price is 45,000 ALL per sqm in the area and 50,000 ALL per sqm for the business premises. The area's average commercial space rent price is 35,000 ALL per sqm, while business premises average 30,909 ALL per sqm. Based on these highlights, it can be noted that the business premises in use tend to have higher sale prices than prices for commercial spaces in the area (that might be due to investments carried out on the premises). In the rent market, competition is higher and tends to close the gap between rent prices.

At all three levels—unit, building, and urban block— respondents scored slightly above average for assessing the neighbouring relationships in the unit, building and urban block. Relationships are perceived slightly better within individual units compared to the broader building and urban block levels.

The business representatives provided information regarding the administrator's presence in the unit and payment of administration fees. About 53% of the business representatives affirm not having a building administrator, and about 75% of respondents affirm not paying the administration fee.

Businesses Survey results show that there has been only one case of collaboration and co-financing among neighbours (maintenance of common unit areas). There is a total lack of collaboration and co-financing in all other areas.

Business representatives provided their perceptions on the extent to which some phenomena occur or are sensed within their premises. Based on respondents' affirmations, no particular concerns are related to air currents (drafts) and noise levels from neighbours. The premises are very well exposed to natural lighting and solar warmth, while thermal loss might be problematic. Dust levels (PM10) and street noise occurrence are the most important concerns, with high percentages of respondents reporting feeling somehow and very much.

The questionnaire section related to energy and consumption aims to explore businesses' energy sources and use approaches in the study areas. Survey data suggest total reliance on electric power for all functions: lighting, cooking, heating, cooling and hot water. Businesses do not use gas, wood, or solar panels. Respondents to the survey provided information regarding energy consumption level and frequency of use of a predefined list of appliances in their business premises.

Appliances like electric, gas and wood stoves, gas heaters, central heating and cooling systems, microwaves, furnaces (kaldaja), dishwashers, washing and drying machines, vacuum cleaners, furnaces, solar panels and aspiration systems are assessed in the "not applicable" category for energy consumption and use frequency. Appliances with high energy consumption and frequency use (when applicable) include electric heaters, LED lighting, and electronic devices/computers.

The reliance on electrical energy and its use frequency affects the energy bill payment. The information provided by business representatives shows no significant differences in the average and maximum energy bills during the cold and warm seasons.

Business representatives participating in the survey suggest that energy consumption has increased over the last five years (affirmed by 67%). For 33% of respondents, energy consumption remained unchanged over the same period. Regarding energy bills, respondents are divided in half, with 50% affirming an increase and 50% affirming that they have remained unchanged over the last five years.

Survey results point to an outstanding awareness of energy-saving solutions among the majority of respondents (93%), with a smaller segment not having heard about them (7%). Most (87%) respondents agree that these appliances effectively reduce energy consumption. This indicates strong confidence in the capability of energy-saving appliances to deliver on their promise of reducing energy use. 13% of respondents are uncertain about the effectiveness of these appliances.

Respondents from the business community in the area provided their input related to aspects such as the level of knowledge of solutions listed, their use, their willingness to implement if possible, and their willingness to implement in the presence of co-financing.

The survey data indicates a generally high level of knowledge about energy-efficient appliances and solutions among respondents (more than 80%). However, a lower knowledge is observed in the case of green roofs for energy efficiency (about 47% of respondents do not know about them). While knowledgeable on energy-efficient solutions and appliances, their use in practice lags behind. Respondents affirm using energy-efficient air conditioners, lighting solutions, washers and dryers, and electronic devices. age

The information from the survey indicates a strong potential demand for a wide range of energy-efficient solutions and appliances if financial means were not a barrier. The highest willingness to adopt energy-efficient solutions relates to air conditioning, lighting, façade and internal insulation, and double-glazed windows (affirmed by 90% to 100% of respondents. Despite the means available, 82% of respondents would not use energy-efficient stoves and cooking appliances, washing machines and dryers (73%), water boilers (64%), and terrace insulations 55%). Such a result might also be related to the lack of interest in these appliances for business purposes. Respondents are divided into half on green roofs for energy efficiency: 50% would use green roofs, and 50% would not even if the means were available.

Most respondents are willing to use energy-efficient appliances if co-financing is available, indicating a strong interest when financial support is offered. The highest willingness to adopt is seen in facade insulation (100%), internal insulation (90%), energy-efficient air conditioning (100%), and flooring with parquet and insulation (82%). Even in the presence of co-financing, businesses affirm not having an interest in green roofs (58%), terrace insulation (55%), solar panels (45%), stove and cooking appliances (82%), electronic devices (75%), washing and drying machines (73%) and lighting solutions (88%).

This section informs about businesses' perceptions of the neighbourhood's overall quality and environmental performance. The general living quality in the targeted areas is perceived as above the average, based on the assessment of business representatives (score 3.6 on a scale from 1 to 5). While the area scores well regarding access to roads, public transport, pedestrian flows, safety, road infrastructure, and connection to the sewerage system, several concerns have been raised. Significant challenges and wide room for improvement persist in greenery in the area, air quality, cultural activities, treat cleaning, water supply and waste management, and certain infrastructure aspects like parks, parking, and sports facilities. Addressing these deficiencies could significantly enhance the overall quality of life in the area.

Responses on the average water retention duration during storms provide insights into how quickly or slowly the water is absorbed or retained within the area. 40% of respondents indicate that water retention during storms lasts less than 10 minutes, therefore, it does not linger for long after rainfall, possibly indicating good drainage or low water retention capacity. About 53% of respondents affirm that water retention lasts less than one hour. Only a minority of respondents affirm experiencing longer-lasting water accumulation (up to 5 hours).

The information regarding moving to another neighbourhood provides insights into their current satisfaction and potential willingness to relocate. About 8% of respondents are willing to move to another neighbourhood if given the chance. 17% of respondents indicated that they would not move to another neighbourhood, and 75% are unsure or undecided about whether they would move to another neighbourhood.

Business representatives suggested that increasing parking spaces, improving lighting and façade insulations, adding green and more public space, and improving waste management practices would enhance the quality of life in the neighbourhood.

Most businesses participating in the survey know about the Green Transition (56%), and about 44% have not heard about it. On the availability and clarity of the information, 6% of the respondents affirm that there is abundant information available on the green transition; 19% acknowledge that information exists but find it difficult to understand, indicating a potential gap in clarity or accessibility of the information; and 44%, stated that they do not have information on the green transition. About 31% of respondents indicated that they do not know if enough information is available.

Business activities and approaches to some aspects might have an environmental impact. Respondents from the business community fully agree with the statement that "public transport is less polluting to the environment than private vehicles" (100%), "presence of greenery (trees, bushes, flowers, etc.) in the neighbourhood reduces the level of air pollution" (100%), "presence of greenery (trees, bushes, flowers, etc.) in the neighbourhood lower the perceived temperature" (100%), and "I save on energy because its price is very high" (79%). About 94% of respondents do not agree with the statement that "My business's daily activity has an impact on the environment" and "The typology of appliances used affects the level of energy consumption."

Survey participants rated the pillars of Green Transition regarding knowledgeability and importance. Business representatives generally affirm knowledge about the listed green transition and sustainability topics. Most respondents affirm the importance of the listed pillars, which is consistently higher than the respondents' knowledge level. The importance of the listed areas is consistently high, with most categories showing a majority considering it fully knowledgeable. Among the listed areas, the highest importance is affirmed by respondents concerning " Sustainable Mobility and Transport" (100%) and " Waste Generation reduction and Plastic Use limitations" (100%) and "Air, Water and Land pollution reduction" (93%). For the abovementioned areas, respondents affirm being somehow and fully knowledgeable. While considering "Clean/renewable energy" and "Protection of biodiversity and ecosystems" important for the green transition, 44% and 31% of the respondents do not know the matter.

The survey information indicates that respondents strongly support various sustainable interventions, with the highest support for thermal insulation of facades (100%) and premises (100%), designing urban gardens (92%) and asphalt replacement with permeable pavements (83%). There is also a general agreement for other interventions, but only at the lower level (particularly in solar panels and living walls). However, willingness to co-finance these interventions is consistently lower, particularly for solar panels and living walls. Interventions related to premises thermal insulation and façade insulations have relatively higher co-financing support, recognising their long-term benefits and cost savings.

The data shows a significant variation in willingness to pay, with some respondents not willing to contribute financially while others are willing to pay up to 35% of the cost. The average willingness to pay of 22% suggests that respondents are moderately willing to support these interventions financially but not to the extent of bearing a substantial portion of the costs.

1.9. Cost-benefit analysis

The cost-benefit analysis (CBA) is the instrument employed for the economic feasibility assessment of the proposed scenarios, including economic, social and environmental impacts. The VAT is an extension of the conventional CBA[10]. Information on costs and benefits is crucial for decision-makers to determine the viability of an investment project and compare competing projects in terms of value added to all stakeholders. In addition to the SE-CBA, the land value capture approach plays a significant role. It assesses the increase in land value resulting from the investment, providing a more holistic view of the project's impact.

- The first step in our assessment process involves identifying project outcomes. These outcomes, which can be positive or negative, are determined by combining information from desk reviews, surveys, expert assessments, and international practice.
- Quantifying and monetising gross outcomes regarding costs and benefits (when possible, conditional on data availability and/or benchmarks).
- Assessment of net impacts, as the difference between the "with the project" versus "without the project" scenarios (the counterfactual). The counterfactual (without the project scenario) considers the amount of change that might have happened, regardless of the intervention. This approach captures the "net change" that can be explicitly attributed to the proposed intervention.
- Assessment of cost and benefits behaviour over the reference period – assess how costs and benefits will change in time (using average growth rates, trends when available or introducing assumptions);
- Discounting of costs and benefits to obtain present values – convert future costs and benefits into present value using a social discount rate;
- Calculating economic performance indicators: the net present value (ENPV), the internal rate of return (IRR), and the benefits-to-costs ratio (BCR).

1.9.1. Economic indicators

The SE-CBA for the proposed investment project employs three widely used economic performance indicators calculated on incremental cash flows.

[10] The origins of this method date back to the 19th century; and it became popular in the 1960s.

- The economic net present value indicator (ENPV) is a standard indicator calculated as the difference between the discounted total benefits and costs arising from the project.

  $\mathrm{ENPV} = \left(\left[\sum \frac{B_i}{(1+sdr)^i}\right]\right) - \left(\left[\sum \frac{C_i}{(1+sdr)^i}\right]\right)$ summed over 0 to n years.

  B_i = project benefits in year i, for i {0,1...n};

  C_i = project costs in year i, for i {0,1...n};

  n = total number of years for project duration – the time horizon;

  SDR = social discount rate.

  Projects with positive ENPV are considered viable, while those with negative net present value are not.

- The internal economic rate of return (IRR) is the ratio that produces a zero value for the economic ENPV. As a rule of thumb, the IRR should be higher than the discount rate used in the analysis (it creates value added). On the contrary, the project destroys value if the IRR is lower than the discount rate.

  $$\left(\left[\sum \frac{B_i}{(1+irr)^i}\right]\right) - \left(\left[\sum \frac{C_i}{(1+irr)^i}\right]\right) = 0$$

- The benefits-to-cost ratio (BCR) is the ratio between the sum of discounted economic benefits and costs over the time horizon considered in the analysis. The BCR informs us of how many euros are generated by the intervention for each euro 1 invested over the time horizon of the project. The following formula summarises the information included in the BCR:

  $$\mathrm{BCR} = \frac{[\sum B_i/(1+sdr)^i]}{[\sum C_i/(1+sdr)^i]}$$

  B_i = project benefits in year i, for i {0,1...n};

  C_i = project costs in year i, for i {0,1...n};

  N = total number of years for project duration – the time horizon;

  SDR = social discount rate.

  Based on the results obtained:

  i. BCR<1.0 means that the project's costs exceed its benefits in economic terms. In other words, the value of each 1€ invested is being destroyed.

  ii. BCR=1.0 means that the project's costs equal its benefits in economic terms. Therefore, while it can proceed with the project, its viability is uncertain. In other words, no added value is created for each 1 € invested.

  iii. BCR>1.0 means that the project's benefits exceed its costs in economic terms. In other words, value is being created for each 1 € invested.

- The simple payback period is a straightforward financial metric used to assess how long it takes to recover an initial investment through the cash flows generated by a project or investment.

1.9.2. The data

The CBA was completed using publicly available data, survey results in the project framework, data from technical projects for proposed interventions, expert assessments, and other data from national and international sources.

Table 11. Data used in the CBA

Metric	Number	Unit	Source

GENERAL INDICATORS			
First Year	2024		
Last Year	2040		
Inflation indexation	3%		Bank of Albania (BoA inflation targeted)
Average Exchange Rate	109	All per Euro, Y2023	Bank of Albania
Social Discount Rate (UE Guidelines)	3%		Source: DG CLIMA (2021) / Economic Appraisal Vademecum 2021-2027
Social Discount Rate	6.28%		Authors calculation
10Y bonds average interest rate (2021-2023)	5.69%		Ministry for Finance, Albania
15Y bonds average interest rate (2021-2023)	6.86%		Ministry for Finance, Albania
Electricity price	0.0555	Euro per kWh	Eurostat 2022S2 https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_204/default/table?lang=en
Electricity fixed tariff	200	ALL per month	Source: National Energy Entity at https://ere.gov.al/sq/tarifat/tarifat-dhe-cmimet
Electricity price (households)	9.5	ALL per kWh	Source: National Energy Entity at https://ere.gov.al/sq/tarifat/tarifat-dhe-cmimet
Electricity price (businesses)	14	ALL per kWh	Source: National Energy Entity at https://ere.gov.al/sq/tarifat/tarifat-dhe-cmimet
CO_2eq shadow prices	EURO per ton		Source: DG CLIMA (2021) / Economic Appraisal Vademecum 2021-2027
The average CO_2 absorption rate for one mature tree	22	kg per year	https://www.eea.europa.eu/articles/forests-health-and-climate-change/
Health benefits of green spaces	Every 10% increase in green space is associated with a reduction in diseases equivalent to a rise in five years of life expectancy.		https://www.eea.europa.eu/articles/forests-health-and-climate-change/
Data from the socio-economic survey			
Households	324	number	Socio-Economic Survey
Businesses	56	number	Socio-Economic Survey
The average size of the apartment	72	sqm	Socio-Economic Survey
Average-size business premises	21	sqm	Socio-Economic Survey
Sale prices, apartments:			

Price in the area	121,859	ALL per sqm	Socio-Economic Survey
Price for the apartment	107,254	ALL per sqm	Socio-Economic Survey
Sale prices, business premises:			
Price in the area	300,000	ALL per sqm	Socio-Economic Survey
Price for the premises	390,000	ALL per sqm	Socio-Economic Survey
Rents, apartments:			
Price in the area	46,618	ALL per sqm	Socio-Economic Survey
Price for the premises	42,809	ALL per sqm	Socio-Economic Survey
Rents, business premises:			
Price in the area	35,000	ALL per sqm	Socio-Economic Survey
Price for the premises	30,909	ALL per sqm	Socio-Economic Survey
Average annual investment, households	472,053	ALL per year	Socio-Economic Survey
Average annual investment, businesses	462,500	ALL per year	Socio-Economic Survey
Households			
Electricity bill, warm season	4,484	ALL per month	Socio-Economic Survey
Electricity bill, cold season	7,198	ALL per month	Socio-Economic Survey
Business			
Electricity bill, warm season	6,442	ALL per month	Socio-Economic Survey
Electricity bill, cold season	6,600	ALL per month	Socio-Economic Survey
Average maintenance cost			
Households	47,890	ALL per month	Socio-Economic Survey
Businesses	23,752	ALL per month	Socio-Economic Survey
Average parking costs	3,000	ALL per month	Expert assessment
1st improving investments	5,034	Euro	Expert assessment (average of three apartments)
2nd improvement investments	7,543	Euro	Expert assessment (average of three apartments)
PV panels cost	56	Euro per sqm	Expert assessment
Solar panel costs	750	Euro	Expert assessment
Preventing soil sealing	150	Euro per sqm	Expert assessment
Rainwater harvesting system	6	Euro per sqm	Expert assessment

Source: Authors' calculations, et al.

1.9.3. Main assumptions

The CBA for the proposed intervention employs an incremental approach for costs and benefits (when possible), assessing the net effects with and without the projects. The counterfactual baseline scenario is defined by Sartori et al. (2015) as "what would happen in the absence of the project" (assuming business as usual or a do minimum approach). Assumptions introduced for the CBA include the following:

A. The reference period employed in the CBA is 16 years (marked with 1 – 16, starting year 2024 and last year 2040). However, the EU guidelines for waste management infrastructure suggest a reference period of 25-30 years (European Commission, 2015).

B. The EU guidelines suggest including a residual value of the investment at the end of the reference period. Therefore, assuming a conservative approach, a residual value at the end of the reference period has not been included.

C. The CBA employs the social discount rate (SDR) to calculate the net present value of future cash flows. The EU guide on cost-benefit analysis suggests using an SDR of 3% without a national approach. Albania has no reference discount or social discount rate (at least based on public information). Nevertheless, interest rates on long-term securities (10-15-year government bonds) were considered a possible benchmark for the SDR. Based on data from the Ministry of Finance, long-term securities are issued regularly, and interest rates have presented low volatility over the last three years. Over the last three years, the 10-year bonds registered an average interest rate of 5.69%; the 15-year bonds issued an average interest rate of 6.86% (issued only during the last three years). Therefore, two alternatives have been used for discounting purposes: the EU SDR rate of 3% and the average interest rate of 10Y and 15Y bonds.

D. All calculations are net of VAT, as the literature suggests for similar studies.

E. General maintenance costs were calculated as a % of the investment.

F. Operating costs build on the technical suggestions and include personnel and other unidentifiable costs.

G. An incremental approach was adopted to account for project implementation's economic, social and environmental costs and benefits. The "without the project scenario" was built considering the continuation of the situation with a business-as-usual approach (when possible).

H. All values in other currencies were converted into euros using the average exchange rate for 2023.

I. The scenarios presented are incremental, meaning that investments, costs, and benefits are cumulative and progressively transferred from one to the other.

1.10. Scenario Analysis

1.10.1. Scenario 0. Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana

A: Identification of the cost and benefit categories

The following table summarises the identified cost and benefit categories for Scenario 0 – business as usual.

Table 12. Scenario 0, identification of cost and benefit categories

	Quantified	Monetised	Included in CBA
S0I1 Investment in renovations (once in 5 years)	Yes	Yes	Yes
S0C1 Electricity costs	Yes	Yes	Yes
S0C2 Annual maintenance cost	Yes	Yes	Yes
S0C3 Parking costs	Yes	Yes	Yes
S0C4 Air quality	No	No	No
S0C4 Noise pollution	No	No	No

SoB1 Less investment needs	Yes	Yes	Yes
SoB2 No gentrification of the neighbourhood	Yes	Yes	Yes

Source: Authors' calculations

B: Monetisation of cost and benefit categories

SoI1 Capital expenditure. Based on the results from the socio-economic survey carried out with households and businesses in the targeted areas, they affirmed carrying out an average annual periodic investment on their premises.

Table 13. SoI1 capital expenditures

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
I1 Investment in renovations (once in 5 years)	1,644,553 Euros
Assumption: The renovation investment is carried out once every five years and is phased into 20.0% in the first year, 25.0% in the second year, 20.0% in the third year, 20.0% in the fourth year, and 15.0% in the fifth year (percentage of the total number of households and businesses).	

Source: Authors' calculations

SoC1 Electricity costs. The average electricity bill (in warm and cold seasons) for households and businesses was collected in the households and businesses survey and used to assess the energy bill costs.

Table 14. SoC1 Electricity costs

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
C1 Electricity costs	249,125 Euro per year
Assumption: Energy costs have been indexed to 3% every five years to account for Albania's inflation rate.	

Source: Authors' calculations

SoC2 Annual general maintenance costs. The average annual general maintenance costs collected in the households and businesses survey were used to assess the energy bill costs.

Table 15. SoC1 Annual general maintenance costs

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
SoC2 Annual general maintenance costs	154,910 Euro per year
Assumption: Annual general maintenance costs have been indexed to 3% every five years to account for Albania's inflation rate.	

Source: Authors' calculations

SoC3 Parking costs. The average annual general maintenance costs collected in the households and businesses survey were used to assess the energy bill costs.

Table 16. SoC1 Annual general maintenance costs

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
SoC3. Parking costs	75,476 Euro per year
Assumption: Annual parking costs have been indexed to 3% every five years to account for Albania's inflation rate.	

Source: Authors' calculations

S0C4 Air quality. Respondents in the survey suggested that one of the most important problems characterising the targeted areas was the poor air quality and presence of PM10 (not monetised and not included in the CBA).

S0C5 Noise pollution. Respondents in the survey suggested that one of the most important problems characterising the targeted areas was noise pollution (not monetised and not included in the CBA).

S0B1 Less investment categories. In the business-as-usual scenario, households and businesses in the area do not invest (the reference is the investment for retrofitting their premises in Scenario 1).

Table 17. S0B1 Less investment needs

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
S0B1. Less investment needs	4,779,260 Euro per year
Assumption: The benefit is phased into 20.0% in the first year, 25.0% in the second year, 20.0% in the third year, 20.0% in the fourth year, and 15.0% in the fifth year.	

Source: Authors' calculations

S0B2 Saving from less gentrification in the area. In the business-as-usual scenario, households and businesses in the area do not invest (the reference is the investment for retrofitting their premises in Scenario 1).

Table 18. S0B2 Saving from less gentrification in the area

Scenario 0: Delayed Transition towards Climate Neutrality for Prefabricated Buildings in Tirana	
S0B2. Saving from less gentrification in the area	1,650,509 Euro per year
Assumption: The benefits are calculated based on the differences between the revealed average prices of the owned/rented premises and the perceived average prices in the area.	

Source: Authors' calculations

All the benefit and cost items have been assessed over the 16-year reference period. Then, using a discount rate of 6.28%, the ENPV, BCR, and IRR are estimated. In addition, the simple payback period indicator is included in the analysis (when possible). The engagement in Scenario 0 presents a positive net present value, which suggests the convenience of the scenario. The results from ENPV are supported by results obtained from the internal rate of return (IRR). IRR greatly exceeds the discount rate, thus suggesting the convenience of Scenario 0. Finally, the benefits-to-costs ratio (BCR) indicates that every Euro invested in the proposed project will create value for society.

Table 19. Scenario 0, economic indicators

Indicator	Unit	Value	Comment
Capital Investment	Euro	2,620,398.0	Estimated capital expenditures for realising the project interventions (including initial investment and replacement costs).
Economic Net Present Value (ENPV)	Euro	4,276,054	The ENPV suggests that the project is viable; thus, the benefits exceed its costs.
Internal Rate of Return (IRR)	%	20%	The internal rate of return (the one that sets ENPV = 0) is considerably higher than the discount rate, suggesting a profitable investment.
BCR	Euro	1.8	The BCR >1 indicates that the project's benefits exceed its costs. In other words, for each 1 Euro invested, 1.8 Euro of value is created.
cumulative discounted benefits	Euro	15,809,907	
cumulative discounted costs	Euro	8,677,351	

Source: Authors' calculations

Figure 8. Scenario 0, summary of CBA

Key Assumption		
Social Discount Rate		6%
Appraisal period (years)		16
Currency		Euro

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Year		**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Discount factor		1.000	0.941	0.885	0.833	0.784	0.738	0.694	0.653	0.615	0.578	0.544	0.512	0.482	0.453	0.427	0.401	0.378
CAPEX																		
Annual investment		-	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911
Total CAPEX		-	**328,911**	**411,138**	**328,911**	**328,911**	**246,683**	**328,911**	**411,138**	**328,911**	**328,911**	**246,683**	**328,911**	**411,138**	**328,911**	**328,911**	**246,683**	**328,911**
Present value of CAPEX		-	309,490	364,020	274,021	257,842	181,963	228,292	268,516	202,129	190,194	134,223	168,398	198,068	149,099	140,295	99,009	124,217
Cumulative PV of CAPEX		3,289,777																
Benefit sources																		
S0B1 Less investment at the current stage		-	716,889	716,889	716,889	716,889	955,852	955,852	-	-	-	-	-	-	-	-	-	-
S0B2 Gentrification of neighbourhood		1,188,367	1,188,367	1,188,367	1,188,367	1,188,367	1,224,018	1,071,015	1,071,015	1,071,015	1,071,015	1,103,146	945,554	945,554	945,554	945,554	973,920	811,600
Total Benefits		**1,188,367**	**1,905,256**	**1,905,256**	**1,905,256**	**1,905,256**	**2,179,870**	**2,026,867**	**1,071,015**	**1,071,015**	**1,071,015**	**1,103,146**	**945,554**	**945,554**	**945,554**	**945,554**	**973,920**	**811,600**
Present Value of Benefits		1,188,367	1,792,760	1,686,907	1,587,303	1,493,581	1,607,959	1,406,820	699,484	658,183	619,321	600,236	484,110	455,526	428,629	403,321	390,892	306,510
Cumulative PV Benefits		15,809,907																
Cost sources																		
S0C1 Electricity costs		249,125	249,125	249,125	249,125	249,125	256,599	256,599	256,599	256,599	256,599	264,297	264,297	264,297	264,297	264,297	272,226	272,226
S0C2 Annual maintenance cost		154,910	154,910	154,910	154,910	154,910	159,557	159,557	159,557	159,557	159,557	164,344	164,344	164,344	164,344	164,344	169,274	169,274
S0C3 Parking costs		75,476	75,476	75,476	75,476	75,476	77,740	77,740	77,740	77,740	77,740	80,072	80,072	80,072	80,072	80,072	82,475	82,475
S0C4 Air quality		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S0C5 Noise pollution		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Costs		**479,511**	**479,511**	**479,511**	**479,511**	**479,511**	**493,896**	**493,896**	**493,896**	**493,896**	**493,896**	**508,713**	**508,713**	**508,713**	**508,713**	**508,713**	**523,975**	**523,975**
Present Value of Costs		479,511	451,198	424,557	399,489	375,902	364,318	342,807	322,566	303,520	285,598	276,797	260,454	245,075	230,605	216,989	210,302	197,885
Cumulative PV of Costs		5,387,574																
Undiscounted cash flows																		
CAPEX		-	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)	(328,911)
Total costs		(479,511)	(479,511)	(479,511)	(479,511)	(479,511)	(493,896)	(493,896)	(493,896)	(493,896)	(493,896)	(508,713)	(508,713)	(508,713)	(508,713)	(508,713)	(523,975)	(523,975)
Total benefits		1,188,367	1,905,256	1,905,256	1,905,256	1,905,256	2,179,870	2,026,867	1,071,015	1,071,015	1,071,015	1,103,146	945,554	945,554	945,554	945,554	973,920	811,600
Net Cash Flow	#	708,855	1,425,744	1,425,744	1,425,744	1,425,744	1,685,973	1,532,971	577,119	577,119	577,119	594,432	436,840	436,840	436,840	436,840	449,945	287,625
Discounted cash flows (SDR1)																		
CAPEX		-	(309,490)	(364,020)	(274,021)	(257,842)	(181,963)	(228,292)	(268,516)	(202,129)	(190,194)	(134,223)	(168,398)	(198,068)	(149,099)	(140,295)	(99,009)	(124,217)
Benefits		1,188,367	1,792,760	1,686,907	1,587,303	1,493,581	1,607,959	1,406,820	699,484	658,183	619,321	600,236	484,110	455,526	428,629	403,321	390,892	306,510
Costs	#	(479,511)	(451,198)	(424,557)	(399,489)	(375,902)	(364,318)	(342,807)	(322,566)	(303,520)	(285,598)	(276,797)	(260,454)	(245,075)	(230,605)	(216,989)	(210,302)	(197,885)
Net Cash Flow	#	708,855	1,032,071	898,329	913,792	859,837	1,061,678	835,721	108,403	152,534	143,528	189,215	55,258	12,382	48,926	46,037	81,581	(15,592)
Cummulative cash flow		708,855	1,740,927	2,639,255	3,553,048	4,412,885	5,474,563	6,310,284	6,418,687	6,571,221	6,714,749	6,903,964	6,959,222	6,971,604	7,020,530	7,066,567	7,148,148	7,132,556

Source: Authors' calculations

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1.10.2. Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana

A: Identification of the cost and benefit categories

The table below summarises the identified cost and benefit categories for Scenario 1 – Enhance Energy Performance of Prefabricated Buildings in Tirana.

Table 20. Scenario 1, identification of cost and benefit categories

	Quantified	Monetised	Included in CBA
S1I1 Investment in improving energy performance (1)	Yes	Yes	Yes
S1I2 Investment in improving energy performance (2)	Yes	Yes	Yes
S1C1 Annual maintenance cost	Yes	Yes	Yes
S2C2 Parking costs	Yes	Yes	Yes
S1B1 Energy saving from I1	Yes	Yes	Yes
S1B2 Energy saving from I2	Yes	Yes	Yes
S1B3 Increased property values	Yes	Yes	Yes

Source: Authors' calculations

B: Monetisation of cost and benefit categories

S1I1 Investment in improving energy performance (1). Expert assessment of the proposed interventions is used to calculate the investment size for improving energy performance with an average size of 5,034 Euro per unit (a household or commercial area).

Table 21. S1 I1 Investment in improving energy performance (1)

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1 I1 Investment in improving energy performance (1)	1,714,488 Euro
Assumption: Interventions to implement the investment are carried out over five years, starting in Y1 and phased in at 15.0% in Y2, 20.0% in Y3, 20.0% in Y4, and 25.0% in Y5.	

Source: Authors' calculations

S1I2 Investment in improving energy performance (2). Expert assessment of the proposed interventions is used to calculate the investment size for improving energy performance with an average size of 7,543 Euro per unit (a household or commercial area).

Table 22. S1 I1 Investment in improving energy performance (2)

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1 I2 Investment in improving energy performance (2)	2,569,291 Euro
Assumption: Interventions to implement the investment are carried out over five years, starting and phased in at 15.0% in Y5, 20.0% in Y6, 20.0% in Y7, 20.0% in Y8, and 25.0% in Y9.	

Source: Authors' calculations

S1C1 Maintenance costs 1. The investments implemented embedded the necessity for general maintenance, quantified as a percentage of the investment value.

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Table 23. S1C1 Maintenance costs 1

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1C1 Maintenance costs 1	85,724 Euro per year
Assumption: annual maintenance costs start in year five and are indexed every five years to account for the inflation rate in Albania.	

Source: Authors' calculations

S1C2 Maintenance costs 2. The investments implemented embedded the necessity for general maintenance, quantified as a percentage of the investment value.

Table 24. S1C2 Maintenance costs 1

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1C1 Maintenance costs 2	128,464 Euro per year
Assumption: Annual maintenance costs start in year ten and are indexed every five years to account for Albania's inflation rate.	

Source: Authors' calculations

S1B1 Energy saving from increased energetic performance (1). The savings from the first investment aiming at increased energetic performance (1) were estimated using information from the socio-economic survey (households and businesses) on the electricity bill.

Table 25. S1B1 Saving from less gentrification in the area

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1B1. Energy saving from increased energetic performance (1)	74,738 Euro per year
Assumption: Average energy saving of 30%	

Source: Authors' calculations

S1B2 Energy saving from increased energetic performance (2). The savings from the first investment aiming at increased energetic performance (2) were estimated using information from the socio-economic survey (households and businesses) on the electricity bill.

Table 26. S1B2 Saving from less gentrification in the area

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1B2. Energy saving from increased energetic performance (2)	74,738 Euro per year
Assumption: Average energy saving of 30%	

Source: Authors' calculations

S1B3 Increase in property values. Improving the energetic performance of the buildings probably could affect and generate an increase in property values.

Table 27. S1B3 Increase in property values

Scenario 1. Enhance Energy Performance of Prefabricated Buildings in Tirana	
S1B3. Increased property values	5,420,993 Euro per year
Assumption: Property values increase by 20%	

Source: Authors' calculations

The engagement in Scenario 1 and implementation of the foreseen investments present a positive net present value, which suggests the convenience of the scenario. The results from ENPV are supported by results obtained from the internal rate of return (IRR). IRR greatly exceeds the discount rate, thus suggesting the convenience of Scenario 0. Finally, the benefits-to-costs ratio (BCR) indicates that every Euro invested in the proposed project will create value for society.

Table 28. Scenario 1 economic indicators

Indicator	Value	Unit	Comment
Capital Investment	7,191,524	Euro	Estimated capital expenditures for realising the project interventions (including initial investment and replacement costs).
Economic Net Present Value (ENPV)	2,578,421	Euro	The ENPV suggests that the project is viable; thus, the benefits exceed its costs.
Internal Rate of Return (IRR)	10	%	The internal rate of return (the one that sets ENPV = 0) is considerably higher than the discount rate, suggesting a profitable investment.
BCR	1.5	Euro	The BCR >1 indicates that the project's benefits exceed its costs. In other words, for each 1 Euro invested, 1.5 Euro of value is created.
cumulative discounted benefits	18,705,470	Euro	
cumulative discounted costs	12,106,566	Euro	

Source: Authors' calculations

Figure 9. Scenario 1, summary of CBA

Key Assumption																		
Social Discount Rate		6%																
Appraisal period (years)		16																
Currency		Euro																
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Year		**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Discount factor		1.000	0.941	0.885	0.833	0.784	0.738	0.694	0.653	0.615	0.578	0.544	0.512	0.482	0.453	0.427	0.401	0.378
CAPEX																		
S0I1 Investment in renovations (once in 5 years)		-	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911
S1I1 Investment in improving energy performance (1)		257,173	342,898	342,898	342,898	428,622	-	-	-	-	-	-	-	-	-	-	-	-
S1I2 Investment in improving energy performance (2)		-	-	-	-	-	385,394	513,858	513,858	513,858	642,323	-	-	-	-	-	-	-
Total CAPEX		**257,173**	**671,808**	**754,036**	**671,808**	**757,533**	**632,077**	**842,769**	**924,997**	**842,769**	**971,233**	**246,683**	**328,911**	**411,138**	**328,911**	**328,911**	**246,683**	**328,911**
Present value of CAPEX		257,173	632,141	667,621	559,696	593,850	466,245	584,954	604,119	517,916	561,621	134,223	168,398	198,068	149,099	140,295	99,009	124,217
Cumulative PV of CAPEX		6,458,645																
Benefit sources																		
S0B1 Less investment at the current stage																		
S0B2 Gentrification of neighbourhood		1,485,458	1,485,458	1,485,458	1,485,458	1,320,407	1,360,020	1,360,020	1,360,020	1,360,020	1,360,020	1,400,820	1,225,718	1,225,718	1,225,718	1,225,718	1,262,489	1,262,489
S1B1 Energy saving from increased energetic performan		11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858	15,858	15,858	19,822	12,250	16,334
S1B2 Energy saving from increased energetic performan		-	-	-	-	-	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858
S1B3 Increase in property values		-	-	-	-	-	2,710,497	-	-	-	-	2,710,497	-	-	-	-	-	-
Total Benefits		**1,496,669**	**1,500,406**	**1,500,406**	**1,500,406**	**1,339,092**	**4,093,274**	**1,390,363**	**1,390,363**	**1,390,363**	**1,397,949**	**4,134,757**	**1,256,971**	**1,256,971**	**1,256,971**	**1,264,785**	**1,286,633**	**1,294,680**
Present Value of Benefits		1,496,669	1,411,814	1,328,454	1,250,015	1,049,750	3,019,362	965,032	908,051	854,436	808,372	2,249,774	643,551	605,553	569,798	539,487	516,402	488,950
Cumulative PV Benefits		18,705,470																
Cost sources																		
S0C1 Electricity costs		249,125	249,125	249,125	249,125	249,125	256,599	256,599	256,599	256,599	256,599	264,297	264,297	264,297	264,297	264,297	272,226	272,226
S0C2 Annual maintenance cost		154,910	154,910	154,910	154,910	154,910	159,557	159,557	159,557	159,557	159,557	164,344	164,344	164,344	164,344	164,344	169,274	169,274
S0C3 Parking costs		75,476	75,476	75,476	75,476	75,476	77,740	77,740	77,740	77,740	77,740	80,072	80,072	80,072	80,072	80,072	82,475	82,475
S0C4 Air quality		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S0C5 Noise pollution		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S1C1 Maintenance costs I1		11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858	15,858	15,858	19,822	12,250	16,334
S1C2 Maintenance costs I2		-	-	-	-	-	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858
Total Costs		**490,722**	**494,459**	**494,459**	**494,459**	**498,196**	**516,654**	**524,240**	**524,240**	**524,240**	**531,826**	**532,154**	**539,967**	**539,967**	**539,967**	**547,781**	**548,118**	**556,166**
Present Value of Costs		490,722	465,263	437,792	411,943	390,549	381,105	363,868	342,383	322,167	307,531	289,552	276,455	260,132	244,773	233,653	219,992	210,042
Cumulative PV of Costs		5,647,921																
Undiscounted cash flows																		
CAPEX		(257,173)	(671,808)	(754,036)	(671,808)	(757,533)	(632,077)	(842,769)	(924,997)	(842,769)	(971,233)	(246,683)	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)	(328,911)
Total costs		(490,722)	(494,459)	(494,459)	(494,459)	(498,196)	(516,654)	(524,240)	(524,240)	(524,240)	(531,826)	(532,154)	(539,967)	(539,967)	(539,967)	(547,781)	(548,118)	(556,166)
Total benefits		1,496,669	1,500,406	1,500,406	1,500,406	1,339,092	4,093,274	1,390,363	1,390,363	1,390,363	1,397,949	4,134,757	1,256,971	1,256,971	1,256,971	1,264,785	1,286,633	1,294,680
Net Cash Flow	(9,546,350)	1,005,947	1,005,947	1,005,947	1,005,947	840,896	3,576,620	866,123	866,123	866,123	866,123	3,602,603	717,004	717,004	717,004	717,004	738,514	738,514
Discounted cash flows (SDR1)																		
CAPEX		(257,173)	(632,141)	(667,621)	(559,696)	(593,850)	(466,245)	(584,954)	(604,119)	(517,916)	(561,621)	(134,223)	(168,398)	(198,068)	(149,099)	(140,295)	(99,009)	(124,217)
Benefits		1,496,669	1,411,814	1,328,454	1,250,015	1,049,750	3,019,362	965,032	908,051	854,436	808,372	2,249,774	643,551	605,553	569,798	539,487	516,402	488,950
Costs	(6,458,645)	(490,722)	(465,263)	(437,792)	(411,943)	(390,549)	(381,105)	(363,868)	(342,383)	(322,167)	(307,531)	(289,552)	(276,455)	(260,132)	(244,773)	(233,653)	(219,992)	(210,042)
Net Cash Flow		748,774	314,410	223,041	278,377	65,351	2,172,013	16,210	(38,450)	14,352	(60,781)	1,825,999	198,698	147,353	175,927	165,539	197,401	154,691
Cummulative cash flow		748,774	1,063,184	1,286,225	1,564,602	1,629,953	3,801,965	3,818,175	3,779,725	3,794,077	3,733,296	5,559,295	5,757,993	5,905,346	6,081,273	6,246,812	6,444,213	6,598,904

Source: Authors' calculations

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1.10.3. Scenario 2. Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods

A: Identification of the cost and benefit categories

The table summarises the identified cost and benefit categories for Scenario 2 – Harvesting Renewables and Rainwater through PV and Nature-Based Solutions for Climate Neutral Neighbourhoods.

Table 29. Scenario 2, identification of cost and benefit categories

	Quantified	Monetised	Included in CBA
S2I1 Photovoltaic panels	Yes	Yes	Yes
S2I2 Solar thermal panels	Yes	Yes	Yes
S2I3 Rooftop rainwater collection system	Yes	Yes	Yes
S2I4 Greening (+30%)	Yes	Yes	Yes
S2I5 Preventing soil sealing	Yes	Yes	Yes
S2C1 Maintenance costs	Yes	Yes	Yes
S0B2 Gentrification of the neighbourhood	Yes	Yes	Yes
S2B1 Income from energy production of photovoltaic panels	Yes	Yes	Yes
S2B2 Saving on energy bill from solar thermal panels	Yes	Yes	Yes
S2B3 Saving on water for irrigation purposes	Yes	Yes	Yes
S2B4 Improved air quality due to increased number of trees	Yes	Yes	Yes
S2B5 Disaster risk resilience and climate change adaption (flood prevention)	Yes	Yes	Yes
S2B6 Increase in property values	Yes	Yes	Yes

Source: Authors' calculations

B: Monetisation of cost and benefit categories

S2I1 Photovoltaic panels. The photovoltaic panel's investment value was retrieved from the expert assessment. Based on the evaluation carried out for the 21 Dhjetori area, the average cost per sqm is about 56 euros.

Table 30. S2 I1 Investment photovoltaic panels

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I1 Photovoltaic panels	573,940 Euro
Assumption: Interventions to implement the investment are carried out over five years, starting in 2025 and phased in at 15.0% in Y1, 20.0% in Y2, 20.0% in Y3, 20.0% in Y4, and 25.0% in Y5.	

Source: Authors' calculations

S2I2 Solar thermal panels. The investment value of solar thermal panels was retrieved from the expert assessment. Based on the evaluation, the average cost of solar thermal panels is about 750 euros per unit.

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Table 31. S2I2 Solar thermal panels

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I2 Solar thermal panels	285,000 Euro
Assumption: Interventions to implement the investment are carried out over five years, starting in 2025 and phased in at 15.0% in Y1, 20.0% in Y2, 20.0% in Y3, 20.0% in Y4, and 25.0% in Y5.	

Source: Authors' calculations

S2I3 Rooftop rainwater harvesting system. The rooftop rainwater harvesting system for sanitary self-consumption purposes, neighbourhood sanitation, and watering purposes investment value was retrieved from the expert assessment. Based on the evaluation, the average rooftop rainwater harvesting system cost is about 14 euros per sqm.

Table 32. S2I3 Rooftop rainwater harvesting system

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I3 Rooftop rainwater harvesting system	105,975 Euro
Assumption: Interventions for implementing the investment are carried out Y5 (2029)	

Source: Authors' calculations

S2I4 Greening of the neighbourhood. The increased greening investment value was retrieved from the expert assessment. Based on the evaluation, the average additional greening to the targeted areas (planting linden trees) costs about 30,050 euros.

Table 33. S2I4 Greening of the neighbourhood.

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I4 Greening of the neighbourhood.	30,050 Euro
Assumption: Interventions for implementing the investment are carried out Y1(2025)	

Source: Authors' calculations

S2I5 Preventing soil sealing. The preventive soil sealing investment value was retrieved from the expert assessment. On average, such an investment costs about 150 euros per sqm.

Table 34. S2I5 Preventing soil sealing

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I5 Preventing soil sealing	27,150 Euro
Assumption: Interventions for implementing the investment are carried out Y2(2026)	

Source: Authors' calculations

S2C1 Maintenance costs. The investments implemented embedded the necessity for general maintenance, quantified as a percentage of the investment value.

Table 35. S2C1 Maintenance costs

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2I1 Photovoltaic panels	28,697 euros per year
S2I2 Solar thermal panels	14,250 euros per year
S2I3 Rooftop rainwater collection system	5,299 euros per year
S2I4 Greening (+30%)	1,503 euros per year
S2I5 Preventing soil sealing	1,358 euros per year
Assumption: (i) general maintenance costs are calculated as 5% of investment value; (ii) annual maintenance costs start after the investment has been completed and are indexed for the inflation rate in Albania starting in Y9.	

Source: Authors' calculations

S0B2 Gentrification of the neighbourhood. Due to the neighbourhood's improved environmental performance and quality of life, some gentrification costs have been included in Scenario 2 (scaled using a confidence indicator of 50% up to Y10 and 30% to Y16). For a conservative approach, out of this amount, only 30% of the benefit is included in the CBA.

S2B1 Income from energy production of photovoltaic panels. On average, the investment in photovoltaic panels generates about 2,3 million euros per year.

Table 36. S2B1 Income from energy production of photovoltaic panels.

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2B1 Income from energy production of photovoltaic panels	2,394,890 Euro per year
Assumption: Indexed for an inflation rate of 3%, the inflation target of the Bank of Albania	

Source: Authors' calculations

S2B2 Saving on energy bills from solar thermal panels. Investing in solar thermal panels is expected to save about 30% on the energy bill of households and businesses in the targeted area. Using the data from the socio-economic survey on the average energy bill from households and businesses, it is assessed as a total saving of 74,738 euros annually.

Table 37. S2B2 Saving on energy bills from solar thermal panels

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2B2 Saving on energy bills from solar thermal panels	74,738 Euro per year
Assumption: Indexed for an inflation rate of 3%, the inflation target of the Bank of Albania	

Source: Authors' calculations

S2B3 Saving on water bills for irrigation of green areas and not drinking purposes. Investing in a rooftop rainwater collection system is expected to save water, particularly for irrigation of green surfaces in the areas of interest. Assuming 10 litres of water for irrigating one sqm of green area for the targeted areas annually, there is a demand for 434 cubic meters of water annually. According to information from the expert assessment, out of 125 litres of water an individual consumes daily, about 61 litres are used for house cleaning, gardening, sanitation, toilets, and car washing. That makes for about 31,407 cubic meters of water consumed annually for non-drinking and cooking purposes. The water price for public institutions in Albania is about 1.29 euros per cubic meter. For households, it is about 0.6 euros per cubic meter.[11]

Table 38. S2B3 Saving on water bills for irrigation of green areas and not drinking purposes

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2B3 Saving on water bills for irrigation of green areas and not drinking purposes	19,331 Euro per year
Assumption: Indexed for an average increase of 10% in water prices	

Source: Authors' calculations

S2B4 Improved air quality for added green areas. Green areas in the targeted areas are projected to increase by about 30% of the current green area. Additional greening includes planting of linden trees for a total of 601 trees. Assuming an absorption rate of 22 kg of CO2eq for an average-size tree[12] and using CO2eq shadow prices[13], the value of improved air quality in the intervention areas has been estimated.

Table 39. S2B4 Improved air quality for added green areas

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2B4 Improved air quality for added green areas	1.3 Euro million till 2040
Assumption: the benefit harvested is about 10% in Y1-Y5, about 20% in Y6-Y10, about 30% in Y11-Y15; and 40% in Y16	

Source: Authors' calculations

S2B5 Savings from disaster risk resilience and climate change adaption (flood prevention). Several studies highlight the benefits related to investments in risk reduction and prevention.[14] The benefits of disaster risks have been estimated, assuming an average saving of 4 euros per 1 euro invested.

Table 40. S2B5 Savings from disaster risk resilience and climate change adaption (flood prevention)

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	Cost
S2B5 Savings from disaster risk resilience and climate change adaption (flood prevention)	532,498 Euro per year
Assumption: A saving ratio of 4:1 is estimated, with the potential to harvest 30% of this benefit annually	

Source: Authors' calculations

S2B6 Increased properties value. Due to a better environment and improved living standards in the targeted area, real estate prices are assessed to increase by about 20% after completing investments. Using information from the socio-economic results on the average size of the apartment and the selling prices in the area expressed by both households and businesses, a total value increase of 5.4 million euros has been assessed (one-time event).

[11] Source: https://www.shuk.al/tirane/tarifat
[12]https://www.viessmann.co.uk/en/heating-advice/boilers/how-much-co2-does-tree-absorb.html#:~:text=do%20to%20help%3F-,How%20much%20CO2%20can%20a%20tree%20absorb%3F,around%20a%20tonne%20of%20CO2.
[13] Source: DG CLIMA (2021) / Economic Appraisal Vademecum 2021-2027
[14] Sources. https://www.voanews.com/a/un-report-investing-in-disaster-risk-reduction-saves-lives-money-/6269328.html
https://www.undrr.org/about-undrr/our-impact
Academic studies find every dollar invested in disaster risk reduction prevention can result in savings of $3 to $15 in disaster losses.
https://openknowledge.worldbank.org/handle/10986/31805
Hallegatte, Rentschler, and Rozenberg (2019) indicate that every US$1 invested in infrastructure resilience could result in US$4 in benefits, helping to mitigate disaster impacts and disruption of critical public services.

Table 41. S2B6 Increased property value

Scenario 2 Harvesting Renewables and Rainwater through PV and Nature Based Solutions for Climate Neutral Neighbourhoods	
S2B6 Increased property value	5,420,993 Euro
Assumption: Based on the investment implementation schedule, 50% of the increase is factorised in Y5 and 50% in Y9. Values are indexed at 3% every five years to account for inflation.	

Source: Authors' calculations

Economic indicators. The engagement in Scenario 2 and the implementation of the foreseen investments present a positive net present value, suggesting the scenario's convenience. The results from ENPV are supported by results obtained from the internal rate of return (IRR). IRR greatly exceeds the discount rate, thus suggesting the convenience of Scenario 0. Finally, the benefits-to-costs ratio (BCR) indicates that every Euro invested in the proposed project will create value for society.

Table 42. Scenario 2 economic indicators

Indicator	Value	Unit	Comment
Capital Investment	7,191,524	Euro	Estimated capital expenditures for realising the foreseen interventions
Economic Net Present Value (ENPV)	10,568,464	Euro	The ENPV suggests that the project is viable; thus, the benefits exceed its costs.
Internal Rate of Return (IRR)	14	%	The internal rate of return (the one that sets ENPV = 0) is considerably higher than the discount rate, suggesting a profitable investment.
BCR	1.9	Euro	The BCR >1 indicates that the project's benefits exceed its costs. In other words, for each 1 Euro invested, 1.9 Euros of value is created.
cumulative discounted benefits	32,268,848	Euro	
cumulative discounted costs	16,802,831	Euro	

Source: Authors' calculations

Figure 10. Scenario 2, summary of CBA

Key Assumption	
Social Discount Rate	6%
Appraisal period (years)	16
Currency	Euro

Year	0 2024	1 2025	2 2026	3 2027	4 2028	5 2029	6 2030	7 2031	8 2032	9 2033	10 2034	11 2035	12 2036
Discount factor	1.000	0.941	0.885	0.833	0.784	0.738	0.694	0.653	0.615	0.578	0.544	0.512	0.482
CAPEX													
S0I1 Investment in renovations (once in 5 years)	-	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911	411,138
S1I1 Investment in improving energy performance (1)	257,173	342,898	342,898	342,898	428,622	-	-	-	-	-	-	-	-
S1I2 Investment in improving energy performance (2)	-	-	-	-	-	385,394	513,858	513,858	513,858	642,323	-	-	-
S2I1 Photovoltaic panels:	-	86,091	114,788	114,788	114,788	143,485	-	-	-	-	-	-	-
S2I2 Solar Thermal Panel:	42,750	57,000	57,000	57,000	71,250	-	-	-	-	-	-	-	-
S2I3 Rainwater collections system:	-	-	-	-	-	105,975	-	-	-	-	-	-	-
S2I4 Greening (increase with 30% the green area)	-	30,050	-	-	-	-	-	-	-	-	-	-	-
S2I5 Preventing soil sealing	-	-	27,150	-	-	-	-	-	-	-	-	-	-
Total CAPEX	299,923	844,949	952,974	843,596	943,571	881,536	842,769	924,997	842,769	971,233	246,683	328,911	411,138
Present value of CAPEX	299,923	795,059	843,760	702,815	739,690	650,256	584,954	604,119	517,916	561,621	134,223	168,398	198,068
Cumulative PV of CAPEX	7,313,423												
Benefit sources													
S0B1 Less investment at the current stage													
S0B2 Gentrification of neighbourhood	825,255	825,255	825,255	825,255	825,255	850,012	850,012	850,012	850,012	850,012	875,513	525,308	525,308
S1B1 Energy saving from increased energetic performance (1)	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858	15,858
S1B2 Energy saving from increased energetic performance (2)	-	-	-	-	-	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396
S1B3 Increase in property values	-	-	-	-	-	2,710,497	-	-	-	-	2,710,497	-	-
S2B1 Income from energy production of photovoltaic panels	-	-	-	-	-	-	2,394,890	2,394,890	2,394,890	2,394,890	2,394,890	2,394,890	2,466,736
S2B2 Saving on energy bill from solar thermal panel:	-	11,211	26,158	41,106	56,053	74,738	76,980	79,289	81,668	84,118	86,641	89,241	91,918
S2B3 Saving of water for irrigation purposes	-	-	-	-	-	19,331	19,331	19,331	21,265	21,265	21,265	23,391	23,391
S2B4 Improved air quality due to increased greening	-	16,121	17,781	19,442	21,103	22,764	48,850	54,321	59,792	65,264	70,735	114,309	122,223
S2B5 Disaster risk resilience and climate change adaptation (flood preventio	-	-	-	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749
S2B6 Increase in property values	-	-	-	-	-	2,710,497	-	-	-	2,710,497	-	-	-
Total Benefits	836,465	867,533	884,142	1,060,500	1,080,845	6,570,345	3,580,156	3,587,936	3,597,719	6,323,723	6,342,729	3,338,141	3,420,579
Present Value of Benefits	836,465	816,310	782,816	883,522	847,303	4,846,549	2,484,936	2,343,295	2,210,947	3,656,729	3,451,160	1,709,080	1,647,882
Cumulative PV Benefits	32,268,848												
Cost sources													
S0C1 Electricity costs	249,125	249,125	249,125	249,125	249,125	256,599	256,599	256,599	256,599	256,599	264,297	264,297	264,297
S0C2 Annual maintenance cost	154,910	154,910	154,910	154,910	154,910	159,557	159,557	159,557	159,557	159,557	164,344	164,344	164,344
S0C3 Parking costs	75,476	75,476	75,476	75,476	75,476	77,740	77,740	77,740	77,740	77,740	80,072	80,072	80,072
S0C4 Air quality	-	-	-	-	-	-	-	-	-	-	-	-	-
S0C5 Noise pollution	-	-	-	-	-	-	-	-	-	-	-	-	-
S1C1 Maintenance costs I1	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396	15,396	19,245	11,893	15,858	15,858
S1C2 Maintenance costs I2	-	-	-	-	-	11,211	14,948	14,948	14,948	18,684	11,547	15,396	15,396
S2C1 Maintenance costs	-	-	1,503	2,905	2,992	5,219	40,020	40,274	40,536	41,518	41,296	42,316	42,611
S0B2 Gentrification of neighbourhood	356,510	356,510	356,510	356,510	356,510	367,205	321,305	321,305	321,305	321,305	330,944	283,666	283,666
Total Costs	847,232	850,969	852,471	853,874	857,698	889,079	885,565	885,819	886,081	894,649	904,394	865,949	866,244
Present Value of Costs	847,232	800,723	754,775	711,378	672,372	655,820	614,658	578,532	544,533	517,336	492,092	443,354	417,318
Cumulative PV of Costs	9,489,409												
Undiscounted cash flows													
CAPEX	(299,923)	(844,949)	(952,974)	(843,596)	(943,571)	(881,536)	(842,769)	(924,997)	(842,769)	(971,233)	(246,683)	(328,911)	(411,138)
Total costs	(847,232)	(850,969)	(852,471)	(853,874)	(857,698)	(889,079)	(885,565)	(885,819)	(886,081)	(894,649)	(904,394)	(865,949)	(866,244)
Total benefits	836,465	867,533	884,142	1,060,500	1,080,845	6,570,345	3,580,156	3,587,936	3,597,719	6,323,723	6,342,729	3,338,141	3,420,579
Net Cash Flow ###	(10,767)	16,565	31,671	206,626	223,147	5,681,267	2,694,591	2,702,118	2,711,639	5,429,074	5,438,336	2,472,192	2,554,335
Discounted cash flows (SDR1)													
CAPEX	(299,923)	(795,059)	(843,760)	(702,815)	(739,690)	(650,256)	(584,954)	(604,119)	(517,916)	(561,621)	(134,223)	(168,398)	(198,068)
Benefits	836,465	816,310	782,816	883,522	847,303	4,846,549	2,484,936	2,343,295	2,210,947	3,656,729	3,451,160	1,709,080	1,647,882
Costs ###	(847,232)	(800,723)	(754,775)	(711,378)	(672,372)	(655,820)	(614,658)	(578,532)	(544,533)	(517,336)	(492,092)	(443,354)	(417,318)
Net Cash Flow	(310,690)	(779,473)	(815,719)	(530,672)	(564,759)	3,540,473	1,285,324	1,160,644	1,148,498	2,577,772	2,824,844	1,097,329	1,032,496
Cummulative cash flow	(310,690)	(1,090,162)	(1,905,881)	(2,436,553)	(3,001,312)	539,160	1,824,484	2,985,129	4,133,627	6,711,399	9,536,243	10,633,572	11,666,068

Year	13 2037	14 2038	15 2039	16 2040	17 2041	18 2042	19 2043	20 2044	21 2045	22 2046	23 2047	24 2048	25 2049
Discount factor	0.453	0.427	0.401	0.378	0.355	0.334	0.315	0.296	0.279	0.262	0.247	0.232	0.218
CAPEX													
S0I1 Investment in renovations (once in 5 years)	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683
S1I1 Investment in improving energy performance (1)	-	-	-	-	-	-	-	-	-	-	-	-	-
S1I2 Investment in improving energy performance (2)	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I1 Photovoltaic panels:	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I2 Solar Thermal Panel:	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I3 Rainwater collections system:	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I4 Greening (increase with 30% the green area)	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I5 Preventing soil sealing	-	-	-	-	-	-	-	-	-	-	-	-	-
Total CAPEX	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683	328,911	411,138	328,911	328,911	246,683
Present value of CAPEX	149,099	140,295	99,009	124,217	146,103	109,981	103,487	73,033	91,627	107,771	81,126	76,336	53,872
Benefit sources													
S0B1 Less investment at the current stage													
S0B2 Gentrification of neighbourhood	525,308	525,308	541,067	541,067	541,067	541,067	541,067	557,299	557,299	557,299	557,299	557,299	574,018
S1B1 Energy saving from increased energetic performance (1)	15,858	19,822	12,250	16,334	16,334	16,334	20,417	12,618	16,824	16,824	16,824	21,029	12,996
S1B2 Energy saving from increased energetic performance (2)	15,396	19,245	11,893	15,858	15,858	15,858	19,822	12,250	16,334	16,334	16,334	20,417	12,618
S1B3 Increase in property values	-	-	-	-	-	-	-	-	-	-	-	-	-
S2B1 Income from energy production of photovoltaic panels	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736
S2B2 Saving on energy bill from solar thermal panel:	94,675	97,516	100,441	103,454	106,558	109,755	113,047	116,439	119,932	123,530	127,236	131,053	134,984
S2B3 Saving of water for irrigation purposes	23,391	23,391	25,730	25,730	25,730	25,730	28,303	28,303	28,303	28,303	31,133	31,133	31,133
S2B4 Improved air quality due to increased greening	130,136	138,050	145,964	205,170	215,722	226,273	236,825	247,376	322,410	336,088	349,766	363,444	452,546
S2B5 Disaster risk resilience and climate change adaptation (flood preventio	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749
S2B6 Increase in property values	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	3,431,250	3,449,817	3,463,831	3,534,098	3,547,753	3,561,502	3,585,967	3,600,771	3,687,587	3,704,863	3,725,077	3,750,861	3,844,782
Present Value of Benefits	1,555,421	1,471,501	1,390,241	1,334,691	1,260,737	1,190,894	1,128,275	1,066,039	1,027,280	971,153	918,797	870,531	839,641
Cost sources													
S0C1 Electricity costs	264,297	264,297	272,226	272,226	272,226	272,226	272,226	280,393	280,393	280,393	280,393	280,393	288,804
S0C2 Annual maintenance cost	164,344	164,344	169,274	169,274	169,274	169,274	169,274	174,353	174,353	174,353	174,353	174,353	179,583
S0C3 Parking costs	80,072	80,072	82,475	82,475	82,475	82,475	82,475	84,949	84,949	84,949	84,949	84,949	87,497
S0C4 Air quality	-	-	-	-	-	-	-	-	-	-	-	-	-
S0C5 Noise pollution	-	-	-	-	-	-	-	-	-	-	-	-	-
S1C1 Maintenance costs I1	15,858	19,822	12,250	16,334	16,334	16,334	20,417	12,618	16,824	16,824	16,824	21,029	12,996
S1C2 Maintenance costs I2	15,396	19,245	11,893	15,858	15,858	15,858	19,822	12,250	16,334	16,334	16,334	20,417	12,618
S2C1 Maintenance costs	42,914	43,961	42,881	43,969	44,310	44,662	45,781	44,710	45,873	46,269	46,677	47,876	46,821
S0B2 Gentrification of neighbourhood	283,666	283,666	292,176	243,480	243,480	243,480	243,480	250,784	200,628	200,628	200,628	200,628	206,646
Total Costs	866,548	875,407	883,176	843,615	843,957	844,308	853,475	860,056	819,352	819,748	820,156	829,644	834,967
Present Value of Costs	392,815	373,400	354,471	318,600	299,910	282,320	268,534	254,627	228,253	214,880	202,293	192,551	182,344
Undiscounted cash flows													
CAPEX	(328,911)	(328,911)	(246,683)	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)	(328,911)	(411,138)	(328,911)	(328,911)	(246,683)
Total costs	(866,548)	(875,407)	(883,176)	(843,615)	(843,957)	(844,308)	(853,475)	(860,056)	(819,352)	(819,748)	(820,156)	(829,644)	(834,967)
Total benefits	3,431,250	3,449,817	3,463,831	3,534,098	3,547,753	3,561,502	3,585,967	3,600,771	3,687,587	3,704,863	3,725,077	3,750,861	3,844,782
Net Cash Flow	2,564,702	2,574,410	2,580,655	2,690,483	2,703,797	2,717,193	2,732,492	2,740,714	2,868,235	2,885,115	2,904,921	2,921,217	3,009,815
Discounted cash flows (SDR1)													
CAPEX	(149,099)	(140,295)	(99,009)	(124,217)	(146,103)	(109,981)	(103,487)	(73,033)	(91,627)	(107,771)	(81,126)	(76,336)	(53,872)
Benefits	1,555,421	1,471,501	1,390,241	1,334,691	1,260,737	1,190,894	1,128,275	1,066,039	1,027,280	971,153	918,797	870,531	839,641
Costs	(392,815)	(373,400)	(354,471)	(318,600)	(299,910)	(282,320)	(268,534)	(254,627)	(228,253)	(214,880)	(202,293)	(192,551)	(182,344)
Net Cash Flow	1,013,507	957,805	936,761	891,874	814,724	798,593	756,254	738,379	707,400	648,502	635,378	601,644	603,426
Cummulative cash flow	12,679,576	13,637,381	14,574,143	15,466,017	16,280,740	17,079,334	17,835,588	18,573,967	19,281,367	19,929,868	20,565,246	21,166,890	21,770,316

Source: Authors' calculations

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1.10.4. Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.

A: Identification of the cost and benefit categories

The table below summarises the identified cost and benefit categories for Scenario 3– Implement value capture instruments to redevelop the entire area.

Table 43. Scenario 3, identification of cost and benefit categories

	Quantified	Monetised	Included in CBA
S3I1 Project development costs	Yes	Yes	Yes
S3C1 Energy costs	Yes	Yes	Yes
S2I2 Solar thermal panels	Yes	Yes	Yes
S3B1 Revenues from selling of residential buildings	Yes	Yes	Yes
S3B2 Revenues from selling of commercial areas	Yes	Yes	Yes
S3B3 Revenues from selling of parking spaces	Yes	Yes	Yes
S3B4 Improved air quality	Yes	Yes	Yes
S3B5 Improved living conditions for vulnerable categories	Yes	Yes	Yes

Source: Authors' calculations

B: Monetisation of cost and benefit categories

S3I1 Project development costs. Estimating the capital expenditure (capex) or the investment value was performed using the residual value analysis, a typical method for determining the land costs the development can support. This involves calculating the market value of the new development and then deducting the total development costs (applicable fees and charges, construction costs and developers' profit). The amount left (residual value) represents what a developer can afford to pay for land and still make the expected profit. The market value of land is then deducted. If the amount is negative, the project is not feasible. A positive amount means the development will generate adequate returns to support a public benefit. The table below details the data and assumptions for calculating the investment value (using the residual land value method).

Table 44. Scenario 3, main assumptions

Item	Value	Unit	Source of information
Average selling prices			
Residential spaces			
21 Dhjetori	2,500	Euro per sqm	Expert assumptions based on market research.
Ali Demi	1,800	Euro per sqm	
Parku teknologjik	1,800	Euro per sqm	
Commercial spaces			
21 Dhjetori	5,000	Euro per sqm	Expert assumptions based on market research.
Ali Demi	4,000	Euro per sqm	
Parku teknologjik	4,500	Euro per sqm	
Parking slots			
Selling price in all areas	25,000	Euro per sqm	Expert assumptions based on market research.
Average rent prices			
Residential spaces			

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21 Dhjetori	450	Euro per month	Expert assumptions based on market research.
Ali Demi	350	Euro per month	
Parku teknologjik	250	Euro per month	
Commercial spaces			
21 Dhjetori	500	Euro per month	Expert assumptions based on market research.
Ali Demi	400	Euro per month	
Parku teknologjik	300	Euro per month	
Parking			
All areas	50	Euro per month	Expert assumptions based on market research.
Selling policy			
Selling policy (years 1-4)			
Selling policy (years 1-5)	10%	10% is paid upon contract signature (Premtim Shitje)	Expert assessment based on market trends
	30%	30% is paid upon building permit issuance	Expert assessment based on market trends
	30%	30% is paid upon the building structure being finished (karabina)	Expert assessment based on market trends
	20%	20% is paid upon other works finished (rifiniturat)	Expert assessment based on market trends
	10%	10% is paid upon the property being registered in the Property Register Office (property certificate received)	Expert assessment based on market trends
Selling policy (years 6-7)	90%	90% on the contract of sale signature	Expert assessment based on market trends
	10%	10% is paid upon the property being registered in the Property Register Office (property certificate received)	Expert assessment based on market trends
Selling policy (years 8-9)	100%	100% is paid upon the property being registered in the Property Register Office (property certificate received)	Expert assessment based on market trends
Selling schedule:	5%	Y2, Y3, Y4	Expert assessment based on market trends
	15%	Y5, Y6	
	10%	Y7, Y8, Y9,	
	5%	Y10	
Average construction costs			
Average construction cost, residential	800	Euro per sqm	Expert assessment based on market trends
Average construction cost (60% of residential)	480	Euro per sqm	Expert assessment based on market trends
Average construction cost (20% of residential)	160	Euro per sqm	Expert assessment based on market trends
Infrastructure impact tax	0.08	8% of total building construction revenues	https://altax.al/taksat-dhe-tarifat-ndaj-nje-shoqerie-ndertimi-banesash/
Reference price for the calculation of the Infrastructure Impact Tax			
for residential purposes	851	Euro per sqm	DCM No 457/2023
for commercial purposes	1,701	Euro per sqm	Expert assumption
for parking purposes	425	Euro per sqm	Expert assumption

Ali Demi (1)			
for residential purposes	808	Euro per sqm	DCM No 457/2023
for commercial purposes	1,616	Euro per sqm	Expert assumption
for parking purposes	404	Euro per sqm	Expert assumption
Parku teknologjik (6)			
for residential purposes	598	Euro per sqm	DCM No 457/2023
for commercial purposes	1,195	Euro per sqm	Expert assumption
for parking purposes	299	Euro per sqm	Expert assumption
Reference selling price AU 10	81,783	ALL per sqm	
21 Dhjetori (7)	92,500	ALL per sqm	DCM No 457/2023
Ali Demi (1)	87,850	ALL per sqm	DCM No 457/2023
Parku teknologjik (6)	65,000	ALL per sqm	DCM No 457/2023
Land development fee	0.09	Euro per sqm	https://altax.al/taksat-dhe-tarifat-ndaj-nje-shoqerie-ndertimi-banesash/
Application fee for building permit	0.01	1% of the total construction cost	https://altax.al/taksat-dhe-tarifat-ndaj-nje-shoqerie-ndertimi-banesash/
CONSTRUCTION COSTS			
Developable land cost	20%	% of total development revenues	Assumption (based on previous experience range applicable from 25% - 45%)
Developer's profit	20%	of total development costs	Assumption

Source: Authors' calculations, et al

The economic value added as a public benefit amounts to Euro 110 million, implying that such an investment project contributes about 3,043 euros per sqm of land and 19,911 euros per square meter of construction. Nevertheless, the cost is about Euro 50 million for the CBA development.

Table 45. Residual land value

	(A) 21 Dhjetori	(B) Ali Demi	(C) Parku tek.	**Total**
I. Development revenues	59,588,877	52,269,599	59,524,325	171,382,800
II.1 Construction costs (Euro)	13,424,694	15,334,608	16,795,096	45,554,398
(+) Infrastructure impact tax	1,574,290	1,707,863	1,383,995	4,666,148
(+) Land development fee	1,912	2,184	2,392	6,489
(+) Application fee for building permit	134,247	153,346	167,951	455,544
II.2 Costs for fees and charges	1,710,449	1,863,394	1,554,338	5,128,181
II. Development costs	15,135,143	17,198,002	18,349,434	50,682,579
Development revenues	59,588,877	52,269,599	59,524,325	171,382,800
(-) Development costs	15,135,143	17,198,002	18,349,434	50,682,579
(-) Developer's profit	3,027,029	3,439,600	3,669,887	10,136,516
(=) Residual land value	41,426,705	31,631,996	37,505,004	110,563,705
per sqm of land	1,140	871	1,032	3,043
per sqm of construction	7,571	5,885	6,456	19,911
(-) Land costs	11,917,775	10,453,920	11,904,865	34,276,560
Value added by the development/public benefit	29,508,929	21,178,077	25,600,139	76,287,145
per sqm of land	812	583	705	2,100
per sqm of construction	5,686	4,340	4,811	14,838

Source: Authors' calculations

S3I1 Development costs. The implementation of the investment project is projected to last 5 years. Therefore, capital outflows for investment purposes are planned at a different percentage over the project implementation duration presented in the following table.

Table 46. Capital outflows for the implementation of the project

Y1	15%	7,602,387 Euro
Y2	20%	10,136,516 Euro
Y3	20%	10,136,516 Euro
Y4	20%	10,136,516 Euro
Y5	25%	12,670,645 Euro
Total		50,682,579 Euro

Source: Authors' calculations

S3C1 Electricity costs. The new construction would include about 691 new apartments of an average size of 70 sqm (based on the average size of the apartment from the socio-economic assessment) and 583 commercial units (based on the average size of the commercial unit from the socio-economic evaluation). These data were used to account for the net energy costs for the additional units in the targeted areas.

Table 47. S3C1 Electricity costs

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3C1 Energy costs	516 Euro per year for households 576 Euro per year for businesses
Assumption: Energy costs have been indexed to 3% annually to account for Albania's inflation rate.	

Source: Authors' calculations

In the redevelopment scenario, there is a wide range of benefits, some of which have been included in the assessment, while the others mostly related to new jobs and businesses created, contributions to economic development, etc., were not included in the analysis (for a conservative approach). The largest benefits from the redevelopment of the area concern the income that might be generated from selling apartments, commercial spaces and parking slots.

- **S3B1** Revenues from selling of residential buildings. The proposed project includes the construction of about 691 apartments and about 31,794 sqm. In part, the built apartments will be allocated to the existing families. Therefore, only the remaining part has been accounted for sale. For each area, the selling market prices were employed to assess the potential income that might be generated. In addition, it is a common practice to phase selling at a schedule and apply a selling policy in instalments based on the work advancements and the developers' business plan.

Table 48. S3B1 Revenues from selling of residential area.

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3B1 Revenues from selling of residential buildings	62,843,476 Euros

Source: Authors' calculations

- **S3B2** Revenues from selling of residential area. The proposed project includes constructing about 583 commercial units and about 12,349 sqm. The built commercial units will be allocated to the existing families. Therefore, only the remaining part has been accounted for sale. For each area, the selling market prices were employed to assess the potential income that might be generated. Idem to residential spaces for the selling policy and schedule.

Table 49. S3B2 Revenues from selling of residential area.

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3B2 Revenues from selling of commercial spaces	37,147,947 Euros

Source: Authors' calculations

S3B3 Revenues from selling parking spaces. The proposed project includes constructing about 679 parking slots. The inhabitants of the area do not currently own private parking spaces. Nevertheless, 50% of the parking spaces will be allocated for public use by the municipality of Tirana. The rest of the parking spaces will be sold at a market price of 25,000 euros per slot. The selling policy and schedule are the same as for commercial and residential spaces.

Table 50. S3B3Revenues from selling of residential area.

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3B3 Revenues from selling of commercial spaces	8,481,738 Euros

Source: Authors' calculations

S3B4 Improved air quality for added green areas. The new project implemented will be equipped with about 2003 Linden trees. Assuming an absorption rate of 22 kg of CO2eq for an average-size tree[15] and using CO2eq shadow prices[16], the value of improved air quality in the intervention areas has been estimated.

Table 51. S3B4 Improved air quality for added green areas

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3B4 Improved air quality	4.1 Euro million till 2040
Assumption: the benefit harvested is about 10% in Y1-Y5, about 20% in Y6-Y10, about 30% in Y11-Y15; and 40% in Y16	

Source: Authors' calculations

S3B5 Improved living conditions of disadvantaged categories of the population. According to law no. 22/2018 "On Social Housing", art. 19, "Any private entity that, after the entry into force of this law, applies for a development and construction permit for buildings with a residential construction area of more than 2,000 square meters, ensures the transfer without compensation of at least 3 per cent of the functional area, with the conditions of a housing appropriate, in favour of the public social housing fund." This provision pertains to private entities seeking development and construction permits for residential buildings exceeding 2,000 square meters in size following the enactment of this law. In this context, these entities must allocate at least 3 per cent of the functional area within the building for the public social housing fund. This allocation must be made without expecting any compensation in return. The purpose of this requirement is to contribute to the availability of affordable housing options for the public, particularly those in need of social housing support. By setting aside a portion of their construction project for this purpose, private entities are helping address housing needs within the community.

Furthermore, if, for any reason, it is not feasible to allocate this designated area within the same residential building under construction, the private entity has the flexibility to provide it within another residential construction area. This ensures that the commitment to support public social housing is still honoured, even if logistical constraints prevent immediate integration into the original development. This provision promotes social housing and community welfare through private sector involvement and contribution. Based on what the regulatory framework foresees, about 1,482 sqm of residential construction is to be transferred from the developer to the social housing fund of the municipality of Tirana (about 21 apartments for a total value of 1,452,440 Euros). In addition, these apartments are rented to vulnerable categories at a social housing rent of 100 euros per month (the author's assumption), which makes for an annual income of about 397,945 euros per year for the municipality of Tirana.

Table 52. S3B5 Improved living conditions of disadvantaged categories

Scenario 3. Build anew - Implement value capture instruments to redevelop the entire area.	
S3B5 Improved living conditions of disadvantaged categories of the population.	Capital gain 1,452,440 euros in Y7 Income from rent

[15]https://www.viessmann.co.uk/en/heating-advice/boilers/how-much-co2-does-tree-absorb.html#:~:text=do%20to%20help%3F-,How%20much%20CO2%20can%20a%20tree%20absorb%3F,around%20a%20tonne%20of%20CO2.

[16] Source: DG CLIMA (2021) / Economic Appraisal Vademecum 2021-2027

	397,945 euros per year
Assumption: social rent of 100 euros per month	

Source: Authors' calculations

Economic indicators. The engagement in Scenario 3 and the implementation of the foreseen investments present a positive net present value, suggesting the scenario's convenience. The results from ENPV are supported by results obtained from the internal rate of return (IRR). IRR greatly exceeds the discount rate, thus suggesting the convenience of Scenario 0. Finally, the benefits-to-costs ratio (BCR) indicates that every Euro invested in the proposed project will create value for society.

Table 53. Scenario 2 economic indicators

Indicator	Value	Unit	Comment
Capital Investment	51,704,694	Euro	Estimated capital expenditures for realising the foreseen interventions
Economic Net Present Value (ENPV)	33,142,370	Euro	The ENPV suggests that the project is viable; thus, the benefits exceed its costs.
Internal Rate of Return (IRR)	13%	%	The internal rate of return (the one that sets ENPV = 0) is considerably higher than the discount rate, suggesting a profitable investment.
BCR	2.1	Euro	The BCR >1 indicates that the project's benefits exceed its costs. In other words, for each 1 Euro invested, 2.1 Euros of value is created.
cumulative discounted benefits	95,993,224	Euro	
cumulative discounted costs	46,332,518	Euro	

Source: Authors' calculations

Figure 11. Scenario 3, summary of CBA

Key Assumption																		
Social Discount Rate		6%																
Appraisal period (years)		16																
Currency		Euro																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Year		**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Discount factor		1.000	0.941	0.885	0.833	0.784	0.738	0.694	0.653	0.615	0.578	0.544	0.512	0.482	0.453	0.427	0.401	0.378
CAPEX																		
S0I1 Investment in renovations (once in 5 years)																		
S1I1 Investment in improving energy performance (1)																		
S1I2 Investment in improving energy performance (2)																		
S2I1 Photovoltaic panels:		-	86,091	114,788	114,788	114,788	143,485	-	-	-	-	-	-	-	-	-	-	-
S2I2 Solar Thermal Panel:		42,750	57,000	57,000	57,000	71,250	-	-	-	-	-	-	-	-	-	-	-	-
S2I3 Rainwater collections system:		-	-	-	-	-	105,975	-	-	-	-	-	-	-	-	-	-	-
S2I4 Greening (increase with 30% the green area)		-	30,050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S2I5 Preventing soil sealing		-	-	27,150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S3I1 Development cost		-	7,602,387	10,136,516	10,136,516	10,136,516	12,670,645	-	-	-	-	-	-	-	-	-	-	-
Total CAPEX		**42,750**	**7,775,528**	**10,335,454**	**10,308,304**	**10,322,554**	**12,920,104**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Present value of CAPEX		42,750	7,316,422	9,150,974	8,588,036	8,092,127	9,530,385	-	-	-	-	-	-	-	-	-	-	-
Cumulative PV of CAPEX		42,720,695																
Benefit sources																		
S0B1 Less investment at the current stage																		
S0B2 Gentrification of neighbourhood																		
S1B1 Energy saving from increased energetic performance (1)																		
S1B2 Energy saving from increased energetic performance (2)																		
S1B3 Increase in property values																		
S2B1 Income from energy production of photovoltaic par		-	-	-	-	-	-	2,394,890	2,394,890	2,394,890	2,394,890	2,394,890	2,394,890	2,466,736	2,466,736	2,466,736	2,466,736	2,466,736
S2B2 Saving on energy bill from solar thermal panel:																		
S2B3 Saving of water for irrigation purposes		-	-	-	-	-	19,331	19,331	19,331	21,265	21,265	21,265	23,391	23,391	23,391	23,391	25,730	25,730
S2B4 Improved air quality due to increased greening																		
S2B5 Disaster risk resilience and climate change adaptatic		-	-	-	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749	159,749
S2B6 Increase in property values																		
S3B1 Revenues from selling of residential buildings		-	-	314,217	1,256,870	2,199,522	3,456,391	5,655,913	17,910,391	17,596,173	10,369,174	4,084,826	-	-	-	-	-	-
S3B2 Revenues from commercial spaces		-	-	185,740	742,959	1,300,178	2,043,137	3,343,315	10,587,165	10,401,425	6,129,411	2,414,617	-	-	-	-	-	-
S3B3 Revenues from selling of parking spaces		-	-	42,409	169,635	296,861	466,496	763,356	2,417,295	2,374,887	1,399,487	551,313	-	-	-	-	-	-
S3B4 Improved air quality		-	53,726	59,261	64,797	70,332	75,868	162,806	181,041	199,275	217,509	235,743	380,967	407,341	433,716	460,090	486,465	683,786
S3B5 Improved living conditions of vulnerable categories		-	-	-	-	-	-	-	1,452,440	1,850,385	1,850,385	1,850,385	1,850,385	1,850,385	1,850,385	1,850,385	1,850,385	1,850,385
Total Benefits		**-**	**53,726**	**601,627**	**2,394,010**	**4,026,642**	**6,220,972**	**12,499,361**	**35,122,302**	**34,998,049**	**22,541,869**	**11,712,787**	**4,809,382**	**4,907,603**	**4,933,978**	**4,960,352**	**4,989,066**	**5,186,387**
Present Value of Benefits		-	50,554	532,679	1,994,493	3,156,593	4,588,838	8,675,632	22,938,509	21,507,747	13,034,966	6,373,076	2,462,334	2,364,264	2,236,622	2,115,811	2,002,408	1,958,696
Cumulative PV Benefits		95,993,224																
Cost sources																		
S0C1 Electricity costs																		
S0C2 Annual maintenance cost																		
S0C3 Parking costs																		
S0C4 Air quality																		
S0C5 Noise pollution																		
S1C1 Maintenance costs I1																		
S1C2 Maintenance costs I2																		
S2C1 Maintenance costs		-	-	-	1,503	2,905	2,992	5,219	40,020	40,274	40,536	41,518	41,296	42,316	42,611	42,914	43,961	42,881
S0B2 Gentrification of neighbourhood		356,510	356,510	356,510	356,510	356,510	367,205	321,305	321,305	321,305	321,305	330,944	283,666	283,666	283,666	283,666	292,176	243,480
S3C1 Energy costs		(199,300)	(199,300)	(199,300)	(199,300)	(199,300)	492,255	492,255	492,255	507,022	522,233	537,900	554,037	570,658	587,778	605,411	623,573	642,281
Total Costs		**157,210**	**356,510**	**356,510**	**358,012**	**359,415**	**370,198**	**326,524**	**361,325**	**361,579**	**361,841**	**372,462**	**324,962**	**325,982**	**326,277**	**326,580**	**336,137**	**286,361**
Present Value of Costs		157,210	335,460	315,653	298,267	281,755	273,072	226,636	235,983	222,205	209,237	202,661	166,376	157,044	147,905	139,301	134,912	108,147
Cumulative PV of Costs		3,611,823																
Undiscounted cash flows																		
CAPEX		(42,750)	(7,775,528)	(10,335,454)	(10,308,304)	(10,322,554)	(12,920,104)	-	-	-	-	-	-	-	-	-	-	-
Total costs		(157,210)	(356,510)	(356,510)	(358,012)	(359,415)	(370,198)	(326,524)	(361,325)	(361,579)	(361,841)	(372,462)	(324,962)	(325,982)	(326,277)	(326,580)	(336,137)	(286,361)
Total benefits		-	53,726	601,627	2,394,010	4,026,642	6,220,972	12,499,361	35,122,302	34,998,049	22,541,869	11,712,787	4,809,382	4,907,603	4,933,978	4,960,352	4,989,066	5,186,387
Net Cash Flow	(51,704,694)	(157,210)	(302,784)	245,117	2,035,997	3,667,227	5,850,775	12,172,837	34,760,978	34,636,470	22,180,029	11,340,325	4,484,419	4,581,621	4,607,701	4,633,772	4,652,929	4,900,026
Discounted cash flows (SDR1)																		
CAPEX		(42,750)	(7,316,422)	(9,150,974)	(8,588,036)	(8,092,127)	(9,530,385)	-	-	-	-	-	-	-	-	-	-	-
Benefits		-	50,554	532,679	1,994,493	3,156,593	4,588,838	8,675,632	22,938,509	21,507,747	13,034,966	6,373,076	2,462,334	2,364,264	2,236,622	2,115,811	2,002,408	1,958,696
Costs	(42,720,695)	(157,210)	(335,460)	(315,653)	(298,267)	(281,755)	(273,072)	(226,636)	(235,983)	(222,205)	(209,237)	(202,661)	(166,376)	(157,044)	(147,905)	(139,301)	(134,912)	(108,147)
Net Cash Flow		(199,960)	(7,601,328)	(8,933,948)	(6,891,810)	(5,217,289)	(5,214,620)	8,448,997	22,702,526	21,285,542	12,825,730	6,170,415	2,295,958	2,207,221	2,088,718	1,976,510	1,867,496	1,850,549
Cummulative cash flow		(199,960)	(7,801,288)	(16,735,236)	(23,627,046)	(28,844,335)	(34,058,955)	(25,609,959)	(2,907,432)	18,378,109	31,203,839	37,374,254	39,670,212	41,877,433	43,966,151	45,942,661	47,810,157	49,660,706

Source: Authors' calculations

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Final remarks

In general findings from the cba suggest that there is a clear indication that scenario 2 is more profitable than scenario 1 in terms of overall socio-economic gains. However, the choice between renovation (scenario 1 or 2) and building anew (Scenario 3) is not as clear.

Table 54. Summary economic indicators for all scenarios

	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Investment	1,644,553	7,191,524	10,568,464	51,704,694
SDR	6.28%	6.28%	6.28%	6.28%
ENPV	4,276,054	2,578,421	10,224,385	33,142,370
IRR	20%	10%	14%	13%
B/C ratio	1.8	1.5	1.9	2.1

In Scenario 0, representing a delayed transition with periodic renovations every five years, the relatively low investment yields a high ENPV of €4,276,054. The IRR of 20% is significantly higher than the discount rate of 6.28%, indicating a strong return on investment. The BCR of 1.8 suggests that for every euro invested, €1.80 of value is created, confirming the project's economic viability. This scenario is economically favourable, yet, given that is not in line with the commitment of the country towards decarbonization, will remain as 'baseline' in this interpretation.

Scenario 1 involves a higher investment to improve energy performance. The ENPV of €2,578,421 indicates positive economic benefits, but it is lower than Scenario 0 despite the higher investment. The IRR of 10% is lower but still exceeds the discount rate, suggesting a profitable venture. The BCR of 1.5 means each euro invested returns €1.50, making it economically viable, though less attractive compared to the other scenarios due to the higher costs and lower relative returns.

Scenario 2 focuses on integrating renewable energy and rainwater harvesting systems. With a significant investment of €10,568,464, it yields an ENPV of €10,224,385, demonstrating substantial economic benefits. The IRR of 14% is higher than Scenario 1 and exceeds the discount rate, indicating a favorable return. The BCR of 1.9 suggests that for every euro invested, €1.90 of value is generated, making this scenario highly beneficial both economically and environmentally.

The most ambitious scenario involves comprehensive redevelopment, requiring an investment of €51,704,694. It offers the highest ENPV of €33,142,370, reflecting significant economic gains. The IRR of 13% is robust, surpassing the discount rate and indicating a profitable investment. The BCR of 2.1 is the highest among all scenarios, suggesting that each euro invested creates €2.10 of value. This scenario, while costly, provides the greatest long-term economic return and value for society. However, the scenario is also the riskiest, given the difficulty in developing an integrated masterplan for the structural units covering the target areas, as per General Local Plan. The high societal value of this scenario can only be demonstrated if there are willing developers to take over implementation of detailed local plans for the whole structural units, and that the criteria for fair compensation of owners and use of residual land value for public use is also met.

Therefore, given the unpredictability of scenario 3, the most realistically feasible option for improved energy performance at neighbourhood level is scenario 2, employing a myriad of methods for increased quality of living: renovation of building energy performance; photovoltaic panels instalment; rainwater harvesting for non-drinkable water usage; planting of trees and interventions against soil sealing.

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1.10. Conclusions and recommendations

The research on transitioning towards net-zero-emission buildings (NZEB) in post-communist urban neighborhoods in Tirana highlights several key findings and insights. The transition to NZEB in urban neighborhoods provides substantial socio-economic and environmental benefits, including significant reductions in energy consumption, greenhouse gas emissions, and improvements in air quality.

Four scenarios were analyzed in the research. Scenario 0, which involves a delayed transition, requires the least capital investment and offers the highest Internal Rate of Return (IRR) but has a modest economic net present value (ENPV). Scenario 1, focusing on enhanced energy performance, requires a higher investment but yields the lowest returns among the options, making it the least attractive economically. Scenario 2, which involves harvesting renewables and rainwater, requires the same investment as Scenario 1 but provides significantly better returns and benefits, making it a more efficient option. Scenario 3, which entails rebuilding anew, requires the largest investment but promises the highest absolute returns, making it the most ambitious and potentially the most impactful.

The research also indicates that implementing Nature-Based Solutions (NbS) such as green roofs and urban greenery can significantly enhance urban microclimate and biodiversity, reduce the urban heat island effect, and improve overall environmental quality. Effective stakeholder engagement, including local communities, government agencies, and urban planners, is crucial for the successful implementation of NZEB strategies. There is a need for alignment with existing policies and legal frameworks to ensure coherence and support for green transition initiatives. All scenarios indicate positive economic indicators, suggesting the viability and benefits of transitioning to NZEB. However, the scale of investment and returns varies significantly, with Scenario 2 providing a balanced approach and Scenario 3 offering the highest value creation in absolute terms.

The energy efficiency (EE) scenario explored improvements to building envelopes, insulation, and the integration of advanced heating and cooling systems. The scenario showed substantial potential for reducing energy consumption and enhancing thermal comfort within the dwellings. EE interventions demonstrated a positive impact on reducing heating and cooling loads, thereby decreasing overall energy demand.

The PV system scenario analyzed the feasibility of installing solar panels on the roofs of prefabricated buildings. The findings indicated that solar panels could generate a significant portion of the buildings' electricity needs, reducing reliance on grid electricity and fossil fuels. This scenario also offered economic benefits through potential savings on energy bills and eligibility for government incentives. However, the initial investment cost and structural requirements were noted as challenges.

The RTRWH study assessed the potential for collecting and utilizing rainwater for non-potable purposes such as gardening, cleaning, and cooling. The analysis indicated that implementing RTRWH systems could effectively reduce the burden on municipal water supplies, manage stormwater runoff, and mitigate the urban heat island effect.

The Envi-MET modelling showed that green and PV roofs could significantly mitigate the urban heat island effect by lowering surface and air temperatures. Additionally, the introduction of green spaces and water bodies through RTRWH systems enhanced local biodiversity and improved urban resilience to climate change.

The study highlighted the influence of urban morphology on air quality and microclimate. Block typologies, prevalent in the study areas, were found to retain more heat and humidity, exacerbating the urban heat island effect. Enhancing ventilation through strategic urban planning and incorporating green infrastructure were recommended to improve air circulation and reduce pollutant concentrations.

The transition to a greener energy sector in Albania faces challenges such as the need for significant investment, the development of regulatory frameworks, and addressing the inefficiencies in existing building stock. However, there are also substantial opportunities for leveraging natural resources, improving energy efficiency, and enhancing urban sustainability. Given its balanced approach between investment and returns, Scenario 2 should be prioritized for implementation. It offers significant socio-economic and environmental benefits, making it a feasible and efficient option for transitioning towards NZEB. Focus should be placed on integrating renewable energy sources such as solar and wind, along with Nature-Based Solutions like green roofs and urban greenery. These measures will enhance environmental performance, improve urban resilience, and contribute to climate change mitigation.

Ensuring that national and local policies are aligned with the objectives of the European Green Deal and the Western Balkans Green Transition Agenda is essential. Developing comprehensive regulatory frameworks to support energy efficiency, renewable energy adoption, and sustainable urban development is also crucial. Engaging local communities, government agencies, and urban planners in the decision-making process is important. Fostering collaboration and co-ownership of green transition initiatives will ensure broad support and successful implementation.

Utilizing a mix of public and private financing, including grants, subsidies, and credit lines, to support energy efficiency projects is necessary. Encouraging the development of energy service companies (ESCOs) and innovative financing models will attract investment. While short-term benefits are important, long-term sustainability and resilience should be emphasized in planning and implementation. Considering the lifespan and maintenance of green infrastructure and energy systems will ensure continued benefits over decades. Improving data collection and monitoring of energy performance, air quality, and environmental impacts is important. Using advanced tools and technologies for real-time monitoring and assessment will inform policy decisions and track progress. Increasing public awareness about the benefits of NZEB and the importance of energy efficiency and renewable energy is also crucial. Implementing educational programs to inform citizens about sustainable practices and encouraging their participation in green transition initiatives will support this effort.

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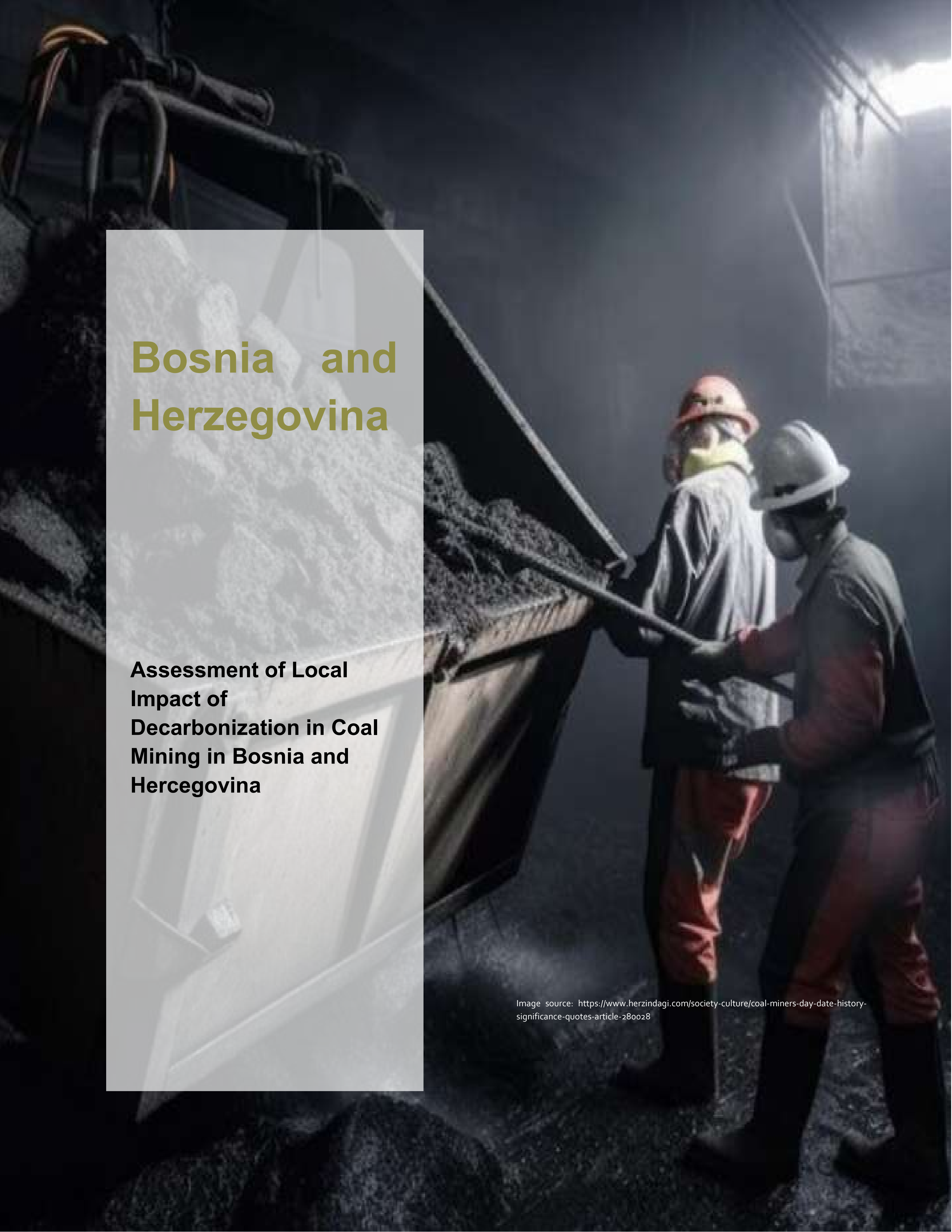
Bosnia and Herzegovina

Assessment of Local Impact of Decarbonization in Coal Mining in Bosnia and Hercegovina



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Bosnia and Herzegovina

Assessment of Local Impact of Decarbonization in Coal Mining in Bosnia and Hercegovina

2.1. Introduction

The research focuses on analysing the potential consequences of future coal mine closures on coal sector workers and local communities in Bosnia and Herzegovina. It specifically examines the labour market implications and budgetary consequences, with a particular emphasis on local labour markets. The primary goal of the research is to provide a policy-relevant analysis of the local labour market effects related to decarbonization in Bosnia and Herzegovina. The anticipated closure of coal mines raises concerns about social and labour impacts, and the research aims to inform the development of strategies to mitigate these effects.

The coal mine closures should be managed to ensure that no one is left behind. The "Economic and Investment Plan for the Western Balkans" and "Guidelines for the Implementation of the Green Agenda for the Western Balkans" documents, released by the European Commission in October 2020, support the transition to climate neutrality in accordance with the principles of Just Transition for All, which state that a successful low-carbon transition must be inclusive and socially just. The government needs to make sure that affected workers and businesses get the help and retraining programs they need to move on to new sources of work and investment and reduce the social and economic effects of the change. Additionally, the government should also consider investing in renewable energy and sustainable industries, which will create new job opportunities and promote economic diversification in these regions.

The design of effective measures to address "just" transition requires conducting research that will produce evidence offering answers to important questions such as "What is the expected impact of coal mine closures on employment?" "How can coal mine closures be managed to ensure no one is left behind?" and "How will coal mine closures affect communities highly dependent on mines?". By answering these questions, policymakers can come up with a better way to close coal mines in a way that protects the rights and well-being of workers and the long-term economic stability of the communities affected. Additionally, examining successful transitions in other industries can provide valuable insights and best practices that can be applied to the coal mining sector.

The coal mine closures will have an effect on firms and their employees. Some firms will shrink (especially those that can't make the change), and others will grow. While these may largely balance out at the national level, this is not a given at the subnational level, where the spatial distribution of specific sectors may result in asymmetric impacts. Most coal and related economic activities that are hard to make climate-neutral tend to be concentrated in one area. This also includes companies that supply coal mines and power plants, which will also face problems as the world moves towards a greener future. Hence, in order to ensure a fairer distribution of benefits and opportunities, policies and support programs will need to be created to specifically target the regions and industries most impacted by these disparities. This will require careful analysis of regional disparities and targeted interventions that consider the unique challenges and opportunities of different regions and sectors. In addition, there may be a need for workforce retraining and reskilling programs to ensure workers are equipped with the skills needed to succeed in new and emerging industries.

Local economic and labour market impact is important to be addressed in a situation of high dependence of local communities on coal mines, both through direct employment in mines as well as indirect upstream employment in firms supplying mines and downstream employment in businesses responding to the provision of goods and services to mine workers. National, regional, and local economic planning, including that related to the Green Agenda, can take into account the anticipated employment effects, and policies can be designed to mitigate the negative impact on workers and facilitate their transition into alternative jobs. To do this effectively, it is essential to understand the scope and nature of these employment effects. Understanding the implications of coal mine closures at the local level will help plan for a just transition, given that socioeconomic situations vary by location. Therefore, a comprehensive approach to climate neutrality must take regional disparities into account in order to achieve equitable outcomes. Such an approach would require addressing the unique challenges and opportunities presented by different regions and providing tailored support to ensure a just and sustainable transition.

The chapter is structured to present first a methodological approach encompassing three main research questions on expected impacts, namely impact on employment, fiscal and budgetary impact in the local economy. In the next section, a brief situation analysis is presented to inform readers about the current (baseline) values of the indicators of the labour market, well-being, and local development in Bosnia and Herzegovina. Then, next section presents the main findings from the assessment of expected impacts, presenting the results of the case study analysis. Finally, section provides some preliminary recommendations.

2.2. Methodology

As BiH implements its Nationally determined contribution (NDC) plan (revised in April 2021) with increased greenhouse gas emissions reduction targets, the country has committed to a series of actions, including increasing the share of renewable energy in its energy mix and therefore considering the gradual phase-out of coal-fired electricity. The closure of coal mines relates to the implementation of this strategy. Such a sensitive transition requires appropriate evidence that will support the design of mitigation measures for workers and communities whose livelihoods will be affected following the closure of coal mines, for a "just transition".

The main objective of this research is to **produce a policy-relevant analysis of the local labour market impacts of decarbonisation in BiH**. To produce the relevant insights into the possible impacts of decarbonisation that need to be considered in designing appropriate policy responses, the research assessed the following expected impacts:

- Negative employment impact of mine closures on the local labour market in BiH;
- Negative fiscal effect on collected social security contributions and income tax, as well as collected value added tax reduced due to the negative employment impact in the local communities affected by the mine closure; and
- Negative budgetary effect based on the reduced taxes and contributions, as well as the increased need for payment of pensions and unemployment benefits in the local communities affected by the mine closure.

The research was conducted using a mixed-methods approach, combining quantitative and qualitative techniques. The conclusion and recommendations are based on the triangulation of data collected within desk research, quantitative modelling using estimation methods, and the implementation of case studies in the selected locations.

The research was conducted in three phases. First, a brief baseline assessment of the labour market, household welfare, and local-level indicators was conducted. The results of this phase are presented in the section below. The aim of this section is to provide a snapshot of the current situation as well as inform decisions about the selection of case study locations. The initial scenarios were developed based on desk research and utilised information from the Framework Energy Strategy of Bosnia and Herzegovina until 2035. The strategy envisaged four different strategic pathways for reducing GHG emissions up to 2035. One of the scenarios is related to the gradual closing of mines and the transition to more green energy resources. Based on the data collected for the baseline assessment, two locations were selected for a case study analysis. Based on the results of the first phase, initial scenarios were adjusted for the purpose of quantifying the size of the impact at the local level in terms of fiscal effects caused by changes in employment level. There are examples of using qualitative data to adjust simulation scenarios in the literature (Lecocq et al., 2021; Nassar et al., 2023; Pye and Bataille, 2016; Ghorbani et al., 2015; Polhill et al., 2010). Using both types of data, conclusions and recommendations for different stakeholders were developed. The overview of the methodology used in this research is presented in Figure 2, while details on the case study selection (Case study selection) and estimation methods are presented in the next sections.

Table 55. Summary of research objectives, activities and methodology, BiH case

Overall research objective	The overall objective of the research is to produce policy relevant analysis of the local labour market impact of decarbonization in BiH.

Main research question	What is the labour market and fiscal (budgetary) effects of decarbonization in BiH?
Sub-questions	• What are the expected job losses due to the closure of coal mines at the local level? • What are the expected fiscal and budgetary implications of such job losses at the local level? • How the negative impact is distributed spatially, i.e. what is the extent of the impact on the most vulnerable communities (the ones where coal mines are located)?
Activities	• Desk research of policies, regulation, initiatives, etc. related to decarbonisation in BiH • Analysis of secondary data to identify vulnerable communities • Selection of communities for a case study • Conducting simulations of labour market and budgetary implications of coal mine closures using fiscal effect estimation tool (cost and benefit analysis) • Semi-structured interviews with stakeholders (PES, ministries of labour, ministries of social policy, regional government, municipal administration, affected businesses, CSOs) • Semi-structured interviews/focus group discussions with affected workers in selected communities • Design a set of policy proposals for introduction of specific measures addressing the need for reskilling and employment support to redundant workers • Design a set of policy proposal for introduction of specific social benefits addressing the need for income support to redundant workers and their families
Research methodology, instruments	• Desk research for theoretical review and discussion • Desk research for policy documents and initiatives • Semi-structured interviews with relevant stakeholders • Semi-structured interviews of focus group discussions with affected workers • Simulations • Data triangulation

Source: authors

2.2.1. Case Study Selection

Job creation from green energy will not necessarily be concentrated in the same areas as the locations of mines, and for this reason, it is important to assess the local impact of such a policy, which should motivate appropriate policies in the most negatively affected areas. The local economic impact will focus on several particularly vulnerable communities as case studies. The case study approach is most commonly used in similar studies (Wagner and Kolde, 2022; Xavier, 2000; Andrews-Speed, 2005; Botham, 2011; Mban, 2008). This study is not focusing on critiquing the closure process but rather on emphasising planning for closure. This research should be an illustrative study—an attempt to illustrate practices adopted by the governance and mines in BiH. Generally, there are two approaches that can be used in conducting such case studies. The first is a single-case study approach (for example, Wagner and Kolde, 2022; Botham, 2011) that focuses on a specific organisation, whereas the second approach, a multiple-case approach, focuses on multiple organisations or individuals (Xavier, 2000; Andrews-Speed, 2005). For this research, the multiple case study approach is relevant since labour market regulations as well as overall policy development can differ between different regions. Therefore, two municipalities with mines were selected for case studies.

In a case study conducted in South Africa, the mine that was the first to receive a "closure certificate" was selected, i.e., one that strictly followed all relevant laws and communicated openly with relevant departments at all levels of government. Another approach was used in a case study looking at mines in the Rhineland district of Germany. This is one of the three regions in Germany that produces the most coal (lignite) and is the most affected by transition. A successful transition in this area was of great national as well as international interest because if the transition fails in a larger mining area (especially in an industrialised country like Germany), smaller areas and less prosperous countries will not take initiatives for structural changes. A similar approach was used in the doctoral dissertation, in which a comparison was made of three mines on three different continents (Boro Gold mine in Mongolia, Cerro Vanguardia mine in Argentina, and Diavik mine in Canada), where the selection criteria were the assumption that the mine will close in the next 10 years, the number of employees in the mine, and the company's willingness to cooperate and contribute to research. In addition to these indicators, in some case studies, such as the five studies carried out in one area in China, other factors such as economic conditions, wealth, and dependency of the coal-producing area were taken into account. In that area in China, coal dominates the energy sector and accounts for 80–85% of primary energy production.

Taking into account all the mentioned examples and the methodologies used, it is concluded that when choosing a mine for observation in case studies, the following indicators need to be considered:

a) Location of the mine and the development of the municipality where the mine is located
b) Information on whether the mine is threatened with closure
c) Dependence of the area on coal production
d) The size of the mine
e) Willingness of the mine to cooperate

Regarding the location and the area where the mine is located, in BiH, it is important to take into account the region and the development of the municipality where the mine is located. It is important to assess both less and more developed municipalities and analyze how the potential closure of the mine can have an impact on both. The largest number of mines in Bosnia and Herzegovina is located in two cantons: Zenica-Doboj and Tuzla cantons. Banovići is a mining town located in the Tuzla Canton with an area of 185 km² and about 24,000 residents according to the latest population census (2013). Zenica is the administrative and economic center of the Zenica-Doboj canton with an area of 558.5 km² and slightly more than 110,000 residents according to the latest population census (2013).

Looking at mines from the perspective of future closures, all mines in BiH are equally at risk of closure, given that BiH has taken decisive action by submitting revised NDCs with more ambitious GHG reduction goals in 2021. As a member of the Energy Community, the country also has to bring its energy sector in line with the EU Acquis Communautaire. The Framework Energy Strategy of Bosnia and Herzegovina until 2035 envisages that the country plans to reach its targets by repurposing and decommissioning some inefficient coal-fired thermal power plants, which will go along with the closure of coal mines. This plan will affect not only people who work in mines but also a large number of workers, businesses, and households, especially in areas that depend a lot on mines. It was recently announced that the FBiH Ministry of Energy, Mining and Industry, together with the World Bank, plans to implement a project that will close three brown coal mines, the first of which is the mine in Zenica.

Despite this, areas that are rich in ores are very dependent on mines. Coal mines have historically played a significant role in the economy of Bosnia and Herzegovina. The country is estimated to have coal reserves of approximately 3.3 billion tons, which represents a significant portion of the country's natural resources. Brown coal and lignite accounted for 52 percent of BiH's primary energy supply in 2019, among the highest shares in the world (only North Korea, South Africa, Mongolia, and China have higher coal dependencies). In 2018, Bosnia and Herzegovina produced 14.3 million tons (Mt) of brown coal and lignite, which were mostly used to generate electricity at power plants near the mines. The analysis of the dependency of local communities on mines is provided in the next section. Banovići is a municipality with an above average level of dependence on mines, while Zenica has a lower level of dependence on mines.

It is also important to consider the size of the mine. The Banovići mine has ore reserves in the amount of 208 million tons of lignite, which makes it one of the largest ore reserves in Europe and the world. The annual production capacity is about 1.27 million tons of coal. The Zenica mine has an annual capacity of 320.000 tons of coal. Based on the previous discussion, two locations were selected as case studies, namely Banovići and Zenica, and after mapping relevant stakeholders (see section 7.3), semi-structured interviews were conducted following the protocols presented in Annex 4.

2.2.2. Estimation of effects at the local level

The employment impact was analysed by first assessing the short-term effect in the size of employment reduction, which included assessment of direct job losses in the mines as well as pathways of transition after dismissal. The information gathered through key informant interviews (KIIs) with representatives of mines was used to adjust the size of job losses (see Annex 7.4). Initial scenarios were revised according to the information collected from KIIs (the first part of the interview protocol used for interviews). The main aim of scenario development was to estimate the size of the employment effect, which will be used for the analysis of fiscal effects representing cost-benefit analysis of potential closure of mines. The scenario development is briefly presented in the following table combining two dimensions: gradual closure of mines and pace of transition of employees depending of the transferability of their skills to other sectors and jobs.

Table 56. Scenario development

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Description of the transition scenario	Short-term effect: Partial dismissal of workers without any transition to other sectors	Short-term effect: Partial dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers without transition into employment
Underlying assumptions	Part of the operations of mines are closed and workers are dissmised, there is no immediate transition into employment	Part of the operations of mines are closed and workers are dissmised, there is at least partial transition of workers into employment	Mine is permanently closing all operations, there is at least partial transition of workers into employment	Mine is permanently closing all operations, there is no immediate transition into employment
Adjustment of scenarios	Scenario adjusted based on qualititative data on the size of dismissal and transition to employment	Scenario adjusted based on qualititative data on the size of dismissal and transition to employment	Scenario adjusted based on qualititative data on the size of dismissal and transition to employment	Scenario adjusted based on qualititative data on the size of dismissal and transition to employment

Source: Authors

In the first scenario, the short-term effect involves the partial dismissal of workers without any transition to other sectors. The underlying assumption is that a portion of the mining operations is closed, leading to immediate worker dismissal with no immediate transition into alternative employment sectors. The size of the dismissal was adjusted using information from interviews, where 19% of workers at Zenica mine were dismissed in the previous year. The same percentage was applied in Banovici mine (for insights from case studies please see sections 4.1.1 and 4.1.2). The second scenario outlines a short-term effect of partial dismissal of workers (19% of workforce) with a transition into employment. Here, part of the mining operations is closed, resulting in the partial dismissal of workers. However, the underlying assumption is that there is at least a partial transition of workers into other employment sectors. The size of transition was calculated according to the description provided below. In the long term, scenario 3 envisions the full dismissal of the remaining number of workers with a transition into employment. The assumption here is that the mine is permanently closing all operations, causing the complete dismissal of workers. However, there is a planned transition for at least some workers into other employment sectors based on the demand for such workers and the transferability of their skills. In contrast, scenario 4 describes the long-term effect of full dismissal of remaining number of workers without any transition into employment. The underlying assumption is that the mine is permanently closing all operations, resulting in the complete dismissal of workers with no immediate transition into other employment sectors.

The pace of the transition of workers to other jobs available at local labour markets in the medium term was assessed within the case studies (questions related to the current skills of workers and the efforts made by different stakeholders to address future skills shortages (see Annex 7.4). Demand for workers of the same occupation in other sectors was calculated by forecasting the rise of employment within sectors and using the distribution of occupations in sectors. The demand also used information on the number of employees that will retire in the same occupation in the following years. For occupations that were classified as administrative occupations, demand in all other sectors other than sector B (Mining and quarrying) was used. The assumption made here is that the skills of administrative workers are more transferable to any other sector than those of technical workers. When it comes to occupations that were classified as technical, additional demand for these occupations was calculated using the rise in employment in sectors A (Agriculture, forestry and fishing), C (Manufacturing), D (Electricity, gas, steam and air-conditioning supply), F (Construction) and H (Transportation and storage). The supply of workers was estimated using only information about dismissed workers in sector B, not considering dismissed workers from other sectors, nor using information about additional supply from education. Information gathered through interviews with stakeholders was also used to adjust scenarios of a transition confirming that some occupations will be harder to transit compared with those who are already employed in the local economy (for example, miners compared to administrative workers). In addition to transitioning into employment, the number of workers transitioning into pension (28%), emigration (2%), and unemployment (63% of active job seekers and 7% of passive job seekers) were estimated using information from the Zenica case study.

Fiscal effect analysis involves utilising information from scenarios on the employment effect and pathways to the transition of workers to other sectors. Previous research reveals that mine phase-out and closure will have an effect on local budgets, among other consequences for local communities. Research conducted by Jolley et al. (2018) revealed that when decommissioned power plants in Ohio no longer pay tangible personal property (TPP) taxes, it resulted in $8.5 million in lost tax revenue for local governments. These findings suggest that a multi-pronged recovery effort will be required to assist this region, which has implications for similar communities in Appalachian Ohio dealing with coal plant closures. Another study (Clarck and Zhang, 2022) conducted in China estimated that jobs supported by the coal power industry would decline from 2.7 million in 2021 to 1.44 million in 2035 and 94,000 in 2050, with job losses from mining alone expected to exceed 1.1 million by 2035. Tax revenues from thermal coal would total approximately CNY 300 billion annually from 2021–2030, peaking in 2023 at CNY 340 billion. This is significantly less than estimated subsidies of at least CNY 480 billion, suggesting coal is likely a net fiscal drain on China's public finances, even without accounting for the costs of local pollution and the social cost of carbon.

The fiscal element of mine closure, as noted in the literature, can be defined in various forms, and it's important to understand these interpretations in order to evaluate the quality of the disclosed information (De Koker, 2020). Following the approach implemented by Jolley et al. (2018) in estimating loss in labour income, which is causing loss in collected taxes from companies, while combining the analysis of pathways to transition based on the assessment of skills transferability to other sectors, the fiscal effect of mine phase-out was estimated for two case studies. Direct and indirect fiscal effects can be distinguished here. For the purpose of this research, the direct fiscal effect was estimated as the loss of collected social security contributions and income tax from redundant employees, which were disbursed from mines. The effect was estimated based on the difference between the average gross and net salary paid to workers in the mining sector for the previous year in a given location. The total loss was then calculated as the monthly loss per worker multiplied by the number of dismissed workers in each scenario, taking into account the number of workers that transited to other sectors where it was applicable. The annual loss presents the multiplication between 12 months and the estimated monthly loss for each location.

When it comes to the loss of value-added tax (VAT), several assumptions were made for the purpose of estimating this indirect fiscal effect. The first assumption was that the entire salary of the worker was spent in that location, and this consumption was entirely taxed with the VAT. The same assumption was used for the income that is received by redundant employees after their dismissal (pensions, unemployment benefits, salaries from employment in other sectors). Based on the scenarios, the estimation of the employment effect (with and without transition to other employment) was used as a starting point for the calculation of the indirect effect. First, the current annual revenue from the collected VAT from the income of redundant workers was calculated. A recalculated VAT rate of 14.53% was used to extract the VAT from the income, based on the assumption that the entire income was spent and taxed in a given location. Based on the scenarios, the number of employees that transitioned to unemployment, pension, emigration, and employment in other sectors was used. Also, their new income was used to estimate the difference before and after dismissal. Therefore, for those who transitioned into employment, the level of unemployment benefit was used, which was 40% of the average net salary paid in the Federation of Bosnia and Herzegovina. For those who were assumed to transit into pension, the average pension was used as new income, while for those who transited into new employment, the same salary was used, as prior to dismissal. For those who were assessed to have emigrated, the entire salary was estimated as the loss as the basis for VAT calculation. The difference between the annual VAT collected based on the salary of redundant workers before dismissal and the VAT collected based on the new types of incomes of workers after dismissal was calculated as the total loss in VAT.

The budgetary effect was calculated as the sum of the loss of fiscal income (both direct and indirect) and the amount of pensions and unemployment benefits that will have to be paid for dismissed workers based on their pathway of transition. Analysing the budget effects of mine closures on local communities is crucial for understanding and mitigating the economic impact on those areas. The primary aim of such analysis is to assess how the closure of mines affects the fiscal health of local communities, including their revenue, employment, and overall economic well-being. This information can guide policymakers, local authorities, and community leaders in developing strategies to mitigate negative impacts and promote sustainable development. These can include various strategies, such as, for example, the diversification of sectors in the local economy.

2.3. Context Analysis: Implementation of decarbonization strategies in Bosnia and Herzegovina

The analysis of the current context in which green transition takes place in BiH is presented here and consists of the four main sections. First, the main information about the "brown" sector and coal mines is presented. Second, the main labour market indicators are presented to inform the reader about the baseline situation at the labour market in BiH, with a focus on the coal sector and an analysis of the distribution of employment by education and occupations. The third section briefly presents the indicators of households' welfare in BiH as a baseline for assessment of the distributional implications of the expected job losses resulting from coal mine closures. Finally, the fourth section presents local-level indicators that are used to identify the vulnerability of different regions and assess the economic situation in selected regions.

2.3.1. Coal mines in BiH

Coal mines have historically played a significant role in the economy of Bosnia and Herzegovina. The country is estimated to have coal reserves of approximately 3.3 billion tones, which represents a significant portion of the country's natural resources. Brown coal and lignite accounted for 52 percent of BiH's primary energy supply in 2019, among the highest shares in the world (only North Korea, South Africa, Mongolia, and China have higher coal dependencies).[17] In 2018, Bosnia and Herzegovina produced 14.3 million tones (Mt) of brown coal and lignite, which were mostly used to generate electricity at power plants near the mines. Seventy percent of the country's electricity production was from coal in 2020. Coal is also widely used for heat generation. However, the dependence on coal has negative implications for the environment and public health, as coal mining and burning emit greenhouse gases and pollutants. To address these issues, Bosnia and Herzegovina had to diversify its energy mix and invest in renewable sources of energy. As part of the Paris Agreement, Bosnia and Herzegovina has agreed to cut its greenhouse gas emissions and use more renewable energy sources like hydroelectric power. This move towards renewable energy sources is not only a response to climate change but also a way to help the economy grow and become less dependent on unstable and expensive fossil fuels.

BiH has taken decisive action by submitting a revised Nationally Determined Contributions Plan (NDC) with more ambitious greenhouse gas (GHG) emissions reduction goals in 2021. As a member of the Energy Community, the country also has to bring its energy sector in line with the EU Acquis Communautaire. Since energy production was responsible for 64% of BiH's greenhouse gas emissions in 2014, the climate strategy's top priority is to get rid of carbon from the energy production industry. With the help of the Energy Community and the country's large potential for renewable energy sources like hydropower, solar, and wind, this ambitious goal is doable. However, the country will also need to implement the necessary policy and regulatory frameworks to incentivize private investment in clean energy and reduce its reliance on fossil fuels. The country plans to reach its targets by

[17] https://www.iea.org/data-and-statistics/

repurposing and decommissioning some inefficient coal-fired thermal power plants, which will go along with the closure of coal mines. This plan will affect not only people who work in mines but also a large number of workers, businesses, and households, especially in areas that depend a lot on mines. Selected CO_2 emission data available is presented in **Error! Reference source not found.**.

Table 57. Selected CO2 emission data for BiH, 2016-2021

Indicator/Year	2016	2017	2018	2019	2020	2021
CO2 (million tons) Annual emission in BIH	21.73	22.16	22.08	20.81	20.93	13.57
CO2 (billion tons) Annual emission in world	35.52	36.1	36.83	37.08	35.26	37.12
CO2 (tons) Per capita in BIH	6.24	6.44	6.49	6.19	6.31	4.15
CO2 (tons) Per capita in world	4.73	4.75	4.79	4.78	4.50	4.69
CO2 share of BiH in world emissions (%)	0.06	0.06	0.06	0.06	0.06	0.04

Source: Our World in Data, https://ourworldindata.org/co2-and-greenhouse-gas-emissions#explore-data-on-co2-and-greenhouse-gas-emissions

As shown in the table above, there is a gradual decrease in the emissions of CO2 from 2017 to 2021 in Bosnia, with the sharpest decrease in 2021 (from 20.93 tons to 13.57 tons). Regarding the CO2 per capita indicator, the one in BiH was higher than the average one in the world. However, in 2021, it fell below the global value of per capita emissions of CO2. Throughout 2016 to 2020, the share of annual CO2 emissions from Bosnia and Herzegovina in the total amount in the world was 0.06%. It fell down to 0.04% in 2021. While global emissions slightly increased, BiH's share in global emissions remained relatively constant and low.

Table 58 compares carbon dioxide (CO2) emissions between Bosnia and Herzegovina and the EU-27 for the period 2019–2021. The comparison is made in terms of total emissions, per capita emissions, and emissions per unit of gross domestic product (GDP) using the EDGAR database.

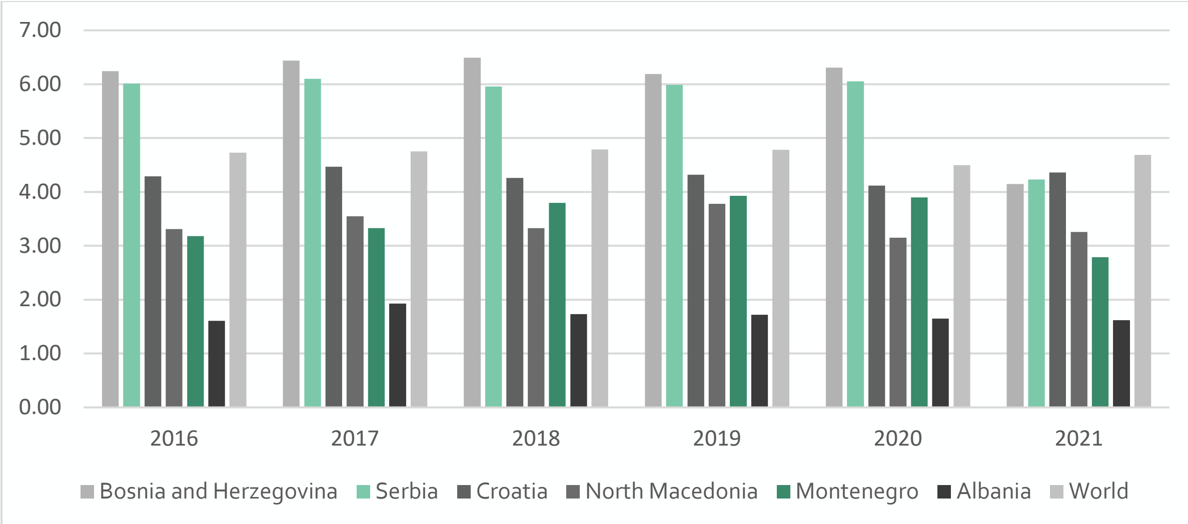
Table 58. Comparison of CO_2 emissions between BiH and EU

Indicator/Year	2019	2020	2021	% of world total
CO2 total emissions				
CO2 (Mton) BiH	22.77	22.55	15.37	0.04
CO2 (Mton) EU27	2,922.05	2,605.12	2,774.93	7.33
CO2 per capita emissions				
CO2 (ton CO2 per capita) BiH	6.50	6.45	4.40	Not applicable
CO2 (ton CO2 per capita) EU27	6.59	5.87	6.25	
CO2 per GDP emissions				
CO2 (ton CO2/1k$) BiH	0.46	0.47	0.30	Not applicable
CO2 (ton CO2/1k$) EU 27	0.15	0.14	0.14	
CO2 (ton CO2/1k$) World	0.29	0.28	0.28	

Source: EDGAR

The data presented in the table above indicates that Bosnia and Herzegovina's total emissions decreased from 22.55 Mton in 2020 to 15.37 Mton in 2021. However, EU27's value has increased from 2605.12 metric tons in 2020 to 2774.93 metric tons in 2021. The percentages of world total emissions reflect the relative contributions of BiH and the EU27 to the global CO2 output, with the EU27 playing a more significant role (0.04% from BiH compared with 7.33% from the EU27). BiH's per capita emissions decreased from 6.50 tons in 2019 to 4.40 tons in 2021. The EU27's per capita emissions showed some variation but generally remained lower than those of BiH. BiH's emissions per unit of GDP decreased from 0.46 in 2019 to 0.3 in 2021. The EU27 had consistently lower emissions per GDP compared to BiH, with values around 0.14. In 2021, BiH had a higher value for the indicator CO2 emissions per GDP than the rest of the world and the EU27.

Figure 12: CO2 emissions per capita in Western Balkan countries (tons)



Source: Our World in Data, https://ourworldindata.org/co2-and-greenhouse-gas-emissions#explore-data-on-co2-and-greenhouse-gas-emissions

As shown in **Figure** 12**22**, in Western Balkan countries, Albania has the fewest CO2 emissions throughout 2016–2021, ranking below average in emissions when compared to world emissions. Croatia, North Macedonia, and Montenegro all have emissions below average when compared to world emissions. Serbia and Bosnia and Herzegovina were above the world average until 2020. Both achieved below-average emissions of CO2 in 2021. As the chart suggests, Bosnia and Herzegovina ranks first in CO2 emissions in comparison to all Western Balkan countries from 2016 to 2020. In 2021, it was positioned below Serbia (4.23) and Croatia (4.36) with a value of 4.15 tons of CO2 emissions. Data suggests that in 2016 and 2017, Bosnia and Herzegovina ranked first in CO2 emissions, Serbia was second, Croatia was third, North Macedonia was fourth, Montenegro was fifth, and Albania was in last place with the fewest emissions. In 2018, 2019, and 2020, Montenegro produced more CO2 emissions than North Macedonia. Data from 2021 shows a few changes. Croatia rose to be the highest producer of CO2 emissions per capita, followed by Serbia and Bosnia and Herzegovina. North Macedonia produced more CO2 emissions per capita than Montenegro.

Table 59: Type of fuel and its production of CO2 in Bosnia and Herzegovina, 2016-2021

Indicator/Year	2016	2017	2018	2019	2020	2021
Annual CO2 emissions from cement	321,656	348,046	380,556	365,257	365,257	365,257
Annual CO2 emissions from gas	421,360	458,000	454,411	428,688	426,328	488,297
Annual CO2 emissions from oil	4,836,480	4,891,440	4,639,394	4,682,592	4,379,193	4,418,250
Annual CO2 emissions from coal	16,150,911	16,458,689	16,600,674	15,333,840	15,762,171	8,294,507

Source: Our World in Data, https://ourworldindata.org/co2-and-greenhouse-gas-emissions#explore-data-on-co2-and-greenhouse-gas-emissions

As **Table** 5956 shows, most annual emissions of CO2 in Bosnia and Herzegovina come from coal, followed by oil, gas, and cement emissions. It is to be noted that production of CO2 from coal had similar values through 2016–2020, while in 2021 it recorded a decrease.

Table 60: GHG per capita emissions (tons) in Western Balkan countries 2016-2021

Country/Year	2016	2017	2018	2019	2020	2021

Bosnia and Herzegovina	8.48	8.62	8.73	8.38	8.66	6.63
Croatia	5.41	5.61	5.31	5.28	5.24	5.35
Serbia	7.00	7.05	6.86	7.00	7.07	5.28
Montenegro	2.43	3.18	4.56	5.26	5.65	4.74
North Macedonia	4.05	4.24	3.94	4.33	3.74	3.83
Albania	3.09	3.38	3.11	3.03	2.97	2.93

Source: Our World in Data, https://ourworldindata.org/co2-and-greenhouse-gas-emissions#explore-data-on-co2-and-greenhouse-gas-emissions

When it comes to GHG emissions (**Table 60**), Bosnia and Herzegovina is the highest producer of GHG emissions per capita in all Western Balkan countries. Albania is the lowest producer of GHG emissions per capita. Bosnia and Herzegovina decreased its GHG emission per capita in 2021 from 8.66 to 6.63 tons, but still remained the highest producer of GHG emission per capita. Serbia produced more GHG emissions than Croatia from 2016 to 2020. In 2021, they reduced their GHG emissions and had a value below the value of Croatia's GHG emissions per capita. Croatia constantly produced similar GHG emissions per capita from 2016 to 2021. Montenegro has an increasing trend from 2016 to 2020. The GHG emissions per capita decreased in 2021, when they fell from 5.65 to 4.74 tons.

Table 61: Greenhouse gas emission per sector in Bosnia and Herzegovina 2015-2019

Sector/Year	**2015**	**2016**	**2017**	**2018**	**2019**
Agriculture	2,900,000.10	2,750,000.00	2,720,000.03	2,569,999.93	2,599,999.90
Land-use change and forestry	-3,720,000.03	-1,740,000.01	-1,730,000.02	-1,730,000.02	-1,730,000.02
Waste	1,130,000.00	1,130,000.00	1,120,000.00	1,120,000.00	1,110,000.01
Industry	500,000.00	509,999.99	529,999.97	560,000.00	550,000.01
Manufacturing and construction	2,119,999.89	2,049,999.95	2,190,000.06	2,400,000.10	2,240,000.01
Transport	3,160,000.09	3,680,000.07	3,839,999.91	3,819,999.93	4,079,999.92
Electricity and heat	12,909,999.85	15,069,999.69	15,380,000.11	15,229,999.54	13,739,999.77
Buildings	1,279,999.97	1,529,999.97	1,200,000.05	1,250,000.00	1,110,000.01
Fugitive emissions	720,000.03	709,999.98	709,999.98	699,999.99	690,000.00
Other fuel combustion	160,000.00	40,000.00	50,000.00	110,000.00	100,000.00
Aviation and shipping	20,000.00	30,000.00	30,000.00	20,000.00	30,000.00

Source: Our World in Data, https://ourworldindata.org/co2-and-greenhouse-gas-emissions#explore-data-on-co2-and-greenhouse-gas-emissions

From the **Table 61**, it is suggested that "electricity and heat" produce the most greenhouse gas (GHG) emissions. It had an increasing trend from 2015 to 2017, then decreased in 2018 and 2019. Other sectors that produce the most GHG emissions are "transport," "manufacturing and construction," "agriculture," "waste," and "buildings." Looking at the data from 2019, the "electricity and heat" sector was the largest producer of GHG emissions (13.7 million tons). Transport was the second largest (4 million tons) and agriculture was the third largest producer of GHG emissions (2.6 million tons).

2.3.2. Labour market in BiH

This section aims to present the current situation in the BiH labour market. The indicators presented here were selected in an attempt to avoid making another labour market diagnostics report; instead, they focus on the issues relevant for the subsequent analysis of the local level impact of decarbonisation. The aim is to inform readers about the issues that need to be taken into account for a better understanding of the employment impact of decarbonisation.

The labour market in Bosnia and Herzegovina is characterised by low employment and high unemployment rates, especially for youth. In such a situation, even minor changes in the labour market are expected to have a significant impact on both the entire economy and the people living in the country. The next table shows the macroeconomic indicators relevant to the labour market in Bosnia and Herzegovina, such as the annual growth of the total GDP in Bosnia and Herzegovina for the period from 2010 to 2020.

Table 62: Basic macroeconomic indicators relevant to the labour market in BiH, 2010-2020

Indicator	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
LFP rate 15-64 (annual %)	54.0	53.8	53.9	53.5	54.2	54.6	54.2	54.5	54.2	55.5	58.2
Employment rate 15-64 (annual %)	39.0	38.7	38.5	38.5	39.0	39.2	40.2	43.0	44.0	46.4	48.8
Unemployment rate 15-64 (annual %)	27.7	28.0	28.6	28.0	28.1	28.2	25.8	21.1	18.9	16.4	16.2

Sources: BiH Agency for Statistics

According to **Table 62**, indicators of the labour market indicate a continuous growth in labour force participation and employment rates. A decrease in the unemployment rate has been recorded since 2015. Still, the increase in the employment rate is also driven by a high level of emigration, particularly among youth.

Statistics on poor productivity and the high share of employment in some sectors suggest that some industries have either not caught up with the technological advancements in the sectors or have not taken advantage of possibilities to improve skills of their employees, or both. Investing in human capital entails ongoing training and development of employees so they may pick up new skills, utilise cutting-edge technology, and eventually become more productive. Similar patterns can be seen when comparing the labour market dynamics in particular sectors of the economy and two administrative divisions. While all other sectors have had a steady increase in the number of employed people, sectors B and E in both administrative units in the country exhibited a diminishing tendency over the analysed period.

Table 63: Employment levels in selected sectors in FBiH, 2016-2021

Sector	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
A Agriculture, forestry and fishing	8,873	10,389	10,940	10,989	10,743	10,984
B Mining and quarrying	13,211	13,267	12,995	13,259	12,671	12,244
C Manufacturing	88,631	100,052	105,098	106,385	101,729	103,541
D Electricity, gas, steam and air-conditioning supply	8,981	8,788	8,703	8,724	8,645	8,549
E Water supply, sewerage, waste management and remediation	7,980	8,267	8,551	8,652	8,527	8,446
F Construction	21,107	24,302	24,936	26,007	26,363	26,334

H Transportation and storage	22,983	23,416	24,062	24,857	24,419	24,419
J Information and communication	12,980	14,035	14,419	15,509	16,224	16,224

Source: Federal Institute of Statistics

Table 63 provides a comprehensive snapshot of workforce dynamics in the Federation of BiH. It can be noted that sectors A, C, F, H, and J experienced an increase in the number of employed persons, while sectors B and D recorded a decline over the analysed period. A similar observation can be made for the other entity regarding employment level per sector (see Table 64).

Table 64: Employment levels in selected sectors in Republic Srprska, 2016-2021

Sector	2016	2017	2018	2019	2020	2021
A Agriculture, forestry and fishing	8,482	8,482	8,530	8,468	8,473	8,704
B Mining and quarrying	5,277	5,357	5,114	5,045	4,731	4,689
C Manufacturing	52,116	54,434	56,436	56,738	58,013	58,816
D Electricity, gas, steam and air-conditioning supply	7,854	8,201	8,680	8,878	8,385	8,310
E Water supply, sewerage, waste management and remediation	4,833	4,956	4,902	5,040	5,026	5,210
F Construction	11,542	11,731	12,155	12,596	13,342	13,973
H Transportation and storage	11,761	11,987	12,073	12,454	12,257	12,486
J Information and communication	5,150	5,587	5,876	6,194	6,342	7,139

Source: Institute of Statistics of Republic Srpska

Decarbonisation will not only affect employees in the selected sectors; it will also have an effect on businesses in the same and related sectors. Therefore, it is important to observe if companies tend to invest in these sectors and whether the number of business entities has increased over time. When the number of businesses is analysed per sector of activity, available data at the entity level shows an increase in the number of registered legal entities in all sectors.

Table 65: Number of legal entities in FBiH 2016-2021

Sectors	2016	2017	2018	2019	2020	2021
A Agriculture, forestry and fishing	1,173	1,218	1,256	1,286	1,313	1,319
B Mining and quarrying	217	221	224	230	235	240
C Manufacturing	5,729	5,886	6,065	6,199	6,348	6,561
D Electricity, gas, steam and air-conditioning supply	256	257	264	280	299	335
E Water supply, sewerage, waste management and remediation	329	330	342	343	350	355
F Construction	2,853	2,932	3,041	309	3,146	3,264
H Transportation and storage	2,263	2,298	2,358	2,416	2,473	2,544
J Information and communication	1,203	127	1,372	1,458	1,526	1,664

Source: Federal Institute of Statistics

The data in the above table suggests that fewer business entities are present in sectors B (mining and quarrying), D (electricity, gas, steam, and air-conditioning supply), and E (water supply, sewerage, waste management, and remediation). Sectors with relatively stable and moderate growth in FBiH include agriculture, forestry, and fishing (Sector A), mining and quarrying (Sector B), and water supply, sewerage, waste management, and remediation (Sector E). Sectors with steady and sustained growth include manufacturing (Sector C) and transportation and storage (Sector H). Sectors with notable increases in the number of legal entities, indicating potential rapid growth, include electricity, gas, steam, and air-conditioning supply (Sector D), construction (Sector F), and information and communication (Sector J).

Similar trends can also be observed for data from the Republic of Srpska. Most sectors in RS show a stable and moderate pace of growth in the number of business entities, indicating a consistent economic environment. The overall trends suggest a resilient and steadily growing economy in RS, with sectors exhibiting varying but generally positive growth rates.

Table 66: Number of business entities in RS 2016-2021

Sector	2016	2017	2018	2019	2020
A Agriculture, forestry and fishing	1,106	1,144	1,180	1,205	1,245
B Mining and quarrying	182	185	192	197	212
C Manufacturing	4,075	4,187	4,324	4,427	4,521
D Electricity, gas, steam and air-conditioning supply	189	200	209	226	243
E Water supply, sewerage, waste management and remediation	241	248	261	269	276
F Construction	1,625	1,696	1,757	1,805	1,875
H Transportation and storage	1,419	1,461	1,499	1,517	1,559
J Information and communication	595	644	694	754	799

Source: Republic Institute of Statistics

It is important to look at not just the number of people who have jobs and businesses that are employing them, but also their skills and abilities. This can be done by looking at the structure of jobs, which can be used to describe the set of knowledge and skills that are needed by different sectors. Since 2011, the most people working in BiH have been in service and business jobs, followed by people who work in agriculture, hunting and breeding, forestry, and fishing.

2.3.3. Household welfare indicators

This section analyses the national-level indicators of welfare, while the local-level welfare indicators, where the difference between coal-dependent and non-coal-dependent communities is analysed, are presented in the section on local-level analysis .

In Bosnia and Herzegovina (BiH), the primary data source for analysing poverty is the Household Budget Surveys (HBS). In total, 7,702 households participated in the 2015 HBS, 4,643 of which were located in the Federation of Bosnia and Herzegovina (FBiH), 2,607 in the Republic of Srpska (RS), and 452 in the Brcko District[18]. The government statistics office uses HBS consumption data to measure poverty, and the official poverty level is set at 60% of the median equivalised household consumption (Agency for Statistics of BiH). One of the causes of this is that, despite being greatly improved in 2011 and 2015, the HBS's income module has historically been thought to be underreported (Sabanovic, 2017; 2018). Based on consumption statistics from HBS, 16.9% of people were considered to be poor, while 26.3% were estimated using the income approach. BiH has significant levels of poverty

[18] The results for HBS conducted in 2021–2022, which were published, did not include the main poverty and inequality indicators.

and inequality, and reduced employment could have a significant negative influence on overall poverty and inequality levels in such a setting.

Table 67: Poverty and inequality indicators in BiH, 2015

Indicator	Bosnia and Herzegovina	Federation BiH	Republika Srpska	Brcko District
Number of households below poverty line	170,619	104,666	62,501	3,452
Number of individuals below poverty line	505,816	332,328	161,849	11,639
Poverty rate (%) - households	16.5	16.0	17.4	15.9
Poverty rate (%) - individuals	16.9	17.1	16.4	17.6
S80/S20 ratio	4.9	5.2	4.3	4.2
Gini coefficient	31.2	31.0	31.4	31.7

Source: Household Budget Survey 2015

In 2015, 170,619 households (16.5% of the total number of households) and 505,816 individuals (16.9% of the total number of individuals) in Bosnia and Herzegovina lived in relative poverty. There are geographical disparities in the distribution of poverty among different entities. The Republic of Srpska has the highest rate of destitution among households, while Brcko District has the lowest. Individual poverty rates are highest in Brcko District and lowest in the Republic of Srpska. The average for Bosnia and Herzegovina, 4.9, indicates that the richest quintile of households consumes 4.9 times more than the poorest quintile. There are no significant differences between administrative entities in Bosnia and Herzegovina. The Gini coefficient indicates the uneven distribution of equalised consumption expenditures in Bosnia and Herzegovina, which was 31.2% with no significant geographical variations observed. In addition to analysing poverty and inequality indicators, it is also important to look into household structure as well as type of settlement, since these can affect households' position in different ways.

Household poverty can be influenced by the employment status and level of education of the household head. The next table presents the structure of households based on the current activity status and education of household heads.

Table 68: Heads of households by current activity status and education in BiH, 2015

Current activity status	BiH	Low education level *	Middle education level **	High education level ***
Full-time employees (%)	35.4	15.2	70.3	14.5
Less than full-time employees (%)	4.5	33.4	63.8	2.9
Unemployed or looking for a first job (%)	8.6	24.9	70.5	4.6
Housewives (%)	10.6	80.1	19.7	0.2
Pensioners (%)	35.9	40.8	54.2	4.9
Other (%)	5.0	78.5	18.4	3.1

Note: * Low education level: No school or completed primary education; ** Middle education level: Completed high school and post-secondary non-tertiary education; **High education level: Completed university degree

Source: Household Budget Survey 2015

In terms of the current activity status of household heads, there are 35.9% of household heads who are pensioners and 35.4% who are full-time employed. Other categories are less represented as household heads. Out of those full-time employed, most of them have completed secondary education (70.3%). In those households where the head's current activity status is housewife, it is important to note that 80.1% have finished lower education levels.

Table 69: Poverty rate based on activity status of household head in BiH, 2015

Activity status of household head	Poverty rate
Employed	11.6
Unemployed or looking for a first job	26.2
Housewife	18.0
Disabled	38.5
Pensioner	16.3
Other	-32.9

Source: Household Budget Survey 2015

The highest poverty rates were recorded in households where heads were disabled (38.5%) and unemployed or looking for a first job (26.2%). The lowest poverty rate was recorded in households with an employed household head. The below table reveals that households whose heads are younger than 65 years old are mainly employed in the construction sector, followed by manufacturing and agriculture, hunting, and forestry. When it comes to single parents with less than two children, most of them are employed in wholesale and retail trade, while single parents with more than two children are mainly employed in the health care sector. Household heads that are living with a partner and children are mainly employed in the construction sector. Older household heads, those over 65 years old, are employed in agriculture, hunting, and forestry. The same can be said for those household heads who are living in multigenerational households.

The analysis indicates that there are notable variations in the distribution of household types across different employment sectors. The prevalence of certain household compositions in specific industries may be influenced by factors such as the nature of the work, regional demographics, and economic conditions. It is also important to note that some of these sectors would be affected by the transition to more green industries and households where the main breadwinner is employed in such a sector.

Table 70: Household composition by industry of employment of household head, %, BiH, 2015

Sector	A.	A1.	A2.	A3.	A4.	A5.	A6.	B.	C.
Agriculture, hunting and forestry	14.3	14.0	9.5	17.4	13.3	14.2	18.9	61.9	18.8
Fishing	0.2	0.0	0.0	0.0	0.0	0.2	0.5	1.0	0.2
Mining and quarrying	3.6	3.2	0.9	0.0	3.0	4.0	4.2	2.4	3.8
Manufacturing	14.2	14.7	10.4	9.1	16.2	15.1	8.9	4.1	12.3
Production and supply of electricity, gas, water	3.3	2.8	1.8	0.0	4.6	3.3	3.9	0.0	4.5
Construction	17.5	12.7	6.7	2.8	16.6	18.9	23.3	9.4	17.1
Wholesale and retail trade	9.6	10.3	15.6	4.0	7.0	9.9	7.2	5.5	8.8
Accommodation and food service activities	3.7	7.7	8.1	1.0	4.5	2.7	1.8	1.2	2.9
Transport, storage and communication	8.2	6.6	5.6	17.0	8.3	8.7	8.4	2.0	9.6
Financial intermediation	1.3	3.3	2.6	3.2	0.7	0.9	0.9	1.0	1.0
Real estate activities	0.9	2.1	0.4	0.0	0.9	0.8	0.7	0.0	7.6
State administration and defence; compulsory social insurance	6.4	5.3	7.1	6.1	4.7	6.7	7.1	1.0	2.4
Education	3.5	4.2	8.8	3.1	4.7	2.7	2.9	1.6	2.1

Health care	2.8	4.8	8.5	20.7	2.7	1.9	0.8	1.8	0.5
Social protection	0.3	0.0	0.4	0.0	0.0	0.5	0.0	0.0	7.7
Other public, communal, social and personal service activities	9.4	6.9	11.4	15.6	12.1	8.9	9.8	4.8	0.2
Activities of households as employers	0.3	0.5	0.9	0.0	0.0	0.2	0.5	1.1	0.3
Extraterritorial organizations and authorities	0.5	1.0	1.2	0.0	0.7	0.2	0.3	1.0	18.8

Legend: A. Household head under 65 years of age; A1. Single; A2. Single with 1 or 2 children; A3. Single with 3 or more children; A4. Couple; A5. Couple with 1 or 2 children; A6. Couple with 3 or more children; B. Household head over 65 years of age; C. Multigenerational households

Source: Own calculations using HBS 2015 data

The next table provides insights into the demographic characteristics of minimum-wage earners in BiH.

Table 71: Minimum wage earners in Bosnia and Herzegovina

Number of minimum wage earners		27,072
As a share of full-time employees		3.6%
Number of minimum wage earners who are household heads		8,568
Average number of household members		3.89
Structure by the educational level (%)	Not completed primary	2.02
	Lower-secondary	16.67
	Upper-secondary	73.23
	Post-secondary	0.00
	Tertiary	8.08

Source: Own calculations using BiHMOD

It is important to emphasise that 31.7 percent of household heads, or 3.6 percent of all working people in the country, earn the minimum wage at the level of the administrative unit where they work. The average household size of minimum wage earners was 3.89, and the majority of them have completed secondary education.

Table 72: Mean wage by household type, BiH 2015

Household type	**Mean wage**
One-person households	875.3
Lone parent with child(ren) aged less than 25	827.0
Couple without child(ren) aged less than 25	865.0
Couple or lone parent with child(ren) aged less than 25 and other persons living in household	915.9
Other type of household	846.3
Total	894.2

Source: Own calculations using BiH HBS 2015 data

When distinguishing different features of the green transition, family composition should also be taken into account. The HBS 2015 data that is currently available reveals that lone parents with children under the age of 25 receive the lowest average salaries. When considering whether to cut jobs, one should take into account the structure of households as well as any potential effects on social policies.

Table 73: Number of social benefits recipients by household type, BiH 2015

Household type	Number of social benefits recepients
One-person households	176
Lone parent with child(ren) aged less than 25	32
Couple without child(ren) aged less than 25	285
Couple or lone parent with child(ren) aged less than 25 and other persons living in household	637
Other type of household	163
Total	1293

Source: Own calculations using BiH HBS 2015 data

According to the analysis of the sample's recipients of social benefits based on data from the HBS in 2015, households with parents, kids, and other members of the household are typically the recipients of these benefits.

Table 74: Number of pension recipients by household type, BiH 2015

Household type	Number of pension recepients
One-person households	1064
Lone parent with child(ren) aged less than 25	52
Couple without child(ren) aged less than 25	1303
Couple or lone parent with child(ren) aged less than 25 and other persons living in household	827
Other type of household	493
Total	3739

Source: Own calculations using BiH HBS 2015 data

Most pension recipients are single-person households or childless couples. But it's also crucial to emphasise that households with partners, children, and other family members do receive pensions. These households are less impacted by the repercussions of the work loss because they have some reliable income to rely on.

2.4. Theoretical framework / literature review

A number of historical examples demonstrate that significant transition in the coal extraction sector has been accompanied by large, persistent, and painful social dislocation, for example in the UK coal mining regions in the 1980s (Baeten, Swyngedouw, & Albrechts, 1999; Caldecott, 2017; Del Rio, 2017; Fothergill, 2017; Gales & Hölsgens, 2017; Harfst, 2015; Jonek Kowalska, 2015; Kok, 2017; Rečková, Rečka, & Ščasný, 2017; Szpor, 2017).

While the national mining employment rate is generally low, locally it can encompass a considerable part of the workforce. Thus, mining labour changes observed regionally will affect the equilibrium and dynamics of local economies, being in this way a potential source of resource curse (or blessing). As a result of new climate-related government policies, new technologies, and associated economic changes, a variety of groups will experience numerous kinds of losses. Where these industries and jobs represent a significant share of local economic activity, there are also likely to be regionally concentrated flow-on losses of multiple kinds in local communities. The main categories of agents at risk of incurring losses as a result of climate policy are: a) individual owners of energy-intensive or emissions-intensive household assets (consumers or households); b) corporate owners of energy-intensive or emissions-intensive business assets (corporations); c) workers currently employed in energy-intensive or emissions-intensive industries (workers); d) communities or regions in which energy-intensive or emissions-intensive industries account for a large share of economic activity (communities). Some of the possible transition policies that can be implemented at different levels are presented in the next figure.

Figure 13. Typology of substantive transition policy options

	1. No support	2. Compensation or grandfathering (backward-looking)	3. Structural adjustment assistance (forward-looking, narrow)	4. Holistic adaptive support (broad)
Workers	No support	Compensation for losses, such as redundancy payments, early retirement benefits	Cash or in kind assistance to retrain or relocate; wage subsidies; targeted unemployment payments	Workers are given strong support not only to find new jobs but also to maintain or develop new valued attachments (of the kind that cannot easily be compensated), e.g. work of a similar social standing, or in the same community
Regions/ communities	No support	Compensation for losses, such as resource transfers to lower levels of government to compensate for reduced tax revenue	Affected communities/regions are supported economically to diversify, e.g. via direct investment in public goods such as infrastructure or innovation; subsidies or tax incentives to businesses in growth sectors; technical assistance.	Affected communities/regions are given broader social-cultural assistance, e.g. investment in social service provision or community cultural and recreational facilities.
Coal mining companies	No support	Compensation for lost asset value or existing assets are 'grandfathered' into the new regulatory regime. State-subsidization of company liabilities (e.g. financial liabilities to employees; site remediation liabilities) can also be considered in this category.	Business are provided cash or in-kind assistance to adapt to the new policy/context, e.g. tied grants for technology upgrading.	-

Source: Green (2017)

A final point about agents is that governments at all levels will also typically be affected by climate-related structural change, in particular through reduced taxation revenue and increased social welfare expenditures. Meso- and macro-level social-scientific studies provide additional evidence of potential socio-economic problems in economically depressed communities affected by industrial transitions (Case and Deaton 2015, 2017; Gest 2016; Lamont 2000; Newman 1995; Pugh 2015, 2016; Vaccaro, Harper, and Murray 2016).

Available literature suggests that examining effects is both important at the national and subnational (local) levels, but impacts are expected to be more negative at the municipality level, where employment in affected sectors represents a significant proportion of total employment. Different methods were used to estimate the impacts of the decarbonisation strategies, both quantitative and qualitative, as well as a mixed-method approach.

Socio-economic impact assessment is a common method used in several research publications. For example, key components of the CSRM closure studies used by Kemp et al. comprised community consultation, a desktop study, including a socio-demographic profile and economic analysis, a workforce survey, and the calculation of impact estimations (on completion of the desktop research). A consultation phase was undertaken for both CSRM mine closure studies. Each study incorporated a core of 40 to 50 one-on-one, face-to-face, semi-structured interviews across a range of stakeholder groups. Each closure study included the preparation of a stand-alone socio-demographic profile, which sought to provide a statistical picture of the area local to both mines. The workforce survey was designed to collect data relevant to workforce planning aspects as well as to assist in estimating community impacts and opportunities.

Another example from Demirkan et al. (2022) used a multistage approach consisting of: 1. identification of relevant indicators; 2. data collection; 3. multi-attribute decision analysis (MADA); 4. ranking of alternatives and their evaluation; 5. sensitivity and scenario analysis. Several studies also used a case study approach and assessed impacts using qualitative methods such as semi-structured interviews with relevant stakeholders.

Coal mine closures have significant impacts on regional and local economies. The closure or repurposing of coal mines and power plants could have significant economic and social consequences, especially in coal-dependent regions that are often highly specialised "mono-industry" areas where the economy and the local identity are closely tied to the coal value chain. Managing closures appropriately and successfully depends on planning for the transition, which may offer significant development opportunities to the local community during operation if managed properly. A quantitative analysis approach can be used to assess the economic, fiscal, and workforce impacts of mine closures. It can help identify costs associated with mine closure as well as policies related to closure. A couple of studies have focused on community wellbeing in the context of mine closure. For example, Odell et al. (2011) developed a framework of socio-environmental indicators by interviewing nearby communities to assess and improve social wellbeing and sustainability through mine closure. The economic impact of coal mining in New Mexico is examined in a report by Peach et al. (2009). The analysis is based on economic multipliers derived from an input-output model of the New Mexico economy. The direct, indirect, and induced impacts of coal mining in New Mexico are presented in terms of output, value added, employment, labour income, and tax revenue. Analysing the local economic impact of coal mine closure requires assessing direct job losses as well as indirect job losses due to reduced demand for goods and services. It also requires identifying development opportunities that mines can offer to the local community during operation that must continue after closure if managed properly. There is no single blueprint for managing the phase-out of coal-fired generation because a great deal inevitably depends on local circumstances and priorities.

2.5. Assessment of expected impacts of coal mine closures

This section presents results obtained from qualitative data and an estimation of effects following the methodological approach explained in Section 2.2. First, insights from desk research and data from interviews and focus group discussions are presented to briefly introduce the analysis of expected impacts at the local level. These data were used in the adjustment of scenarios for which employment, fiscal, and budgetary effects were calculated and presented in the section below.

2.5.1. Zenica case study

Brown coal mine "Zenica" d.o.o.[19]- Zenica operates as part of the public company Elektroprivreda BiH concern as a dependent company. The Zenica mine has the largest balance and potential brown coal reserves in the area of the Zenica-Sarajevo coal basin. Coal production was carried out in three pit capacities: Stara jama, Raspotočje and Strajani. The mine was first case where reduction of workers happened due to various reasons, one of them being implementation of the Framework Energy Strategy of Bosnia and Herzegovina until 2035. According to KIIs conducted in Zenica, due to a series of problems, they first closed the Stranjane pit, last year the Stara pit, and now one pit is working. The plan is to close the Raspotočje pit by 2028, as far as information is passed to mine. The process of reorganization of mines in FBiH has been ongoing since 2019, and since then the mines have been under pressure.

The company currently has **615** employees after laying off **147** workers, with **95** dismissed as redundant and others leaving by mutual agreement due to the closure of the Stara jama facility. A care plan was implemented, offering incentive severance pay for amicable contract terminations, which **52** workers accepted. The remaining **425** employees work at one pit, with the rest in services and administration. The company aimed for self-sustainability with 641 workers, but 152 remained unassigned due to **qualifications** or **health issues**. A program for redundant employees was created, but only 52 workers mutually terminated contracts. Retraining was challenging, especially for jobs in the pit. Surveys indicated workers' reluctance to join Geop, a company established for mine workers. Most laid-off workers were in services, leading to the plant's closure. Vocational education levels varied, and job opportunities in related companies were limited. About **80** more employees **are expected to retire** in the next few years, contributing to workforce reduction.

When it comes to profiles of dismissed workers, they are different for digger workers compared with workers in administrative units. The **digger workers**, with 20-30 years of experience, have unemployed wives and multiple children, **relying solely on their mining salaries**. Graduates of mining school, they work in risky positions with

[19] https://rmuzenica.ba/

limited prospects in other sectors due to their specialized skills. Most are **disabled** and **unfit for physically demanding jobs outside mining**. The closure of previous mines in Zenica was perceived as an experiment, leaving untapped ore. **Administrative workers**, often older individuals who transitioned from pits, **have additional family income sources** and are mostly economic school graduates. Layoffs increased workload for both pit and administrative workers. Most employees are older, making reemployment challenging, and the younger ones prefer staying in the mine. The union expresses dissatisfaction with the handling of layoffs, sacrificing a portion of workers and families. Dismissed workers **face difficulties finding jobs**, particularly due to **age** and **disabilities**. There is a demand for miners abroad, notably in Slovenia, but current miners are hesitant to leave Bosnia and Herzegovina.

The care program for dissmised workers involved collaboration with the employment service, establishing infrastructure jointly. Those taking severance pay lose unemployment benefits eligibility. The bureau buys up to 3 years of service for all dismissed workers, enabling them to retire. While **37** workers opt for **retirement**, **4** choose other retirement options. For remaining workers, the bureau must provide unemployment benefits (**95**) according to the law. In addition, **benefits** for those who relied entirely on the salary (digger worker profile) **are not enough to support their families**, and therefore, they are at risk of entering poverty. Many former workers found employment in the **construction sector** in Zenica, but also **few** (2-3) of them emigrated to Croatia and Slovenia. When it comes to training and retraining opportunities offered by public employment service (PES), workers who are at risk of future job loss would participate, depending on the offered occupation. For the present miners, even retraining in occupations in the construction sector is not an option due to working at height.

The mine's **cooperation with education institutions**, both formal and informal, **is limited**. The mine faces challenges in retraining disabled Category II workers for other jobs, particularly in occupations with a shortage of skilled workers in pit mining. While there is a training system and service within the mine for unskilled workforce development, specific occupations rely on secondary schools. However, in Zenica, there is **insufficient enrollment for pit mining jobs**, and efforts to attract students to mining-related careers have faced disinterest. The closure announcement and negative public discourse contribute to the lack of enthusiasm among high school students. Employees seeking further education must go outside the company, and there has been a lack of mine initiatives for student career guidance. The image of mining has shifted negatively in the last 3-4 years, with miners no longer recommending the profession to their children. The perception could change with a positive public image and the introduction of green job projects. Involvement of education ministries is necessary for program development, but progress is slow, leading to a lack of belief in future prospects. Although it is hard for digger workers to transition to green jobs, for example, in the installation of solar panels, only one company in Zenica trains workers for solar panel installation; no other formal or informal education initiatives have been established.

Customers and suppliers who do business with the mine, as well as the wider local community, have already been affected by the reduction in mine operations. Also, cooperation with social work centers is lacking. Considering that the complete closure of the mine is planned in the future, the joint action of a wider circle of interested parties is necessary. The company has implemented a unique type of dismissal in the FBiH and emphasizes the need for government and ministry involvement to **coordinate efforts for worker transition, training, and retraining**, which is currently missing. While the company accepted workers during previous dismissals, there are no established models or policies to address their current situation. The company is developing a long-term business plan for the next three years, focusing on technological improvement, research, and worker employment. World Bank loans and projects for biomass and solar power plants offer potential solutions, but the company expresses uncertainty about the available resources. The goal is to revitalize the mine, incorporating new technology to reduce harmful gas emissions and promote energy production.

2.5.2. Banovići case study

Brown coal mine "Banovići"[20] deals with production, beneficiation (processing) and sale of coal. It has six organizational units in its composition; two production plants "Surface Coal Mining" and "Underground Coal

[20] https://www.rmub.ba/

Mining", "Railway Transport", "Separation", "Standard and Services" and "Directorate". When it comes to the market, the mine markets its entire production both domestically and internationally. About 70% of the coal is placed in the Tuzla Thermal Power Plant. The share of exports in the total placement is about 17%, of which 5% is direct, and 12% is indirect. The remaining 11% of the amount of coal is marketed to customers for general and wide consumption. The mine currently employs 2,798 workers, of which 217 are highly skilled personnel, which is 7.5% of the total number of employees.

There is a trend of decreasing workforce through **natural attrition and retirement**, with approximately **100** workers leaving each year. Production costs have risen due to outdated equipment and a lack of investments. Some positions may need to be filled by hiring new workers. While there are limitations on new employment decisions from the FBiH Government, cooperation is generally good. Trained workers leaving for Western European countries has occurred sporadically but is not alarming. The average salary increased by 17% in the previous year, and other benefits were also raised. The company maintains positive relations with unions and emphasizes finding ways to support workers in the event of layoffs, although this is not currently considered an option.

Given that the Framework Energy Strategy of Bosnia and Herzegovina until 2035 envisaged closing operations of some mines, the company started reorganising its operation accordingly. The company is committed to reducing the workforce through natural attrition without resorting to layoffs, even though there won't be immediate staff reductions due to a sudden drop in the demand for coal. There is a consideration for possible restructuring within the mine. Discussions with the World Bank are ongoing to seek assistance for upcoming projects. Plans include the construction of a solar power plant on the land previously exploited by the mine. The company is engaging in talks with the World Bank representatives regarding the utilization of large areas for this purpose. Additionally, they are exploring opportunities for land conversion, potentially for industrial, agricultural, or tourist purposes, providing employment for their workers. The company is in the conceptual phase of these solutions, aiming to benefit the mine and reduce electricity costs.

In the Tuzla Canton (TK), there are **833** individuals with mining occupations at the records of PES offices who have completed some secondary vocational education, with the least having a university degree, particularly only **56** mining engineers. The highest number is in the mining technician profession, but they were employed the least in the previous period. Miners and plant operators with the vocational education were mostly employed. Although there is a high demand for miners, approximately 200 workers wanted for the Kreka mine at the beginning of the year, there is a lack of interest from the unemployed due to negative media portrayal and uncertainty about the future of the mines. This poses a challenge as the mining industry will continually need these professions due to an **aging workforce** approaching retirement. Similar issues are observed in **construction professions**, with a shortage of available workers on record. There is also increasing pressure for work permits for foreign workers in construction, mining, and hospitality due to emigration. The PES faces potential challenges if mass layoffs occur in the mine, both financially and in encouraging workers to find employment elsewhere. Communication between the service and mine representatives regarding transitions and layoffs is lacking. Past large layoffs from companies have strained the service financially, and after mine closure, there would be less need for administrative staff due to quick re-employment of those on record.

The cooperation of mine and PES with education institutions is limited. The company engages in retraining efforts, collaborating with the Secondary School Center in Banovići, offering on-the-job training within the mine, and occasionally facilitating employees' further education for relevant certificates. They have a contract with the High School Center for student practical training. However, interest in mining professions among younger generations is declining, reflected in lower enrollment in secondary schools and mining courses. The Mining School's closure this year exacerbates the issue, leaving a gap in education for mining professions in Tuzla. Fewer children are enrolling in vocational schools, possibly influenced by parental perceptions favoring high schools and colleges. The company attempted retraining programs with limited success, and there is **a lack of adult education centers** for mining occupations. The decline in enrollment for mining-related courses in the past decade, coupled with the absence of training programs since 2015, has resulted in a loss of focus among the unemployed. Interest in retraining programs for mining occupations remains low, with more enthusiasm for CNC operator and welder occupations. There are no specific adult education centers for mining occupations, but a few exist for those seeking migration to EU countries. PES collaborates effectively with educational institutions to communicate labor market demands, although there is a perceived lack of response from the ministry regarding deficit occupations.

The company highlights excellent cooperation with the local community, emphasizing the mutual dependence between the mine in Banovići and the municipality. The entire local economy relies heavily on the mine, and the municipality and the mine are interdependent. Future plans, especially for land repurposing, require financial support from local communities and owners. The company acknowledges the need for suppliers to adapt to the planned changes, but this transition will span at least 30 years. The broader population will be also affected, particularly those using the Tuzla TPP or relying on coal for heating.

2.5.3. Local level indicators

Analysis of data from the selected case studies of municipalities with coal mines is important in the context of mining closure, which is the result of decarbonisation, one of the core tenets of the green agenda. On a larger scale at the national level, the research assumes that the closing of a mine will have some, but not so substantial impact on the development and structure of the labour market due to the low share of coal mine employment in total employment. However, it will be substantial at the local level, where a coal mine is the primary employer. In order to take the appropriate action, it is required to analyse empirical data and estimate the effects it may have on the population and overall development of the municipalities because it is of considerable importance in some of them. As a result of their isolated locations and lack of access to major commercial hubs, many coal districts have weak local economies that are frequently dominated by miners and power plants. Indicators of the labour market and local development for the selected locations are analysed in the set of tables that are shown below. These indicators were obtained from official statistics. The indicators are provided at the level of selected location and compared to the average municipality in the entity where these locations are (in this case FBiH).

Table 75: Stock of employed in selected municipalities and FBiH, 2016-2021

Municipality	2016	2017	2018	2019	2020	2021
Banovići	5,169	5,100	5,084	5,368	5,256	5,204
Zenica	24,501	26,590	27,102	27,587	27,136	26,906
Average municipality in FBiH	5,696	6,315	6,501	6,648	6,506	6,572
Stock of employed in FBiH	457,974	505,201	519,800	531,483	520,162	525,397

Source: Own calculations based on data from FBiH Institute of Statistics

As the above data suggests, Banovići have a slightly lower stock of employed people compared to the average municipality in FBiH, while the stock in Zenica is considerably higher.

To analyse the situation compared to the total population, labour force, and working-age population in selected municipalities, the analysis is further focused on employment and unemployment indicators for selected municipalities compared to the average municipality in the entity where available, as well as compared to the entity level.

Table 76: Employment to population ratio in selected municipalities and FBiH, 2016-2021 (%)

Municipality	2016	2017	2018	2019	2020	2021
Banovići	22.64	22.37	22.35	23.74	23.35	23.35
Zenica	22.28	24.24	24.76	25.23	24.87	24.85
Average municipality in FBiH (calculated)	17.47	19.18	19.85	20.35	19.91	
FBiH (calculated)	20.76	22.95	23.67	24.27	23.81	24.23

Source: Own calculations based on data from FBiH Institute of Statistics

According to the data on employment to population ratio presented in the above table, both selected municipalities have values above the average municipality in FBiH,. The ratio had an increasing trend in both municipalities in the first part of the analysed period and started decreasing from 2020.

Table 77: Employment rates in selected municipalities and FBiH, 2016-2021 (%)

Municipality	2016	2017	2018	2019	2020	2021
Banovići	30.57	30.26	30.57	32.71	32.52	32.58
Zenica	31.44	34.40	35.41	36.37	36.24	36.38
Average municipality in FBiH (calculated)	25.14	27.59	28.71	29.57	29.14	
FBiH (calculated)	29.37	32.59	33.78	34.81	34.37	35.04

Source: Own calculations based on data from FBiH Institute of Statistics

The above table shows a similar situation with employment rates as with the indicator of employment to population ratio. Both selected municipalities follow the same increasing trend in employment rates as the average municipality in FBiH.

Table 78: Unemployment rates in in selected municipalities and FBiH, 2016-2021 (%)

Municipality	2016	2017	2018	2019	2020	2021
Banovići	51.15	48.98	47.52	43.62	44.94	43.34
Gračanica	48.06	43.49	40.71	38.79	40.37	38.39
Breza	38.66	37.64	36.24	34.53	35.66	34.24
Zenica	47.31	43.58	42.06	39.91	40.75	39.22
Kakanj	50.48	47.96	45.84	44.52	45.97	44.94
Travnik	36.33	34.54	33.66	33.57	35.91	35.85
Tuzla	32.44	32.83	30.72	31.47	32.58	33.38
Živinice	59.68	55.88	52.51	48.31	48.51	47.41
FBiH (calculated)	44.83	40.91	38.83	36.68	38.33	36.32

Source: Own calculations based on data from FBiH Institute of Statistics

Regarding the unemployment figures, the below table shows that municipalities Breza, Travnik, and Tuzla had constantly lower unemployment rates compared to the unemployment rate for FBiH, while all other municipalities had rates that were above the FBiH level. The highest differences can be observed in Banovići, Kakanj, and Živnice, but there is a decreasing trend in the difference between the respective municipality and the FBiH level.

Table 79: Average net wages in selected municipalities and FBiH, 2016-2021

Municipality	2016	2017	2018	2019	2020	2021
Banovići	844	859	916	911	979	1,017
Zenica	845	828	868	908	935	967
Average municipality in FBiH (own calculation)	763	788	812	838	864	
Average FBiH (FZS data)	839	860	889	928	956	996

Source: Own calculations based on data from FBiH Institute of Statistics

Analysing wages in addition to employment patterns is crucial when examining local labour markets because wages provide valuable insights into the quality of jobs, economic well-being, and the overall health of the labour market.

Data presented in the above table show that Zenica had constantly below average net wage compared to the average municipality in FBiH, as well as the average net wage in FBiH according to the publicly available data. In contrary, the wages in Banovici were either slightly below or above the net wage level of the average municipality in FBiH.

2.6. Scenario analysis

2.6.1. Employment effects

Following the methodological approach in estimating the size of employment effects in the local communities that are or may be affected by mine closure, the number of those workers who are expected to be retired, emigrate, active or passive job seekers, and transited into employment in other sectors is estimated. The effect was calculated for each scenario that includes short- and medium-term effects as well as pathways of transition of workers, keeping constant the percentage of those who are going to be retired, emigrate, and be inactive or passive job seekers.

The following two tables present the results for each municipality. The lower number of workers that are to be dissmised are in Zenica than in Banovići. In addition, since Zenica municipality is less dependent on mines compared with Banovići, employment effects will have lesser consequences for the local community.

Table 80: Estimated employment effect in Zenica

Zenica	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Description of the transition scenario	Short-term effect: Partial dismissal of workers without any transition to other sectors	Short-term effect: Partial dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers without transition into employment
Pensioners	41	41	172	172
Unemployed active job seekers	92	0	385	77
Unemployed passive job seekers	11	11	46	46
Emigrated	3	3	13	13
TOTAL REDUCATION	147	55	615	308
Transited to employment in other sectors	Not applicable	92	Not applicable	307

Source: Authors' own calculation

The first scenario described the real dismissal of workers from Zenica mine that happened in the previous year. This is a scenario that does not consider the transition of workers to jobs in other sectors, which, according to KII, is hard to achieve for workers with mainly technical skills. But due to the fact that, according to the calculation of demand for workers, both administrative and technical staff have the opportunity to get employed in the local economy of Zenica municipality, the second scenario assumes that all unemployed active job seekers are about to find a new job in other sectors. In the third scenario, all remaining workers at the mine are expected to be dismissed. The negative employment effect in this scenario is the highest compared to other scenarios, given that it does not account for the transition of workers into other sectors available in the municipality. This is not the most likely scenario but the most pessimistic one, which assumes that all workers are dismissed and no transition into employment happens for those who can be considered active job seekers. In the event of full dismissal of workers where some transition into employment happens, the total negative employment effect is considerable when compared with the first and second scenarios.

In the Banovići case study, the percentage of those who transitioned into another status after dismissal at Zenica mine was used. In all scenarios, it can be noted that the size of the effect is higher since more workers are employed by Banovići mine. The results are presented in Table 81.

Table 81: Estimated employment effect in Banovići

Banovići	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Description of the transition scenario	Short-term effect: Partial dismissal of workers without any transition to other sectors	Short-term effect: Partial dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers with transition into employment	Long-term effect: Full dismissal of workers without transition into employment
Pensioners	151	151	630	630
Unemployed active job seekers	338	209	1413	1284
Unemployed passive job seekers	40	40	169	169
Emigrated	11	11	46	46
TOTAL REDUCATION	540	411	2258	2129
Transited to employment in other sectors	Not applicable	129	Not applicable	129

Source: Authors' own calculation

For the first two scenarios, the same percentage of workers (19%) that were dismissed at Zenica mine was used to assess the impact in Banovići. The first scenario does not assume any transition into employment, while the second one calculates for such a transition based on the demand for workers in other sectors in the municipality (all sectors for administrative workers and selected sectors for technical workers; see section on methodology for more details). Out of those who transited into employment in other sectors, 78% of them are administrative workers, and 22% are technical workers. Therefore, in the second and fourth scenarios, there are at least some workers who would transition into employment, while others are considered active job seekers. When compared to the Zenica case, where in the second scenario all active job seekers were finding a new job, in Banovici it is not the case. This implies that workers will have less opportunity to find a new job given the size of the negative employment impact and the forecasted demand for employment in other sectors. Again, the most severe consequences are assessed in the third scenario.

2.6.2. Fiscal and budgetary effects

Using the information on the size of the employment effect and pathways presented in the previous section, direct and indirect fiscal effects were calculated, as well as budgetary effects. The results are presented in the following two tables for each location separately.

Table 82: Estimated negative fiscal and budgetary effects in Zenica (annually)

Scenario	Direct fiscal effect (BAM)	Indirect fiscal effect (BAM)	Additional budget needed for payment of pensions and unemployment benefits (BAM)	Total budgetary effect (BAM)
Scenario 1	1,311,093.00	231,783.72	910,596.00	2,453,472.72
Scenario 2	490,545.00	107,785.86	332,100.00	930,430.86
Scenario 3	5,485,185.00	969,707.41	3,809,636.33	10,264,528.74
Scenario 4	2,742,827.01	555,293.49	1,876,241.66	5,174,362.16

Source: Authors' own calculation

Results that are obtained for Zenica case indicate that Scenario 3 has the highest direct fiscal effect (BAM 5,485,185.00), followed by Scenario 4 (BAM 2,742,827.01). Scenario 1 has the third-highest (BAM 1,311,093.00), and Scenario 2 has the lowest (BAM 490,545.00). This reflects the size of employment reduction as well as transition of some dismissed employees into employment in other sectors. The similar patterns for other categories of effect are same, where Scenario 3 consistently shows the highest fiscal and budgetary effects among all categories. Scenario 4 generally follows, being the second-highest in most categories. Scenario 1 and Scenario 2 have lower effects compared to Scenarios 3 and 4. These comparisons help in understanding the relative impact of different scenarios on the fiscal and budgetary aspects, aiding decision-makers in assessing trade-offs and making informed policy choices.

When it comes to Banovići case, the results are presented in the following table.

Table 83: Estimated negative fiscal and budgetary effects in Banovići (annually)

Scenario	Direct fiscal effect (BAM)	Indirect fiscal effect (BAM)	Additional budget needed for payment of pensions and unemployment benefits (BAM)	Total budgetary effect (BAM)
Scenario 1	4,584,863.61	791,305.19	3,343,632.03	8,719,800.83
Scenario 2	3,489,071.73	630,476.09	2,532,438.90	6,651,986.72
Scenario 3	19,181,572.23	3,310,562.53	13,988,664.62	36,480,799.39
Scenario 4	18,085,780.35	3,149,733.43	13,177,471.49	34,412,985.28

Source: Authors' own calculation

Similar to Zenica case, Scenario 3 has the highest direct fiscal effect (BAM 19,181,572.23), followed by Scenario 4 (BAM 18,085,780.35). Scenario 1 has the third-highest (BAM 4,584,863.61), and Scenario 2 has the lowest (BAM 3,489,071.73). When it comes to indirect fiscal effect, Scenario 3 also has the highest indirect fiscal effect (BAM 3,310,562.53), followed by Scenario 4 (BAM 3,149,733.43). Again, Scenario 3 requires the highest additional budget for social support (BAM 13,988,664.62), followed by Scenario 4 (BAM 13,177,471.49). Scenario 1 has the third-highest (BAM 3,343,632.03), and Scenario 2 has the lowest (BAM 2,532,438.90). In total, Scenario 3 has the highest negative total budgetary effect (BAM 36,480,799.39), followed by Scenario 4 (BAM 34,412,985.28). Scenario 1 has the third-highest (BAM 8,719,800.83), and Scenario 2 has the lowest (BAM 6,651,986.72).

In conclusion, the analysis of estimated negative fiscal and budgetary effects in Zenica and Banovići provides valuable insights into the potential consequences of different scenarios on employment and related financial aspects. The direct and indirect fiscal effects, along with the additional budget needed for social support, were calculated and presented for each location, respectively.

In Zenica, Scenario 3 consistently exhibits the highest direct and indirect fiscal effects, as well as the highest additional budget needed for pensions and unemployment benefits. This suggests that Scenario 3 has the most significant impact on fiscal and budgetary aspects, reflecting the size of employment reduction and the transition of some dismissed employees into other sectors. Scenario 4 generally follows, being the second-highest in most categories, while Scenarios 1 and 2 show comparatively lower effects.

Similar to Zenica, in Banovići, Scenario 3 also demonstrates the highest direct and indirect fiscal effects, as well as the highest additional budget needed for social support. Scenario 4 follows as the second-highest in most categories. Scenario 1 has the third-highest effects, and Scenario 2 has the lowest effects in all categories. Overall, Scenario 3 has the highest negative total budgetary effect, emphasizing its substantial impact on fiscal and budgetary considerations.

These comparisons help decision-makers understand the relative impacts of different scenarios in each location, assisting in the evaluation of trade-offs and the formulation of well-informed policy choices. The results underscore the importance of considering both direct and indirect fiscal effects, as well as the additional budget needed for social support, when assessing the overall budgetary implications of employment-related scenarios in Zenica and Banovići.

2.7. Conclusions and Recommendations

The research emphasized the potential consequences of future coal mine closures in Bosnia and Herzegovina, particularly focusing on the labor market and budgetary implications with an emphasis on local communities. The primary goal was to provide policy-relevant analysis to address the challenges related to decarbonization, ensuring a just transition for affected workers and communities. The study aligns with the principles of the "Just Transition for All" as outlined in the "Economic and Investment Plan for the Western Balkans" and "Guidelines for the Implementation of the Green Agenda for the Western Balkans" by the European Commission. These documents stressed the importance of an inclusive and socially just transition to climate neutrality. Bosnia and Herzegovina's commitment to reducing greenhouse gas emissions by increasing the share of renewable energy and gradually phasing out coal-fired electricity as part of its revised NDC plan, motivated this research. The research's primary objective was to provide a policy-relevant analysis of the local labor market impacts associated with this decarbonization effort, focusing on mitigating measures for affected workers and communities to ensure a "just transition."

The research identified and assessed the expected impacts of decarbonization, particularly the negative effects on local labor markets, social security contributions, income tax, and overall fiscal implications in communities affected by coal mine closures. The study employed a mixed-methods approach, combining quantitative and qualitative techniques, including desk research, quantitative modeling, and case studies in selected locations. The three-phase research process included a baseline assessment of the labor market and household welfare, informing the selection of case study locations. Initial scenarios based on the Framework Energy Strategy of Bosnia and Herzegovina until 2035 were adjusted using data from the baseline assessment. The selection of two case study locations allowed for a closer examination of the local-level impact in terms of fiscal effects resulting from changes in employment levels. The methodology involved a triangulation of data collected through desk research, quantitative modelling, and case studies, with adjustments made based on qualitative insights. This comprehensive approach ensured a thorough examination of the potential impacts of decarbonization on the local labor market and fiscal aspects. In essence, the research is an important step toward understanding and addressing the challenges associated with the transition away from coal in Bosnia and Herzegovina, providing evidence-based insights for policymakers to design effective and just mitigation measures.

Bosnia and Herzegovina has historically relied significantly on coal, with coal and lignite accounting for 52% of the country's primary energy supply in 2019, one of the highest shares globally. However, this dependence has adverse environmental and public health implications due to emissions from coal mining and burning. In response, BiH aims to diversify its energy mix, increase the use of renewable sources, and reduce GHG emissions. The data analysis reveals a positive trend in reducing CO_2 emissions in BiH, with a notable decrease in 2021. This aligns with the country's commitment to cut emissions and increase the share of renewable energy. Comparisons with the EU-27 indicate BiH's decreasing emissions, lower per capita emissions, and decreasing emissions per unit of GDP.

However, BiH remains a higher emitter per capita compared to the EU-27. The analysis of CO2 emissions in Western Balkan countries places BiH as a significant emitter, although there has been a decrease in emissions. The sectoral breakdown indicates that most emissions come from coal, followed by oil, gas, and cement. In terms of GHG emissions per capita, BiH leads among Western Balkan countries but has made some reductions in 2021. The assessment of energy production sources in 2021 reveals that renewable energy sources constitute 42% of total energy production in BiH, showing progress in diversifying the energy mix. Notably, solar panel production recorded a significant increase, contributing to an overall rise in renewable energy production.

The labor market in Bosnia and Herzegovina faces challenges characterized by low employment and high unemployment rates, particularly among youth. Even minor changes in the labor market are expected to have significant impacts on the overall economy and the people living in the country. The macroeconomic indicators suggest continuous growth in labor force participation and employment rates, coupled with a decrease in the unemployment rate since 2015. However, the increase in the employment rate is influenced, in part, by a high level of emigration, particularly among the youth. The most significant employment sectors are manufacturing industry (Sector C) and wholesale and retail trade (Sector G), representing more than half of the employed population. Sectors directly impacted by decarbonization, such as mining and quarrying (Sector B), show fewer jobs in comparison. Wage trends indicate average wage increases between 2016 and 2021, with variations across different industries. Case studies in Tuzla Canton and Zenica-Doboj Canton reveal sector-specific wage variations, emphasizing the economic diversity within regions.

The household welfare indicators highlight the impact of poverty and inequality in BiH. The Household Budget Surveys (HBS) reveal that, in 2015, 16.9% of people were considered poor based on consumption data, while 26.3% were estimated using the income approach. Poverty rates vary based on education levels, with the highest rates observed among households where heads have no completed education or primary education. Other factors influencing poverty include disability and employment status, with the highest poverty rates recorded in households where heads are disabled or unemployed.

The analysis of local-level data for municipalities in Bosnia and Herzegovina (FBiH) reveals the critical importance of understanding the potential impacts of mine closures resulting from decarbonization, particularly in areas where mining is the primary employer. While the national-level impact might be limited due to the low share of coal mine employment in total employment, the repercussions at the local level, where isolated coal districts lack access to major commercial hubs, can be substantial. The employment and unemployment indicators for selected municipalities underscore the mixed trends in the Federation BiH. Some areas, such as Gračanica, Živinice, and Tuzla, exhibit consistent growth in employment, while others, like Banovići, Zenica, and Kakanj, face fluctuations and declines. Unemployment rates also vary, with Breza, Travnik, and Tuzla consistently having lower rates than the FBiH level. The Municipal Development Index (MDI) provides a comprehensive view of the overall development level of selected municipalities. Tuzla emerges as the municipality with the highest overall development, while Breza has the lowest MDI.

Two case studies were selected, Zenica and Banovici municipality, as the first one less dependent and the second one highly dependent on mine operations. The brown coal mine "Zenica" is undergoing significant changes and challenges due to the implementation of the BiH Framework Energy Strategy until 2035, resulting in the closure of certain pits. The reduction in the workforce, aimed at achieving self-sustainability, has led to layoffs, and the retraining of workers has proven challenging, especially for those in physically demanding pit mining roles. The closure of previous mines in Zenica has left a negative impact, affecting workers' families and contributing to the reluctance of high school students to pursue mining-related careers. The perception of mining has shifted negatively in recent years, posing difficulties for workers seeking further education and transition to alternative sectors. The mine is grappling with the need for a positive public image and the introduction of green job projects. In contrast, the brown coal mine "Banovići" is proactively adapting to the changing landscape, recognizing the potential closure of mines outlined in the BiH Framework Energy Strategy. The company is exploring opportunities for diversification, including the construction of a solar power plant and land conversion for industrial, agricultural, or tourist purposes. Plans are in place to reduce the workforce through natural attrition, avoiding immediate staff reductions. Discussions with the World Bank for assistance in upcoming projects and potential solutions are ongoing. The mine is engaging with education institutions, offering on-the-job training and collaborating with the

Secondary School Center in Banovići to address the decline in interest in mining professions among younger generations. The company maintains positive relations with unions and emphasizes finding ways to support workers in the event of future layoffs.

Both mines face challenges related to workforce transitions, retraining efforts, and changing perceptions of mining occupations. However, while "Zenica" grapples with the negative aftermath of closures and a decline in interest, "Banovići" demonstrates a proactive approach in seeking alternative solutions, collaborating with stakeholders, and diversifying its operations to ensure long-term sustainability. The contrasting situations highlight the importance of strategic planning, community engagement, and adaptability in navigating the complexities of transitioning from traditional coal-dependent economies.

The results indicate that Zenica, being less dependent on mines compared to Banovići, would experience lesser consequences in terms of employment effects. The Banovići case study, which employs more workers, shows higher impacts in all scenarios. The percentage of workers who transitioned into another status after dismissal at Zenica mine was used to assess the impact in Banovići for the first two scenarios. The first scenario does not assume any transition into employment, while the second considers such transitions based on the demand for workers in other sectors. In both municipalities, the scenarios highlight the challenges workers may face in finding new jobs, especially in the more severe third scenario. Banovići, due to its higher workforce in the mining sector, is anticipated to experience a larger negative employment effect. The analysis emphasizes the importance of considering worker transitions and the demand for employment in other sectors in understanding the potential consequences of mine closures on local employment.

The analysis focused on estimating the direct and indirect fiscal effects, as well as budgetary impacts, associated with various scenarios in Zenica and Banovići following potential mine closures. The calculations were based on the size of employment effects and pathways to transition, shedding light on the financial consequences of different scenarios on local employment. In both case studies, the scenario assuming the immediate closure of mines without the transition of employees into other available sectors showed the highest negative fiscal and budgetary effects. The smallest negative fiscal and budgetary effect in both cases was associated with the partial dismissal of workers and the limited transition into employment of those who could be considered active job seekers. The negative budgetary effect in Zenica ranges from 1 to 10 mill BAM per year, considering the different options presented under different scenarios. In Banovići, the size of the negative budgetary effect ranges from 6.6 to 36.5 mill BAM per year.

Based on the conclusions drawn from the research, the following recommendations are offered for different stakeholders.

- When it comes to policy makers and local institutions, following actions are recommended:
- Promote Diversification: Encourage and support diversification strategies in coal-dependent regions. Provide incentives for companies to explore and invest in alternative sectors, such as renewable energy, tourism, and agriculture.
- Invest in Education and Training: Develop and implement education and training programs that equip workers with skills relevant to emerging industries. Collaborate with local educational institutions and companies to bridge the skills gap.
- Community Engagement: Prioritize community engagement and involve local residents in the decision-making process. Establish mechanisms for ongoing communication between policymakers, companies, and communities to address concerns and ensure a transparent transition process.
- Financial Support: Allocate funds for social support programs, including retraining initiatives, unemployment benefits, and pension support, to assist affected workers during the transition period.
- Another important stakeholder in the transition are mine companies and their related partners. They may involve in some of these actions:
- Proactive Planning: Anticipate and plan for industry transitions well in advance. Companies should assess the long-term viability of their operations, explore alternative business models, and engage with stakeholders to navigate the changing economic landscape.

- Invest in Green Technologies: Embrace green technologies to reduce environmental impact and enhance the overall sustainability of operations. Consider partnerships with organizations involved in renewable energy projects to diversify revenue streams.
- Employee Support Programs: Establish support programs for employees facing layoffs, including retraining opportunities, career counseling, and assistance in transitioning to other sectors. Prioritize the well-being of the workforce during times of change.

Transition process can be hard for all those affected by such events. Therefore, multi-stakeholder collaboration among government agencies, companies, local communities, and non-profit organizations can not be overestimated. A coordinated effort is essential to successfully navigate the complexities of a just transition, ensuring that all stakeholders are heard and involved. To do so, it is necessary to establish clear and accessible channels for disseminating information about transition plans, alternative employment opportunities, and support programs. Transparency and effective communication are key to building trust within communities. This can also be achieved by continuous monitoring and evaluation of transition initiatives. Regularly assess the effectiveness of implemented programs, adjust strategies as needed, and learn from both successful and unsuccessful experiences to inform future decision-making.

By incorporating these recommendations into their planning and decision-making processes, stakeholders can contribute to a more just and sustainable transition away from coal dependence in Bosnia and Herzegovina, ensuring the well-being of affected workers and communities.

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Montenegro

Waste management sector transformation and its impact towards JGT in Montenegro

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Montenegro

Waste management sector transformation and its impact towards JGT in Montenegro

3.1. Introduction

This research case explores the potential of producing alternative fuels (AF) from waste in Montenegro, specifically refuse-derived fuel (RDF) and solid recovered fuel (SRF), aligning with the country's commitments under the Sofia Declaration on the EU Green Deal. The study focuses on Podgorica and the surrounding central region, including Cetinje and Danilovgrad.

Currently, recycling rates are minimal, with over 97.5% of collected waste being landfilled. In 2019, Montenegro generated approximately 340,823 tonnes of municipal solid waste (MSW), averaging 548 kg per inhabitant (CMS, 2021). Montenegro faces significant challenges in meeting EU Waste Framework Directive standards. The country has only two sanitary landfills, while approximately 150 informal landfills exist in the northern region (EEA, 2022). Waste management is recognized as a major environmental issue, with inadequate infrastructure and low public awareness.

The research explores the environmental and economic potential of producing AF from waste for industries operating high-temperature kilns. While Montenegro's economy is primarily tourism-based and import-dependent, the production of AF could generate a micro-economy from waste treatment, reduce landfilled waste, and provide environmental and economic benefits.

The study analysed legal and strategic frameworks, conducted stakeholder interviews, and developed 3 scenarios for AF production. **It estimates that by 2025, Podgorica, Danilovgrad, and Cetinje could potentially produce 57,525 tons of AF annually from their municipal waste.** More details on the methodology, the state of art, and the desk review conducted, are included in the Extended Country Report[21]. The research findings are expected to enhance awareness of Green Transition issues pertinent to the waste management sector in Montenegro (and Western Balkans).

3.2. Methodology

The study investigates the potential for alternative fuel production to decrease reliance on fossil fuels, boost the competitiveness of Montenegrin businesses in international markets, reduce the carbon footprint through the substitution effect of alternative fuels and lower the volume of waste sent to landfills.

Table 84. Research objective and questions

Overall research objective	The overall objective of the research is to explore the possibilities of using pre-defined waste streams as a source for alternative fuel production in the territory of Podgorica and the central region of Montenegro as a means towards implementing the Green Agenda for WB.		
Central research question	What is the potential of Podgorica Region in the waste management sector to engage in alternative fuel production?		
Sub-questions:	What are the economic, environmental and social costs and benefits of co-processing waste in the Podgorica region?		
	Scenario 0 Business, as usual, waste is being landfilled untreated. What are the economic and environmental losses from this process?	**Scenario 1** Montenegro applied the Waste Management Hierarchy in 2023, a 25% recycling rate	**Scenario 2** Montenegro fully complies with the Waste Framework and implements a 45% recycling rate whilst there is a

[21] Extended research study report- Montenegro.

	and AF production; what are the benefits?	landfill phase-out IN 20250 due to MBT and AF being marketed.

Source: Authors

A mixed methodology approach was used to address research questions and the overall objective of the research project. The qualitative and quantitative data for municipal waste, as well as commercial and industrial waste generated at regional and national levels, were obtained by consulting key background documents such as National and Local Waste Management Plans, Waste Management Strategies, Annual Reports, data sourcing from Environment Agencies, and the statistical office. Additionally, information was collected from relevant institutions, entities, and companies responsible for waste generation, collection, transportation, storage, recovery, treatment, and final disposal to gather comprehensive data and cross-check various sources. Municipal waste was not weighed before disposal at landfills or deposit sites in most territories. Consequently, the reference used to determine the amount of waste was based on indicative calculations sourced from the generation norms in each region and specific types of sources that generate waste.

3.3. Selection of study area

This project's study area is considered a central region of Montenegro. According to the current **National Waste Management Plan (NWMP), 2015-2020** central region is defined as the area of Podgorica, Cetinje, Danilovgrad, Nikšić, Plužine and Šavnik. The center of this region is Podgorica. The national waste management plan defined that it is necessary to form a new regional enterprise that would deal with waste management within this region or, by signing additional contracts with the region's members, extend the responsibilities to the regional company Deponija d.o.o. from Podgorica.

However, with the decision to amend the national waste management plan[22], four centres will be established to enhance waste management. The central part includes the capital city of Podgorica, which can accept waste from the Old Royal Capital Cetinje and the Municipality of Danilovgrad. Therefore, activities of this project will consider these three units: Podgorica, Cetinje and Danilovgrad. Regional centre in Podgorica, which contains a centre for secondary selection of components of mixed waste that can be reused or recycled; sanitary landfill; facility for dismantling vehicles out of use and preparation for reuse and/or recycling of their parts; as well as two recycling yards; was seen as a regional center of this wider region. Basic characteristics of the regional center for the secondary selection of components of mixed waste that can be reused or recycled indicate the fact that the capacity of this plant is 15% greater than the capacity necessary for the processing of waste that should come after the primary selection has been carried out on the territory of all local self-government units of the region - plant capacity is 250 t/day. In contrast, according to the calculation, the estimated amount of waste to be processed is 206.95 t/day.

Table 85. Population and waste in targeted municipalities

Municipality	Population (number)	Amount of waste collected (in tons)
Podgorica	192,968	85,100
Cetinje	14,538	4,570
Danilovgrad	18,340	4,996
Total	225,846	94,666

Source: Monstat[23]; Report on the implementation of NWMP for 2022[24]

[22] Decision on amendment of the National Waste Management Plan, available here: https://wapi.gov.me/download-preview/0e0eec95-a53b-4a98-b0f5-58e3c37ae887?version=1.0

[23] National Statistic Agency Monstat, available here: https://monstat.org/cg/page.php?id=273&pageid=48

[24] Report on the implementation of the National Waste Management plan for 2021, available here: https://wapi.gov.me/download-preview/81b21759-e429-4599-b94c-8c9fb3bcf69f?version=1.0

However, the distance between the municipalities of Plužine and Šavnik, the economic power of these municipalities and the amount of waste generated in them, as well as the significant amount of waste generated in the municipality of Nikšić, lead to the conclusion that a more practical and acceptable solution is the construction of the MRF plant in Nikšić, for the needs of these three municipalities.

Podgorica is the most populated city in Montenegro, with 192,968 citizens, while Cetinje and Danilograd are smaller. In all three cities, there are 225,846 citizens, while the amount of waste generated and collected in these three municipalities is 94,666 tons. More details are presented in Table 7.

A sanitary landfill, "Livade," has been constructed in Podgorica to serve the needs of three municipalities. This landfill can accept waste from the municipalities of Nikšić, Plužine, and Šavnik after primary and secondary separations. There are no plans for constructing new landfills. Still, it is recommended that the possibility of expanding the Livade landfill in the future be explored, as suggested by a recent feasibility study. Hereby, the proposal of this research does not support the idea of expanding landfilling operations but rather to invest in 3 transfer stations (TS) in the respective municipalities of Nikšić, Plužine, and Šavnik and further invest in the construction of a recovery facility in Livade that will produce AF from refused waste.

To facilitate a simpler, more straightforward, and economically profitable waste collection, it is proposed to establish recycling yards in the territories of Cetinje, Danilovgrad, and Podgorica, as well as Plužine and Šavnik. This will enable the population to separate special waste streams more effectively. Currently, Podgorica already has seven recycling yards.

Consequences of a careless attitude toward waste and a lack of environmental awareness have led to numerous dump sites of various sizes throughout the country, particularly along roads and riverbanks. The operation and management of these sites fall under the responsibility of the municipalities, which lack the necessary capacities, resources, and infrastructure.

For the municipalities relevant to this study, the following conditions were observed:

- In Cetinje, 15 unregulated landfills (dump sites) contain mixed municipal waste, non-hazardous construction waste, and a combination of both.
- Danilovgrad has two registered locations with unregulated landfills: Klikovače (two sites near the Spuž railway station) and Bogićevica.
- In Podgorica, there are 8 unregulated landfills, all of which have been sanitized.

3.4. Why Alternative Fuels in Cement production?

Alternative fuels, also known as non-conventional and advanced fuels, are materials or substances other than traditional fossil fuels that can be used in cement production. These include used car tires, plastics, packaging waste, wood waste, paper, sewage sludge, agricultural waste, and waste oils. Two important types are:

- Refuse Derived Fuel (RDF): Fuel generated from municipal solid waste (MSW) and other combustible refuse, with a calorific value of 8-14 MJ/kg. (Gendebien et al. 2003)
- Solid Recovered Fuel (SRF): A high-quality alternative fuel produced from commercial waste, meeting specific standards (CEN/TC 343) with a calorific value of 17-22 MJ/kg.

The cement industry, known for its high energy consumption and environmental impact, is increasingly turning to alternative fuels as a sustainable solution (EC, 2010). The advantages of using these alternative fuels in cement production are significant. They increase energy efficiency, reduce waste disposal costs, and lower emissions compared to fossil fuels. The high temperatures in cement kilns (1800-2000°C) ensure complete combustion of harmful components, with no residue as all materials are incorporated into the clinker.

Quality is crucial when using alternative fuels. The EN15359 - 2011 standard provides a framework for SRF classification, focusing on net calorific value, chlorine content, and mercury levels. This ensures consistency and reliability in fuel performance. Cement production is energy-intensive, requiring 3.2 to 6.3 GJ of thermal energy and

110-120 kWh of electricity per ton of cement. With energy procurement constituting 40% of operational costs, the shift to alternative fuels offers significant economic benefits.

Various industries contribute to the waste streams used for alternative fuel production. These include textiles, chemicals, wood products, paper, food, machinery, and retail sectors. This diversification ensures a steady supply of raw materials for fuel production.

Greenhouse gas performance:

Alternative fuels like RDF-SRF/MSW have significantly lower CO_2 emission factors (8.7 kg CO_2/GJ) compared to traditional fuels like petcoke (101 kg CO_2/GJ) and coal (96 kg CO_2/GJ) [25].

The use of alternative fuels (AF) in cement kilns generates a range of air emissions, as identified by the European Commission's Best Available Techniques Reference (BREF) document in 2010. These emissions, released from the kiln system, encompass a variety of pollutants including oxides of nitrogen (NO_x), sulfur dioxide (SO_2), dust, volatile organic compounds (VOC), polychlorinated dibenzodioxins and dibenzofurans (PCDDs and PCDFs), metals and their compounds, hydrogen fluoride (HF), hydrogen chloride (HCl), carbon monoxide (CO), ammonia (NH_3), and heavy metals. These pollutants stem from both pre-treatment and post-treatment processes, with kiln emissions representing a combination of combustion and process-related outputs. Notably, the primary pollutants such as NO_x, sulfur oxides (SO_x), CO, non-methane volatile organic compounds (NMVOC), and NH_3, along with heavy metals and persistent organic pollutants (POPs), are primarily attributed to fuel combustion.

3.5. Waste management framework in Montenegro

Montenegro is a relatively small country in the WB, with an average of 619,211 inhabitants (following a declining trend over the last three years)[26] and steadily increasing tourist flows. From an administrative point of view, Montenegro is divided into 25 municipalities and three regions.

Waste management is under the jurisdiction of local self-governments – 25 municipalities. The waste management services are planned and administrated based on the laws on waste management, local self-government, communal utilities, the National Waste Management Plan, and the local Waste Management Plans.

Considering the aspirations of WB countries, Montenegro in particular, to join the EU and adopt EU standards for an environmentally friendly, economically viable and hygienically safe collection and disposal of municipal waste is of high priority. In addition, the Waste Framework Directive suggests that waste treatment plants such as landfills should minimize the amount of refuse being landfilled to nearly zero by 2050. With decarbonization targets linked mainly with industries applying the IED Directive, the demand for alternative fuels with a minor carbon footprint has risen. Among different alternative fuels, this research will explore the potential of RDF - Refuse Derived Fuel from Urban Waste and SRF - Solid Recovered Fuel from industrial waste that could be produced, marketed and co-processed in the Montenegrin case. At the same time, the research project will provide indications related to technical, economic, and environmental aspects (costs and benefits) through a pilot scheme for waste to be recovered and not landfilled in the Podgorica Region (targeted research area).

According to the Report on the implementation of the National Waste Management Plan for 2021, communal utilities collected 280,452 tons of municipal solid waste. Of this, 158,549 tons were disposed of in sanitary landfills in Podgorica and Bar, while 57,401 tons were temporarily disposed of. Additionally, 4,732 tons of paper, metal, plastic, and glass were separated for recycling through primary and secondary selection, 23,400 tons of packaging were collected by private companies, and 15,440 tons of green waste from parks and green areas were collected

[25] Co-Processing Municipal Solid Waste and Sewage Sludge in the Cement Industry (Lawrence Berkeley National Laboratory, 2012). http://eetd.lbl.gov/sites/all/filespublications/co-processing.pdf

[26] Data from Monstat: Estimated mid-year number of population for 2021 available at: https://www.monstat.org/uploads/files/demografija/procjene/2021/procjene%20po%20opstinama%2C%20sredina%20godine.xlsx

separately. However, private companies collected packaging independently of any Extended Producer Responsibility (EPR) schemes, and the separately collected green waste remains untreated.

The National Waste Management Plan for 2021 highlights the waste management infrastructure in key municipalities. Podgorica, with its developed infrastructure, includes a sanitary landfill, a recycling center, seven recycling yards, and extensive communal utility coverage. Danilovgrad disposes of its waste at the Livade landfill in Podgorica, where green waste is collected separately but remains inadequately treated due to lack of equipment. Cetinje disposes of mixed communal waste at the Livade landfill without prior separation. Monstat data from 2021 indicate that Montenegro generated about 1.5 million tons of waste, with 325,707 tons being municipal waste, and a population coverage rate of 87.6%. Less than 2% of municipal waste was recycled, with most being landfilled in Podgorica and Bar or disposed of in unregulated landfills, contributing to significant environmental pollution. Effective municipal solid waste (MSW) management requires coordinated local government actions, following the 4R approach (Reduce, Reuse, Recycle, Recover), as per the Waste Management Framework Directive. However, current practices lack comprehensive treatment methods and accurate waste measurement systems.

3.5.1. Waste management overview

In Montenegro, there is no organized or systematized collection of data regarding the type of waste generated collected. Based on the annual report on implementing the National Waste Management Plan for 2021, the submitted data shows that municipal companies collected 280,452 tons of municipal waste in 2021. The percentage of waste collected for recycling in 2021 is 14.35% (recyclable paper, cardboard, plastic and metal waste from municipal waste amounts to 4,732 tons, 23,400 tons of packaging collected by legal entities and 15,477 tons of "green" waste).

For the preparation of the Draft National Waste Management Plan for the period 2023 -2028, several data sources were used, and it was calculated that in Montenegro, the following waste composition is generated: organic waste 40,66%; plastic waste 15,35%; paper/cardboard 15,05%, composite packaging 2.59%; metals 3.31%; glass 5,66%; wood 2,51%; textile 3,30% and others 11,56%. Calculation on the estimated waste composition in the future was generated and presented in Table 8.

Table 86. Waste composition projections for Montenegro

Waste Typology	2022		2025		2030		2040	
	% urban waste	ton per year	% communal waste	ton per year	% communal waste	ton per year	% communal waste	ton per year
Organic waste	40.18%	136,101	39.44%	140,598	38.26%	137,962	38.26%	143,987
Plastic	16.04%	54,329	17.64%	62,849	18.06%	65,575	18.06%	67,946
Paper/ cardboard	15.73%	53,283	17.30%	61,640	17.71%	64,313	17.71%	66,638
Composite packaging	2.70%	9,157	2.97%	10,593	3.04%	11,053	3.04%	11,452
Metal	3.46%	11,726	3.81%	13,565	3.90%	14,154	3.90%	14,665
Glass	5.91%	20,034	6.50%	23,176	6.66%	24,181	6.66%	25,055
Wood	2.62%	8,890	2.89%	10,284	2.96%	10,730	2.96%	11,118
Textile	3.30%	11,188	3.30%	11,772	3.3%	11,995	3.30%	12,429
Other	10.04%	34,050	6.15%	21,967	6.10%	22,232	6.10%	23,036
Total	**100%**	**338,759**	**100.00%**	**356.444**	**100.00%**	**363,195**	**100.00%**	**376,328**

Source: Draft National Waste Management Plan for 2023 – 2028

When it comes to the contribution of the targeted municipalities in waste generation, according to the Draft National Waste Management Plan for 2023 – 2028, Podgorica contributes 28.2%, Danilovgrad 2.4% and Cetinje with 2.3% of the total waste generated in Montenegro.

According to the waste management hierarchy, open dumping systems like landfills should be considered the last resort in the waste management process. One effective method for material recovery is waste conversion, which can be utilized as fuel through waste-to-energy (WtE) processes, including waste incineration and Refuse Derived Fuel (RDF), as outlined in DIRECTIVE 2008/98/EC.

MN's primary waste management principle aligns with the EU Framework Directive on Waste, adhering to the "waste hierarchy." This hierarchy prioritizes reducing waste generation, followed by reuse, recycling, recovery, and disposal as the final option.

According to Monstat data in Montenegro, the percentage of waste collection service coverage is 87.7 in 2022. The total generated communal waste is 335,797.6 tons, while 321,139.5 tons were collected. The average citizen generates 1.5 kg per day or 544,1 kg per year, while 1.4 kg per day or 502.3 kg per year.

Table 87. Amount of waste generated and managed per inhabitant in Montenegro

	2021	**2022**
Estimated number of citizens	619,211	617,213
Number of days in the year	365	365
Total collected communal waste in t	308,904.2	321,139.5
Total collected communal waste per person per year in kg	498,9	502,3
Total collected communal waste per person per day in kg	1.4	1.4
Total generated communal waste in t	325,707.5	335,797.6
Total generated communal waste per person per year in kg	526	54
Total generated communal waste per person per day in kg	1.4	1.5
Percentage of the waste collection service coverage	87.6	87.7

Source: Monstat, 2022[27]

3.5.2. Waste management costs

Waste management costs in the municipalities within the targeted area are determined at the municipal level, and there are variations in the methodologies used to define these costs. As a result, the figures are not easily comparable. Generally, the costs are calculated based on the square meters of the serviced property rather than the amount of waste generated by each individual or entity.

Three municipal companies handle waste collection: Čistoća in Podgorica, Komunalno in Danilovgrad, and Komunalno Cetinje. These companies charge residents and businesses for waste collection and disposal services. The relationship between these companies and the Livade Landfill involves specific contracts and financial arrangements.

A special price for municipal waste disposal at the Livade Landfill in Podgorica has been set for users outside the registered regional territories (Podgorica, Danilovgrad, and Cetinje). This price is **36.00 EUR per ton** of disposed waste, excluding VAT.

The Law on Communal Services (Official Gazette of Montenegro Nos 55/16 and 66/19) prescribes how the fees for communal services and, consequently, waste management services are determined through the adopted Decree on Detailed Elements and Methodology for Determining the Prices of Utility Services (Official Gazette of Montenegro, No 55/20). The decree prescribes four models for calculating the waste management fee:

- a model based on area (square metres) of living space or used space;
- a model based on the number of household members;

[27] https://monstat.org/uploads/files/otpad/2022/Stvoreni%20i%20obra%C4%91eni%20otpad%20u%202022.godini.pdf

- a model based on the mass of municipal waste;
- a model based on the volume of municipal waste.

3.4.3. Waste management in the study area

Based on the data for the targeted municipalities, it can be observed that most of the waste generated and collected in these areas is disposed of in the Livade landfill in Podgorica:

- 65,209 tons from Podgorica,
- 3,270 tons from Danilovgrad,
- 4,999 tons from Cetinje.

In Podgorica, separate waste collection is implemented. Still, the amount of waste collected for recycling is very limited: **14,474 tons of paper, 190 tons of plastic, and 51 tons of metal**. Some waste is collected separately and classified as recycled, even though it is disposed of in the landfill without treatment. **This includes 9,004 tons of bulk waste, 9,172 tons of green waste collected in Podgorica, and 1,300 tons of green waste collected in Danilovgrad.** All other waste is not collected separately.

Table 88. Amount of waste generated and collected in the study area

No	Area	Landfilled	Separately collected for reuse and recycling (recyclable fraction)				Separately collected bulk and green waste		Totally collected
		Livade	Paper	Plastic	Glass	Metal	Bulk	Green waste	
1.	Podgorica (93,5%)	65,209	1,474	190		51	9,004	9,172	**85,100**
2.	Danilovgrad	3,270						1,300	**4,570**
3.	Cetinje	4,999							**4,999**
Total		**73,478**	**1,474**	**190**		**51**	**9,004**	**10,472**	**94,669**

Source: Annual Report on National Waste Management Plan for 2021

Analyzing the amount of waste generated and collected in Podgorica over the last three years reveals that the quantity of collected waste has remained approximately constant at around 66 tons per year. There has been no significant progress in recycling rates, with a decrease in collected paper in recent years. The amount of separately collected plastic waste was very small in 2022, totalling 240 tons, while the amount of metal waste was even smaller. Glass is not collected separately at all. Although bulk and green waste are collected separately, they are not treated and disposed of in landfills.

Table 89. Waste quantities (in tons) in Podgorica

Year	JLS	Landfilled	Separately collected for reuse and recycling (recyclable fraction)				Separately collected bulk and green waste		Totally collected
		Livade	Paper	Plastic	Glass	Metal	Bulk	Green waste	
2022	Podgorica (93,5%)	66,178	1,326	240		103	9,004	9,172	**86,023**
2021	Podgorica (93,5%)	65,209	1,474	190		51	9,004	9,172	**85,100**

2020	Podogrica (93,5%)	66,107	2,275	145	105	56	24,554	106	**93,348**

Source: Annual reports on the implementation of the National Waste Management Plan

Waste collected in the Old Royal Capital Cetinje is not being separately collected or treated. The amount of waste collected is around 5000t per year. It is being disposed of in sanitary landfills without any treatment.

Table 90. Waste quantities (in tons) in Old Royal Capital Cetinje

Year	JLS	Landfilled	Separately collected for reuse and recycling (recyclable fraction)				Separately collected bulk and green waste		Totally collected
		Livade	Paper	Plastic	Glass	Metal	Bulk	Green waste	
2022	Cetinje	5,078							**5,078**
2021	Cetinje	4,996							**4,996**
2020	Cetinje	5,247							**5,247**

Source: Annual reports on the implementation of the National Waste Management Plan

Waste collected in the Municipality of Danilovgrad is not being separately collected or treated in any way besides separately collected green waste. The amount of waste collected amounts to around 5000 per year. It is being disposed of in a sanitary landfill, Livade, without any previous treatment.

Table 91. Waste quantities (in tons) in Danilovgrad

Year	JLS	Landfilled	Separately collected for reuse and recycling (recyclable fraction)				Separately collected bulk and green waste		Totally collected
		Livade	Paper	Plastic	Glass	Metal	Bulk	Green waste	
2022	Danilovgrad	4,065						1.300	**5,365**
2021	Danilovgrad	3,270						1.300	**4,570**
2020	Danilovgrad	3,801						1.260	**5,061**

Source: Annual reports on the implementation of the National Waste Management Plan

3.6. Strategic, regulatory and legal framework

Montenegro has been working to develop a comprehensive framework for waste management, aligning its policies and practices with European Union standards. The country's approach is guided by several key strategic documents and legislative acts, which have evolved over time to address the growing challenges of waste management and the transition towards a more circular economy.

The National Waste Management Strategy of Montenegro until 2030, adopted in 2015, serves as the cornerstone of the country's waste management policy. This strategy outlines a vision for establishing a sustainable waste management system, emphasizing the importance of waste reduction, efficient primary waste selection, and the development of effective recycling systems. It also recognizes the need to manage special waste streams and introduces the concept of a circular economy approach to waste management. Importantly, the strategy highlights the significance of improving enforcement mechanisms and raising public awareness about sustainable waste management practices.

Building on this strategy, the **National Waste Management Plan** (NWMP) 2015-2020 set forth more concrete objectives and actions. This plan aimed to improve the legislative and legal systems governing waste management, establish local planning frameworks, and introduce separate waste collection systems. It set ambitious targets, including achieving 50% recycling of materials such as glass, paper, metal, and plastic by 2020, as well as 70% recycling of non-hazardous construction waste. The plan also emphasized the need for technical support and infrastructure development to realize these goals.

As Montenegro continues to refine its approach, a **new Draft National Waste Management Plan** (DNWMP) for 2023-2028 has been developed. This draft plan proposes more advanced waste treatment methods, particularly for materials unsuitable for reuse or recycling. It emphasizes the potential of waste as both a material and energy resource, aligning with broader circular economy principles. Notably, the draft plan outlines the development of waste management infrastructure, including treatment plants with a total capacity of 170,000 tons per year, signaling a significant investment in the country's waste management capabilities. Complementing these waste-specific strategies, the **Energy Development Strategy 2030** recognizes the potential for waste-to-energy production. This strategy identifies opportunities in using agricultural by-products, biomass from waste, and sewage sludge as energy sources, further integrating waste management with the country's energy policies.

The legislative backbone of Montenegro's waste management system is the **Law on Waste Management**. This law, which partially transposes EU legislation, is founded on key principles such as sustainable development, proximity and regional waste management, precautionary measures, the "polluter pays" principle, waste hierarchy, and extended producer responsibility. It provides definitions for different types of waste (municipal, commercial, industrial) and sets specific recycling targets. Recognizing the need for further alignment with EU standards, a **new draft Law on Waste Management** is in development. This draft aims to enhance the efficiency of resource use, promote circular economy principles, and ensure long-term competitiveness. It represents Montenegro's ongoing efforts to harmonize its legal framework with EU directives and best practices.

At the local level, the **Law on Communal Utilities** plays a crucial role in defining responsibilities for municipal waste management. This law places the onus on municipalities to manage waste collection, treatment, and disposal, typically through municipal communal utilities. In the context of alternative fuels, Montenegro is working to align with European standards for Refuse Derived Fuel (RDF) and Solid Recovered Fuel (SRF). The European framework classifies RDF as waste according to the European Waste List, while Directive 2018/851/EC provides conditions under which certain wastes can cease to be classified as waste. The European Standardization Commission has established standards for SRF, which Montenegro is working to adopt and implement.

Despite these strategic and legislative efforts, Montenegro faces significant challenges in fully aligning with EU waste management directives, particularly the **Waste Framework Directive** and the **Landfill Directive**. The country struggles with insufficient rates of separately collected, recycled, and biologically treated waste. There is a pressing need to set realistic targets underpinned by robust implementation strategies, build capacity across the waste management sector, and establish proper enforcement mechanisms.

3.6.1. Governance of waste management

The governance of waste management in Montenegro involves a complex interplay of institutions at various levels. At the central level, the Ministry of Tourism, Ecology, Sustainable Development and Development of the North leads the development of national legislation and strategic frameworks for waste management. The Ministry of

Economic Development supports the transition to a circular economy, while the Agency for Environmental Protection handles licensing, monitoring, and database management related to waste. MONSTAT, the national statistical office, plays a crucial role in collecting and publishing waste-related data. The Administration for Inspection Affairs oversees environmental protection enforcement.

At the regional level, Montenegro has established four waste management centers in Podgorica, Nikšić, Bijelo Pole, and Bar, aiming to improve waste management efficiency across the country. These centers serve multiple municipalities and aim to centralize waste management operations.

Local governments bear significant responsibility for waste management within their territories. They develop and implement local waste management policies, adopt plans, and manage municipal waste landfills. In major cities like Podgorica, specialized companies such as Deponija d.o.o. and Čistoća d.o.o. handle various aspects of waste management. Similar arrangements exist in other municipalities, with entities like Komunalno l.l.c. in Danilovgrad and Communal Utility l.l.c. in Cetinje managing local waste operations.

Beyond government institutions, a range of stakeholders contributes to waste management efforts in Montenegro. Civil society organizations such as NGO Green Home and NGO Zero Waste Montenegro play crucial roles in advocacy, education, and promoting sustainable waste practices. The business community, represented by entities like the Chamber of Economy of Montenegro and the Innovation and Entrepreneurship Centre Technopolis, supports the development of circular economy initiatives. International organizations, including UNDP Montenegro, GIZ Montenegro, and the Delegation to the European Union of Montenegro, provide valuable support through funding, technical assistance, and policy guidance.

The current waste management situation in Montenegro presents a mixed picture. According to the 2021 implementation report of the National Waste Management Plan, the country collected 280,452 tons of municipal solid waste, with 158,549 tons disposed of in sanitary landfills and 57,401 tons temporarily disposed of. Only 4,732 tons of recyclables were separated, highlighting the significant room for improvement in recycling rates. Private companies collected an additional 23,400 tons of packaging waste. Data from MONSTAT for the same year provides a broader perspective, indicating that Montenegro generated about 1.5 million tons of waste overall, with 325,707 tons classified as municipal waste. The population coverage rate for waste management services reached 87.6%, showing good progress in service provision. However, recycling rates remain low, with less than 2% of municipal waste recycled. Approximately 49.38% of waste is disposed of in sanitary landfills, with the remainder often ending up in less controlled environments. These figures underscore several key challenges facing Montenegro's waste management system. There are notable discrepancies in data collection and reporting between different institutions, partly due to the lack of proper weighing equipment at many municipal landfills. The country has only two sanitary landfills, located in Podgorica (Livade) and Bar (Možura), with many municipalities still relying on temporary landfills or open dumpsites. This situation leads to significant environmental concerns, including soil and water pollution.

Furthermore, Montenegro lacks a comprehensive treatment method for the full range of Municipal Solid Waste (MSW). The current system struggles to effectively separate, recycle, and treat different waste streams, leading to missed opportunities for resource recovery and environmental protection. Looking to the future, Montenegro needs to focus on several key areas to improve its waste management system. Implementing an integrated waste management approach based on the 4R principle (Reduce, Reuse, Recycle, Recover) will be crucial. This approach should align closely with the EU's Waste Management Framework Directive, providing a clear hierarchy for waste management decisions.

Improving data collection and reporting mechanisms is essential for effective policy-making and monitoring progress. Significant investments in infrastructure for separate waste collection and recycling are needed to increase recycling rates and reduce reliance on landfills. The country should also focus on developing and implementing realistic targets underpinned by proper implementation strategies, ensuring that goals are ambitious yet achievable.

Building capacity across the waste management sector and strengthening enforcement mechanisms will be crucial for the successful implementation of new policies and practices. Promoting circular economy principles in waste management can help shift the focus from waste disposal to resource recovery and reuse.

Enhancing cooperation between different stakeholders, including government entities, the private sector, and civil society organizations, will be vital for developing comprehensive and effective waste management solutions. Increasing public awareness and education on proper waste management practices can help drive behavioral changes necessary for a more sustainable approach to waste.

Finally, exploring and implementing innovative technologies for waste treatment and recycling can help Montenegro leapfrog some of the challenges faced by older waste management systems. This could include advanced sorting technologies, waste-to-energy solutions, and digital platforms for waste tracking and management.

3.7. Scenario set-up

The overall research objective of this study was to explore the possibilities of using pre-defined waste streams as a source for alternative fuel production in the territory of Podgorica and the central region of Montenegro as a means towards implementing the Green Agenda for Western Balkans.

While exploring the potential of Montenegro's central waste management region to engage in alternative fuel production, this study focused on the capital city of Podgorica, Old Royal Capital Cetinje, and the Municipality of Danilovgrad. It is based on the data collected from the desk research and the stakeholder interviews.

The following table reflects the quantity of waste per municipality based on the waste composition by fractions, determined by the Draft National Waste Management Plan and projections on the amount of collected waste for 2025. Data presented here are calculated based on the percentage of their share in the generation of total waste in Montenegro and presented in t/year:

- Podgorica 28.2%
- Danilovgrad 2.4%
- Cetinje 2.3%

Table 92. Waste by fractions (in ton)

Fraction	t/y in MNE (2025 ref. year)	Podgorica	Danilovgrad	Cetinje
		28.20%	2.40%	2.30%
Organic waste	140,598	39,649	3,374	3,234
Paper and cardboard	62,849	17,723	1,508	1,446
Composite packaging	6,164	1,738	148	142
Metal	10,593	2,987	254	244
Glass	13,564	3,825	326	312
Wood	10,284	2,900	247	237
Textile	11,772	3,320	283	271
Other	21,967	6,195	527	505
Total		**78,337**	**6,667**	**6,389**

Source: Authors' calculations based on data from draft NWMP

Below are possible scenarios for the production of alternative fuels in the form of RDF/SRF in the mentioned municipalities based on the data and information collected on the quantity and quality of waste and existing plans and possibilities.

3.7.1. Scenario 0

This scenario represents the "business as usual" or "do minimum" approach to waste management in Montenegro. It assumes that current practices will continue, with only routine interventions planned by authorities on an annual basis. Although aware of the Green Agenda for the Western Balkans, authorities have not yet allocated the necessary technical and financial resources, effectively postponing significant changes to future years.

To develop this scenario, waste fraction predictions for Montenegro in 2022 were utilized from the Draft National Waste Management Plan. These predictions were used to calculate the estimated waste composition for each of the targeted municipalities: Podgorica, Danilovgrad, and Cetinje.

The waste fractions considered potentially suitable for RDF/SRF (Refuse-Derived Fuel/Solid Recovered Fuel) production include Plastic; Paper and cardboard; Composite packaging; Wood; Textile.

Table 93. Estimated waste quantities for RDF/SRF production

Fraction	t/y in MNE (2022 ref. year)	Podgorica	Danilovgrad	Cetinje	Total	RDF	SRF
		28.20%	2.40%	2.30%			
Organic waste	136,101	38,380	3,266	3,130	44,777	-	-
Plastic	54,329	15,321	1,304	1,250	17,874	17,874	-
Paper and cardboard	53,283	15,026	1,279	1,226	17,530	17,530	-
Composite packaging	9,157	2,582	220	211	3,013	9,302	-
Metal	11,726	3,307	281	270	3,858	-	-
Glass	20,034	5,650	481	461	6,591	-	-
Wood	8,890	2,507	213	204	2,925	3,384	-
Textile	11,188	3,155	269	257	3,681	-	3,874
Other	34,050	9,602	817	783	11,202	7,371	-
Total	338,758	**78,337**	**6,667**	**6,389**	**111,451**	**55,461**	**3,874**

Source: Authors' calculations based on data from Monstat

In this scenario, a fraction of the potential alternative fuel will be disposed of in the landfill and not used for any purpose except for the small amount that is being recycled. In Podgorica, out of waste with the potential to be used as an alternative fuel, a recycled fraction is presented in the table below:

Table 94. Estimated waste quantities for RDF/SRF production in Podgorica

Fraction/Year	Paper and cardboard (ton)	Plastic (ton)	Total (ton)
2022	1,326 t	240 t	1,566 t
2021	1,474 t	190 t	1,664 t
2020	2,275 t	145 t	2,420 t
Average	1,691 t	191 t	1,883 t

Source: Authors' calculations based on data from Monstat

In Danilovgrad and Cetinje, there is no separate collection or recycling.

Table 95. AF potential with excluded recycled materials with an average of last three years

Fraction	RDF potential	SRF potential	Recycled
Organic waste	-	-	-
Plastic	17,874	-	191
Paper and cardboard	17,530	-	1,619

Composite packaging	9,302	-	-
Metal	-	-	-
Glass	-	-	-
Wood	3,384	-	-
Textile	-	3,874	-
Other	7,371	-	-
Total	**55,461**	**3,874**	**1,810**
Total AF potential with excluded recycled materials	**53,651**	**3,874**	**In total AF: 57,525**

Source: Authors' calculations based on data from Monstat

This means that out of the total waste generated in Podgorica, there has been an average of 1,691 tons of paper and cardboard and 191 tons of plastics per year in the last three years. If this amount is excluded from the potential for alternative fuel usage, it results in **53,651 t of RDF fuel potential and 3,874 t of SRF potential, or 57,525 t of AF, which is disposed of in the landfill.**

It is essential to highlight that most of the waste generated in Montenegro, especially in the area targeted with this study, is generated in Podgorica. That amounts to 85,71% of the total waste generated in these municipalities.

3.7.2. Scenario 1

In Scenario 1, authorities start preparing for a green transition in the waste management sector, which is in the framework of the Green Agenda for WB. In this case, authorities provide for legislation alignment and dedicate additional funding to the waste management sector to implement the waste management hierarchy, pilot production marketing, and use of alternative fuel. Montenegro applies the Waste Management Hierarchy in 2023, a 25% recycling rate and AF production.

For this purpose of the development of this scenario, in the table below, there are presented quantities of the waste fraction for each municipality targeted with this project that could be potentially used for the production of RDF/SRF below based on the projection of waste amount and fractions for the reference year 2025. The total amount is taken for each fraction, possibly used as an alternative fuel (RDF/SRF), including plastic, paper, cardboard, composite packaging, wood, textile, and other organic waste.

Table 96. Waste fractions suitable for alternative fuels (RDF&SRF)

Fraction	t/y in MNE (2025 ref. year)	Podgorica	Danilovgrad	Cetinje	Total	RDF	SRF
		28.20%	2.40%	2.30%			
Organic waste	140,598	39,649	3,374	3,234	46,257		
Plastic	62,849	17,723	1,508	1,446	20,677	20,677	
Paper and cardboard	61,640	17,382	1,479	1,418	20,280	20,280	
Composite packaging	10,593	2,987	254	244	3,485	3,485	
Metal	13,565	3,825	326	312	4,463		
Glass	23,176	6,536	556	533	7,625		
Wood	10,284	2,900	247	237	3,383	3,383	
Textile	11,772	3,320	283	271	3,873		3,874
Other	21,967	6,195	527	505	7,227	7,227	
Total	**356,444**	**100,517**	**8,555**	**8,198**	**117,270**	**55,052**	**3,874**

Source: Authors' calculations based on data from Monstat

According to this calculation, out of **117,279 tons** of waste estimated to be generated in Podgorica, Danilovgrad and Cetinje in 2030, potentially **55,052 tons** can be used for RDF, and **3,874 tons** can be used for SRF, which makes a total of **58,926 tons** of possible alternative fuel. Moreover, there is a potential of approximately **4,000 t** of animal waste generated annually at the national level and recognized as a potential alternative fuel in Montenegro.

3.7.3. Scenario 2

In Scenario 2 Montenegro fully complies with the Waste Framework, implementing a 45% recycling rate. A landfill phase-out IN 2025 is being marketed due to MBT and AF.

Since there is no cement industry in Montenegro, nor metallurgy that works at full capacity, or any company with the permit to work on co-processing in Montenegro, there are two possibilities for this type of fuel:

- Development of new facilities with waste-to-energy purposes (which is not highly accepted in the country) and
- Export of alternative fuel materials.

According to the population projections and economic growth of the region, it is accepted that a moderate 12% growth until 2025, resulting in an overall **131,355 tons** of waste estimated to be generated in Podgorica, Danilovgrad and Cetinje in 2030, potentially **57,805 tons** can be used for RDF and **4,105 tons** can be used for SRF which makes a total of **61,910 tons** of possible alternative fuel.

Finally, **<u>this study's cost-benefit analysis is based on the research and assumptions of the first scenario</u>** for further technical and financial calculations upon the design of the technological plant and the establishment of the entire functional scheme for producing alternative fuels.

Regarding the selected area for the location of the facility, during the data collection process and the meetings held with all stakeholders, some possible options were discussed. Several municipalities have expressed interest in building a combined transfer station in their territory, including the AF production plant. Regardless, none of the municipalities, at this stage, has the necessary financial and technical capacities to build and keep a facility of this nature in operation. Meanwhile, in addition to these possibilities, the capacities and potential of Livade landfill to expand its range of services have been verified with the main focus on increasing its life expectancy, improving environmental conditions, or implementing legal requirements regarding the waste pyramid classifications. Based on this, this document analyses the landfill of **Livade is a potential area (approximately 5,500 m2) for the construction of a joint plant of all municipalities that deposit waste there and that are interested in establishing a functional scheme for the production of RDF/SRF** by signing profitable contracts/agreements that are win-win for all parties.

Among others, Livade landfill, due to its position and ongoing segregation processes, is estimated to possess the necessary capacities and opportunities for constructing a facility according to technical requirements and concerning the existing legal and strategic documents.

3.8. Technical proposal

3.8.1. Best Available Technology for Municipal Solid Waste as Clean Fuel in Cement Industry

This section is dedicated to pre-drafting Best Available Technology to use municipal solid waste as clean fuel (RDF or SRF) in the cement industry. The Best Available Techniques (BAT) concept is an evidence-based tool for establishing emission limit values in environmental permits (OECD 2019). It aims to prevent and control industrial emissions, aligning with the European Union's Industrial Emissions Directive. The effectiveness of Refuse Derived Fuel (RDF) production can be enhanced by integrating informal waste pickers into formal employment, contributing to the circular economy.

The success of alternative fuel projects using municipal solid waste depends on various factors, including waste and industry regulations, economic considerations, technical expertise, and cross-sector cooperation. RDF implementation contributes positively to numerous Sustainable Development Goals (SDGs), as noted by Nabila

Shahata (2022). These benefits include improved health and well-being, reduced environmental impacts, enhanced industrial competitiveness, decreased waste management costs, and advancements in clean energy and sustainable urban development.

RDF quality is crucial, given the low calorific value of raw municipal solid waste. Two main qualities are considered:

1. RDF for the calciner: 12-17 GJ/ton, 50-80 mm granulometry
2. RDF for the main burner: 18-23 GJ/ton, 20-35 mm granulometry

An innovative pre-combustion chamber allows kilns to accept lower quality RDF (10-13 GJ/ton, up to 300 mm), potentially reducing preparation costs.

The proposed technological scheme for co-processing municipal waste in Livade includes:

- Capacity: 350 tons per day
- Annual production: 70,000 tons of alternative fuel
- Key processes: waste separation, shredding, screening, magnetic and eddy current separation, wind sifting, and drying

The production line incorporates various equipment, including:

- Vibrating feeder
- Hydraulic primary shredder (two-shaft)
- Trommel screen
- Eddy current and magnetic separators
- Wind sifter/drum density separator
- Secondary shredder
- Dryer

This system aims to improve the quality of recyclable waste streams and produce RDF/SRF for energy recovery. Manual separation is also employed to reduce impurities and enhance recyclable waste quality. However, this introduces operational risks that must be managed through proper safety measures and equipment.

The process involves multiple stages of material handling and processing, from initial waste reception to final RDF/SRF production. It incorporates principles of circular economy by allowing for the recycling of certain components and the production of alternative fuel for the cement industry.

The implementation of BAT for using municipal solid waste as clean fuel in the cement industry offers a promising solution to waste management challenges while contributing to sustainable industrial practices.

3.8.2. Expected product quantity and qualiy analysis

a. Description and features of the expected output

- Final product size: most <50mm
- Fluffy RDF (moisture <20%);
- Caloric value around 3000Kcal. (For optional, Use the RDF Pelleting system the caloric value can be increased by around 20%)

b. Requirements from industry:[28] SRF/RDF:

- Quality for main burner
- LCV: 20 to 25 gigajoules per ton
- Moisture: < 15%,
- Granulometry: 20 to 30 mm
- Quality for pre-calciner

[28] Alternative Fuels-BAT.IFC 2017.

- LCV: 13 to 15 gigajoules per ton
- Moisture: 15% to 25%
- Granulometry: 50 to 80 mm

c. **Other specific requirements from the industry**[29] (Caputo 2001)

Max ash content (% by wt.—dry basis):	20
Max Cl content (% by wt.):	0.9
Max S content (% by wt.):	0.6
Max volatile Pb content (mg/kg—dry basis):	200
Max Cr content (mg/kg—dry basis):	100
Max soluble Cu content (mg/kg—dry basis):	300
Max Mn content (mg/kg—dry basis):	400
Max Ni content (mg/kg—dry basis):	40
Max As content (mg/kg—dry basis):	9
Max Cd & Hg content (mg/kg—dry basis):	7

The elementary analysis of urban waste in Montenegro is proof of the guarantee given by the production company, where 82% of the average amount of urban waste is organic mass, combustible, and suitable for the production of RDF and SRF. The remaining 18% is inorganic mass that will be removed from the waste through manual separation by operators or will be removed by line separators.

The minimum heating value expected of RFD /SRF will be = 2800 kcal/kg.This value will be increased by decreasing the moisture of feed waste in the dryer.

AF production in Livade MBT is expected to be 57,525 tons/year.

3.8.3. Assessment of technical approach

Total capital investment is derived from the sum of fixed direct and indirect capital investment. Direct cost involves costs for main machinery and equipment, their auxiliaries and installation (piping, insulation, painting, electrical equipment and materials, grid connection, power and lighting, instrumentation and controls, process buildings and structures, site development; services utilities, and provision of water, air, firefighting services); and land lease. Indirect costs include engineering and supervision, construction expenses, contractor fees, and contingency. The indirect cost is estimated to be about 10% of the direct investment cost (Narawute Srisaenga 2016).

Meanwhile, operation and maintenance costs are generally divided into fixed operating costs, variable operating costs, and general expenses. Fixed operating costs include maintenance, operating labour, supervision, plant overheads, capital charges or interest payments, laboratory expenses, insurance, and local taxes. Variable operating cost items include raw materials, utilities, miscellaneous operating materials, and transportation. General expenses include administrative expenses, distribution and marketing expenses, research and development expenses, and gross earning expenses. (Narawute Srisaenga 2016)

Table 97 - Equipment Quotation. (GEP ECOTECH company)

No.	Equipment name	Power (KW)	Quantity (set)	Amount (USD)
1	Vibrating feeder TSW1548	15	1	**48000**

[29] RDF production plants: I Design and costs. Antonio Caputo.2001

2	Belt Conveyor GBC1000-18 Width 1000mm, Length 18m;	2	1	**15000**
3	Hydraulic Primary Shredder GP16	200	1	**430000**
4	Belt Conveyor GBC1400-12 Width 1400mm, Length 12m;	4	1	**17500**
5	Trommel GTS2580	30	1	**125000**
6	Belt Conveyor GBC1000-18 Width 1000mm, Length 18m;	4	1	**25000**
7	Belt Conveyor GBC1200-8 Width 1200mm, Length 8m;	3	1	**15000**
8	Belt Conveyor GBC1400-8 Width 1400mm, Length 8m;	3	1	**16000**
9	Magnetic Separator RCYD-14	4	2	**35000**
10	Vibrating feeder GZG1500-4	2*3	1	**16000**
11	Eddy current separator GECS-17	11	1	**105000**
12	Belt Conveyor GBC1400-14 Width 1400mm, Length 14m;	4	1	**21000**
13	Wind sifter FX1400	55	1	**135000**
14	Belt Conveyor GBC1400-10 Width 1400mm, Length 10m;	3	1	**14700**
15	Distributing bin	--	3	**16500**
16	Belt Conveyor GBC1000-15 Width 1000mm, Length 15m;	3	2	**42500**
17	Secondary shredder GSD15	2*110	2	**435422**
18	Belt Conveyor GBC1000-22 Width 1000mm, Length 22m;	5.5	1	**29800**
19	Belt Conveyor GBC1000-17 Width 1000mm, Length 17m;	4	1	**21800**
20	Rotary drum drying system HG3232 With RDF burner and exhaust air disposal system	110+132+160	1	**830000**
21	Belt Conveyor GBC1000-10 Width 1000mm, Length 10m;	2.2	1	**14000**
22	Belt Conveyor GBC1000-20	5.5	1	**25800**

	Width 1000mm, Length 20m;			
23	Belt Conveyor GBC650-8	2.2	1	**11300**
	Width 650mm, Length 8m;			
24	Belt Conveyor GBC650-36	11	1	**45800**
	Width 650mm, Length 36m;			
25	Belt Conveyor GBC650-8	2.2	1	**11300**
	Width 650mm, Length 8m;			
26	Belt conveyor GBC1200-15	5.5	1	**20900**
	Width 1200mm, Length 15m;			
27	Manual sorting platform GBC1400-15	7.5	2	**124500**
	Width 1400mm, length 15m with 10 worker stations			
28	GEP intelligent control cabinet	TOTAL POWER APPROX 2200KW	1	**187800**
	intelligent monitoring, Siemens PLC system with touch screen, integral control			
	Full auto/Manual control (switchable)			
	TOTAL			USD 2,835,622

Source: GEP ECOTECH company

Table 98. Necessary spare parts since year 0, including their cost

1-year spare parts (including spare parts in installation and testing)

No.	Equipment name	Item	Amount (USD)
1	Vibrating feeder TSW1548	Grate bars, springs	9170
2	Hydraulic Primary Shredder GP16	Cutter's maintenance cost, hydraulic wearable parts (Materials and service)	127925
3	Belt Conveyor	Rolling drums	38600
4	Trommel GTS2580	Bearings	8010
5	Magnetic Separator RCYD-14	Belts, bearings	4629
6	Vibrating feeder GZG1500-4	Springs	7040
7	Eddy current separator GECS-17	PU endless-belts, bearings, oiler	6090
8	Wind sifter FX1400	Endless-belts	13461

9	Secondary shredder GSD15	Cutters	82000
10	Rotary drum drying system HG3232	Seal flake, lifting plate, supporting wheel, big and small gears, RDF burner wearable parts	2250
11	GEP intelligent control cabinet	Electrical components	40725
			USD 339,900

Source: GEP ECOTECH company

Explanation:

Due to the maintenance policy, companies store in the warehouse their spare parts that have a significant impact on the production line because, in the event of damage, the time that it takes to get the production line back to work can take a very long time (assembly specifications or shipping of the spare parts can be delayed). The amount of USD 339,900 is due to the fact that these spare parts must be in the warehouse because they greatly impact the process.

Considering an initial production of 250-300 tons of RDF per day, it is assumed that the consumption rate of electric energy will vary between 650-900kWh/daily.

3.9. Economic analysis

The CBA was completed using publicly available data from the municipalities involved in the project and other national sources and information from direct interviews with stakeholders and other national and international institutions.

Table 99. Data used in the CBA

Indicator	Value	Unit	Source
Start of evaluation period	2024		Expert assessment
End of the evaluation period	2040		Expert assessment
Exchange rate USD/Euro Year 2023	0.924	Euro per unit of USD	https://www.exchangerates.org.uk/USD-EUR-spot-exchange-rates-history-2023.html
Social Discount Rate (UE Guidelines)	3.0%		Source: DG CLIMA (2021) / Economic Appraisal Vademecum 2021-2027
Production capacity	50,000	Tons per year	Expert assessment
RDF& SRF Average selling price, minimum	27	Euro per ton	Assumption based on information from Holcem operations
RDF& SRF Average selling price, maximum	60	Euro per ton	Assumption based on information from Holcem operations
RDF& SRF Average selling price, average	44	Euro per ton	Expert assessment
Landfill depositing fee in Montenegro	35.0	Euro per ton	Expert assessment & municipality
CO_2 and GHG savings from engaging in RDF&SRF production	17,890	Tons per year	Expert assessment

Source: Authors' calculations

General Assumptions

The CBA for the proposed intervention employs an incremental approach for costs and benefits (when possible), assessing the net effects with and without the projects. The counterfactual baseline scenario is defined by Sartori et al. (2015) as "what would happen in the absence of the project" (assuming business as usual or a do minimum approach). Assumptions introduced for the CBA include the following:

- The reference period employed in the CBA is 16 years (marked with 1 – 16, starting year 2024 and last year 2040). However, the EU guidelines for waste management infrastructure suggest a reference period of 25-30 years (European Commission, 2015).
- The EU guidelines suggest including a residual value of the investment at the end of the reference period. Therefore, assuming a conservative approach, a residual value was included at the end of the reference period (30% of the initial investment).
- The CBA employs the social discount rate (SDR) to calculate the net present value of future cash flows. The EU guide on cost-benefit analysis suggests using an SDR of 3% without a national approach. In Montenegro, there is no reference discount or social discount rate. Therefore, discounting was conducted using the EU reference rate.
- All calculations are net of VAT.
- General maintenance costs were calculated as a % of the investment.
- Operating costs build on the technical suggestions and include personnel and other unidentifiable costs.
- An incremental approach was adopted to account for project implementation's economic, social and environmental costs and benefits. The "without the project scenario" was built considering the continuation of the situation with a business-as-usual approach (when possible).
- All values in other currencies were converted into euros using the average exchange rate for 2023.

Economic indicators. The CBA for the proposed investment project employs three widely used economic performance indicators calculated on incremental cash flows.

- The economic net present value indicator (NPV) is a standard indicator calculated as the difference between the discounted total benefits and costs arising from the project.

  $\mathrm{NPV} = \left(\left[\sum \frac{B_i}{(1+sdr)^i}\right]\right) - \left(\left[\sum \frac{C_i}{(1+sdr)^i}\right]\right)$ summed over 0 to n years.

  B_i = project benefits in year i, for i {0,1…n};
  C_i = project costs in year i, for i {0,1…n};
  n = total number of years for project duration – the time horizon;
  SDR = social discount rate.
  Projects with positive NPV are considered viable, while those with negative net present value are not.
- The internal economic rate of return (IRR) is the ratio that produces a zero value for the economic NPV. As a rule of thumb, the IRR should be higher than the discount rate used in the analysis (it creates value added). On the contrary, the project destroys value if the IRR is lower than the discount rate.

  $$\left(\left[\sum \frac{B_i}{(1+irr)^i}\right]\right) - \left(\left[\sum \frac{C_i}{(1+irr)^i}\right]\right) = 0$$

- The benefits-to-cost ratio (BCR) is the ratio between the sum of discounted economic benefits and costs over the time horizon considered in the analysis. The BCR informs us of how many euros are generated by the intervention for each euro 1 invested over the time horizon of the project. The following formula summarises the information included in the BCR[30]:

  $$\mathrm{BCR} = \frac{[\sum B_i /(1+sdr)^i]}{[\sum C_i /(1+sdr)^i]}$$

  B_i = project benefits in year i, for i {0,1…n};
  C_i = project costs in year i, for i {0,1…n};
  N = total number of years for project duration – the time horizon;

30

SDR = social discount rate.

Based on the results obtained:

- BCR<1.0 means that the project's costs exceed its benefits in economic terms. In other words, the value of each 1€ invested is being destroyed.
- BCR=1.0 means that the project's costs equal its benefits in economic terms. Therefore, while it can proceed with the project, its viability is uncertain. In other words, no added value is created for each 1 € invested.
- BCR>1.0 means that the project's benefits exceed its costs in economic terms. In other words, value is being created for each 1 € invested.

3.9.1. Costs and benefits

Capital expenditure. The estimated initial investment costs are about USD 2,835,622.00, detailed in Table 24. In addition, replacement costs are assessed to account for about USD 339,900.00. As listed in Table 24, replacement costs include replacing short-life equipment and spare parts over the reference period. Therefore, as per the European Commission (2015), both initial investment and replacement costs constitute the total capital expenditure for the realisation of the project and amount to about USD 3,022,265.00. Furthermore, the investment is assumed to be completed in the second year of the reference period (2025), and the replacement costs will occur in the third year.

Table 100. Capital expenditure

Investment project	Cost (in USD)
I1 Initial investment	2,835,622
I2 Replacement costs	339,900
Total capital expenditure	3,022,265
RV Residual value	850,687

Source: Authors' calculations

Current expenditure. The estimated current expenditures include costs for the facility's regular maintenance and operationalisation (personnel, energy, and other costs) and energy used from the production facility.

Table 101. Current expenditures

Cost item	Quantified	Monetised	Included CBA
C1. General maintenance	Yes	Yes	Yes
C2. Operating costs	Yes	Yes	Yes
C3. Energy	Yes	Yes	Yes

Source: Authors' calculations

- C1. General maintenance. General maintenance costs are estimated as a percentage of initial investment costs (excluding replacement costs) and presented in Table 26. For the CBA, maintenance costs are assumed to amount to about 5% of the initial investment or about Euro 131,020.00.

Table 102. General maintenance costs

1% of initial investment	Euro 26,204
2% of initial investment	Euro 52,408
3% of initial investment	Euro 78,612
5% of initial investment	Euro 131,020
7% of initial investment	Euro 183,428
10% of initial investment	Euro 262,040

Source: Authors' calculations

Maintenance costs change over the reference period. For example, about 75% of the maintenance costs will be allocated in the first three years after the initial investment is completed. In the next five years, maintenance costs will be consumed at 95% and 100% for the rest of the reference period.

- C2. Operative costs. Operational costs, including personnel, administrative, and other unidentifiable costs, amount to about Euro 1 million.
- C3. Energy consumption. Based on the plant size (5.5 MW) and production capacity (RDF 250 tons daily), electricity consumption is assessed at about 650-900 kWh daily (information from an expert). Eurostat data on electricity prices for final non-household customers suggest an average price during 2022 of about 12.81 ALL per kWh (or about Euro 0.1 per kWh). Given the current upward trends in energy prices, a constant increase in the average price for electrical energy for non-household consumers of 3% annually is assumed.

Estimated benefits. Table 27 summarises the benefits derived from the investment project in RDF&SRF production. All three benefit sources are included in the cost-benefit analysis.

Table 103. The benefits sources

Benefit item	Quantified	Monetised	Included in CBA
B1. Revenue from selling activity of RDF&SRF	Yes	Yes	Yes
B2. Increased life of the landfill	Yes	Yes	Yes
B3. Saving on CO2 emissions	Yes	Yes	Yes

Source: Authors' calculations

- B1. Revenue from selling activity of RDF&SRF. The products from the production process constitute the main source of revenues in the CBA, along with other elements listed below. The market research suggests a minimum selling price of 27 Euro per ton to a maximum selling price of 60 Euro per ton. An average price of 44 euros per ton was considered for the analysis to assess the potential revenue generated over the project duration. In addition, based on the current trend in international markets on energy prices, an annual increase of 5% was considered. In the counterfactual scenario, without the project, it is assumed that at least 75% of the amount of waste that could be used to produce RDF&SRF would be landfilled. Therefore, a revenue stream might be assessed by employing a 35 Euros per ton depositing fee.
- B2. Increased landfill life. A large part of waste disposed of for RDF&SRF production is used, so less waste has to be deposited in the landfill, extending its life. The landfill's extended life is assessed and monetized by applying the same landfilling fee over the reference period.
- B3. Saving in CO_2 emissions. The expert assessment suggests that the production of RDF&SRF saves about 17,890 CO2 and GHG emissions per year. The benefits from saving CO2 emissions have been included in the calculation of economic indicators in the CBA, using shadow prices of CO2eq from DG Clima Economic Appraisal Vademecum 2021-2027.

3.9.2. Economic indicators results

All the benefit and cost items have been assessed over the 16-year reference period. Then, a discount rate of 3% is used to estimate the NPV, BCR, and IRR. In addition, the simple payback period indicator is included in the analysis.

The estimation of net costs and benefits on a 16-year reference period and discounting using the social discount rate of 3%, all the economic indicators presented in Table 28, suggest the viability of the investment project. The project presents a positive net present value, suggesting that net benefits associated with it outpace costs for realisation. The results from NPV are supported by results obtained from the internal rate of return (IRR). IRR greatly exceeds the social discount rate, thus suggesting the profitability of the proposed investment. Finally, the benefits-to-costs ratio (BCR) indicates that every Euro invested in the proposed project will create value for society.

Table 104. The economic indicators

Indicator	Unit	Value	Comment
Capital Investment	Euro	2,620,398.0	Estimated capital expenditures for realising the project interventions (including initial investment and replacement costs).
Net Present Value (NPV)	Euro	2,620,398	The NPV suggests the project is viable; thus, the benefits exceed its costs.
Internal Rate of Return (IRR)	%	19%	The internal rate of return (the one that sets NPV = 0) is considerably higher than the discount rate, suggesting a profitable investment.
BCR	Euro	1.7	The BCR >1 indicates that the project's benefits exceed its costs. In other words, for each 1 Euro invested, 1.7 Euro of value is created.
Simple payback period	7th	Year	The investment presents a simple payback period in the seventh year of operations.

Source: Authors' calculations

3.10. Discussions on findings

The present case study focused on three targeted areas (Podgorica, Danilovgrad, and Cetinje), and estimations were carried out based on the potential waste volume produced in these areas. The scenario includes establishing a production facility for an investment of Euro 2.6 million, located in an area of 5,500 sqm within the layout of Livadei Landfill. In contrast, the extension as-build project allows this new instalment to be accommodated parallel to the existing segregation and recycling unit. The assessment showed that from an economic point of view, the use of waste streams for RDF&SRF production could benefit Montenegro, even on a limited scale. Meanwhile, if additional waste quantities generated in the other regions of Montenegro were to be included in the assessment, the produced alternative fuels would have the potential to increase substantially (intensifying the export activity into international markets.

Another benefit of the RDF facility is its contribution to extending the lifespan of the Livade landfill by at least 8 years, given the reduced yearly amount of waste for final disposal. Further, if alternative fuel is co-processed at a temperature above 14,500C, it could reduce a considerable amount of greenhouse gasses emitted into the air. For instance, the consumption of the annual AF produced at Livade could lead to an overall reduction of 17'890 tons of CO_2 per year.

Some findings for further discussion include:

- Currently, the law on waste management is not being appropriately implemented. The drafting of the new law on waste management started in 2017 and is still ongoing. The long-lasting process of drafting the new law is assessed, providing an alibi for those who should have implemented the existing law on the national and local levels, too. In addition, by-laws on different topics enabling the full implementation of the current law are missing. Therefore, important practices like the EPR or DRS schemes and recycling practices are not yet applicable (among other aspects).
- The National Waste Management Plan expired in 2020, and the strategic document provides the general strategic framework for this sector, but the new one has not yet been adopted. Lacking a guiding strategic framework, those in charge of the services (municipalities, communal utilities) cannot adequately plan their activities and budgets.
- The EU Waste Hierarchy states that Montenegro and other countries that aspire to be part of the European Union should implement the waste hierarchy and all necessary steps regarding waste prevention,

preparing for reuse, and recycling before waste recovery. Since Montenegro practically paused its own activities while waiting to adopt the new law on waste management, there is a lot to do to establish the EU Waste Hierarchy, and co-processing is not the highest on the list of activities to be implemented.

- The waste management information system is not functional, even though it was developed due to an international project. Besides this, there is no reliable data to feed into the system; therefore, there is different information from different sources.
- Great expectations have arisen for the new waste management law. Soon to be adopted, the new law on waste management will, among other things, include setting landfilling tariffs (expected to be higher than the current level). Therefore, local entities in the waste management service will see landfilling costs increase, and the stimulus to reduce landfilled waste quantities is expected to be higher.
- Different private companies are interested in engaging in alternative fuel production. Nevertheless, the investment is considerable, and exposure to regulatory risks makes it difficult for them to engage in such an activity.
- The Montenegrin economy relies heavily on tourism, and all economic branches that have the potential to use this type of energy, such as the textile industry, chemical industry, wood and wood products, paper and paper products, food industry, machinery and equipment, and electronic industry related to waste production, have a minor share in the country's economy. Lacking a direct potential user and "process champion" of alternative fuels somehow inhibits the general approach and perception of alternative fuel production. Yet, international markets and exporting might be an interesting and economically viable opportunity to allocate the produced quantities.
- Human resources are a key factor in waste management. In the Montenegrin case, the local implementing authorities lack significant capacities (human and financial resources) to improve the waste management system.
- Co-processing is recognized as waste incineration and does not have a high expectancy in the country. The Government of Montenegro's previous plan to build one incinerator for all the waste generated in Montenegro in 2016 was not accepted by organizations and citizens whose opinion is more favourable to recycling. Most stakeholders believe that waste treatment in Montenegro will make it impossible for the country to achieve recycling targets.
- As for waste tyres, landfill Možura got the permit to process, granulate, and export them as recycled material. For specific waste streams such as waste tyres, the new Law on Waste Management defines an EPR system, and it is expected to organize a system of collection, preparation for recycling, and recycling within this system.
- There are ongoing feasibility projects for using biogas from the sanitary landfills in Montenegro for energy production, both in Deponija Livade in Podgorica and Deponija Možura in Bar. There is an initiative to develop a recycling centre in Nikšić, which would include cooperating with Ironworks Nikšić in the co-processing of residual waste. No feasibility study has been conducted to assess alternative fuel production's potential. A feasibility study is ongoing to co-process the sludge from the Municipality of Budva, and there is a plan to construct a new wastewater system in Podgorica with a waste-to-energy system for the sludge.
- The ash generated through potential co-processing is categorized as hazardous waste, and Montenegro has no adequate solution. Montenegro still has problems with the hazardous waste generated through the work of the industry in the last 20 years and is still dealing with it.

3.11. Preliminary conclusions and recommendations

Waste management poses significant social and environmental challenges for Montenegro. There is an inadequate regulatory and strategic framework to support effective waste management services at both national and local levels. The Law on Waste Management has been in development for seven years but has not yet been adopted. Furthermore, relevant stakeholders, including those responsible for implementation such as communal utilities, have not been properly involved in the preparation process. The National Strategy expired in 2020, and new local waste management plans have not been developed or adopted.

Currently, Montenegro is not applying the waste hierarchy at the national or municipal level, including in the capital Podgorica, the Old Royal Capital Cetinje, and the Municipality of Danilovgrad, which were the focus of this study. Recycling targets set by law have not been achieved within the planned period, and municipalities lack separate waste collection systems. They do not select separate waste streams that could be recycled. Additionally, there is a lack of adequate data on different waste streams for collected waste in the country, including the targeted municipalities. Numerous illegal landfills exist across the country, containing various types of waste.

There are only two sanitary landfills, one in Podgorica covering the central region and one in Bar covering the southern region. Waste generated in the northern part of Montenegro, including Nikšić, ends up in temporary illegal landfills, which are not sanitary. Public authorities have not prepared any Waste Prevention Programs or Extended Producer Responsibility (EPR) schemes for different waste streams such as plastic and waste tires.

To address these issues, Montenegro should approve the new Law on Waste Management following a thorough consultation process with stakeholders and in alignment with EU Directives. The regulatory framework must be completed with all necessary bylaws to enable its implementation. Renewing the strategic framework with a National Waste Management Plan is essential, paving the way for the renewal and implementation of local waste management plans.

The implementation of Extended Producer Responsibility (EPR) for businesses should be prioritized to reduce their medium- to long-term environmental footprint. An already developed waste information system should be implemented and populated with relevant and accurate data gathered by local communal utilities and private companies. Standardization and methodologies for data collection must be established to ensure reliable statistics for the waste management sector.

Engaging different stakeholders, including institutions and organizations, in awareness-raising campaigns about waste management practices and their contribution to environmental protection is crucial. Illegal dump sites and temporary landfills must be closed as soon as possible. Action plans should be prepared for processing organic waste, which accounts for more than 40% of the waste generated in Montenegro. Inert and green waste must be separately collected.

Private companies collecting waste and operating without adequate permits should be supported and included in official waste management streams and operations. Local communal utilities should extend their services to a wider area, increase the percentage of collected waste, and renovate their capacities, including vehicles and containers. Introducing incentives for home composting, especially in rural areas, and encouraging recycling practices are also necessary. Finally, waste generation reduction practices, such as establishing low plastic zones, should be supported to foster a more sustainable environment.

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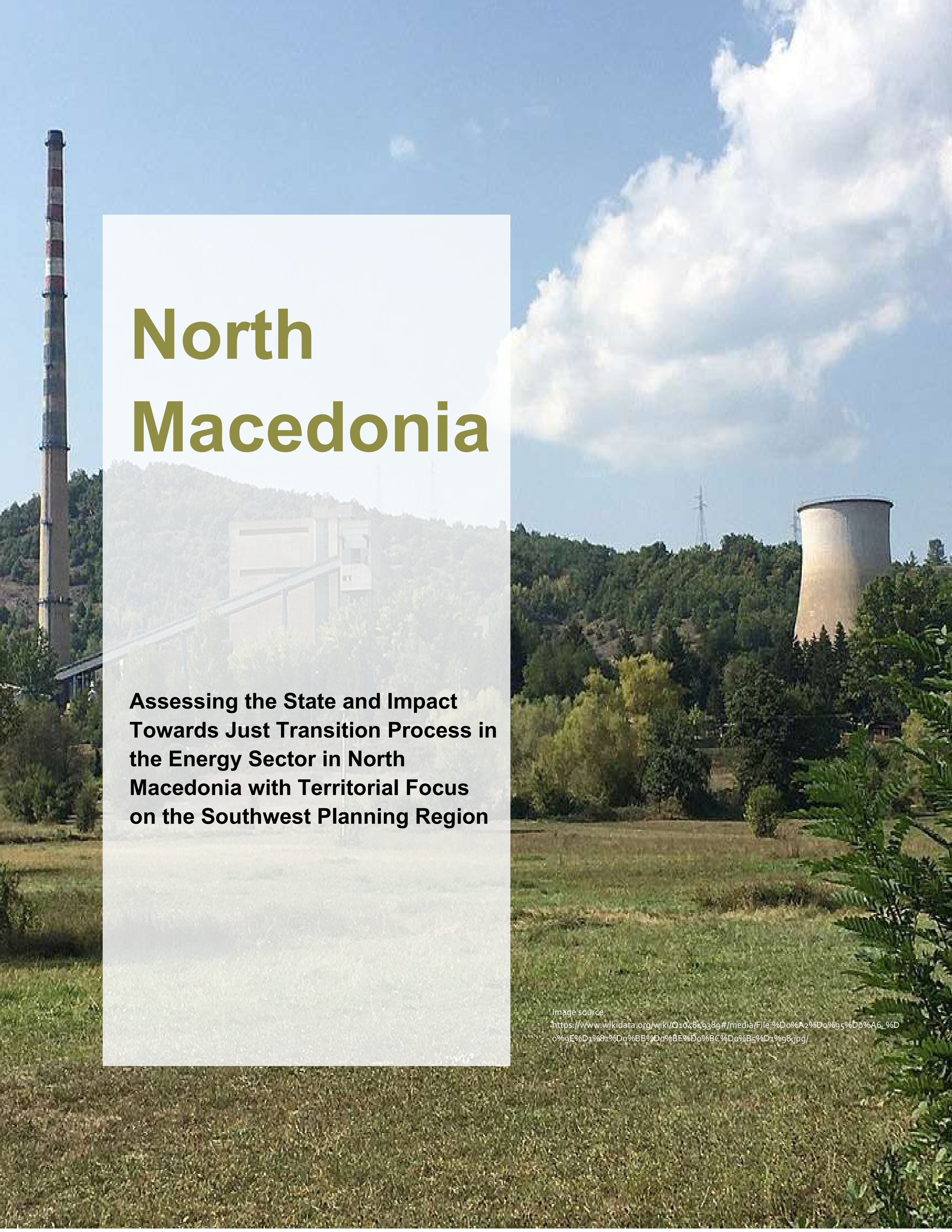

North Macedonia

Assessing the State and Impact Towards Just Transition Process in the Energy Sector in North Macedonia with Territorial Focus on the Southwest Planning Region

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North Macedonia

Assessing the State and Impact Towards Just Transition Process in the Energy Sector in North Macedonia with Territorial Focus on the Southwest Planning Region

4.1. Introduction

The Republic of North Macedonia (RNM) is on the path towards EU accession with the goal to become a member state. The country has only very recently started the screening process - after more than a decade of EC's recommendations for opening up the negotiations (i.e. 2004 signed the SAA, since 2009 EC recommends a start of the negotiations, and in 2022 the screening process noted the start of EU membership negotiation process).

RNM, is facing the challenges of transitioning towards a greener, more sustainable energy future. This endeavour entails large magnitudes of effort restrained by myriad of limitations, nonetheless one of the larger steps involve coal phase-out which means starting with decommissioning of the coal-fired thermal plants.

By aligning with the goals outlined in the GAWB, RNM seeks to leverage its natural resources, innovative capacity, and stakeholder collaboration to navigate the challenges and capitalise on the opportunities associated with the transition towards a greener and more resilient energy system yet, abiding to the principle of "just transitions".

This shows the relevance of the research for identification of the current status and developments as well as challenges and opportunities presented by the shift-away from coal-based energy production while focusing on territorial socio-economic impacts of the transition in the Southwest planning region (SWPR).

The research gives an overview of the current situation via presenting the status of the energy and climate policies and assesses how and to what degree the energy transition policy plan(s) fit in the territorial and just aspects. The research focuses on a territorial perspective of a specific place-based effects in the SWPR of RNM and places into perspective the importance of energy transition and decarbonization to bring energy security, but more importantly **to incorporate proper backing with social justice and benefits of the place-based approach which is often neglected**.

The possible implications on the socio-economic aspects in the SWPR, a lagging region compared to the rest of the country, are being closely examined. In the SWPR, one of the oldest and most obsolete coal-fueled thermal plants, TTP Oslomej, is located and is the **first in line to be retired.**

The current strategic framework and policy discourse of RNM concerning green transition are focused on the decarbonisation. The energy sector is considered as the most urgent, through coal phasing-out. Transition from coal to renewable energy sources (RES) presents theoretically and practically a blend of variety of opportunities as well as obstacles.

Nevertheless, achieving full economic and social advantages demands a holistic and inclusive approach. The setting up of a proper governance structure and the collaboration among the governmental entities, industries, and local communities is essential to set up environment for a smooth(er) and fair(er) transition to a sustainable economy, which are leveraging territorial and place-based potentials (incl. skills, and knowledge) - in the formal decision-making mechanisms.

The current policy set-up and governance structure in RNM – which is in the onset of formal establishment and not yet 'operational' (with specific implementable actions to be evaluated), even though described as "hybrid" model, it is considered and perceived to be very top-down, lacking various aspects, among which is the place-based and bottom-up inclusive approach. Furthermore, it is perceived to be externally pushed i.e. though the initiatives, interest and 'offers' of support from primarily the international community and the international financial institutions.

Therefore, the research findings can contribute to the process of policy making and to a degree in the legislative processes because it gives backed empirical evidence that there is a need to incorporate specific tailor-made programs that will reflect the capacities, skills and knowledge of the specific place in designing an approach which considers both, social and economic implications of coal phasing out, rather than the design of a generalised approach. It should address the needs of groups affected by the transition to foster acceptance of coal phase-out policies.

Furthermore, it notes the suggestions for policy setters, of the necessity to integrate just transition measures into coal phase-out strategies by robust interactions between the central with the local/regional authorities, as well as broad stakeholder engagement and inclusion, all to enable enhancement of both legitimacy and feasibility of the transition process.

Contribution to the Decarbonisation Green Transition Pillar & the Just Transition Strategy

The research contributes significantly to the Green Agenda for the Western Balkans, particularly in the area of decarbonization. By focusing on the socially just and inclusive processes, this research sheds light on the development of national and local policies, with a specific emphasis on the SWPR – Kicevo area.

The research also delves into governance and socio-economic assessment, mirroring the EU's transition practices for developing place-based just transition plans. This includes identifying and assessing the level of preparedness and approaches taken so far, as well as plans undertaken to consider the socio-economic impacts of transitioning away from one of the oldest TPPs in SWPR.

This research case specifically also contributes to key policy frameworks: i) Energy Strategic Policy Framework: by providing a comprehensive analysis of the socio-economic impacts of decommissioning TPPs, thus aims to assist in shape a more effective energy strategy for the region; ii) Just Transition Policy and Strategic Framework: The research identifies possibilities for practices for a socially just transition, ensuring that local communities are not left behind as the region moves towards a more sustainable energy future; iii) Climate Action Policy: By assessing the readiness of SWPR to transition away from fossil fuels, this research informs climate action policy and encourages policymakers to prioritize environmentally friendly alternatives. By addressing these key policy frameworks, this research plays a role in supporting the Green Agenda for the Western Balkans and driving meaningful change towards a more sustainable energy future.

Contribution to improved policy-making at national/regional/local level and relevance to local/ regional stakeholders

Contribution Results	National policy making	Local policy-making
Central vs. local governance (dis) balance (Lack) Communication channels among stakeholders and consensus	Governance structure should be more open, perceptive and inclusive of the local (place) needs – of the region and local policy makers and all stakeholders.	The local authorities especially the LSGU need to be more proactive, (to undertake) inclusive and strategic role; to be innovative (economic, just, green, etc.) in positioning themselves in the transition process
Socio-economic vs. financial benefits	Purely financial benefits/costs are different and contradictory when compared to scenarios which are socio-economic sensitive.	Purely financial benefits/costs are different and contradictory when compared to scenarios which are socio-economic sensitive and local authorities should be innovative and proactive in supporting the transition process.

4.2. Methodology

The overall objective of the case research is to assess the potential impacts of the just transition of TTP Oslomej though designing and assessing different scenarios within the current policy and plans, from socio-economic and territorial aspect for the SWPR.

Thus, the central research question is: what is the potential (mid-) long-term regional socio-economic impact from implementation of just transition scenario for TTP Oslomej.

Table 105. Research questions, activities and methods

	Scenario 0 – Business as usual - Closure of TPP Oslomej by 2027 without Transition – baseline scenario	**Scenario 1 – Decommissioning with Technical Activities and Just Transition (by 2040)**	**Scenario 2 - Decommissioning with Just Transition via Partial Renewable Energy Substitution (RES/PV) and Labour Transitioning (by 2040)**
Overall research objective	Assess the territorial socio-economic impact of the just transition of TTP Oslomej scenarios (within current policy context)		
Central research question	What is the size and what are the potential long-term (15 years) regional socio-economic impact from the implementation of just transition scenario of the TTP?		
Sub-questions:	• What is the current state of and the degree of alignment of the just transition policies of North Macedonia, with the EU? • What is the size of the regional socio-economic contributions of the energy sector on the regional SWPR economy to be directly and indirectly impacted with the TPP's retirement? (economic losses) • What are the economic costs and benefits (identification, scope, and size) of the baseline scenario vs. the decommissioning of the coal TTP with inclusion of just processes and possibly partial substitution of energy production with RES?		
	• What are (identification & quantification) the assumed local/regional effects: costs and benefits, on the economic production (value added: direct and along the supply chain) from only **retiring** TPP Oslomej? • What are (identification & quantification) the assumed local/regional social effects, costs and benefits, on the labour market (direct and indirect employment) from only **retiring** of TPP Oslomej? • What are other socio-economic costs from operation from only **retiring** of TPP Oslomej: Environmental costs, Social - workforce transition costs, Health costs, etc. • What are the other elements that have impact on the effects, costs and benefits from retiring TPP Oslomej?	• What are (identification & quantification) the assumed local/regional effects, costs and benefits, on the regional economy (value added) from proper **decommissioning** of TPP Oslomej which includes JT processes through **labour support measures**? • What are (identification & quantification) the assumed local/regional social effects, costs and benefits, on the labour market (direct and indirect employment) including just aspects from JT decommissioning of TPP Oslomej? • What are other costs & benefits from operation and proper decommissioning of TPP Oslomej: Environmental costs, Social - workforce transition/reskilling costs, Health costs, etc. • What are the other elements that have impact on the effects, costs and benefits from decommissioning and JT activities of TPP Oslomej?	• What are (identification & quantification) the assumed local/regional effects, costs and benefits, on the economic production (value added) from **JT decommissioning** and in addition **substitution** of the energy production (partial) **with RES** / PV of TPP Oslomej? • What are (identification & quantification) the assumed local/regional social effects, costs and benefits, on the labour market (direct and indirect employment) from JT decommissioning and substitution of the energy production with RES / PV of TPP Oslomej? • What are the assumed local/regional effects, costs and benefits, on the **environment** (GHG emissions) from JT decommissioning and substitution of the energy production with RES / PV of TPP Oslomej (identification & quantification)? • What are the other elements that have impact on the effects, costs and benefits from the JT decommissioning and substitution of the energy production with RES / PV of TPP Oslomej?

Source: Authors

The research was structured around addressing the central question of understanding the socio-economic impact of decarbonising and phasing-out coal of TPP Oslomej in SWPR in RNM.

There are several reasons for choosing this specific case. Some of the reasons are the urgency/timeliness - as the TPP is being first in line for retirement of the two TTPs – Oslomej and Bitola. The TPP in question was already supposed to be retired (set in policy strategic docs) however still operates with increased production level. In the past period, there was no 'plan' or effort to mitigate the effects of the retirement of the plant; thus, it was considered a good time to 'show' that such efforts are necessary. Second reason is the likelihood, as the TPP Oslomej contributes significantly less to the national energy production, and the coal reserves are depleted, it can be retired without posing significant disturbances to the energy security.

The primary goal was to conduct a comprehensive assessment of the potential long-term regional socio-economic consequences resulting from the closure of the TPP Oslomej in SWPR. **The aim was to gather evidence to support a policy option that includes just transition actions for the affected workforce, advocating for a more sustainable approach instead of a simple shutdown of operations by showcasing the possible effects of both options.** Nevertheless, our goal was not to present rigorous quantification of the options (as there are limited resources for such an endeavour) but rather to provide a comparison that pinpoints towards the direction and to give another argument for the necessity for fast implementation of the 'best' option not solely from financial but best socio-economic option for the region, stressing the importance of implementation of timely policies and actions that incorporate a well-designed just transition actions as most beneficial in the long run.

To achieve this objective, the study utilized a **mixed-method research approach**, combining direct quantitative methods with qualitative content analyses. The research focused on evaluating current policies and efforts in the realms of energy, climate action, and just transitions. This approach allowed for a thorough examination of the impact of decarbonization efforts on the local economy, and the workforce, while also considering the implementation of measures to support a smoother transition for those that are affected.

- By using a mixed-method approach, the study sought to gain a comprehensive understanding of the consequences of transitioning away from coal fuelled energy production at TPP Oslomej. Through a combination of quantitative data analysis and qualitative assessment of policy efforts and stakeholder perceptions of the process, the research aimed to provide deeper insights into the socio-economic dynamics and the viability of implementing just transition measures in the area. This method allowed for a more thorough evaluation of both the advantages and hurdles linked to the transition, enabling the development of well-informed policy recommendations based on a holistic assessment of the situation.

The socio-economic analysis includes an evaluation of the regional economic fundamentals and the readiness for the transition process. It provides a comprehensive overview of the socio-economic characteristics of the coal dependant region, identifying potential impacts of transitioning towards decarbonization on the economic and social sectors.

The analysis encompasses an examination of relevant policies that directly and indirectly impact the workforce affected by the transition, emphasizing the importance of policy analysis in framing the research context.

Qualitative data included information gathered through conducting interviews with stakeholders particular and especially among policymakers to understand how the transition is affecting jobs, local economies, and social well-being.[31]

- In a first step, the focus is on grasping the direct and indirect interrelations of the sector (coal production energy sector) with the other economic sectors in the SWP region. Accordingly, in order to derive more accurate estimates an input-output model analysis (IOM) tool is applied to derive the direct and indirect

[31] Note: I*n the next period this will be extended with focus groups discussions with other local stakeholders specially to validate the identified costs and benefits, and the perception of the inclusion in the governance and decision-making process*.

impact estimates for the variables of regional economic value added and indirect labour. These are used then as input in the next step for further scenario development.

- After estimating the indicators for the regional economy, for the scenarios, a CBA is conducted through constructing and estimating the costs and benefits, not only from purely financial aspect but incorporate the social and economic components though inclusion of selection of costs and benefits associated with the three different scenarios. Estimates on the monetization of the costs and benefits are derived on statistical data, literature review and based on viable assumptions within array of strategic, policy and other documents concerning RNM and TPP Oslomej (various reports).

- In the process of estimating the possibilities for the case in question, a CBA was employed to estimate and sum up the costs and benefits of several policy or scenario alternatives, and to compare these by converting the costs and benefits into present value (PV). Based on this, support and policy alternatives are proposed to highlight the positive effects that can be achieved from the social safety net alternatives, for a more just transition process of TPP Oslomej.

The governance readiness assessment combines desk research with semi-structured interviews to review EU, national, and (possibly) regional and local climate-related strategies and regulatory documents. Interviews were conducted with policymakers at national, regional, and local levels to capture diverse perspectives and insights.

- Primary data collection involved semi-structured interviews with key stakeholders at policy, implementation, and beneficiary levels.

- Secondary data sourced from: State Statistical Office (SSO) of North Macedonia, including detailed Labour market survey (non-publicly open data), national and regional environmental, economic and social related data were used, to inform the analysis. Socio-economic impacts are linked to decarbonization through I-O using the most recent available System of National Accounts (SNA) SIOT tables and modelled across the scenarios. A range of qualitative but also quantitative data are sourced through the use of public information act requests (RAPI) directed to and provided from the national state-owned electricity producer (ESM) in which auspices the specific power plant in question.

Data Collection Methods

Document Desk Analysis involved reviewing official reports, policy documents and strategic framework documents, legal framework documents and CSO and international subject related documents and publications, research documents, policy studies, media articles etc. related to the thermal plant and the coal phase-out in the WB region, country, and specific to TPP Oslomej. The document analysis is essential in understanding the context, regulatory framework, and public discourse surrounding the transition.

Secondary data analysis, together with the document desk analysis was essential in designing the I-O and CBA models. The secondary data were assessed and used from the official statistics, government databases, academic journals, organizational reports etc. Rationale: necessary for designing the models in defining inputs and assumptions for the scenario design.

Semi structured interviews are selected to collect in-depth qualitative data from key policy makers to gain specific insights on the subject: experiences, insights, and concerns regarding the process of transition. Interviews helped in exploring the complex policy factors on the feasibility and implications of the transition in the region. They offered more nuanced policy and governance relations and perspectives for the context beyond the publicly available information and discourse.

Surveys were used to gather quantitative data on stakeholders' perceptions, attitudes, and preferences related to the governance of transition, risks from insufficient stakeholder engagement and perception for implementation of the place-based approach and levels of stakeholder engagement.

The research employed a non-probabilistic sampling strategy for both semi-structured interviews and surveys, focusing on participants with specific knowledge and expertise relevant to the study's objectives. For the semi-structured interviews, participants were deliberately selected based on their roles as policy makers, implementers, or direct supporters of the just transition in the region. This targeted approach ensured that interviewees possessed in-depth knowledge and experience pertinent to the research questions. Similarly, the survey sampling technique targeted individuals well-informed about the green transition process, including representatives from central and local government, civil society organizations, and field experts. By utilizing this purposive sampling method for both data collection techniques, the study aimed to gather rich, relevant insights from key stakeholders and informed individuals, enhancing the quality and depth of the data collected on the just transition and green transformation processes.

Data Analysis Procedures

The research employed a mixed-methods approach for data analysis, combining thematic analysis, statistical analysis, and content analysis. Thematic analysis was used to draw conclusions from semi-structured interviews on specific themes such as policy design, governance, structures, mechanisms, intergovernmental collaboration, strategic plans, and obstacles. Statistical analysis techniques, including descriptive and inferential statistics, were applied to analyze survey data and present visual representations where needed. Content analysis was utilized throughout the desk research to interpret data from various sources, including documents, reports, and legislative frameworks.

The research instruments included Cost-Benefit Analysis (CBA) and Input-Output (I-O) modeling. The I-O approach employed regionalization of national input-output tables using local quotients to estimate regional coefficients. This method was used to compute multipliers for jobs and value-added, which informed the CBA assumptions. The CBA followed a three-step approach: defining requirements and assumptions, obtaining and systematizing data, and analyzing monetized costs and economic benefits for each scenario option.

Ethical considerations

Ethical considerations were prioritized throughout the research process. Participants were informed about the study's purpose, objectives, and scope, and their consent was obtained prior to participation. Confidentiality and privacy protection measures were implemented, with personal information fully anonymized. In rare cases where institutional representatives expressed personal opinions contrary to official stances, these were either omitted or fully anonymized if deemed relevant to the research.

Limitations and challenges

The study faced several limitations, including data availability and quality issues, challenges in stakeholder representation, and the influence of contextual factors beyond the study's control. Time and resource constraints also limited the scope and depth of the research. To address these limitations, the researchers relied on multiple data sources, applied triangulation methods, and prioritized research objectives based on available resources.

The research findings and policy implications are context-specific, which limits their scalability to other regions. However, by combining different methodological approaches and contextualizing the findings within the local context, the study aimed to provide a robust and comprehensive analysis of the socio-economic impact of the TPP Oslomej phase-out.

While the research generally adhered to the planned timeline and activity schedule, some activities were completed ahead of schedule, while others were postponed due to various contextual reasons, external dependencies, and methodological adjustments. These changes were documented in periodic activity logs to maintain transparency and accountability throughout the research process.

4.3. Policy and Legal Context

Current energy landscape in North Macedonia

Fossil fuels continue to play a significant role in North Macedonia's energy mix, with electricity generation being the primary contributor to the country's greenhouse gas (GHG) emissions. The domestic energy production in RNM indicates a trend of decreasing production and increased import dependency[32]. Recently, there are indications of gradual dependency decrease on coal-based production, nevertheless the contribution of the coal-fired thermal power plants (TPP) is still contributing to around 70% of the domestic production (ERC, 2023).

The production of the electricity by the coal-fuelled TPP Oslomej, situated in the Southwest planning region (SWPR) contributes with less than 5% of the total domestic electricity production (ERC, 2023)[33]. At the same time, RES contribute to around 29% of the energy production[34] predominantly from hydropower (25% hydropower, and 4% from solar, wind and bio sources cumulatively). Coal's heavy use in energy production, widespread reliance on wood and coal for heating, and elevated levels of pollution from transportation all play a part in air quality problems and total emissions. Electricity production accounts for approximately 60% of total greenhouse gas emissions, while the transport, heating, and agricultural sectors each contribute with around 10% (MoEPP, 2023).

In addition, North Macedonia has an aging and outdated energy generation infrastructure that heavily relies on fossil fuels. This poses a significant challenge but also offers the potential to improve energy efficiency and security. The country has set ambitious targets for reducing greenhouse gas emissions, with a strong emphasis on advancements in the energy sector[35]. Meeting these goals will require substantial reductions in emissions across all economic sectors, particularly focusing on the energy industry. Following the European Green Deal (EGD), and as a contracting Party of the Energy Community (EnC, 2006), North Macedonia has committed to working towards achieving climate neutrality by 2050 while also matching current per capita GDP levels of some neighbouring EU countries (MoE, 2019, Energy Development strategy). In 2021, the country pledged to reduce GHG emissions by more than 50 percent compared to 1990 levels by 2030.

Progress in reducing GHG emissions and air pollution has been limited. The country, however, has paradoxically increased energy production by reviving older energy generation capacities in response to the recent energy crisis. In the onset of the energy crisis RNM derailed from past policy efforts and instead of decreasing it increased the coal fuelled energy production. However, at the same time there has been accelerated private investments in RES, particularly in photovoltaics (PVs)[36]. This last development is in line with the decarbonization strategy efforts for increased RES share, and the overall Enhanced National Determined Contributions (MoEPP, 2021a; MoEPP, 2021b) objectives outlined in the energy and climate strategies (MoEPP, 2021c).

Decarbonization policy landscape in North Macedonia

The national and sectorial strategic documents provide direction for decarbonization efforts in the energy sector (MoE, 2019), with the aim to create integrated internal energy market which is more efficient, environmentally friendly, and competitive in supporting the economic growth. Likewise, the country's climate policy and strategic documents (MoEPP, 2021c) outline the commitments to mitigation and adaptation. These decarbonization plans hinge on the expansion of RES (mainly hydropower plants and PVs), to reach 38% of gross energy consumption from RES by 2030 and the goal for RES in the electricity sector production to reach 66% by 2030. Nevertheless, the investment needs to achieve these targets are large with ambitious investment agenda in place. The two crucial strategies for climate action and energy (MoEPP, 2021c; MoE, 2019) as the most comprehensive documents outlining climate change measures including the plans for decarbonization & adaptation, estimate capital investment needs (both public and private) in the range between €18.5 bill. to €34.1 bill. (through 2050), which

[32] The production of electricity of JSC ESM in 2021 compared to 2010 has decreased by 50%.
[33] Production contribution for Y2022, which has drastically increased in 2021 and 2022, after gradual decrease starting from 2012 to 2020; local coal reserves have been depleted and the increased production is fueled by externally procured (imported) coal. Energy and water services regulatory commission of RNM (ERC), Annual reports, (2023)
[34] RES electricity production is variable on an annual level, foremost due to the hydro power plants capacities.
[35] In 2021 the country pledged to decrease GHG emissions by more than 50 percent by 2030 (compared to the1990 levels).
[36] According to ERC statements, during 2022 and 2023, 551 MW newly installed and operational RES PV capacity are added (399 MW in 2023, 152 MW in 2022).

would be 4.3-8.0% of the annual GDP (Y2023). The viability for securing and leveraging funding of such a colossal size[37] is questionable given the history of the outturns of such ambitions failing to effectuate fast or at all. For instance, it had been already set that the decommissioning of TPP Oslomej to have taken place in 2021, which did not occur and has been postponed yet again. There is no guarantee that the region will abide by the opting-out commitment on the legacy coal-fuelled power plants as in 2021 the EnC initiated legal cases against four of the WB countries for breaching emission ceiling (EnC, 2021).

It is undoubtedly that the success of decarbonization via coal phasing-out (as well as other climate adaptation endeavours) by large will be determined by the local adaptive capacity. The complex nature of the interplay between the adaptive capacity and the 'place' calls for an inclusive unequivocally all-social efforts and engagement. Thus, the more mindful is the approach in which 'places' shape the collective understanding of just transition, the better it will be for effective actions to be taken. The transition design or conceptualization of the overall green transitions based on a specific place-based aspects are still lacking in the country. The advancement on a policy level yet considerably determined by the top-down central level, can be noted in the national document Just transition roadmap (MoE, 2023b) and the Investment plan for accelerated coal transition (MoE, 2023a) which envisage the closure of the plant as most viable option coupled with intentions for replacement of energy with PV RES.

4.4. Theoretical framework / literature review

The term 'just transition' refers to "[greening the economy in a fair and inclusive way of everyone concerned ..., creating decent work opportunities and leaving no one behind]" (ILO,2022[38].).[39] Originating in the 1970s in the late 1990s and 2000s, the ICFTU incorporated the concept into climate discussions, emphasizing the necessity to address employment concerns arising from the decarbonization of economies. Initially it was focused on "justice for workers" and later on the concept evolved to encompass broader principles of equity in transitioning towards environmentally sustainable economies. It typically applies to economic contexts dominated by industries with significant environmental impacts, where a large portion of the population is employed in these industries, and the local economy is heavily reliant on them. Nowadays more widely and broadly underscores the importance of ensuring widespread and equitable distribution of benefits and minimizing the burdens of adjustment across countries, communities, and population groups during the transition (IRENA, ILO, 2021[40])

Transitioning away from coal in energy production stands as a pivotal element in attaining regional and global carbon neutrality goals (as per Paris Agreement) which is requiring a swift reduction in coal usage. This shift entails reallocating resources and reshaping employment landscapes, potentially leaving workers stranded and affecting communities. Nationally, this transition is anticipated to yield socioeconomic and distributional ramifications, and especially in the two coal dependant regions Southwest and Pelagonia where the two thermal power plants are located.

TPP Oslomej is located in municipality of Kichevo in the SWPR. The closure of coal mines and coal field power plants is considered to be a 'social episode' as it is impacting individuals, households, families, communities, and local governments. Understanding and effectively managing this transition is crucial for ensuring its fairness and justice[41] The theoretical and empirical literature[42] extensively discusses the socioeconomic effects of coal pashing out, however the governments and the private sector often overlooked these impacts, as argued due to lack of necessary 'social performance capabilities' i.e. to effectively recognize, evaluate, and address the significant social

[37] **This raises another flag of caution as the PIM processes are weak and the past paints a picture of investment outlays have not been efficiently nor effectively been realized with significant capital budgeting bias.**

[38] ILO, 2022, "Gender equality, labour and a just transition for all", October 2022 Policy Brief, p.3.

[39] The concept of 'just transition' was created by trade unions in the 1970s, while the activist Mazzocchi T., is credited to coining the term. Eisenberg, 2019, "Just Transitions." The concept of 'just transition' was created by trade unions in the 1970s

[40] IRENA and ILO, 2021, "Renewable Energy and Jobs – Annual Review 2021", p.84.

[41] Chaloping-March, M., 2008. "Business Expediency, Contingency and Socio-political realities – a case of unplanned mine closure". In Fourie, A., et al. (Eds.), Proceedings of the Third International Conference on Mine Closure. Australian Centre for Geomechanics, Perth. pp 863–872.

[42] See Bainton, N.A. and S. Holcombe, 2018, "The Social Aspects of Mine Closure: A Global Literature Review." Centre for Social Responsibility in Mining (CSRM), Sustainable Minerals Institute (SMI), The University of Queensland: Brisbane.

risks and trends associated with the transition (World Bank, 2022[43]). Additionally, while governments typically mandate ex-ante impact assessments, the experience shows that the focus has been on the environmental rehabilitation and site/location decommissioning rather than addressing the socioeconomic transition (Owen, et. al,2018[44]).

Government policies play a crucial role in shaping the socioeconomic impacts of power plant retiring. However, each region and locality has its unique characteristics, thus tailored measures are necessary to facilitate a just and fail transition. The presence or absence of suitable government policies and regulations significantly influences the social outcomes and the socioeconomic effects, and vary depending on whether the affected area is diverse, developed economy or it relies heavily on the coal plant which is undergoing closure (or repurposing). It's thus to be expected that regions dependent on a single industry (not diversified mono-industry) will face challenges in adapting. On the bright side moving away from coal can unearth new opportunities, and identifying and effectively managing these opportunities is key to laying the groundwork for sustainable development in the long term. Nonetheless, there are limited detailed case studies showcasing such successes (Bainton et al. 2018[45]). On the other hand, there is evidence suggesting that poorly managed transitions can have enduring negative effects (Beatty, 2019[46]).

Generally, the multifaceted and evolving nature of the social dimensions surrounding power plant closures renders them unsuitable for conventional project management approaches employed in the physical decommissioning process. Thus, these social aspects necessitate specialized attention. The closure or the coal-fired power plants (TPPs) is not a onetime event but a process of extended period that can span from several years to as much as decades, particularly when they are the backbone of the local economies and communities. There's a growing body of good practice guidelines addressing the social aspects of closure (eg. Wuppertal Institute 2022[47]; World Bank 2020[48])

Irrespective of the unique attributes of individual countries or regions, the conceptualization of energy transition, sufficiently addressing the imperatives of sustainable development encompassing decent work, regional development, and social equity, stands as a fundamental requirement for formulating local, regional, or national action plans (Sharpe and Martinez-Fernandez, 2021).

Transition to a greener and energy-efficient, renewables-based power sector in the North Macedonia should be relatively easy as there are not many TPP capacities. Nevertheless, the country notes decades of underinvestment in the energy sector and delays of coal phasing out, thus the lagging energy sector. The fact remains that the energy transition faces obstacles some of which are evidently the large coal dependence (thus energy (in)security) and relatedly the politics for energy in general.

A crucial aspect of achieving the energy transition to an environmentally sustainable – green transition, is a largely a matter of justice, as people which are either directly and indirectly affected in the particular territories are in vulnerable situations, and stand to suffer the most, therefore the way and approaches of how it is to be done matters vastly. Although these transitions are necessary and at this point only a matter of when and how, (not if) a top-down approach is not generating effective measures fast enough and to the desired levels (UNEP, 2020; Rogelj et al, 2016; Schindler, 2019, etc.) and the speeding up on the coal phase-outs will need further efforts of political action. The importance of local communities is central in energy just transition process, as it is more importantly of

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[43] World Bank, 2022, "Just Transition for All. A feminist Approach for the Coal Sector".

[44] Owen, J. and D. Kemp, 2018, "Mine closure and social performance: an industry discussion paper". Centre for Social Responsibility in Mining, Sustainable Minerals Institute, The University of Queensland: Brisbane.

[45] Bainton and Holcombe, 2018, "A critical review of the social aspects of mine closure", Resources Policy 59 (2018) 468–478.

[46] Beatty, C., Fothergill, S. and Gor, T., 2019, "The State of the Coalfields 2019". Available at: https://www.coalfields-regen.org.uk/wp-content/uploads/2019/10/The-State-of-the-Coalfields-2019.pdf.

[47] Wuppertal Institute (2022). Just Transition Toolbox for coal regions. Available at: https://www.coaltransitions-toolbox.org/

[48] World Bank (2020). Mine closure A toolbox for governments. Available at: https://documents1.worldbank.org/curated/en/278831617774355047/pdf/Mine-Closure-A-Toolbox-for-Governments.pdf

how the process of energy transition is being managed while not only when and if the set targets and objectives are achieved (for example see Van Veelen & der Horst, 2018; Hess, 2018).

There are more than a few approaches to estimating the costs and benefits from coal phase out and the economic impacts of the transition. One of these is through the use of a cost benefit analysis (CBA) as commonly used in the efforts to quantifying the effect of policies to initiate debate for designing public policies and not only for coal plant decommissioning or repurposing but in other energy related fields (e.g. Arrow et al., 1996; Dietz & Hepburn, 2013; Jindal & Shrimali, 2022; Araújo et al., 2016; Wang et al., 2015, Noel & McCormack, 2014; Sidhu et al., 2018) including climate policies (e.g. Tol, 2001).

There are abundance of studies focusing on retirement and decommissioning of coal plants and its various aspects, some of which are Fleischman et al. (2013) and Raimi (2017), for the economic returns of the uneconomic coal plants, Kefford et al. (2018) focused on the effect of early coal plant retirement and communities, as does Shrimali (2020). Furthermore, other studies examined the impact of decommissioning on the local communities such as Haggerty et al. (2017), finding that there are significant negative consequences of an uncoordinated, local environmental policy, Hamilton et al. (2017), examined transition support mechanisms for local communities and recommended aligned policies for workforce development, while Rinscheid & Wüstenhagen (2019) examine citizens' perspective, etc.

Furthermore, the issue of solutions which may be technically and economically achievable, are not always feasible due to political and social aspects (see more in Biehl et.al (2023); Jewell & Cherp, 2020; Ribera, 2020, etc.). Input-output models are also another venue taken by authors, or a combination with other methods, such as in Heinrichs et al. (2017), Feng et. al. (2023) examined the loss of jobs in the lignite sector and interrelated sectors Pao-Yu (2019) and correlated social costs.

4.5. Policy Structure

4.5.1. Governance Structure

Transition from coal to RES presents a blend of variety of opportunities and obstacles at the same time for RNM and the SW region. Achieving the full economic and social advantages demands a holistic and inclusive approach. Collaboration among the governmental entities, industries, and local communities is essential to ensure a smooth and fair transition to a sustainable economy, leveraging territorial and place-based potentials, skills, and knowledge.

The proposed institutional structure for JT in RNM, is envisaged to be a 'hybrid' model led by a National Coordinator (the Minister of Economy), overseeing a Just Transition Council & Secretariat (composed of various ministries and stakeholders). The structure to date is in its initial stage and its 'success' is to be seen however it is already perceived as following top-down approach which is not sufficiently inclusive. It is recommendable that the structure relies on the lessons learnt from other structures which are relatable and have been externally supported and initiated, which have become non-functional (eg. NCSD and NCCC).

Within the JT structure the envisaged regional working groups should serve as essential platforms for linking and adjusting state and regional policies and actions to achieve a sustainable JT, particularly in the two regions that are most affected with the transformation process, one of which is the SW region. Nevertheless, the envisaged design should be appropriately operationalised, technically backed and financially supported with a clear operating plan in order to focus on addressing the specific needs and challenges particularly in the directly affected municipalities, in this case Kichevo.

At the same time the local authority, the most to be affected municipality – Kichevo, perceives that their engagement in the design phase of the national governance structure has been limited. They have not been sufficiently involved and therefore they consider the governance structure as imposed. Furthermore, given the overall national governance context and structure they also see themselves on the outskirts due to not being powerful enough to have effect on the national policy design. The major concern for the local economy is that if it is not appropriately supported there is an anticipation of a worst-case scenario which will further aggravate and induce outmigration of the labour force, affecting negatively the demographic and socio-economic structure of the region.

The research findings indicate that North Macedonia requires a broader societal consensus on a decarbonisation approach and the energy transition. The consensus between relevant stakeholders, including civil society, academia, and the private sector, lacks. A just transition plan for the coal phase-out could facilitate this process and the recently adopted Just Transition Roadmap (June 2023) envisages activities and actions to contribute to this end. Therefore, the government's responsiveness to just transition concerns should be strongly improved by heightened with comprehensive stakeholder representation in the formal decision-making mechanisms. Tailoring place-based transition support policies to address the needs of the affected is crucial for fostering acceptance of coal phase-out policies to be specifically tailored to the SW planning region and the area of Kichevo.

4.5.2. Stakeholder engagement

The green transition is an essential process that aims to alleviate the impact of climate change while attaining sustainable economic growth in the long run. North Macedonia has recognized 36 significant stakeholders in the green transition, including governmental entities, consulting firms, public organizations, start-ups, non-governmental organizations, community groups, academic institutions, and research sectors.

- Government actors, who make up the majority of key actors, play an important role in shaping policies and regulations that promote the green transition and decarbonization. To ensure effective implementation of the green agenda, a more holistic and horizontally coordinated approach is required.
- Civil society actors, such as non-governmental organizations (NGOs) and community groups, play an important role in raising awareness and advocating for sustainable practices. They frequently collaborate with government and other key stakeholders to promote sustainable practices and ensure that the green transition benefits all members of society.
- Consulting firms and start-ups that offer expertise and innovative solutions are critical in promoting long-term economic growth and reducing the environmental impact of various industries. They help in investing in renewable energy technologies, waste reduction, and sustainable agricultural practices, among other things.
- The academic and research sectors provide important insights and knowledge that guide the actions of other key actors. They conduct research on various aspects of the green transition, such as renewable energy, climate change, and sustainable development, and help to develop innovative solutions.

Nevertheless, a more coordinated approach that involves all key actors is necessary to ensure the effective participative implementation of the green agenda and achieve a sustainable low-carbon economy in North Macedonia. Collaboration and coordination among these actors are critical to ensuring the just transition. The research, however, indicates that the country's green agenda is being led individually by specific Ministries rather than through a holistic and horizontally coordinated approach.

In the process of conducting the research the following activities for stakeholder engagement during the research process were implemented particularly in assessing the governance of JGT in RNM:

Table 106. Stakeholder engagement table

Activity	Contribution to research	Engaged Stakeholders
Stakeholder mapping - identification of key stakeholders responsible for JT decarbonisation-related processes in North Macedonia, and mapping of their roles and responsibilities.	The stakeholder mapping contributed to the design of the research scenarios. Additionally, it helped in framing the policy and strategic context, and in identifying potential risks, assumptions, opportunities and	5 stakeholders: MoE Energy sector, MOEPP, RBD, Municipality of Kichevo, CRD SWPR 3 female + 3 male participants

	limitation to the development and implementation of the research scenarios.	
Preparation of semi-structured questionnaire, and scheduling and implementation of interviews with relevant stakeholder representatives	Conducted detailed interviews on the policy aspects of JT and decarbonization with policy stakeholder representatives relevant for feeding-in information to all scenarios, especially on scenario 3 where JT policy plans and expectations are considered.	3 stakeholders: MoE – Energy sector, MOEPP, Ministry of Labour and Social Policy (MLSP) 4 female + 2 male participants

Source: Authors

In the following phase, CEA will conduct validation of the findings and preliminary scenarios developed with the input-output and CBA, through focus groups with relevant stakeholder representatives and will implement a public awareness poll, through the social media network, to assess the citizen awareness and opinion about the JT process in the SWPR region.

Governance Assessment – Findings from interviews with relevant institutions[49]

All interviewed parties agreed that the just transition process is a complex issue that requires multi-stakeholder involvement, and active participation and involvement. When the interviews were conducted, the governance structure was not yet formally approved, but all interviewees were informed about it, and agreed that the Ministry of economy should steer the process, since it is responsible for the Energy policies and strategy, as well as for the coal phase-out.

The interviewees see the complexity of the issue, and raise the importance of coordinated effort, where all concerned parties will have a sit at the table and contribute justly to this complex issue. In that sense, the proposed structure, that involves the Prime Minister as Chain, and all line ministries engaged, is perceived as adequate.

One of the concerns expressed was the potential oversight in adequately addressing all aspects of the Just transition, as a complex process if it remains to be managed through the Energy Sector at the Ministry of Economy. Namely, without a dedicated Sector for Just Transition some critical issues such as environment impact and impact on vulnerable communities, may not receive the necessary attention and care during the transition process.

The central government institutions' representatives see the importance about proactive engagement of the local government on this matter. However, their concern is that the local government does not recognise their role in the process, and takes passive participation, which was confirmed with the interviews with the local self-government representatives. Namely, the local government sees this as centrally-led / imposed process, in which they have little to no saying. The communication is from central to local level, and the local self-government representatives do not feel they have power to influence or shape the policies and support measures that facilitate the process (even though they are formally consulted and informed). One of the key questions raised on local level is if the just transition process will not provide access to equally paid jobs for the employees that are directly affected. The salaries in the energy sector are significantly higher compared to the average salary, and this being an employment in state owned enterprise is considered a "secure" job, unlike in the private sector. The risk of failing to match the salaries (economic benefits) for the employees and other stakeholders in the supply chain that will be directly tackled with the just transition process is expected to lead to economic out migration of entire families. This will have a major and long-term impact on the local economy, labor market and the development of the entire micro region.

[49] The interviews with the state institutions representatives took part from 08-22 May 2023. The Researchers conducted interview with representatives from the MoE, MoEPP, MLSP, representatives from the LSGU Kichevo, DEU

Another issue raised, referred to the overall capacities of the different stakeholders to uptake the transformation process. This includes the capacities of the relevant national and local institutions, but also of the private and civil society sector.

Thus, the success of the just transition depends on the collective capacity of all stakeholders to effectively fulfil their respective roles. Failing to address capacity gaps within any of these sectors may result in significant bottlenecks, compromises, and setbacks in the transition process as a whole. Therefore, capacitated stakeholders are important for achieving a smooth, inclusive, and sustainable transition.

Overall, the assessment of the governance approach of the just transition process shows that multi-stakeholder and complex issue as the just transition requires well-governed, inclusive and coordinated process. It is crucial to address adequately the complexities of the matter, prevent oversights, and build the capacities needed to overcome challenges and seize opportunities associated with the transition process.

4.6. Scenario Development

The discussion surrounding climate neutrality in RNM largely centres on national policies aimed at climate neutrality, as outlined in the Green Agenda and related climate-related laws and strategic documents. However, the focus primarily revolves around technical aspects of transition, particularly within the energy sector and specific industry actors such as coal-fired thermal power plants (TPPs).

While climate and energy policy documents prioritize the technical aspects and effects of TPPs, there's a noticeable lack of consideration for the socio-economic aspects of the transition. This is particularly evident in addressing the challenges faced by local communities during the transition period.

Upon analysis of strategic documents, it becomes apparent that there is currently no clear, integrated plan addressing decarbonization, especially on a regional level, that comprehensively considers the socio-economic welfare, such as the TPP Oslomej in the SWPR.

However, there's a growing momentum for the concept of a just transition in North Macedonia, particularly concerning the retirement of coal-fired thermal plants, driven by international entities like the EU, OECD, and EBRD. Efforts are underway to develop policies and structures for coordinating just transition efforts, although these processes are currently confined to institutional channels and lack broader public visibility.

The South-Western region has been identified as an environmental hotspot in various national strategic documents, highlighting the need for improvement in long-term planning regarding spatial plans, environmental protection, health, economic development, and sustainable growth. Efforts have been made to assess the socio-economic implications of various scenarios under specific assumptions.

Given the policy context and stakeholder discussions, three scenarios have been devised and selected for assessment, with the scope remaining largely consistent but incorporating contextual changes. These scenarios aim to explore the potential impacts of different transition pathways.

The SW region has been identified as hotspot i.e. hazardous spot for the environment in a number of national strategic horizontal or vertical documents. This needs to be improved, in terms of the long-term planning of the spatial plans of the country, environmental protection, health protection, economic development and sustainable growth, etc. Hence, efforts were made, to evaluate the socio-economic implications on the society in case of several scenarios under certain assumptions.

Given the policy context and the co-design discussions with stakeholders at the onset of the project, exploring the impact of three possible scenarios was devised. The scope of the scenarios has largely remained the same during the past period with some changes reflecting some contextual changes. The three scenarios devised and selected to be assess are explained below.

Scenario 0 – Business as usual (Closure of TPP Oslomej by 2027 without Transition) – baseline scenario

This baseline scenario assumes that no preparatory or transition activities will be undertaken, and the TPP Oslomej will continue to operate as usual until its policy-committed closure date in 2027. In the absence of any mitigation measures, the expected outcome is that the plant will cease operations without any compensation for job losses or economic value added that will be lost as a result of its closure.

Scenario 1 – Decommissioning with Technical Activities and Just Transition (by 2040)

This scenario is more progressive than Scenario 0 and involves the closure of the TPP Oslomej in accordance with international standards and relevant technical requirements. The decommissioning process will encompass decommissioning, remediation, environmental abatement, demolition, and cessation of coal-based production at the plant. To mitigate the economic, social, and environmental impacts in the SWPR, just transition measures related to the affected labour force will be implemented. The expected outcome is that the TPP Oslomej will be decommissioned and proper transition activities will be completed by 2040.

Scenario 2 - Decommissioning with Just Transition via Partial Renewable Energy Substitution (RES/PV) and Labour Transitioning (by 2040)

This scenario builds upon Scenario 1 by additionally incorporating partial substitution of energy production with renewable energy sources (RES) with PV systems investment. The scenario also envisions alternative economic activities in primary, secondary, and tertiary economic sectors in the SWPR region to substitute for the added value and direct employment opportunities for workers currently employed at Oslomej and those indirectly affected. This advanced scenario is expected to achieve a more comprehensive transition by ensuring that TPP Oslomej is decommissioned and proper transitioning activities with functional energy substitution have been completed by 2040.

It is to be acknowledged that the development of each economic activity sector in the region has not been considered in these scenarios, with factors such as market value evolution, existing and future market trends, investment return periods, institutional engagement, and provision of a favourable environment for substitution have not been taken into account. Future studies should consider these parameters to provide a more nuanced understanding of the potential outcomes of each scenario.

4.6.1. Scenario analysis – Approach 1: Input output analysis

Scenario 0 - Closure (Retiring) of TPP Oslomej by 2027 (Baseline Scenario**)**	**Scenario 1 –** Decommissioning According to Standards and incudes Just Transition Activities	**Scenario 2 –** Decommissioning with Just Transition via Partial Substitution of Energy Production
Envisages/assumes that the TPP Oslomej will be closed down (retired) without any preparatory activities or activities that will that will mitigate effects such as compensation for job substitution or other transition activities to reduce the effects on both the regional economy as well as for workforce. - the local multipliers for the sector indicate expectations for jobs losses and the economic value added losses upon closure that will affect the sector directly as well as other interlinked sectors of the regional economy. **Assumption of the scenario 0:**	Envisages**/**assumes closure of the TPP Oslomej which is in accordance with standards and relevant technical activities – i.e. decommissioning process which includes remediation**,** environmental abatement**,** demolition**,** and ceasing of operations of TPP Oslomej**,** which in this process will generate modest economic activities in the same sector up until the completion of the decommissioning process. **Assumptions**: Under the scenario 1 of decommissioning of TPP Oslomej with be with proper (technical) activities for including engineering, preparatory and cleaning**,** safety, separation and demolition activities. The scenario	Closure of TPP Oslomej with just transition measures undertaken for full direct job substitution in RES/PV and in the another sector. **Assumptions**: Under the scenario 2 builds up the S1 of decommissioning of TPP Oslomej and assumes activities of transition measures for substitution of the direct job losses and absorption in the other sectors. The distribution of the substitution effect is expecting partial RES/PV workforce absorptions (16%) while the remaining equally distributed by the primary secondary and tertiary sector. The RES/PV assumption of the number of jobs that can be potentially

Under the scenario, for I-O, the TPP will be closed at once and there will be no activities concerning remedial or job transition of the current employees, neither there would be activities for standard and technically proper preparations for decommissioning. TPP will operate (as now) until closure and as of current policy documents to take place in 2027, i.e. life span of 5 years – production from imported lignite.	assumes activities according to which processes that need to be implemented on-site lasting seven to ten-year period to prepare the location for brown field investment and full removal of the facility. Since there is no specific decommissioning study for TPP Oslomej[50], assumptions from comparable literature and examples are used.	absorbed is based on the plans for jobs created by the announcements for new PV units on the site. The remaining are equally distributed in the other sectors.
Expectations: **Employment**: closure of the TPP with no other actions, based on the regional multipliers is estimated to have the overall effect of: job loss of 965 as direct FTEs from the TPP Oslomej as one-off event (in one year). And additional 1,223 indirect FT job equivalents will be lost; Total of 2,198 jobs lost in the SWPR **Gross Value Added:** Considering the connectivity and the interrelation of the sectors, the region will face a loss of value added that contributes to the regional economy: directly will be 470.8 mil MKD and additional indirectly 601.7 mil MKD (thought the related sectors) or Total of 1.072 mil MKD (~17.4 mil EUR). Besides the direct effect within the mining and energy sector, the indirect effect will mostly have affected the same sector group (Mining, manufacturing, electricity, gas and water supply, sewerage, waste management, remediation activities) followed by the sectors wholesale and trade, and agriculture and forestry.	Expectations: **Employment**: decommissioning scenario, based on the regional multipliers is estimated to full decommissioning completion, there would be overall job loss of 612 direct FTEs from the TPP Oslomej as one-off (in one year) while 353 FTE will be used in the decommissioning process (estimated for seven to ten years), and another 782 indirect jobs will be lost. Total of 1,395 jobs lost in the SWPR if the TPP is closed via proper decommissioning. **Gross Value Added:** Considering the connectivity and the interrelation of the sectors, the region will face a loss of value added that contributes to th regional economy, directly effect of 299 mil MKD and additionally indirectly 382 mil MKD or total of 680.5 mil MKD (~11 mil EUR). Besides the direct and indirect effect within the same sector, most affected sectors are expected to be wholesale and trade, and agriculture and forestry.	Expectations: **Employment:** decommissioning with full job transiting structure spread across the RES units, and equally between the thee general sectors will absorb the fully the direct employment, however given the regional quotients for the linkages between the sectors 'feeding' employment together with the indirect FTE effect would result in 1233 FTE lost, but at the same time create 936 indirect FTEs, mostly in the secondary sector. On a balance, the overall effect will be almost 300 overall FTE lost in the SWPR. **Gross Value Added:** Considering the connectivity and the interrelation of the sectors, the region will face a loss of value added that contributes to the regional economy, directly with an estimated value of 37 mil MKD and additionally indirectly loss of 103 mil MKD or total of loss of 66 mil MKD. Besides the direct and indirect effect which are largest in the same composite sector, the next positively affected sector is trade (wholesale and retail).

Source: Authors

[50] The absence of decommissioning study for TPP Oslomej, to date - June 2023, confirmed by MoE. The just transition policy planning with the intended strategic documents to be prepared/enacted and structures set up, referred to as 'Road map' should encompass a decommissioning study.

Table 107. Estimation of employment and economic value added contribution

#			Mill. EUR
Direct jobs – FTE*	965	GVA* - Direct	7.65
Indirect jobs - FTE	1,233	GVA - Indirect	9.78
Total	2,198	Total	17.4

* FTE-full time equivalent; GVA-gross value added

Contribution of potential losses in %

Total Employment in SWPR (#)	75,292	2.9%
Total GVA – SWPR (mil. EUR)	848	2.1%

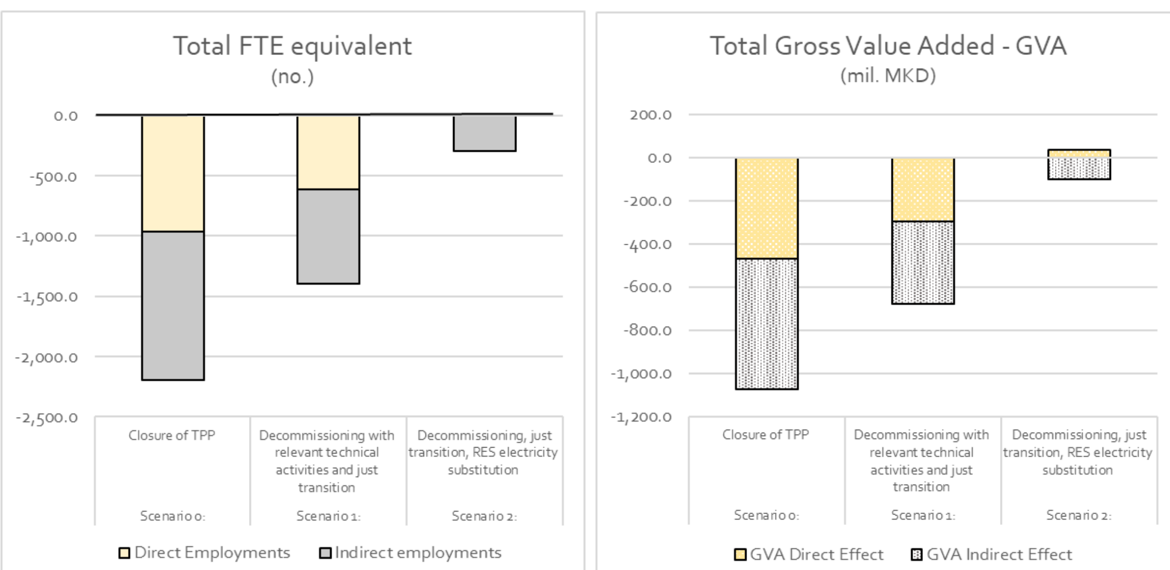
**SWPR-Southwest planning region of North Macedonia

Indirect effect distribution in other sectors in % (NACE)	
B_E Mining, manufacturing, electricity, gas & water supply, etc.	82%
G_I Wholesale and retail trade	6%
A_ Agricul. forestry&fishing	4%
F_Construction	2%
O_Q Public administration, etc.	1%
M_N Professional, scientific and technical activities, etc.	1%
K Financial & insur.	1%
RSTU Arts, entertainment and recreation, etc.	1%
L_Real estate	1%
J_Information & comm.	0%

*NACE, Nomenclature of Economic Activities

Source: authors calculation based on input-output analysis derived for SWPR; primary data based on SSO's: SIOT tables, labour statistics, regional statistics and information from ESM annual reports.

Figure 14: Scenario comparison – I-O: FTEs and GVA



Sources: own calculations

- The scenario comparison with this method indicates that seen through the indicators of FTE (full time employment equivalent) loss/generation and GVA gained/loss the closure of Oslomej (in any point in time) will generate a loss of almost 2,200 full time equivalent jobs, almost half of which through direct job loss (the current employees in TPP Oslomej) and a little more than a half in the interlinked sectors within the regional economy.
    - The largest impact as a result of the multiplying effects in other sectors is expected in the same cluster of sectors: mining, processing industry, electricity supply[51], followed by wholesale and retail trade, and agriculture.
- In terms of GVA the closure of Oslomej will generate loss of 1.072 mill MKD, ~40% of which can be attributed to the direct activity of the entity, and 60% from the indirect multiplying effect on the related sectors, largely in the same sector group where mining and electricity belongs, and less in wholesale and trade, and agriculture sector.
- The alternative scenarios which assumes that there are activities which will enable immediate process of transition of the labour and substitution in the three sectors: agriculture, processing and services, and the PV investment production site can generate employment for most of the lost jobs however does not fully absorb the loss of FTE.
    - Restructuring of the local economy towards goal for generating additional gross value for the economy will require more efforts for redistribution in the sectors that contribute with higher value predominantly in the tertiary services sector.
- Workforce substitution activities aimed at reskilling, redistribution and assistance in self-employment is necessary process that is the pillar of the social aspect of JT processes and will without a doubt at least compensate for the direct and indirect job losses and value-added losses in the regional economy. They essential component is timely implement the JT process for labour adaptation through systematic and organized manner to respond to the needs of the directly concerned and affected workers, and timely adjustment of the overall supply chains linked entities.

[51] Due to the lack of disaggregated regional statistical data, the effect cannot be further disaggregated.

4.6.2. Scenario analyses –Approach 2: Cost benefit analysis

PART 1: Financial evaluation		
Scenario 0	**Scenario 1**	**Scenario 2**
Assumptions: TPP Oslomej is to continue to operate up until 2027. (extended from the initially assumed 2025 as year of closure, due to the continuation of the operation of TPP Oslomej, with an expected lifespan of additional 5 years) based on Energy Strategy of RNM extension due to the energy crisis with increased rather than reduced production intensity. Production in the following years up to closure, will be in average 233 GWh per annum, which is the average amount of production in the last two consecutive years. The estimated reserves of coal locally are assumed to be already depleted from the site, based on the past reporting that the input - coal is procured via importing. **A) Investment costs** No new investments are foreseen in the period **B) Revenues** The revenues in the assumed production capacity, are estimated based on the average price for MWh of a surplus sold as per the annual report of ESM for 2022. For simplicity assumptions of the overall financial records of ESM AD for electricity production. **C) Operating costs** Due to the lack of detailed financial indicators, the share is considered as per AD ELEM reports and is projected in the	**Assumptions**: In the Decommissioning scenario for TPP Oslomej, which includes remediation, environmental abatement, demolition, and closure, just transition measures are planned to alleviate the economic, social, and environmental impact in the Southwest Planning Region. The central assumptions in this scenario are that TPP Oslomej will be retired as expeditiously as possible, coal-based energy production operations will cease immediately, and activities for the proper technical decommissioning will promptly commence. As of now, there is no decommissioning study developed therefore, assumptions will be based on a similar study. The projections cover a period starting from 2023, with at least one year allocated for planning. The implementation period for all technical measures (6 years) and cleaning (decontamination - 4 years) - expected to span optimally for 10 years. The decommissioning of TPP Oslomej with proper (technical) activities for including decommissioning are covering engineering, preparatory and cleaning, safety, separation and demolition activities. **A) Investment costs**	**Assumptions**: The Scenario 2 builds on extension of the previous Scenario 1 by adding an option of partial/full substitution of the energy production from coal production with RES photovoltaic energy production stations (RES PVS). The central assumptions in this scenario are that TPP Oslomej will be retired as expeditiously as possible, coal-based energy production operations will cease immediately, and activities for the proper technical decommissioning will promptly commence, while simultaneously substitution with an investment of 2 PV investments from the public sector (ESM) and 2 PV stations with the PPPs contracts[52] (2*10 MW PVSs+2*50 MW PVSs). The assumption is based on the viability taking into consideration the announced plans for such investments from the GoNM and the publicly available and non-confidential studies and reports of ESM and the creditors. **A) Investment costs** The decommissioning expenses that will be a cash outflow as projected in the Scenario 1 remain valid and are retained in this scenario. The new additional investments considered is the value of the public investments as contribution from the public partner ESM in the three PVSs as the years

[52] GoNM press release for announcement of PVs in Olsomej with PPP, https://vlada.mk/node/26857

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operating expenses with the same coefficient (7.03%) used for revenue and net profit assumptions. **D) Financial evaluation: net present value (NPV)** **Positive Financial (NPV) of 735 million denars (11.9 million EUR).** This indicates that the scenario is financially profitable, as there are no planned investments in the period, the plant has exceeded its useful life, and revenues from sales are still being generated.	No new investments are foreseen in the period reviewed in this scenario – this is divestment activity. **B) Revenues** The revenues from electricity production are set at 0 denars, because the primary assumption for decommissioning is to start immediately with full ceasing of operations. There is expected revenue stream from scrap at the end of the process i.e. from sales of the materials from the dismantling. **C) Operating costs – dismantling works** The operating costs for planning of the dismantling, security measures, dismantling and demolishing, supervision of the dismantling and demolition, preparation of the demolished materials, their transportation and removal, decontamination are estimated at least 34.3 mil EUR. The costs for soil revitalization of polluted soils are not considered in the cost and their consideration is another significant stream of funding that needs to be considered if it is taking place. **D) Operating costs – Labour engagement** As there will be a requirement for human resources to work over the next decade, for implementation of the decommissioning of the plant, approximately 350 full-time equivalent employees (both skilled and unskilled labour) will be needed during this period. It is anticipated that the current staff employed at TPP Oslomej can contribute to the workforce, mitigating the impact on the direct unemployment to some extent. The expenses will be allocated according to an annual schedule, with monthly costs determined by the demand for skilled and unskilled labour based on the average wages in the industry for the previous year. **E) Financial evaluation: net present value (NPV)**	preceding the announced operation initiation with values of 1.4 mil EUR in Y0, and 0.2 mil EUR in Y1. There will be no cash outflows for PPP contracts, but interest expenses will be incurred annually for five years based on loan conditions. Loan and grant investments are not considered as cash inflows or annuity payments as cash outflows, which partially offset each other. **B) Revenues** In Scenario 2, the revenues are consistent with the potential scrap value at the conclusion of decommissioning. Plus, the notable cash inflow will come from the electricity production revenues once the PVSs are up and running. The estimated production values are set at 15 GWh per year for PV1 and PV2, and 18% of the production for PV3, with prices aligned with average market rates on HUPX. **C) Operating costs** **Labour engagement** Over the next decade, human resources will be needed to carry out the decommissioning of the plant outlined in Scenario 1. In addition, labour requirements will involve a minimal number of individuals at the PVSs, with an estimated 1 Full-Time Equivalent (FTE) per installed Megawatt-hour (MWh) - equating to 10 for the first PVS and another 10 for the second PVS, with the annual cost of estimated annual salary costs for skilled labour. The engagement of an extra 100 FTEs will be necessary for the PPP PV, although these expenses will be considered outflows for the private partner. **Operations and maintenance (O&M)** Over the lifespan of the new investments from the public partner in the two PVs, the necessary O&M is estimated to be 1.5% of the total investment values.

	Negative NPV in the amount of 1.86 bil denars (-30 mil EUR) This scenario financially un-profitable as there are no new investments envisaged however there are substantial financial costs associated with the decommissioning activities for services and work as well for labour.	**D) Financial evaluation: net present value (NPV)** **Positive Net Present Value (NPV)** only if the projection's lifespan is extended to 25 years. It is a valid justification for extending the timeline, as investments of this nature typically have a longer lifespan The financial NPV amounts **to 621 million denars (approximately 10.1 million euros),** accompanied by an MIRR of 6% and an Internal Rate of Return (IRR) of 8.22%.

PART 2: Economic Evaluation - The economic valuation besides the financial costs and benefits, includes a series of additional identified costs and benefits related to the concerning scenario as additional to the financial flow to identify the economic profitability of the scenario

Scenario 0	Scenario 1	Scenario 2
E) Pollution Costs affecting Human Life The HRAPIE model takes into account the costs related to early deaths and health impacts, and placed into the given scenario for the average annual production, the cost of the pollution from TPP Oslomej costs are estimated at 91.5 mill MKD per year of operations (~1.5 mil EUR[53]) - based on the production and effects per GWh is estimated. 220 GWh production is equivalent to 1 human life lost and health costs of ~5,700 EUR per 1 GWh produced. **F) Social Costs and Benefits (savings): Jobs Loss vs. Substitution of Professions** These costs are directly related to number of unemployed persons due to the closure of the plant (assumed to start at 2027). The monetization of the costs will be based on the assumption that the cost will be equal to the amount of allowance in a case of unemployment due to business reasons – currently at 17% of the average gross national salary and 26% of the average net salary (Y2022). Starting from 2028 there would be additional 76 million denars as 80% of the employees will use this social assistance, while at least 20% is assumed that will immediately reintegrate in the labour market. As some of these employees are assumed to be able to transfer to other sectors, while others will acquire new qualifications and cannot be expected to remain inactive until the end of their working life, it is assumed that they will gradually re-enter the labour market at a rate of 20% per year, with 20% of them unable to reintegrate into the labour market (Y8 to	**E) Pollution Costs affecting Human Life / Benefits (Savings) with Cessation** The HRAPIE model takes into account the costs related to early deaths and health impacts, and placed into the given scenario for the average annual production, the cost of the pollution from TPP Oslomej costs are estimated at 91.5 mill MKD per year of operations (~1.5 mil EUR[55]). These are estimated to last at least two more years after ceasing of the operations, after which will be converted and considered as monetary benefits as these will not be burden to the society. **F) Social Costs and Benefits (Savings): Jobs Loss vs. Substitution of Professions & Reskilling** In this scenario the primary setup is envisioning decommissioning process plus appropriate measures for mitigating the effects for labour as a just process assisting the community and the mitigating the effects. Based on the anticipated labor requirements for the decommissioning process (as provided above), it is expected that a portion of the workforce involved in the decommissioning project will transition and be directly engaged in the decommissioning activities, thus partially alleviating the immediate job loss pressure. It is projected that a certain percentage of the direct labour force will be retained each year from Year 1 onwards (at 41%, 32%, 18%, and 11% for the period Year 1 to Year 4, and at 10% from Year 5 to Year 7 from the direct labour force), encompassing a mix of skilled and unskilled labour.	**E) Pollution Costs affecting Human Life / Benefits (Savings) with Cessation of Operations** The HRAPIE model takes into account the costs related to early deaths and health impacts, and placed into the given scenario for the average annual production, the cost of the pollution from TPP Oslomej costs are estimated at 91.5 mill MKD per year of operations (~1.5 mil EUR[56]). These are estimated to last at least two more years after ceasing of the operations, after which will be converted and considered as monetary benefits as these will not be burden to the society. **F) Social Costs and Benefits (Savings): Jobs Loss vs, Substitution of Professions & Reskilling** The direct job losses will generate costs which are financial burden on the social system due to unemployment and is arising from the current regulatory set up of the country. The costs in the state social system would arise as a result of the additional unemployed in the case of casing of the operations of the TPP and consider them as costs. These costs are directly related to number of unemployed persons due to the closure of the plant (assumed to start immediately). The monetization of the costs will be based on the assumption that the cost will be equal to the amount of allowance in a case of unemployment due to business reasons. These costs could amount to 99 thousand denars annually per person.

[53] Ibid.
[55] Mike Holland, The Unpaid Health Bill – How coal power plants in Western Balkans make us sick
[56] Mike Holland, The Unpaid Health Bill – How coal power plants in Western Balkans make us sick

Y15). This cost will therefore reduce annually in the projection period.

As per the intersectoral relatedness, the I-O analysis showed that this particular scenario (Scenario 0) will result in additional >1,200 FTE losses, which will also generate costs for the social system. Under the same assumption of re-entering the labour market as for the direct FTE, this will generate additional costs of 97 million starting the year after closure and will gradually reduce as well.

G) Environmental Protection: Costs and Benefits (Savings)

The state budget[54] of North Macedonia in the fiscal 2022, envisaged 1.04 billion MKD in two programs for environmental protection and enhancement of the environment (or in average 571 MKD per capita). For fiscal 2023, there are more ambitious plans for 1.8 billion MKD. However, given the history of overestimated budgets versus actual execution, the costs and benefits in the coming period are estimated based on a lower amount, in line with the average actual execution rate (70% of the planned budget, or 1.26 billion MKD).

Considering that these funds are for the entire territory of the country, it is assumed that they are equally distributed among each citizen. Thus, the costs for Y0 are 703 MKD per citizen, or 127.7 million MKD for the SWPR.

This is the monetized amount as a cost during the operations of TPP Oslomej while will turn into savings once TPP is closed. Given the increasing interest in the subject of environmental protection, it is assumed that the funds will have an incremental trend of an average +3% annually as well.

H) Regional Economy Value Added: Costs and Benefits

The Input-Output analysis for the region in the concerning scenario provides a good indication of the economic value

For the remaining workforce not engaged in the project, costs for social assistance programs will be incurred at nationally prescribed rates.

With simultaneous and well-thought-out planning utilizing available reskilling and self-employment support programs, it is anticipated that the requalification of the workforce will be initiated through two approaches: 1) providing training for reskilling and 2) offering grants for self-employment opportunities.

This process is anticipated to unfold gradually over a period of three years, allowing the market (both private and public sectors) to adequately meet the needs of the labour force (both direct and indirect) and alleviate pressure on the system while remaining sufficiently rapid.

With this approach in mind, it is estimated that approximately 80% of the workforce directly or indirectly impacted by the plant closure could benefit from at least one of the programs. The remaining 20% is expected to reintegrate into the labour market immediately and may not require any form of assistance or may be covered by the pension system.

G) Environmental Protection: Costs and Benefits (Savings)

Given the same baseline for environmental protection's costs and benefits as in Scenario 0 concerning the dynamics (see Scenario 0, point G), this scenario is proceeded with in the same manner.

It is assumed that during the first 4 years of decommissioning, the programs will continue to cover costs, which from Y5 onwards will be considered as savings, i.e., monetized benefits. The dynamics for increase is retained as in the former scenario 0 to be able to make comparisons. The estimated cost and benefit

In addition to the scenario 1 with the start of the operations of the new PV investments a small portion of the current employees of the TPP will also transferred in the new operations as green jobs, labour conversion of 1 FTE per 1 MW installed capacity for RES PVs.

There is expectation that 20% of the labour force directly and indirectly affected by the close of the plant will be able to transition into the labour force and find jobs without the need for any assistance, and be reabsorbed by the market force in a natural spontaneous re-employment.

For the remainder of the labour force there is still a need to for simultaneous and well-thought-out planning on utilizing the currently available reskilling and self-employment support programs. In this scenario, it is anticipated that the requalification of the workforce will be initiated through the same two approaches: 1) providing training for reskilling and 2) offering grants for self-employment opportunities.

This process is anticipated to unfold gradually over a period of three years, allowing the market (both private and public sectors) to adequately meet the needs of the labour force (both direct and indirect) and alleviate pressure on the system, while remaining rapid enough for workers to maintain their skills and mitigate the effects of long-term unemployment (which may further cause skill erosion, decreased employability, and generate the need for much larger costs for re-entering the market after a person has been in long-term unemployment).

Careful and well planned and at the same time relatively fast market accumulation of the labour is necessary and the assumption is as following in terms of market absorption of FTE equivalents of direct and

[54] Final account of the Budget of RNM for 2022, and Budget of RNM for 2023, at https://finance.gov.mk/%d0%b4%d0%be%d0%ba%d1%83%d0%bc%d0%b5%d0%bd%d1%82%d0%b8-2/, Census 2021 population at https://makstat.stat.gov.mk/PXWeb/pxweb/mk/MakStat/MakStat__Popisi

added that the TPP plant contributes to the regional economy in the SWPR. The benefits and the costs of the gross value added section in the scenario are based on the assessments in the I-O following both indirect and direct value added, accordingly adjusted with the percentage of active persons in the labour market for the given period. In a year of operations (intensity of production equal to the one in 2022) the direct and indirect GVA contribution is estimated at 1.07 bill MKD (~17.43 mil EUR).

The estimated overall benefits during the operational period will be converted into costs once operations come to an end, representing opportunities foregone for added regional economic value. Following any periods of losses (occurring after Year 5), these costs are reduced to 80% under the assumption that at least 20% of the Gross Value Added (GVA) will be absorbed (redirected) in other sectors, as the workforce relocates to different economic sectors without any assistance (natural market transition). Additionally, this reduction factor is gradually decreased by 10 percentage points each year until it reaches and remains at 50% for the duration of the specified time period.

per annum is around 2 mil EUR and gradually increasing to 3 mil EUR by the Y15.

H) Regional Economy Value Added: Costs and Benefits

The Input-Output analysis for the region in the concerning scenario provides a good indication of the economic value added that the TPP plant contributes to the regional economy in the SWPR. (Details for the mirroring in the scenarios can be seen in Scenario 0, point H))

Given that this scenario involves decommissioning activities that necessitate specific labor inputs contributing to regional value added, as well as the implementation of a planned just transition support system for those directly and indirectly impacted workers, there will be a range of effects on the regional economy. The activities for decommission and the activities for 20% immediately entering the regional labour force without assistance is assumed to contribute to the regional economy 'as usual'. The remaining workers are expected to enter the labour force based on the dynamics of reskilling and self-employment programs, thereby boosting the Gross Value Added (GVA). This transition is anticipated to lead to a reduction in costs and an increase in benefits over time.

indirect labour force. With the dynamics at the end of Y4 the market would have had all affected workforce integrated in the regional market.

The costs associated with both the assistance programs are determined by the average estimated expenses for state assistance provided by the national Employment Service Agency for employment services and programs. According to the 2024 operating program, the average cost per participant for reskilling training programs is approximately 1,300 EUR, and for grant assistance for self-employment, it is 6,600 EUR[57]. As currently designed the programs entail certain criteria and conditionalities.

The benefits in form of savings will start generating as part social savings as the unemployment assistances will decrease with entering the market as well as will be cumulated as economic GVA with the re-entering the labour market and contributing to the different sectors of the regional economy

G) Environmental Protection: Costs and Benefits (Savings)

Given the same baseline for environmental protection's costs and benefits as in Scenario 0 and Scenario 1 concerning the dynamics (see Scenario 0 & 1, point G), this scenario is proceeded with in the same manner. It is assumed that in the first 4 years during the decommissioning as well as the operationalization of the new RES, the environmental programs will continue to cover costs, which from Y5 onwards will be considered as savings, i.e., monetized benefits.

The dynamics for increase is retained as in the former scenario 1 to be able to make comparisons. The estimated cost and benefit per annum is around 2 mil EUR and gradually increasing to 3 mil EUR by the Y15.

[57] Assumptions based on the current plan within the Operational Plan for active employment programs and measures and services on the labor market of the National Employment Service Agency of RNM, available at http://ouhhrq.ttu.cc

H) Regional Economy Value Added: Costs and Benefits

The Input-Output analysis for the region in the concerning scenario provides a good indication of the economic value added that the TPP plant contributes to the regional economy in the SWPR. Given that this scenario involves decommissioning activities that necessitate specific labour inputs contributing to regional value added, as well as the implementation of a planned just transition support system for those directly and indirectly impacted workers, there will be a range of effects on the regional economy. Furthermore, a portion of the workforce will be accumulated by the new RES PVs.

The activities for decommission and the activities for 20% immediately entering the regional labour force without assistance is assumed to contribute to the regional economy 'as usual'. The remaining workers are expected to enter the labour force based on the dynamics of reskilling and self-employment programs, thereby boosting the Gross Value Added (GVA). This transition is anticipated to lead to a reduction in costs and an increase in benefits over time.

Scenario 0: Economic evaluation (ENPV)

Scenario 0	MKD	EUR
ENPV	2,577,376,370	41,894,934
MIRR	9.7%	
BCR	1.3	

Scenario 1: Economic evaluation (ENPV)

Scenario 1	MKD	EUR
ENPV	5,221,922,653	84,881,708
MIRR	15.2%	
BCR	3.4	
IRR	25.7%	

Scenario 2: Economic evaluation (ENPV)

Scenario 2	MKD	EUR
ENPV	8,848,980,557	143,839,086
MIRR	21.1%	
BCR	5.6	
IRR	55.5%	

4.6.3. Summary of Scenario Comparison – CBA

Summary of the scenarios indicates that financially simply closing the plant without any activities is most profitable, decommissioning is a long process that entails financial outflow with significant amount, while investments in RES are profitable endeavour that can cover decommissioning expenses and still be profitable in a long-run. Nevertheless, from socio-economic perspective the economic NPV is progressing as the scenarios are more advanced, meaning that socio-economically simply closure of the plant is least favourable, assistance in labour displacement is more favourable and additional investment in RES energy security increase is the most favourable option.

Table 108. CBA scenario assessment summary in mill EUR

	S0*	**S1**	**S2**
Financial - Cash flow	12.9	-38.7	8.7
Financial – NPV	12.0	-31.4	10.1
Costs			
Social costs (Dir. & Indir.)	-12.1	-5.0	-4.4
Labor reskilling costs		-6.9	-6.3
Health costs	-7.4	-3.0	-3.0
Environmental costs	-10.3	-8.3	-8.3
Reg. economy loss	-106.3	-30.9	-12.7
Benefits			
Environmental savings	28.4	28.4	28.4
Social savings	26.9	8.4	50.4
Health savings	16.4	19.3	19.3
Reg. economy gains	87.2	176.7	153.1
Economic evaluation – NPV	**41.9**	**84.9**	**143.8**
MIRR	**9.7%**	**15.2%**	**21.1%**
BCR	**1.3**	**3.4**	**5.6**

Note: *S0- Scenario 0: Closure of TPP - 'as is' or baseline

S1- Scenario 1: Decommissioning with just transition process (labour assistance)

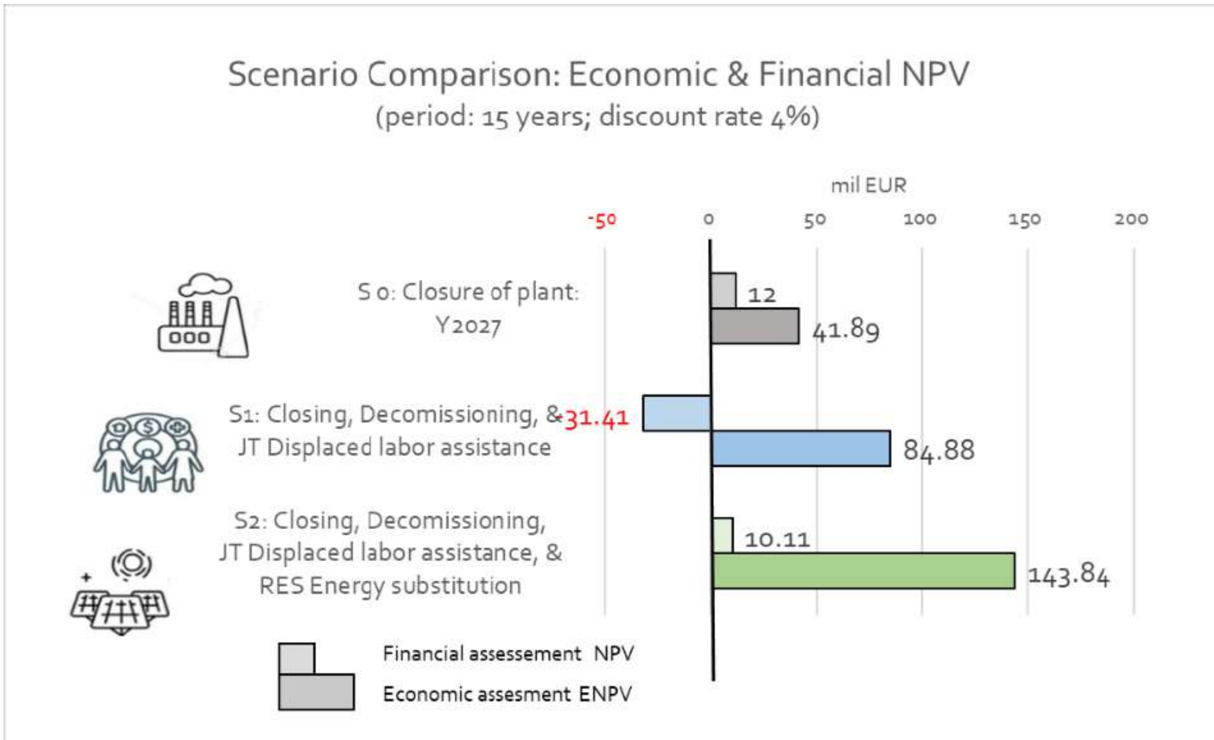
S2 - Scenario 2: Decommissioning, just transition processes and (partial) RES/PV energy substitution

Table 109. Scenario Comparison Economic & Financial Indicators

Scenario	**Name**	**Financial assessment (NPV)**	**Financial assessment (MIRR)**	**Financial assessment (IRR)**	**Economic assessment (ENPV)**	**Economic assessment (MIRR)**	**Economic assessment (IRR)**	**Economic assessment (BCR)**
1	**S0: Closure of plant: Y2027**	11.96	n/a	n/a	41.89	9.7%	n/a	1.30
2	**S1: Closing, Decommissioning, & JT Displaced labour assistance**	-31.41	-23.0%	n/a	84.88	15.2%	25.7%	3.36
3	**S2: Closing, Decommissioning, JT Displaced labour assistance, &**	10.11	6.0%	8.2%	143.84	21.1%	55.5%	5.59

	RES Energy substitution							

Figure 15: Scenario Comparison Economic & Financial NPV



Note: period 15 years; discount rate 4%; in mill EUR

Source: Author's calculations

4.7. Research findings

Policy and Governance Assessment

- RNM has advanced policy and strategic framework, as well as well-defined governance structure, and is evaluated by the EC (EC Country Progress Reports) as a country with some level of preparation on environment and climate change. However, the country needs to accelerate the implementation of the Green Agenda and the economic and investment plan, including the just transition process. moreover, the country needs to improve the governance and institutional capacities for policy implementation.

- There is currently a lack of comprehensive consensus among all societal segments, particularly at lower government tiers, it is imperative for addressing this gap to implement a place-based just transition plan for phasing out coal. Effective and timely implementation of such a plan is essential in achieving its objectives.

- The proposed institutional structure for JT, is envisaged to be a 'hybrid' model composed of various ministries and stakeholders. The structure is perceived as centralised and not sufficiently inclusive. The local stakeholders represented through the planned regional working groups are planned to ensure linking and adjusting state and regional policies and actions to the specificities and needs of the two affected regions. However, the operationalisation, technical back-up and financial support for functional governance structure on SWPR level, is lacking.

- It is essential for the design and the implementation of the measures to be tailored to the specific requirements and challenges of a given the territory, considering that SWPR has high unemployment, and long-term unemployment rates, inactivity activity. These initiatives must be meticulously tailored with a profound comprehension of the distinctive socio-economic traits of the locale and its capacity of the society to foster sustainable green development. This nuanced approach will not acknowledge the diverse circumstances across the two regions but will also underscore the significance of aligning interventions with local conditions to optimize effectiveness and promote enduring positive outcomes. Furthermore, the design and operationalization of labour market assistance programs and social safety nets programs designed for the microregion where TPP Oslomej is located needs to be targeted so that there are appropriate direct labour and indirectly affected labour. Both should have access to the resources and support needed to successfully navigating through the transition.

Socio-Economic Assessment

- The process of transitioning of the regional economy in the SWPR to a greener economy with a primary goal and step aimed at decarbonization through ceasing the operations of TPP Oslomej, inevitably will have effects on the socio-economic status of the region.

- The I-O analysis indicates that the supply chains and interlinkages of the sectors in the region, will not only be reflected in the direct effect of job losses (965), but will also have an effect on the other sectors through indirect job losses with amount than the amount of the direct effect (1,233) (total of over two thousand).

- The most affected sectors in the direct job loss are the mining/electricity production. As many jobs in the same sector group that covers manufacturing, water supply & waste management will be affected, indirectly (1,006), as support sectors.

- The effects will be spilled over mostly in wholesale and retail (79), agriculture (53) and construction (23) and less in professional & administrative services, and other sectors (72).

- In mitigating the regional economic loss - value added in the region, a 'compensation' of the loss will be more effective when the redistribution of the economic output is focused in the sectors that are providing higher value added. This requires labour reskilling and upskilling towards the tertiary- service provision sectors and secondary – manufacturing & processing sectors, and to a smaller degree in the primary – agriculture sector. However, the feasibility for reskilling and upskilling for the tertiary service provision sector should be assessed and considered, given the knowledge and skills gap of the existing labour force (directly and indirectly affected with the closure of TPP Oslomej). Key challenges to be considered are education access, mobility, technological barriers, adaptability, employees' age, etc.

- Prioritizing financial aspects suggest that designing and implementing processes and activities to support affected communities are costly and less preferable, while the comprehensive evaluation incorporating economic and social dimensions reveals a significantly different outcome. When the economic and social costs and benefits are taken into account as primary evaluation criteria, the landscape shifts. In instances where well-designed and effectively implemented options include support for just transition processes, they emerge as markedly more favourable over both the medium and long term. This broader perspective not only accounts for immediate financial expenditures but also considers the broader societal and economic impacts, highlighting the importance of investing in sustainable and just transition measures.

- The CBA assessments of the designed possible scenarios show through several indicators such as the benefit-to-cost ratio (BCR) that the option of plant closure without any other actions is financially better option but socio-economically the worst option to be chosen (BCR, 1.3), while proper decommissioning with labour assistance programs while financially expensive, from socio-economic perspective presents substantially larger benefits (BCR, 3.4) and when enhanced with green energy substitution it is most favourable (BCR, 5.6).

4.8. Conclusions and Recommendations

Strategic and Regulatory conclusions and recommendations

Republic of North Macedonia (RNM) faces significant exposure to the effects of climate change as the country has committed to an **ambitious agenda** aimed at mitigating and adapting to climate change, with a target of reducing GHG emissions by more than 50% by 2030 (compared to the 1990 levels). The first step in decarbonisation in the energy sector in RNM primarily means **phased decommissioning** of outdated and environmentally harmful coal-fired power plants in order to meet emissions targets and support the green transition.

North Macedonia needs to make decarbonisation a policy priory, with development of a strategy for **feasible coal phase-out,** properly designed and integrated in line with different horizontal policies. Energy and climate policies have been adopted by the array of different strategic documents including: Energy Strategy (2020-2040); RNM's NECP (2022, and under revision with flexibility for decommissioning timeline), however implementation has been evaluated as slow with the expectations for the NECP to provide clarity on TPPs' decommissioning deadlines); RNM has not yet defined and kept a 'date' for coal phase out (coal electricity generation have increased recently due to rising energy price); climate neutrality objective has not been backed up by legal basis and still there is no national adaptation strategy and enacted climate law; Just Transition Roadmap (adopted 2023), and Accelerated Coal Transition Investment Plan (ACT IP, introduced 2024)

a. The prepared Just Transition Roadmap (JTR), offers pathways for a fair energy transition, focusing on clean energy, private sector development, skills enhancement, and climate action. The roadmap also **proposes an institutional structure**, led by a National Coordinator (the Minister of Economy), overseeing a Just Transition Council & Secretariat (composed of various ministries and stakeholders). The structure to date although in its initial stage is perceived as following vastly top-down approach which is lacking engagement of stakeholders from the lower tier of government as well as the affected stakeholders.

b. The formal approval of relevant laws and strategic documents in RNM have **progressed** although slowly, and often have been facing delays, e.g. the Law on Climate Action which has been drafted for a log period is still not officially adopted. Furthermore, the former Energy Strategy has been envisioning substantial investments in hydropower plants over the past decade however these have not been realized. The current Energy Development Strategy (which encompasses with over sixty policy measures) indicates that the country **lags** in reaching the set targets.

The RNM's priority in achieving the climate goals is set within the decarbonisation of the energy sector. RNM copes with **obsolete and aged energy infrastructure** which is highly reliant on fossil fuels. Coal-fired power plants represent over half of total domestic electricity generation, with facilities dating back to the 1960s. To achieve emission reduction goals and facilitate a shift towards sustainability for decarbonisation and transitioning with coal phasing out there is a pressing need for **substantial investments** (public, private and IFIs).

c. Some **strategic progress has been made** in building up a financing framework for energy and climate policies, through the recent ACT IP, preceded by the Growth Acceleration Financing Plan which proposed financing instruments such as green bonds, a Hybrid National Green Fund for SMEs, Energy Efficiency Fund and a Strategic Green Investment Fund for supporting investments in RES and energy efficiency - nevertheless, its actual operationalization has been lacking a public (re)view of the implementation status.

Governance Structure & Stakeholder Involvement

Transition from coal to RES presents a blend of variety of opportunities and obstacles at the same time for RNM and the SW region. Achieving the full economic and social advantages **demands a holistic and inclusive approach**. Collaboration among the governmental entities, industries, and local communities is essential to ensure a smooth and fair transition to a sustainable economy, leveraging territorial and place-based potentials, skills, and knowledge.

The **proposed institutional structure for JT**, is envisaged to be a 'hybrid' model led by a National Coordinator (the Minister of Economy), overseeing a Just Transition Council & Secretariat (composed of various ministries and stakeholders). The structure to date is in its initial stage and its 'success' is to be seen however it is already perceived as following top-down approach which is not sufficiently inclusive. It is recommendable that the structure relies on the lessons learnt from other structures which are relatable and have been externally supported and initiated, which have become non-functional (eg. NCSD and NCCC).

a. The envisaged regional working groups should serve as essential platforms for linking and adjusting state and regional policies and actions to achieve a sustainable JT, particularly in the two regions that are most affected with the transformation process, one of which is the SW region. The envisaged design should be **appropriately operationalised, technically backed and financially supported** with a clear operating plan in order to focus on addressing the specific needs and challenges particularly in the directly affected municipalities, in this case Kichevo.

b. The local authority, the most to be affected municipality – Kichevo, perceives that their engagement in the design phase of the national governance structure has been limited. They have not been sufficiently involved and therefore they consider the governance structure as imposed. Furthermore, given the overall national governance context and structure they also see themselves on the outskirts due to not being powerful enough to have effect on the national policy design. The **major concern for the local economy** is that if it is not appropriately supported there is an anticipation of a worst-case scenario which will further aggravate and induce **outmigration of the labour force**, affecting negatively the demographic and socio-economic structure of the region.

North Macedonia requires a **broader societal consensus** on a decarbonisation approach and the energy transition. The consensus between relevant stakeholders, including civil society, academia, and the private sector, **lacks**. A just transition plan for the coal phase-out could facilitate this process and the recently adopted Just Transition Roadmap (June 2023) envisages activities and actions to contribute to this end.

North Macedonia should follow the evidence from different contexts and cases which indicate that the state's capacity, as a policy setter, to integrate just transition measures into coal phase-out strategies is enhanced by robust interactions between political and economic institutions and broad stakeholder engagement and inclusion. This enhances both the **legitimacy and feasibility** of the transition process.

The government's responsiveness to just transition concerns **should be strongly improved** by heightened with comprehensive stakeholder representation in the formal decision-making mechanisms. Tailoring place-based transition support policies to address the needs of the affected is crucial for fostering acceptance of coal phase-out policies to be **specifically tailored** to the SW planning region and the area of Kichevo.

While there is currently a **lack of comprehensive consensus** among all societal segments, particularly at lower government tiers (LSGU Kichevo particularly), it is imperative for addressing this gap to implement a place-based just transition plan for phasing out coal. **Effective and timely implementation** of such a plan could possibly facilitate achieving its objectives.

It is essential for the design and the implementation of the measures to be tailored to the specific requirements and challenges of the region. The **SW planning region is an economically lagging region** with locally significant influence of the thermal power plant. There is a need for the initiatives to be meticulously tailored with a profound comprehension of the distinctive socio-economic traits of the local community and its capacity for fostering sustainable green development in a timely manner. Otherwise, the effects may be **detrimental** not only to the local economy but to the social structure leading to further economic disparities and drive migration in the region.

Economic & Social significance

The Southwest planning region (SWPR) is one of the less developed regions (second to last contributing to merely 8% of the national GVA and lower average productivity (92% national average). The SWPR's GDP per capita is 75.9% of the national average with continuous declining trend. The region economic activity (besides trade and accommodation) is dependent on the secondary economic sector i.e. manufacturing, electricity and mining contribute (jointly) with 17%, while the primary sector GVA is very low (4%, with drastic fall in the last two decades). The **ceasing of the energy production** of the TPP Oslomej will have **significant effects on the local socio-economic structure** in the already fragile local economy.

The time-inconsistent plans for TPP decommissioning of RNM will without a doubt disproportionately affect the population in the coal-dependent SW region (along with Pelagonia). The region faces **socioeconomic challenges even more strongly** than the rest of the country. The regional energy sector seems to be **unable to cope** with the global and policy intentions for cheaper and greener energy. Despite the resurgence of lignite in the energy mix lately (energy crisis), gross electricity produced by lignite is declining but RES are just starting to pick up in the region.

Establishing and maintaining a balance between the aim of accelerating decarbonisation and ensuring cost-effectiveness while upholding principles of just transition is vital. **Prioritising financial considerations alone may overlook the social implications** of the transition, which are likely to come into play in the medium to long term as jobs and economic interests are at stake. The research findings underscore the necessity of taking a comprehensive approach to energy transition encompassing not only financial and technical considerations but also broader territorial, economic, and social implications of the transformation disruption.

The SWPR (along with Pelagonia region) is facing a **coal-income trap** where substantial jobs and income are tied to the declining coal sector which is expected to fully 'close'. Thus, it is crucial **to find and support viable alternatives** to preserve existing jobs and create new ones. Most of the TPP energy production is conventional, with limited FDIs in the region, high unemployment rates across sectors and workforce skill levels, expected to particularly impact young people and women (among which there is high inactivity rate). The poor air quality and public infrastructure further diminish the quality of life and cause outmigration.

There is an **urgent need to prepare specific decommission study** with detailed operating plan for TPP Oslomej which will be accompanied with specific plan for social safety net and reskilling of the workforce. The design of the policies in RNM are still on a high-level policy while at the same time the set date targets are quite short. The decommissioning processes experienced by many cases have shown that it is a long process that affects many beyond the directly affected labour force and shapes the future of the regions. This endeavour needs to be aligned with the regional and local development strategies.

The simulated effects through scenario assessments (CBA scenario comparison) clearly indicates that when prioritising and looking into financial implication only designing and implementing activities to support affected communities are costly and thus may not be financially preferable. However, a more comprehensive evaluation which is incorporating **economic and social dimensions reveals a significantly different outcome** for **decommissioning TTP Oslomej.** When the economic and social costs and benefits are taken into account as primary evaluation criteria the scenario of decommissioning coupled with JT measures which are well-designed, emerge as markedly **more favourable over both the medium and long term**. This broader perspective not only accounts for immediate financial expenditures but also considers the broader societal and economic impacts, highlighting the importance of investing in sustainable and just transition measures.

It will be of utmost importance for policy measures specifically designed for the coal dependant region related to TPP Oslomej for development of a comprehensive policy addressing the social and economic impacts which will focus on establishment **a tailor-made social safety net program** covering: unemployment benefits, pension programmes, income support, healthcare coverage, in liaison with comprehensive labour reskilling program and training, career counselling, entrepreneurship support. These should be designed based on the labour needs with active consultation and engagement accompanied with monitoring and evaluation mechanisms to support affected workers (and those indirectly along the supply chain).

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Serbia

From conventional to green - key elements for development of the city of Kragujevac sustainable mobility strategy

Image source: https://ona.telegraf.rs/putovanja-destinacije/3757071-kragujevac-istorija-grada-i-znamenitosti

5. Serbia

From conventional to green - key elements for development of the city of Kragujevac sustainable mobility strategy

5.1. Introduction

The Republic of Serbia has committed to aligning with the European Green Deal by endorsing the Green Agenda for the Western Balkans (GAWB) at the 2020 Sofia Summit, followed by the GAWB Action Plan at the Brdo Summit in October 2021. Since then, Serbia has initiated the process of decarbonizing its economy and industry, along with measures to promote a just green transition. This includes the adoption of the Law on Climate Change prepared by the Ministry of Environment and a set of new energy laws, including the first Law on Renewable Energy Sources and the new Law on Energy Efficiency and Rational Use of Energy.

In 2021, Serbia adopted several important policies under the Decarbonization (Climate, Energy & Mobility) pillar. These include the Integrated National Climate and Energy Plan (INECP) for 2021-2030 with a vision until 2050, the Law on the Spatial Plan of the Republic of Serbia, the Draft Spatial Plan of the Republic of Serbia 2021-2035 (in procedure), the Long-Term Building Renovation Strategy until 2050, the Sustainable Urban Development Strategy until 2030, the Climate Strategy & Action Plan, and the Strategy for Development of the Energy Sector until 2025 with projections until 2030. The Ministry of Mining and Energy is also developing two key documents for implementing the green transition justly – the Energy Development Strategy and the Integrated National Plan for Energy and Climate up to 2050.

Other national policies under the four pillars of the GAWB include the Law on Waste Management, the Law on Packaging and Packaging Waste, the Waste Management Program for 2022-2031, the Industrial Policy Strategy for 2021-2030 (Circular Economy), the Law on Environmental Protection, the Air Protection Law, the Law on Waters, the Law on Soil Protection (Depollution), the Law on Nature Protection, the National Strategy for Sustainable Use of Natural Resources and Goods, the Biodiversity Strategy, the Law on Agriculture and Rural Development, and the Law on Planning and Construction (Sustainable Food Systems and Rural Areas). The decarbonization pillar has made the most progress in applying the principles of the green transition.

These laws and policies have initiated several activities and projects related to the Just Green Transition (JGT). Key national initiatives include the EU for Green Agenda in Serbia, advancing medium and long-term adaptation planning, ALTERENERGY - Energy Sustainability for Adriatic Small Communities, the Roadmap for Circular Economy in Serbia, the Initiative for a Just Green Transition and Decarbonization in Serbia, the ECO SYSTEM Programme, and Zero Waste Municipalities.

Current overviews of JGT policies in Serbia are mainly national, but there are examples of regional and local policies. Significant regional policies include the Sustainable Energy and Climate Action Plan for the City of Belgrade (SECAP), the Sustainable Urban Mobility Plan for Belgrade, the Green City Action Plan for Belgrade, and the Vojvodina Environmental Protection Program for 2016-2025. Local activities are mostly concentrated in larger, well-developed municipalities and cities like Novi Sad, Niš, Kragujevac, Kraljevo, and Subotica.

In the research territory, the city of Kragujevac, the situation is better than in most Serbian local governments. Over the past decade, Kragujevac has adopted several important local policies related to JGT, such as the Spatial Plan of the City of Kragujevac, the Local Waste Management Plan, the Program of Local Economic Development, and the Strategy of Integral Urban Development of the Central City Zone - Kragujevac 2030. However, many of these documents are expired or nearing expiration. The preparation and adoption of new policies present an excellent opportunity to incorporate JGT principles and set an example for other local governments in Serbia.

The research case of UB-GEF within the Green Force action will focus on the first pillar of the Green Agenda for the Western Balkans (cleaning energy sources & protecting the climate), particularly the aspect of a just transition in Smart and Sustainable Mobility. As noted by Woodcock et al. (2007), "sustainable mobility offers improvements in individual health as well as a cleaner and healthier environment." Therefore, the case study aims to integrate proposed solutions into innovative land-use management, urban design, and planning to reduce health-related environmental burdens in inner urban zones, foster equitable access to public transport, enhance its quality and use, and promote sustainable urban mobility patterns.

The sense of place, a multidimensional concept encompassing cognitive, emotional, and behavioral facets of place attachment, will be used to understand well-being. This concept will play different roles in establishing positive relations with place and will be included in the research approach. A participatory approach will ensure the verification of procedures, data, and concepts, while enhancing the sense of belonging to the idea and final solution. Citizens are expected to respond positively to the transformation of public city transport into ecologically sustainable systems, influencing station layouts, routes, and more.

Understanding the Transition of the Public Transport System in the City of Kragujevac

The research focuses on the ongoing investments in Kragujevac's public transport system. The Bus Transformation Project is not a corridor study or a service plan. Instead, based on extensive research and public engagement, this project aims to provide a strategy with a bold, new vision and a series of recommendations to guide the future of buses in the City of Kragujevac (CKG). Public input from all demographics and areas in CKG indicated that transforming the bus system means improving the basics—providing fast, frequent, reliable, affordable bus service that feels like a unified system and is not limited by geographic or funding boundaries.

Public city transport (PCT) cannot be observed separately from the total city traffic. Transforming PCT also means reducing private car use and switching to bus transportation. The average number of cars in Serbia is 300 per 1,000 inhabitants, slightly higher in Kragujevac at around 320. In absolute numbers, this involves about 30,000 users per day (almost 50,000 before the Covid pandemic). Transport policy measures can reduce car use levels by promoting walking and cycling and developing a new transport hierarchy. This can be achieved by slowing down urban traffic, reallocating space to public transport, implementing parking controls and road pricing, and making public transport easier to use.

Kragujevac has completed a Traffic Study for the General Urban Plan (GUP), which was used in the initial analysis. The research also includes certain urban and technical solutions that can improve PCT, such as traffic organization through the street use system, dominant traffic routes for buses, greater traffic throughput, traffic signals, the layout of bus stops, parking policy, and financial mechanisms for (de)motivating arrival in central areas. The research could also form the basis for a gradual transition to a carbon-free public transport system, providing insights into whether it is possible to transition step-by-step to a carbon-free system in the city.

The research aims to define scenarios, after extensive analysis and surveys, that will provide the best effects for increasing the share of public transportation, reducing the number of cars in the central area, and reducing pollution by using electric vehicles. The pilot idea is for passengers to use conventional buses to get to the edge of the central area and then transfer to electric buses, which will distribute passengers to their destinations with a well-distributed frequency of departures. This will be combined with other policies to (de)motivate certain types of traffic, adapted to urban planning parameters and technical solutions. This research should serve as input for developing urban plans to ensure the implementation of this idea, adapting it to the wider city context through the eventual construction, expansion, or reconstruction of existing roads, and integrating it into other urban elements.

The study includes an analysis of European guiding documents such as the EC Declaration 1370/2007, national strategies, positive examples of cities in the region, city sectoral strategies, existing plans, and urban policies. It also covers the socio-economic transformation of PCT towards sustainability, emphasizing a participatory and open approach to specify and calibrate goals and desired solutions. The new PCT strategy will combine conventional traffic with improved performance outside the central area and completely new electric buses in the city center, along with new solutions for stationary traffic and smart improvements in supporting infrastructure such as stations, signaling, and notification systems.

Additionally, the study examines the basic status of air pollution in the city, identifying the main problems related to air pollution and the contributing factors, especially in the central zone. This comprehensive approach ensures that the transition to a sustainable public transport system in Kragujevac is well-informed, strategically planned, and effectively implemented.

5.2. Methodology

The integral method was used as the basis for planning sustainable urban systems in this study. This method explores the interrelationships among economic, social, and spatial development factors and the necessity of planning in relation to the broader environment. Through this process, the ecological-economic dimension gains its social justification and overall valorisation. To establish sustainable harmony between economic development and the environment, planning focuses on integrating space and the environment into socio-economic development for the ecological health of the local community. The function of planning and public responsibility is approached holistically, interactively, and in accordance with environmental capacity. Therefore, integrated planning of key segments is particularly important for socio-economic and spatial-ecological cohesion in spatial development. Emphasis on arranging economic activities within the context of social responsibility considers their impact on the natural and living environment. In the spirit of global sustainable development, where the economic gain of an area equals the ecological effects of its actions on space, city planning aims to prevent resource exploitation, emphasize the city's specificity and identity, and promote social awareness of the importance of preserving a high-quality environment.

The **research approach** included document research, analysis of similar experiences from abroad and in some Serbian cities, legislative background analyses, semi-structured interviews with local policy actors and stakeholders, fieldwork and surveys to engage with citizens, and cost-benefit analysis. Special attention was given to the territorial implications of the green transition, especially its effects on spatial policies. Recommendations related to spatial planning, urban planning policies, and instruments that would support the green agenda (green transition) in Serbia were clearly highlighted.

Data collection methods involved detailed research of planning documents and studies, numerous meetings with local authorities and significant stakeholders, and a survey disseminated through official internet channels and direct contact with public transport users in Kragujevac. Proposed routes for future electric buses were established after field visits, consultations with traffic experts, and the city's chief urban planner. In the final phase of the research, the schedule of stations, the number of buses needed, and their departure intervals will be specified.

The **sampling strategy** involved a survey answered by more than 450 public transport users. The survey covered the basic pillars of the green transition and gathered citizens' opinions about a possible transition to sustainable public transport, its impact on the environment, and their awareness of the need to change traditional transport methods. It also indicated the effects on human health, social well-being, and sustainability. The summary results were prepared in detail, and the directions obtained were considered.

Parallel discussions with the city administration explored accompanying activities to enhance the transition's effectiveness. These included banning traffic in the central area of the city (completely or during certain parts of the day) except for electric buses and taxis, banning parking (except for residents), offering economic incentives for the transition (such as ticket price reductions and free transportation in the initial phase), and installing solar panels at bus stops and pollution meters in buses.

In terms of data analysis procedures, researchers collected data from the Open Data Portal, the Statistical Office of the Republic of Serbia, the Republic Geodetic Authority, the Serbian Business Registers Agency, official documents adopted by the City of Kragujevac, and various studies and research. COPERT and GTFS tools for Kragujevac were used for scenario purposes. Significant data were calculated and created using GIS tools for geospatial analyses.

Figure 16. Census Circles in the city core zone

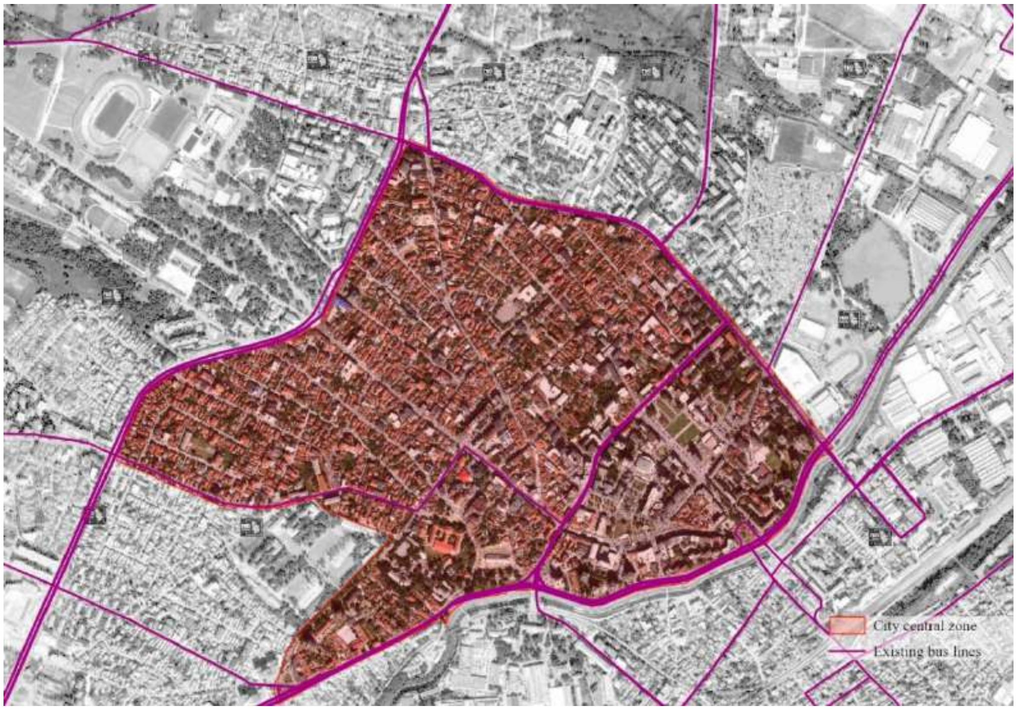
Source: Author's elaboration

The central area of Kragujevac is divided into 93 Census Circles, which were used for data collection on the number of inhabitants, households, age structure, and other relevant information. Data from the Census provided accurate estimates of the population affected by the scenario. Business Register data gathered from the Serbian Business Registers Agency was used to estimate the economic impact of the proposed scenario and its effect on workers and daily commuters.

Urban buses, mostly equipped with heavy-duty diesel engines, have significant energy and environmental impacts. The research identified bus pollutant emissions (CO, CO_2, HC, NOX) at road sections, intersections, and bus stops for different fuel types, exploring changes in emissions for different locations. MDD values for different locations indicated that there were more obvious differences in emissions between road sections and intersections. Heat maps were applied to better understand emissions changes.

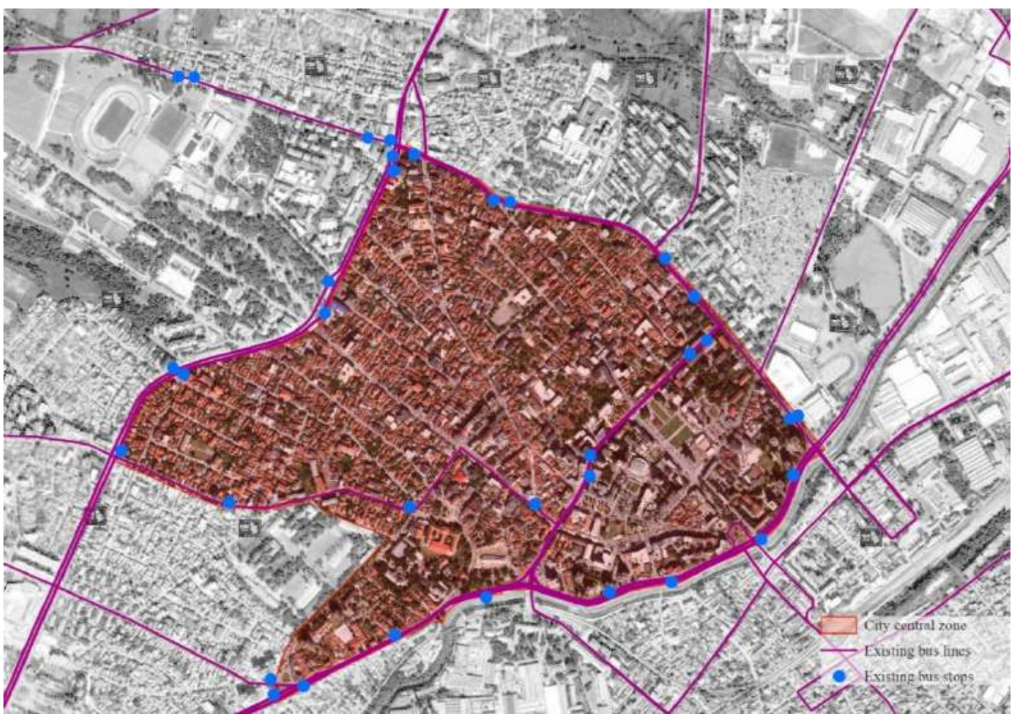
The field data consisted of two parts: (1) bus vehicle characteristic data include fuel type, vehicle speed, and acceleration; and (2) emission situation data include bus pollutant emissions of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC), and nitric oxides (NOX).

Figure 17. Existing bus lines passing through the city center zone



Source: Author's elaboration

Figure 18. Spatial distribution of the bus stops



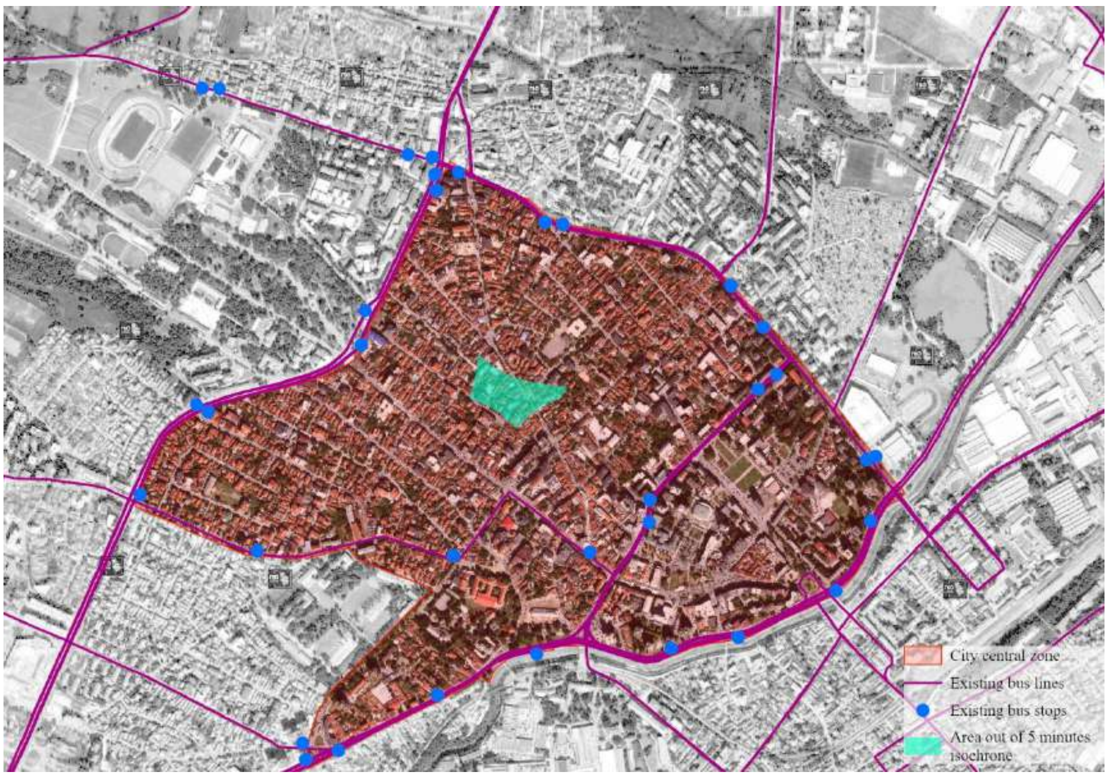
Source: Author's elaboration

Ecological impact was calculated based on the:

- Number of existing bus lines passing through the city center zone
- Number of daily trips
- Spatial distribution of the bus stops
- Spatial distribution of the crossroads
- Length of the bus line
- Emission values for different types of engines with internal combustion (EURO 5, EURO 4 etc.) based on the Wang, C., Sun, Z. and Ye, Z. (2020).
- Walking 5 minutes isochrones distances from the bus stops

Numerous documents adopted by the City of Kragujevac or created by the city administration were used for data collection and understanding present conditions and future goals in city development. These documents included the City of Kragujevac Traffic Development Strategy 2012-2022, the Traffic Study for the General Plan of Kragujevac 2025, traffic infrastructure analyses for the General Plan of Kragujevac 2025, and research studies on public city and intercity transport.

Figure 19. Area marked in red – not accessible in 5 minutes walking distance from the bus stop



Source: Author's elaboration

Ethical considerations involved consultations with the ethics officer and coordination with other consortium members regarding the research approach. During the research, no unexpected obstacles were encountered. Existing **challenges** included new material for local experts, insufficient knowledge of Green Transition principles among citizens, resistance to new systems, financial uncertainty, and the need for investment. However, the local administration, key managers, citizens, and other stakeholders showed complete openness. Preliminary survey results indicated great interest in improving the environment, using modern transportation modes, and thinking about a sustainable future.

The timeline was mostly respected, with some variations in data arrival. Regular meetings with local actors in Kragujevac and field visits were conducted. Consultations with experts from various fields (civil and construction engineers, economists, sociologists, geographers, lawyers) significantly contributed to the research through advice and highlighting important aspects of this complex issue.

5.3. Policy and Legal Context

From the outset, the research focused on analyzing the legislative, planning, and institutional support necessary for the green transition. This foundational work is documented in the Regional Mapping Report (D4.2 Regional Mapping Report). Following a comprehensive assessment at the national and regional levels, the analysis was then narrowed down to the local level to gain a more detailed understanding of specific municipal contexts.

For the City of Kragujevac, numerous documents, either adopted by the city or created by its administration, were instrumental in data collection and provided crucial insights into both the current state and future development goals. These documents include:

City of Kragujevac Traffic Development Strategy 2012-2022

This strategy outlines the city's long-term vision for traffic management and infrastructure development over a decade. It highlights key areas for improvement and provides a roadmap for achieving a more efficient and sustainable transport system.

Traffic Study for the General Plan of the City of Kragujevac in 2025

This study offers an in-depth analysis of the city's traffic patterns, challenges, and potential solutions. It serves as a critical tool for planners and policymakers to make informed decisions about future traffic management strategies.

Traffic Infrastructure Analyses for the General Plan of the City of Kragujevac in 2025

These analyses provide a detailed examination of the existing traffic infrastructure, identifying bottlenecks and areas needing enhancement. They also propose new infrastructure projects aimed at improving traffic flow and reducing congestion.

Public City and Intercity Transport in the City of Kragujevac – Research Study

This study focuses on the public transport system within the city and its connections to surrounding areas. It evaluates the efficiency, coverage, and user satisfaction of public transport services and suggests improvements to make the system more user-friendly and environmentally sustainable.

Many of these reference documents directly or indirectly opened up opportunities for incorporating new spatial planning concepts that align with principles of environmental sustainability. This holistic approach not only addresses immediate transportation needs but also contributes to broader ecological and social goals, towards a just green transition.

5.4. Theoretical framework

Urban transport has the function of integration, connecting the city's functions of work, housing, entertainment and recreation. Transport is inseparable from the economic development of the city and has a decisive influence on the quality of life of city residents. However, it should always be remembered that the demand for traffic is, in fact, a derived demand. Mobility itself depends on the spatial arrangement of activities in the city - as the spatial-physical structure of the city changes, so does the demand for traffic.

Sustainable urban mobility refers to a transport strategy that minimizes negative environmental effects, economic inefficiency and social inequality.

The most important negative environmental effects of city traffic at the local and regional level are; local air pollution, noise pollution, traffic congestion and traffic accidents, confiscation of city land. At the global level, these are: energy consumption and GHG gas emissions.

Reducing the negative effects of city traffic can be achieved by applying various measures from the domain of urban planning and land use as well as traffic policy. For the effectiveness of measures to be fully manifested, the timing of their implementation is extremely important. Therefore, it is not only necessary to implement all groups of measures together, but the coordination of traffic strategy and spatial development must reach a very high level.

5.5. Stakeholder engagement

Apart from several online meetings with various experts, good cooperation with the administration of the city of Kragujevac has already been noted. The survey that was conducted was structured in such a way as to include various ethnic, gender and educational categories of the population. Special care was taken to talk to people who are frequent users of public transport, those who live in the central area of the city, but also those who come to work every day from distant parts of the city or outside it. Concrete (preliminary) data are given in Annex to this document.

5.6. Core findings

After a detailed analysis of existing spatial and development documentation, legal assumptions and constraints, discussions with stakeholders and authorities, development scenarios for public urban transport in the central zone of Kragujevac were created. The definition of scenarios was preceded by an extensive survey that reflected the opinions of residents and transport users regarding the state of public urban transportation and future expectations.

5.6.1. Survey on the Satisfaction Level of Public Transport Users and Preferences Towards the Introduction of Electric Buses

The purpose of this survey was to assess the level of satisfaction among the citizens of Kragujevac with the current public transport system and to explore the potential for introducing electric buses. The goal was to identify existing issues and areas for improvement within Kragujevac's public transport system. Data was collected using interview methods.

The survey sampled 424 respondents, which is considered satisfactory given Kragujevac's population of approximately 150,000, with a 5% margin of error at a 95% confidence level. Of the total responses, 257 questionnaires were filled out online, while 167 were conducted in the field.

Field surveys were conducted by interviewing users of public transport services at selected roundabouts and the busiest stations in different areas of Kragujevac, during peak hours (7am to 9am and 3pm to 5pm) and off-peak times. This approach ensured the representativeness of the sample and created the methodological preconditions for the validity of the results. All urban zones of Kragujevac were covered during two characteristic parts of the day, reflecting public transport occupancy levels.

Satisfaction and the importance of certain attributes of public transport were measured using a five-point Likert scale. Although a seven-point scale is also commonly used, the five-point scale was deemed more appropriate for the conditions in Serbia and for the specific circumstances of field-based questionnaire completion. The Likert scale is suitable as it allows respondents to clearly express their opinions using an equal number of positive and negative categories.

The questionnaire comprised a single A4 sheet with closed-ended questions. The number and type of questions were designed to ensure a high completion rate. The expected time to fill out the questionnaire was approximately five minutes. Subsequent statistical analysis and calculations were performed using SPSS software to ensure robust data analysis and interpretation.

5.6.2. Statistical analysis

Frequencies and descriptive statistics were used to understand the distribution of responses for every survey question.

Table 110. Age of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	14-25	86	20.3	20.3	20.3
	26-45	176	41.5	41.5	61.8
	46-65	135	31.8	31.8	93.6
	65+	27	6.4	6.4	100.0
	Total	424	100.0	100.0	

Source: SPSS, Author's calculations

The largest age group among respondents is the 26-45 years old category, comprising 41.5% of the total respondents. The second-largest group is the 46-65 years old category, making up 31.8% of the respondents. The 14-25 years old group represents 20.3% of the respondents. The smallest group is those aged 65 and older, accounting for 6.4% of the respondents.

Most of our survey respondents are in the 26-45 and 46-65 age groups, indicating a middle-aged demographic predominance in our sample. This age distribution can be very informative, as different age groups may have varying perspectives and preferences regarding public transport and electric buses.

Table 111. Education level of respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Elementary school	12	2.8	2.9	2.9
	High school	346	81.6	82.6	85.4
	University degree	61	14.4	14.6	100.0
	Total	419	98.8	100.0	
Missing	System	5	1.2		
Total		424	100.0		

Source: SPSS, Author's calculations

Among the valid responses the majority of respondents, 82.6%, have only completed high school. A significant minority, 14.6%, have obtained a university degree. A very small portion, 2.9%, have only completed elementary school.

The high proportion of respondents with a high school education suggests that the survey sample predominantly consists of individuals with a moderate level of education. The smaller proportions of respondents with elementary or university education indicate that there may be differing levels of engagement with public transport, potentially influenced by educational attainment. This distribution can be used to understand and segment the data for further analysis, particularly when examining preferences and satisfaction with public transport services among different educational groups.

Table 112. Frequency of public transport use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	171	40.3	40.4	40.4
	4 to 6 days a week	63	14.9	14.9	55.3
	1 to 3 days a week	66	15.6	15.6	70.9
	1 to 3 days a month	43	10.1	10.2	81.1
	Less than one day a month	48	11.3	11.3	92.4
	I do not use it at all	32	7.5	7.6	100.0
	Total	423	99.8	100.0	
Missing	System	1	.2		
Total		424	100.0		

Source: SPSS, Author's calculations

Among the valid responses the largest group, 40.4% of the respondents, use public transport daily; 14.9% of the respondents use public transport 4 to 6 days a week (frequent users); 15.6% of the respondents use public transport 1 to 3 days a week (moderate users); 10.2% of the respondents use public transport 1 to 3 days a month (occasional users); 11.3% of the respondents use public transport less than one day a month (rare users); 7.6% of the respondents do not use public transport at all (non-users).

A significant portion of respondents use public transport frequently, with 40.3% using it daily and an additional 30.5% using it between 1 to 6 days a week. Over half (55.3%) of the respondents use public transport at least 4 days a week, indicating a high dependence on public transport.

Given that 18.8% use it occasionally (1 to 3 days a month or less), there is a potential to convert these occasional users into more frequent users through improved services or incentives. The 7.5% of non-users represent a group that could be targeted with initiatives to encourage public transport use, such as improved service quality. This distribution provides a comprehensive overview of how often different segments of the population use public transport, which is crucial for planning improvements and assessing the potential impact of introducing electric buses in the city center.

Table 113. Most common purpose of travel

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Traveling to/from work	200	47.2	48.1	48.1
	Going to school/university	61	14.4	14.7	62.7
	Shopping	21	5.0	5.0	67.8
	Recreational reasons	35	8.3	8.4	76.2
	Visiting family/friends	34	8.0	8.2	84.4
	Other reasons	65	15.3	15.6	100.0
	Total	416	98.1	100.0	
Missing	System	8	1.9		
Total		424	100.0		

Source: SPSS, Author's calculations

Among the valid responses nearly half (48.1%) use public transport for commuting to/from work; 14.7% of respondents use public transport for educational purposes. Those are primary and secondary purpose. Among other purposes 5% of respondents use public transport for shopping; 8.3% use it for recreational reasons; 8.0% use public transport to visit family and friends. In addition to this 15.3% of respondents indicated other reasons for using public transport.

The high percentage of respondents using public transport for commuting to/from work indicates that any improvements to public transport services will primarily benefit the working population. While work and school commutes are predominant, there are still substantial numbers of respondents using public transport for shopping, recreation, and visiting family/friends. The relatively high percentage of "Other reasons" (15.6%) suggests there are various unspecified uses of public transport that could be further explored to understand the full range of public transport needs and preferences. This data is important for understanding reasons why people use public transport in Kragujevac, and it can help in planning improvements and campaigns to encourage public transport usage across different segments of the population.

Table 114. Type of ticket

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single ticket	173	40.8	41.3	41.3
	Monthly pass	206	48.6	49.2	90.5
	I do not buy a transport ticket	40	9.4	9.5	100.0
	Total	419	98.8	100.0	
Missing	System	5	1.2		
Total		424	100.0		

Source: SPSS, Author's calculations

Among the valid responses a significant portion of respondents (41.3%) use single tickets, while the majority (49.2%) use monthly passes. A smaller portion (9.5%) do not buy a transport ticket at all.

The highest percentage of respondents use monthly passes, suggesting that a large number of users are frequent and regular public transport users. This group may benefit most from consistent and reliable services. Also, a substantial proportion of respondents use single tickets, indicating that there is a significant number of occasional or less frequent public transport users. The 9.4% of respondents who do not buy transport tickets could indicate evasion, or other reasons not covered by the survey.

Understanding the distribution between single ticket users and monthly pass holders is crucial for revenue planning and service optimization. Monthly pass holders often expect different service levels compared to single ticket users. This distribution helps in understanding the ticket purchasing behaviour of public transport users, which can inform decisions regarding pricing, service improvements, and marketing strategies to increase public transport usage in Kragujevac.

Among the valid responses the majority of respondents (65.1%) do not change bus lines during their journey; a smaller portion of respondents (18.9%) change bus lines once during their journey; a minority of respondents (16%) change bus lines multiple times.

Table 115. Changing bus lines on journey

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, multiple times	67	15.8	16.0	16.0
	Yes, once	79	18.6	18.9	34.9
	No	272	64.2	65.1	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: SPSS, Author's calculations

The high percentage of respondents who do not change bus lines suggests a preference for direct routes. This indicates that most users have access to direct routes or prefer routes without transfers. The combined percentage of respondents who change bus lines (almost 35%) indicates that a significant portion of users need to transfer at least once during their journey. This highlights the importance of efficient and well-coordinated transfer points in the public transport system. For the 16% who change buses multiple times, improving the connectivity and reducing the need for multiple transfers could enhance their travel satisfaction. This data provides insights into the travel patterns of public transport users in Kragujevac, particularly regarding their need to transfer between bus lines. It can inform decisions on route planning, scheduling, and service improvements to enhance the user experience.

Table 116. Willingness to pay higher price for better quality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	212	50.0	50.5	50.5
	No	208	49.1	49.5	100.0
	Total	420	99.1	100.0	
Missing	System	4	.9		
Total		424	100.0		

Source: SPSS, Author's calculations

Among the valid responses little more than a half of the respondents (50.5%) are willing to pay a higher price for better quality public transport; just under half of the respondents (49.5%) are not willing to pay a higher price.

The respondents are almost evenly split in their willingness to pay a higher price for better quality public transport, with half valuing improved quality enough to pay more, while the other half may be more price-sensitive or satisfied with the current quality.

Since half of the respondents are willing to pay more, there is potential for introducing higher-priced options for enhanced services or implementing quality improvements (increased frequency, better comfort, reduced travel time etc.) with a justified price increase. This data is very important for planning any price adjustments or quality improvements in the public transport system in Kragujevac.

Table 117. Amount willing to pay compared to current price

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Up to 25% higher	167	39.4	77.3	77.3
	Up to 50% higher	32	7.5	14.8	92.1
	Up to 2 times higher	13	3.1	6.0	98.1
	More than 2 times higher	4	.9	1.9	100.0
	Total	216	50.9	100.0	
Missing	System	208	49.1		
Total		424	100.0		

Source: SPSS, Author's calculations

Of the number of respondents willing to pay higher price for better quality of public transport the majority (77.3%) are only willing to pay up to 25% higher than the current price. This, of course, suggests that a modest price increase is more acceptable to the majority. A smaller portion (14.8%) are willing to pay up to 50% higher, indicating that some respondents are open to a more significant price increase for better quality. Only 6% are willing to pay up to 2 times higher, and a fraction (1.9%) are willing to pay more than 2 times higher, indicating that such a high price increase would not be well-received by the majority.

The majority's willingness to pay up to 25% higher suggests that a modest increase in fares could be feasible without significant pushback, provided that the quality improvements are evident. This data helps in understanding the extent to which respondents are willing to financially support quality improvements in public transport, informing pricing strategies and service enhancement plans in Kragujevac.

Table 118. Car ownership or access

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	249	58.7	58.7	58.7
	No	175	41.3	41.3	100.0
	Total	424	100.0	100.0	

Source: Author's calculations

Most of the respondents (58.7%) have access to a car. This indicates that more than half of the survey participants either own a car or have the possibility to use one. A significant portion of respondents (41.3%) do not have access to a car. This indicates that a substantial number of people rely on other modes of transportation, such as public transport, walking, or cycling.

The 41.3% of respondents without car access may be more reliant on public transport, making it crucial for the city to ensure that public transport services are efficient, reliable, and meet the needs of these users. The 58.7% with car access might be potential users of public transport if it is improved. Strategies to attract these car users to public transport could include highlighting the benefits of reduced congestion, environmental benefits etc. The high percentage of car access suggests a potential challenge in terms of parking space availability and traffic congestion, especially in the central zone. This highlights the importance of parking restrictions and other traffic management measures. **Next 12 questions refer to the user satisfaction with various aspects of public transport in Kragujevac.**

Table 119. Statistics

		Satisfaction with frequency	Satisfaction with travel time	Satisfaction with comfort of waiting	Satisfaction with comfort of the journey	Satisfaction with availability of seats	Satisfaction with cleanliness
N	Valid	421	420	418	419	418	417
	Missing	3	4	6	5	6	7
Mean		2.8124	3.2310	2.3828	2.7303	2.7057	2.9448
Median		3.0000	3.0000	2.0000	3.0000	3.0000	3.0000
Std. Deviation		1.28004	1.20322	1.34357	1.27031	1.22407	1.33709
Variance		1.639	1.448	1.805	1.614	1.498	1.788

Source: Author's calculations

Table 120. Statistics

		Satisfaction with information availability	Satisfaction with ease of connection	Satisfaction with station proximity	Satisfaction with safety	Satisfaction with environmental impact	Satisfaction with cost of transportation
N	Valid	419	417	418	418	418	418
	Missing	5	7	6	6	6	6
Mean		3.1313	2.9257	3.4569	3.1914	2.8541	3.1531
Median		3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
Std. Deviation		1.38497	1.18959	1.25207	1.20221	1.20162	1.26775
Variance		1.918	1.415	1.568	1.445	1.444	1.607

Source: Author's calculations

Generally, median values around 3 suggest that most respondents rate satisfaction as moderate across most aspects. Higher standard deviations and variance suggest more variability in opinions among respondents, with some aspects having higher variability than others.

"Satisfaction with station proximity" has the highest mean (3.4569), suggesting it is the most critical factor for respondents (next are "Satisfaction with travel time", and "Satisfaction with safety"). "Satisfaction with comfort of waiting" has the lowest mean (2.3828), well below neutral.

"Satisfaction with information availability" and "Satisfaction with comfort of waiting" have higher standard deviations (1.38497 and 1.34357, respectively) and higher variance, indicating a wider spread of responses around the mean. " Satisfaction with ease of connection " has the lowest standard deviation (1.18959), indicating that most respondents have similar opinions about this aspect.

Our data provides insights into the perceived satisfaction levels across various dimensions of public transport. Understanding these ratings helps in identifying areas where improvements are needed to enhance overall satisfaction among users. Those areas, primarily, are: comfort of waiting, comfort of the journey, availability of seats and frequency of public transport.

Table 121. Satisfaction with frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	76	17.9	18.1	18.1
	Mostly dissatisfied	105	24.8	24.9	43.0
	Both satisfied and dissatisfied	120	28.3	28.5	71.5
	Mostly satisfied	62	14.6	14.7	86.2
	Completely satisfied	58	13.7	13.8	100.0
	Total	421	99.3	100.0	
Missing	System	3	.7		
Total		424	100.0		

Source: Author's calculations

Most respondents (43%) are not satisfied at all or mostly dissatisfied with the frequency of public transport; a significant portion (28.5%) are satisfied or completely satisfied with the frequency of public transport.

The 18.1% who are not satisfied at all and the 24.9% who are mostly dissatisfied indicate areas where improvements in frequency are needed. Also, understanding the 28.5% who have both satisfied and dissatisfied feelings can help in targeting improvements to specific aspects of frequency that could enhance overall satisfaction.

Table 122. Satisfaction with travel time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	40	9.4	9.5	9.5
	Mostly dissatisfied	72	17.0	17.1	26.7
	Both satisfied and dissatisfied	133	31.4	31.7	58.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	Mostly satisfied	101	23.8	24.0	82.4
	Completely satisfied	74	17.5	17.6	100.0
	Total	420	99.1	100.0	
Missing	System	4	.9		
Total		424	100.0		

Source: Author's calculations

A majority (41.6%) are satisfied or completely satisfied with travel time while a significant portion (31.7%) have both satisfied and dissatisfied feelings about travel time. Only minority of respondents (9.5%) are not satisfied at all with travel time. Understanding that 9.5% of respondents are not satisfied at all and 17.1% are mostly dissatisfied indicates areas where improvements in travel time could be focused.

Table 123. Satisfaction with comfort of waiting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	157	37.0	37.6	37.6
	Mostly dissatisfied	71	16.7	17.0	54.5
	Both satisfied and dissatisfied	106	25.0	25.4	79.9
	Mostly satisfied	41	9.7	9.8	89.7
	Completely satisfied	43	10.1	10.3	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

A significant portion (37.6%) are not satisfied at all with the comfort of waiting; about 25.4% have both satisfied and dissatisfied feelings about the comfort of waiting. Only 20.1% are mostly satisfied or completely satisfied with the comfort of waiting.

The 37.6% who are not satisfied at all and the 16.7% who are mostly dissatisfied indicate areas where improvements in the comfort of waiting are needed. Strategies to increase this satisfaction level could focus on providing more comfortable waiting environments, such as shelter, seating, and amenities.

Table 124. Satisfaction with comfort of the journey

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	84	19.8	20.0	20.0
	Mostly dissatisfied	106	25.0	25.3	45.3
	Both satisfied and dissatisfied	119	28.1	28.4	73.7
	Mostly satisfied	59	13.9	14.1	87.8
	Completely satisfied	51	12.0	12.2	100.0
	Total	419	98.8	100.0	
Missing	System	5	1.2		
Total		424	100.0		

Source: Author's calculations

Almost half of all respondents (45.3%) are not satisfied at all or mostly dissatisfied with the comfort of the journey. On the other hand, only 12.2% are completely satisfied with the comfort of the journey.

The 20.0% who are not satisfied at all and the 25.0% who are mostly dissatisfied indicate areas where improvements in the comfort of the journey are needed. Strategies to build and increase this satisfaction level could focus on improving seating comfort, temperature control, minimizing disruptions during travel etc.

Table 125. Satisfaction with availability of seats

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	78	18.4	18.7	18.7
	Mostly dissatisfied	112	26.4	26.8	45.5
	Both satisfied and dissatisfied	129	30.4	30.9	76.3
	Mostly satisfied	53	12.5	12.7	89.0
	Completely satisfied	46	10.8	11.0	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

A majority of respondents (45.5%) are not satisfied at all or mostly dissatisfied with the availability of seats. Only 23.7% are mostly satisfied or completely satisfied with the availability of seats.

The 18.7% who are not satisfied at all and the 26.4% who are mostly dissatisfied indicate areas where improvements in the availability of seats are needed. Policies to potentially increase this satisfaction level could focus on ensuring adequate seating capacity during peak times and improving the layout of seating within vehicles.

Table 126. Satisfaction with cleanliness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	74	17.5	17.7	17.7
	Mostly dissatisfied	91	21.5	21.8	39.6
	Both satisfied and dissatisfied	107	25.2	25.7	65.2
	Mostly satisfied	74	17.5	17.7	83.0
	Completely satisfied	71	16.7	17.0	100.0
	Total	417	98.3	100.0	
Missing	System	7	1.7		
Total		424	100.0		

Source: Author's calculations

Almost 40% of respondents are dissatisfied (either not satisfied at all or mostly dissatisfied) with cleanliness; 34.7% of respondents are satisfied (either mostly satisfied or completely satisfied). A significant portion (25.7%) has mixed feelings about cleanliness.

Table 127. Satisfaction with information availability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	68	16.0	16.2	16.2
	Mostly dissatisfied	77	18.2	18.4	34.6
	Both satisfied and dissatisfied	102	24.1	24.3	58.9
	Mostly satisfied	76	17.9	18.1	77.1
	Completely satisfied	96	22.6	22.9	100.0

	Total	419	98.8	100.0	
Missing	System	5	1.2		
Total		424	100.0		

Source: Author's calculations

Most of respondents (41%) are satisfied (either mostly satisfied or completely satisfied); 34.6% of respondents are dissatisfied (either not satisfied at all or mostly dissatisfied) with information availability. Also, a significant portion (24.3%) has mixed feelings about information availability. The respondents who are dissatisfied highlight a critical area for improvement. Steps should be taken to identify specific issues causing dissatisfaction and address them effectively. Strategies that could help in this direction are Real-Time information systems, enhanced communication channels (e.g. social media) etc.

Table 128. Satisfaction with ease of connection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	54	12.7	12.9	12.9
	Mostly dissatisfied	99	23.3	23.7	36.7
	Both satisfied and dissatisfied	138	32.5	33.1	69.8
	Mostly satisfied	76	17.9	18.2	88.0
	Completely satisfied	50	11.8	12.0	100.0
	Total	417	98.3	100.0	
Missing	System	7	1.7		
Total		424	100.0		

Source: Author's calculations

A significant portion of respondents, 36.6%,, are dissatisfied with the ease of connection. This indicates that more than one-third of the respondent's experience difficulties when transferring between buses or other forms of transport. This may reflect issues such as long waiting times, poorly synchronized schedules, or complicated transfer processes. Almost third of respondents (30%) are generally satisfied with the ease of connection. Also, 32.5% of respondents have mixed feelings about the ease of connection. These individuals might have experienced inconsistent service or found the connection process acceptable but not optimal.

Based on our data, numerous steps can be taken to improve satisfaction with ease of connection such as: improved scheduling, Real-Time updates, increased frequency etc.

Table 129. Satisfaction with station proximity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	39	9.2	9.3	9.3
	Mostly dissatisfied	48	11.3	11.5	20.8
	Both satisfied and dissatisfied	124	29.2	29.7	50.5
	Mostly satisfied	97	22.9	23.2	73.7
	Completely satisfied	110	25.9	26.3	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

Majority of respondents, almost one half, are mostly satisfied and completely satisfied with the proximity of public transport stations. They likely find stations conveniently located, accessible, and well-integrated into their travel patterns.

On the other hand, these categories (Not satisfied at all and mostly dissatisfied) account for 20.8% of responses. This indicates that about fifth of respondents are dissatisfied with the proximity of public transport stations. Reasons could include stations being far from residential or commercial areas, inconvenient access points, etc.

Based on the data, some policies can be recommended to improve satisfaction with station proximity, such as integration with urban planning and accessibility improvements.

Table 130. Satisfaction with safety

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	39	9.2	9.3	9.3
	Mostly dissatisfied	77	18.2	18.4	27.8
	Both satisfied and dissatisfied	142	33.5	34.0	61.7
	Mostly satisfied	85	20.0	20.3	82.1
	Completely satisfied	75	17.7	17.9	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

Majority of respondents (38.2%) are mostly satisfied and completely satisfied. About a quarter of respondents are dissatisfied with the safety of public transport. Reasons could include concerns about crime, lack of security measures etc. Policy recommendations to enhance satisfaction with the safety of public transport can include infrastructure improvements and better security measures.

Table 131. Satisfaction with environmental impact

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	66	15.6	15.8	15.8
	Mostly dissatisfied	90	21.2	21.5	37.3
	Both satisfied and dissatisfied	149	35.1	35.6	73.0
	Mostly satisfied	65	15.3	15.6	88.5
	Completely satisfied	48	11.3	11.5	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

Dissatisfied respondents account for 37.3% of responses. This suggests that over a third of respondents are not satisfied or have significant concerns about the environmental impact of public transport. Reasons could include emissions, noise pollution etc. Mostly satisfied and completely satisfied make up 27.1% of responses, indicating that just over a quarter of respondents are satisfied with the environmental impact of public transport. They likely perceive public transport as best available option regarding environmental impact.

The data reflects a mixed sentiment regarding satisfaction with the environmental impact of public transport. Some of the most efficient policies to enhance satisfaction with the environmental impact of public transport are transition to cleaner technologies, promotion of sustainable practices and awareness campaigns.

Table 132. Satisfaction with cost of transportation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	46	10.8	11.0	11.0
	Mostly dissatisfied	87	20.5	20.8	31.8
	Both satisfied and dissatisfied	125	29.5	29.9	61.7
	Mostly satisfied	77	18.2	18.4	80.1
	Completely satisfied	83	19.6	19.9	100.0
	Total	418	98.6	100.0	
Missing	System	6	1.4		
Total		424	100.0		

Source: Author's calculations

Responses are, somewhat, equally distributed. Most of respondents (38.3%) are satisfied with the cost of transportation. They likely find the cost reasonable or feel they receive adequate value for the money spent. On the other hand, categories "Not satisfied at all" and "Mostly dissatisfied" account for 31.8% of responses. This suggests that a significant proportion of respondents have concerns or are dissatisfied with the current cost of transportation. Reasons could include affordability issues, perceived lack of value for money, or comparison with other transport options.

Based on our data, recommendations can include service improvements and price adjustment (even making public transport free through subsidies) in order to make public transport just and available for everyone, including low-income individuals.

Next 12 questions refer to what respondents consider or perceive as important regarding various aspects of public transport in Kragujevac.

Table 133. Statistics

		Importance of frequency	Importance of travel time	Importance of comfort of waiting	Importance of comfort of the journey	Importance of availability of seats	Importance of cleanliness
N	Valid	415	414	415	414	414	414
	Missing	9	10	9	10	10	10
Mean		4.3614	4.2826	4.0843	4.6377	3.9807	4.4130
Median		5.0000	5.0000	5.0000	5.0000	4.0000	5.0000
Std. Deviation		1.01413	.99141	1.18775	.70221	1.17875	.93928
Variance		1.028	.983	1.411	.493	1.389	.882

Source: Author's calculations

Table 134. Statistics

		Importance of information availability	Importance of ease of connection	Importance of station proximity	Importance of safety	Importance of environmental impact	Importance of cost of transportation
N	Valid	415	415	415	414	415	415
	Missing	9	9	9	10	9	9
Mean		4.4530	4.1976	4.2771	4.4831	4.2048	4.2627
Median		5.0000	5.0000	5.0000	5.0000	5.0000	5.0000

Std. Deviation	.97410	1.03769	.94426	.94316	.99709	1.06137
Variance	.949	1.077	.892	.890	.994	1.127

Source: Author's calculations

All factors have means above 4, indicating they are generally considered important by respondents. "Importance of Comfort of the Journey" has the highest mean (4.6377), suggesting it is the most critical factor for respondents (next are "Safety", and "Cleanliness"). "Importance of Availability of Seats" has the lowest mean (3.9807), indicating it is still important but comparatively less so compared to the other factors.

The median for most variables is 5, which means that at least half of the respondents rated these factors as "Very Important". The median for the "Importance of Availability of Seats" is 4, indicating a slight difference in central tendency compared to the other variables.

"Importance of Comfort of Waiting" and "Importance of Availability of Seats" have higher standard deviations (1.18775 and 1.17875, respectively) and higher variance, indicating a wider spread of responses around the mean. "Importance of Comfort of the Journey" has the lowest standard deviation (0.70221), indicating that most respondents have similar opinions about this factor.

The high means and medians suggest a general consensus that all twelve factors are important to respondents for an effective public transportation system. Policymakers should prioritize improvements in the most highly rated areas, particularly comfort of the journey, safety, and cleanliness, while also considering the diverse opinions on factors like the availability of seats and comfort of waiting.

Table 135. Importance of frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	12	2.8	2.9	2.9
	Mostly unimportant	18	4.2	4.3	7.2
	Equally important and unimportant	39	9.2	9.4	16.6
	Mostly important	85	20.0	20.5	37.1
	Very important	261	61.6	62.9	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

Main point here is that the vast majority (83.4%) of respondents consider frequency of public transport to be either "Mostly important" or "Very important". This data suggests that improving the frequency of public transportation is likely to be well-received by most of the population, as it is a crucial factor for most respondents.

Table 136. Importance of travel time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	10	2.4	2.4	2.4
	Mostly unimportant	16	3.8	3.9	6.3
	Equally important and unimportant	53	12.5	12.8	19.1
	Mostly important	103	24.3	24.9	44.0
	Very important	232	54.7	56.0	100.0
	Total	414	97.6	100.0	

Missing	System	10	2.4		
Total		424	100.0		

Source: Author's calculations

A vast majority (80.9%) of respondents consider travel time to be either "Mostly important" or "Very important". On the other hand, much smaller portion (19.1%) of respondents are neutral or consider travel time to be of low importance. Our data suggests that improving travel time by public transport is s a significant factor for most respondents.

Table 137. Importance of comfort of waiting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	26	6.1	6.3	6.3
	Mostly unimportant	17	4.0	4.1	10.4
	Equally important and unimportant	69	16.3	16.6	27.0
	Mostly important	87	20.5	21.0	48.0
	Very important	216	50.9	52.0	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

A majority (73%) of respondents consider the comfort of waiting to be either "Mostly important" or "Very important". Only a small fraction of respondents considers the comfort of waiting to be of low importance, with 4.1% saying it is "Mostly unimportant" and 6.3% indicating it is "Not important at all".

Table 138. Importance of comfort of the journey

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	3	.7	.7	.7
	Mostly unimportant	5	1.2	1.2	1.9
	Equally important and unimportant	21	5.0	5.1	7.0
	Mostly important	81	19.1	19.6	26.6
	Very important	304	71.7	73.4	100.0
	Total	414	97.6	100.0	
Missing	System	10	2.4		
Total		424	100.0		

Source: Author's calculations

Almost all (93%) of respondents consider the comfort of the journey to be either "Mostly important" or "Very important", while only 7% of respondents are neutral or consider the comfort of the journey to be of low importance.

Table 139. Importance of availability of seats

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	24	5.7	5.8	5.8
	Mostly unimportant	24	5.7	5.8	11.6
	Equally important and unimportant	75	17.7	18.1	29.7
	Mostly important	104	24.5	25.1	54.8
	Very important	187	44.1	45.2	100.0
	Total	414	97.6	100.0	
Missing	System	10	2.4		
Total		424	100.0		

Source: Author's calculations

More than 70% of respondents consider the availability of seats to be either "Mostly important" or "Very important", while less than 30% of respondents are neutral or consider the availability of seats to be of low importance.

Table 140. Importance of cleanliness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	13	3.1	3.1	3.1
	Mostly unimportant	6	1.4	1.4	4.6
	Equally important and unimportant	36	8.5	8.7	13.3
	Mostly important	101	23.8	24.4	37.7
	Very important	258	60.8	62.3	100.0
	Total	414	97.6	100.0	
Missing	System	10	2.4		
Total		424	100.0		

Source: Author's calculations

Almost 87% of respondents consider cleanliness to be either "Mostly important" or "Very important", while 13.2% of respondents are neutral or consider cleanliness to be of low importance.

Table 141. Importance of information availability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	11	2.6	2.7	2.7
	Mostly unimportant	16	3.8	3.9	6.5
	Equally important and unimportant	31	7.3	7.5	14.0
	Mostly important	73	17.2	17.6	31.6
	Very important	284	67.0	68.4	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

A significant majority (86%) of respondents consider the availability of information to be either "Mostly important" or "Very important", while about 14% of respondents are neutral or consider the availability of information to be of low importance.

Table 142. Importance of ease of connection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	11	2.6	2.7	2.7
	Mostly unimportant	21	5.0	5.1	7.7
	Equally important and unimportant	61	14.4	14.7	22.4
	Mostly important	104	24.5	25.1	47.5
	Very important	218	51.4	52.5	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

A significant majority (77.6%) of respondents consider ease of connection to be either "Mostly important" or "Very important". On the other hand, around 23% of respondents are neutral or consider ease of connection to be of low importance.

Table 143. Importance of station proximity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	8	1.9	1.9	1.9
	Mostly unimportant	12	2.8	2.9	4.8
	Equally important and unimportant	59	13.9	14.2	19.0
	Mostly important	114	26.9	27.5	46.5
	Very important	222	52.4	53.5	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

Very significant portion (81%) of respondents consider station proximity to be either "Mostly important" or "Very important", while around 19% of respondents are neutral or consider station proximity to be of low importance.

Table 144. Importance of safety

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	12	2.8	2.9	2.9
	Mostly unimportant	9	2.1	2.2	5.1
	Equally important and unimportant	33	7.8	8.0	13.0
	Mostly important	73	17.2	17.6	30.7
	Very important	287	67.7	69.3	100.0

	Total	414	97.6	100.0	
Missing	System	10	2.4		
Total		424	100.0		

Source: Author's calculations

A vast majority (86.9%) of respondents consider safety to be either "Mostly important" or "Very important", while 13.1% of respondents are neutral or consider safety to be of low importance.

Table 145. Importance of environmental impact

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	12	2.8	2.9	2.9
	Mostly unimportant	12	2.8	2.9	5.8
	Equally important and unimportant	64	15.1	15.4	21.2
	Mostly important	118	27.8	28.4	49.6
	Very important	209	49.3	50.4	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

Over 78% of respondents consider environmental impact to be either "Mostly important" or "Very important". On the other hand, 21.8% of respondents are neutral or consider environmental impact to be of low importance.

Table 146. Importance of cost of transportation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important at all	17	4.0	4.1	4.1
	Mostly unimportant	12	2.8	2.9	7.0
	Equally important and unimportant	55	13.0	13.3	20.2
	Mostly important	92	21.7	22.2	42.4
	Very important	239	56.4	57.6	100.0
	Total	415	97.9	100.0	
Missing	System	9	2.1		
Total		424	100.0		

Source: Author's calculations

Almost 80% of respondents consider the cost of transportation to be either "Mostly important" or "Very important", while around 20% of respondents are neutral or consider the cost of transportation to be of low importance.

Table 147. Advantages of electric buses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	147	34.7	36.2	36.2
	No	259	61.1	63.8	100.0
	Total	406	95.8	100.0	

Missing	System	18	4.2
Total		424	100.0

Source: Author's calculations

This data provides insights into the perceptions of respondents regarding the advantages of electric buses, which can guide strategies for promoting and improving public transport services in Kragujevac.

A majority of respondents (63.8%) are not familiar or does not recognize advantages of electric buses. On the other hand, 36.2% of respondents see benefits or advantages in using electric buses. Understanding the reasons behind the negative perception or (most likely) lack of information can help in addressing concerns related to the adoption of electric buses, such as cost or performance. Promoting the advantages that electric buses offer, such as reduced emissions and lower operating costs, could potentially increase familiarity and acceptance among respondents and the broader community.

Table 148. Willingness to use electric buses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	376	88.7	89.7	89.7
	No	43	10.1	10.3	100.0
	Total	419	98.8	100.0	
Missing	System	5	1.2		
Total		424	100.0		

Source: Author's calculations

A significant majority, 89.7% of the valid respondents, indicated they are willing to use electric buses. This indicates strong support for the adoption of electric buses among the survey participants. Only 10.3% of the valid respondents are not willing to use electric buses.

The high willingness to use electric buses suggests that introducing electric buses in Kragujevac could be well-received by the public. This provides a solid foundation for implementing such an initiative. Understanding the concerns of the 10.3% who are unwilling to use electric buses can help in creating targeted communication and addressing any barriers to adoption, such as concerns about cost or reliability. The strong support for electric buses can be used to justify policy decisions, investments, and initiatives aimed at improving the public transport system with more sustainable options.

The obtained data highlights the overall positive attitude towards electric buses, indicating a favorable environment for introducing electric bus services in Kragujevac.

Table 149. Opinion on additional transfer affecting decision

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	115	27.1	30.0	30.0
	No	268	63.2	70.0	100.0
	Total	383	90.3	100.0	
Missing	System	41	9.7		
Total		424	100.0		

Source: Author's calculations

Of all valid respondents that are willing to use electric buses only 30% indicated that an additional transfer would affect their decision to use electric buses. This suggests that for almost a third of the respondents, the convenience of their journey is a significant factor. A majority (70%) of valid respondents indicated that an additional transfer would not affect their decision. This suggests a willingness to accommodate minor inconveniences for the benefits offered by electric buses. Either way, ensuring minimal transfers or providing convenient transfer options (e.g. investing in infrastructure that facilitates easy transfers such as well-designed hubs) could enhance satisfaction and adoption rates.

5.7. Scenario development

Reducing the negative effects of urban transport and achieving sustainable urban mobility can be realized by applying various policies from the domain of urban planning and land use as well as transport policy.

These measures and their immediate effects can be described as follows:

1. measures to reduce the total needs for transport in the city - reduction of the total volume of vehicle-kilometers traveled or the total volume of passenger kilometers traveled by urban transport;
2. measures to improve the technical-technological efficiency of vehicles and fuel - reduction of air pollutants, energy consumption and/or CO_2 emissions per vehicle-kilometer driven by different types of urban transport;
3. measures limiting the use of private motor vehicles - reducing the total volume of vehicle-kilometers traveled by cars and motorcycles;
4. measures promoting sustainable forms of urban transport (public transport, bicycle and walking) – increasing the share of public transport, bicycle use and walking in the total number of trips and the total volume of passenger kilometers traveled (Vračarević, 2023).

In defining the scenarios, the focus was placed on the area of transport policy, although actions from that domain alone cannot unlock the full potential of sustainable urban mobility. This focus was chosen because policies from the domain of urban planning are more difficult to realize in practice and require a very long period to be properly defined through adequate planning and strategic documents and later (at least partially) implemented. The importance of this is even greater given the conditions and environment that characterize our country—a very large bureaucracy, significant political influence, and marked uncertainty. The impact of urban development and urban form on transport patterns in Kragujevac, as well as their interdependence, can serve as the basis for future research that will rely on the results of this study.

Therefore, in addition to curbing the need for mobility, a structural shift towards the use of urban transport types that are most desirable from environmental and social perspectives—public transport and non-motorized transport—is necessary. Since most trips in urban areas do not exceed five kilometers, there is considerable potential for stimulating walking and bicycle use. For longer journeys, public transport provides an alternative to the car (Vračarević, 2023).

A significant aspect of our analysis is the notably higher energy efficiency of public transport compared to private cars. Private vehicles consume on average 2-3 MJ/pkm, diesel buses nearly 1 MJ/pkm, while light rail systems consume only 0.3 MJ/pkm (Schafer and Victor, 1999). These drastic differences in energy consumption also result in significantly lower CO_2 emissions per passenger kilometer traveled by public transport. Cars produce between 124.2g and 130.9g (depending on whether they use oil or gasoline), buses emit 89.1g, and rail systems only 60.2g of CO_2 per passenger kilometer (Santos, Behrendt, and Teytelboym, 2010).

The essence of all policies aimed at sustainable urban development and sustainable urban mobility is perhaps best described by Banister (Banister, 2008) who emphasizes the necessity of a complete change of approach in transport planning—from physical dimensions to social ones, from a mobility paradigm to an accessibility paradigm, from motorized to all types of urban transport, and from the segregation of people and transport to their integration.

Based on the policy context and structured discussions with stakeholders, four scenarios were developed to explore the impact of possible transition pathways within the scope of sustainable urban mobility in Kragujevac. These scenarios aim to address the challenges and opportunities related to different aspects of urban transport. They are ordered from the easiest to the most difficult to achieve in practice.

Table 150. Scenario development

Scenario 0 - (Baseline Scenario)	Scenario 1 – "Green baby steps"	Scenario 2 – "Moderate transition"	Scenario 3 – "(Almost) sustainable mobility"
Continuation of current trends in urban transport and urban development without any new interventions and policies.	City central zone served by free electric buses, because of which the expected goals will be reached: reduced air pollution and greenhouse gas emissions, lower energy consumption, stimulated public transport use, decreased traffic congestion.	City central zone served by free electric buses and limited parking opportunities in and around the central zone as a result of which the expected goals will be reached: reduced air pollution and greenhouse gas emissions, lower energy consumption, stimulated public transport use, decreased traffic congestion, discouraged private car use, promoted walking and cycling, reclaimed urban space for public use.	City central zone served by free electric buses, limited parking opportunities in and around the central zone and lower number of private vehicles in central zone with decreased traffic intensity as a result of which the expected goals will be reached: reduced air pollution and greenhouse gas emissions, lower energy consumption, stimulated public transport use, decreased traffic congestion, discouraged private car use, promoted walking and cycling, reclaimed urban space for public use, generated revenue for sustainable mobility investments, improved urban mobility and quality of life through an integrated approach.

5.7.1. Scenario 0 - (Baseline)

The urban system of Kragujevac, as well as cities of a similar size, is heavily burdened by intense traffic and frequent traffic jams, resulting in increased travel time to destinations, higher fuel consumption, significant air and soil pollution, and dissatisfaction among citizens and other transport users. Special problems occur in the central areas of the city, which suffer from particular pressure and additional load. Public transport, which is currently reduced to the use of conventional buses and taxis, faces similar problems, exacerbated by an insufficiently dispersed urban matrix, narrow and impassable streets, and the absence of yellow lanes on all routes.

The area under consideration, rectangular in shape with an area of 154 hectares, includes mainly commercial and residential content, along with many public buildings, a pedestrian zone, green spaces, and protected cultural sites. This area attracts many users who either conduct business or live there. Accessibility to this zone is ensured through individual vehicles and 45 city traffic lines, which accommodate a large percentage of about 30,000 public transport users per day. A pronounced concentration is especially present on border traffic dominants such as Nikole Pašića Street.

The average mobility of Kragujevac inhabitants, determined by a household survey, amounts to 2.21 trips per day, which, when applied to the population of approximately 152,400, results in 336,750 daily trips. The network of public urban and suburban passenger transport in Kragujevac consists of 35 lines with a total operational length of 641.66 km. The city network consists of 23 lines with a total operational length of 301.38 km, while the suburban subsystem has 12 lines with an operational length of 340.28 km. Public city and suburban transport operate from 03:50 AM to

11:15 PM, with peak periods from 05:00 to 08:00 AM, 12:30 to 4:00 PM, and 6:00 to 8:00 PM, during which the highest number of departures occur.

Public city and suburban transport in Kragujevac operate with 65 vehicles, including 31 diesel-powered and 34 CNG-powered vehicles. Approximately 40% of the total daily mileage covered by diesel vehicles is within the central zone, totalling around 3,400 km per working day. In the entire central zone, there are approximately 4,000 marked parking spaces, which is potentially sufficient for stationary traffic. However, most spaces are nearly permanently occupied by residential parking, and the low parking fees and presence of parking lots in the city center further motivate increased traffic into this zone.

Precise measurements of noise pollution and air pollution levels during peak hours in the central zone of Kragujevac (around 1,200 hectares) are not currently available, but they are more pronounced than in other areas. The same applies to the total traffic count. These measurements are planned to be conducted during the preparation of the Traffic Study for Kragujevac.

In the broader urban area of Kragujevac, approximately 146,000 residents live, marking a decrease of about 7.5% compared to the previous census year (2011). However, it is expected that ongoing migratory movements, especially from rural to urban areas, will stabilize this negative trend. Kragujevac, as the economic center of the region and even the Republic, with a significant car industry (FIAT), an established economic zone for high-tech industries and science (MIND park) and completed transportation links with Serbia's major development corridors (European Corridor X), anticipates a population increase of 10% by 2030 according to the city's planning documents.

As this is predominantly a commercial, administrative, and residential zone, overall traffic (both public and private) is at an extremely high level. During peak hours, congestion is significant, travel times are extended, and pollution levels increase. Consequently, the quality of life and work in the area is reduced, potentially leading to an increase in respiratory and other illnesses and necessitating high costs for remediation.

The baseline scenario is rejected as unacceptable because the city is developing in an unsustainable way and suffers many negative effects from urban transport at local and regional levels, as well as contributing to key environmental problems at the global level.

5.7.2. Scenario 1

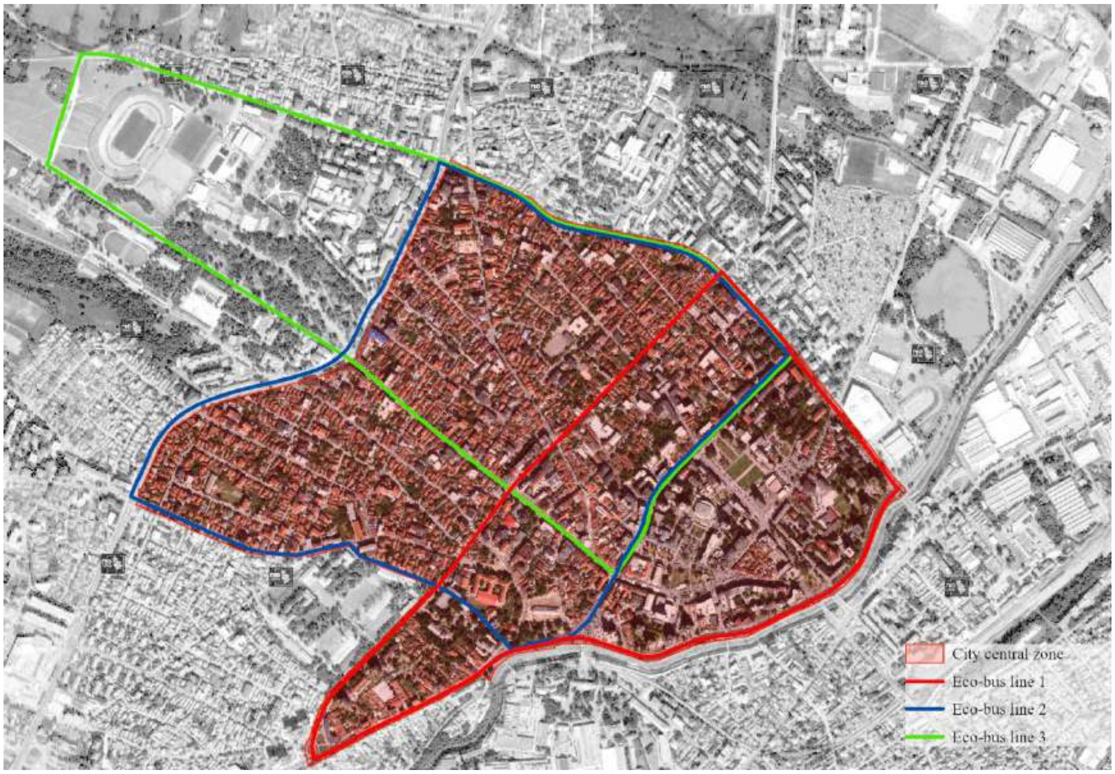
The idea involves combining technical innovations, urban planning solutions, synchronized development policies, and the support of the city administration and local public institutions. The implementation of such a scenario would form the basis for developing the Public Urban Mobility Strategy and incorporating it into the General Urban Plan that will soon be developed for the construction area of the Kragujevac settlement.

The research includes developing a possible scenario. Conventional diesel-fueled buses will drive to the border of the targeted territory and drop off passengers at a properly distributed number of stops. It is also assumed that the existing parking lots will be used, and a minimum of two new ones will be built for individual vehicles (at the border itself or within the zone, as is the current situation). Additionally, the construction of at least one new street to improve the accessibility of the central area and relieve the already overloaded roads is proposed.

The second part includes a detailed plan to completely ban the use of conventional city transport vehicles within the zone and introduce electric buses to replace them. These electric buses would operate along the border of the territory and within it, aiming to ensure a 5-minute isochron from every place in the center to an electric bus station. Individual vehicles would still be allowed entry, but policies such as charging for parking and discouraging long stays or reducing access time to certain parts of the zone would gradually limit their use. The final realization of the scenario is expected to increase citizens' interest in using this type of transport and restore confidence in the reliability of public transport.

Technically, it is necessary to develop special places for charging and servicing buses near the route, ensure quick responses to unplanned events, provide replacement vehicles when necessary, and incorporate smart technologies to enhance implementation. These technologies include solar panels at stations, information systems, sensors on buses to measure pollution, improved ticket sales and verification systems, and enhanced horizontal and vertical markings.

Figure 20. Three eco bus lines in the city of Kragujevac



Source: City of Kragujevac, elaborated by authors

*Legend: Blue - eco line 1 / Red - eco line 2 /Green - possible eco line 3

Effects can be expected in terms of reducing air and soil pollution, reducing noise, and eliminating potential stress and illness caused by these phenomena. An increased need for walking and cycling, through specially marked paths and routes, is also anticipated.

Finally, the economic effects will be visible not only through fuel savings but also through the improvement of the overall content of the central zone, creating a cleaner and better-quality environment. This improvement will lead to an increase in real estate and free space prices. Positive effects from the redistribution of transport movements would directly affect the economic aspects of system functioning by increasing its own income (income from the sale of transport services) and enhancing the ecological sustainability of the city transport system in Kragujevac, as evidenced by the reduction of harmful emissions caused by passenger cars. In this way, the city of Kragujevac would directly implement the EU strategy related to achieving sustainable development goals and improving quality of life in relation to transport systems, through the realization and management of a policy based on achieving residents' mobility with limited use of passenger cars.

5.7.3. Scenario 2

In Scenario 2, a new dimension involves limiting parking opportunities in and around the central zone. This will primarily be achieved through parking restrictions and reducing the number of on-street parking spaces. Literature often proposes parking fees and limiting the number of parking spaces as an effective alternative for solving congestion problems, especially in situations where it is impossible to implement congestion charges effectively

(Verhoef, Nijkamp, and Rietveld, 1995). However, it should not be overlooked that congestion in cities can partly be caused by the lack of free parking spaces. Many studies (Arnott, Palma, and Lindsey, 1991; Calthrop, Proost, and Dender, 2000) have shown that the best effect on reducing congestion is achieved when congestion charges and parking charges (restrictions) are implemented simultaneously.

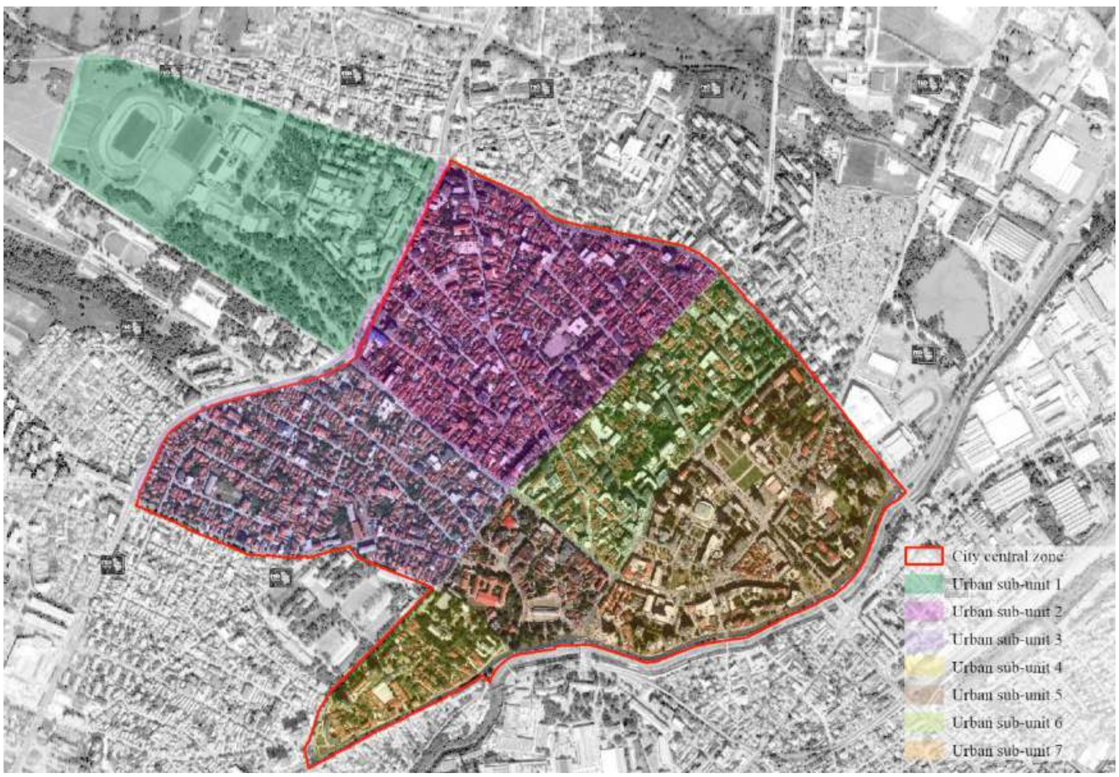
A parking lot, like a city road, can be considered a common resource that will be overused (congested) if it is free. Parking restrictions can indirectly and successfully discourage the use of cars in urban areas, serving as a simple instrument to implement. However, this measure will only be successful if alternatives to private transport, such as an efficient public transport system, are available. Therefore, limiting parking spaces can significantly reduce car use and redirect city dwellers to public transport. Consequently, the surfaces can be repurposed for other uses (Vračarević, 2023).

In this scenario, the decision has been made to reduce the number of parking spaces in key locations within and near the central zone. The detailed spatial distribution of parking spaces and the number to be revoked are as follows. The entire area is divided into seven urban units, each limited by the routes of the three planned public transport lines (electric buses):

- **Unit 1 (Great Park)**: There are currently 640 parking spaces (PS). Parking and/or garage facilities are planned for the reconstruction of the city stadium, with a capacity of 300 PS. Interventions to abolish parking spaces are planned around the city sports center, where about 50 PS will be removed and replaced at another location.
- **Unit 2 (Old Town)**: There are currently 475 PS. On the perimeter of Unit 2, new parking/garage facilities are planned for the reconstruction of the clinical center, adding 250 new PS. Interventions include removing 60 PS from the linear parking lot along Kralja Aleksandar I Karađorđevića Street to form a two-way bicycle path connecting the city center with Great Park, the city sports center, and the central city park "Šumarice," as well as nearby settlements. Additionally, 30 PS will be removed next to the Clinical Center to create a green area.
- **Unit 3 (Erdoglija)**: There are currently 130 PS. New parking/garage facilities with a capacity of 400 PS for public use are planned within the repurposed military complex on the perimeter of Unit 3. Interventions include expanding the transport network, extending the existing profile, and building the new route of Daničićeva Street, which is the planned "blue line" of public transport.
- **Unit 4 (Mala Vaga)**: There are currently 50 PS. New parking/garage facilities with a capacity of 200 PS for public use are planned within the repurposed military complex on the perimeter of Unit 4, along with public garages along the Lepenica River (capacity of 200 PS). Interventions include expanding the traffic network by widening Kneza Miloša Street to four lanes, which is the planned "red line" of public transport.
- **Unit 5 (Milošev venac)**: There are currently 125 PS. No new parking/garage facilities are planned for public use. Interventions include expanding the traffic network by building the new route of Daničićeva Street (the planned "blue line" of public transport) and widening Kneza Miloša Street to four lanes (the planned "red line" of public transport). The planned block road connection between Branko Radičevića Street and City Market opens up the possibility of closing parts of some block roads and transforming them into pedestrian streets or streets with a special usage mode, eliminating around 35 PS.
- **Unit 6 (Svetozar Marković block)**: There are currently 715 PS and garage spaces (GS), including a multi-storey parking garage with 180 GS. No new parking/garage facilities are planned for public use. Interventions include removing 30 PS from the linear parking lot along Kralja Aleksandar I Karađorđevića Street to form a two-way bicycle path, resulting in the abolition of about 90 PS when combined with unit 2. Additionally, the existing profile of Milovana Gušića Street will be expanded to four lanes, which is the planned "red line" of public transport.
- **Unit 7 (City Center)**: There are currently 1530 PS. Significant retail parking and garage capacities (185 PS and 115 GS) and sports zones (80 PS) are present on the perimeter of Unit 7, totaling 380 parking spaces.

Although there appears to be ample parking capacity, over 1,000 public PS are in parking lots predominantly used by city center residents. Therefore, for employees and users of the city center, around 500 PS are available, which is insufficient. The largest new capacities are planned here, with around 1,400 PS for public use to be realized through multi-storey above-ground or underground public garages. Interventions will focus on freeing up areas of the central city core for landscaping and greening, prioritizing active traffic participants such as pedestrians, cyclists, and e-scooter users. Eliminating vehicular and stationary traffic in the city center and constructing public garages will abolish a total of 350-450 existing PS, resulting in a total capacity of around 1,500 PS for non-residents after construction. No new housing is planned in the city center, so the number of residents will not increase, but the need for parking will be limited by current capacities.

Figure 21. Seven urban sub-units in the city of Kragujevac



Source: City of Kragujevac, elaborated by authors

5.7.4. Scenario 3

Scenario 3 is the most difficult to achieve, primarily because it entails discouraging private transport, which is challenging to implement due to significant public resistance. Traveling by car still provides the greatest comfort and freedom of movement, and in developing countries such as Serbia, the automobile is often considered a status symbol. One of the most effective instruments to achieve this goal is congestion pricing/charges.

Congestion charges are a corrective instrument aimed at reducing traffic congestion and thus increasing average driving speed. When certain goods are free, people tend to consume them more than when they have to pay a price reflecting the cost of use. By introducing the congestion charge, the road (a good with a limited supply) would be allocated to those who value it the most, based on the well-known principle of willingness to pay. In theory, this charge should equal the marginal costs of congestion imposed on other drivers (excessive cost of petrol, time, etc.). Initially, the marginal cost of an additional vehicle is negligible because it does not cause significant congestion;

however, as road capacity approaches its maximum, the marginal cost practically tends to infinity (Newbery, 1990). Although representing an economically optimal solution, this is impossible to apply fully due to numerous limitations. Therefore, it is generally applied either to certain parts of the road or aimed at specific road users. The congestion charge will be optimally effective only if it is adapted to the time and location, i.e., it should not be the same for all users at all times of the day. It is unnecessary to emphasize how different the external effect of one additional vehicle is during peak hour in an urban environment compared to an area with less traffic intensity during off-peak hours (Vračarević, 2023). Overall, the congestion charge ensures that decision-makers face the full social cost of travel, leading to efficient road use, internalizing an externality, and achieving efficiency gains and urban growth (O'Sullivan, 2018).

Given that congestion charges can also generate significant tax revenues, they are designed differently depending on the primary goal. The systems in Singapore, Great Britain, and the USA primarily aim to reduce traffic congestion, while those in Norway mainly focus on generating income and increasing safety (Timilsina and Dulal, 2010).

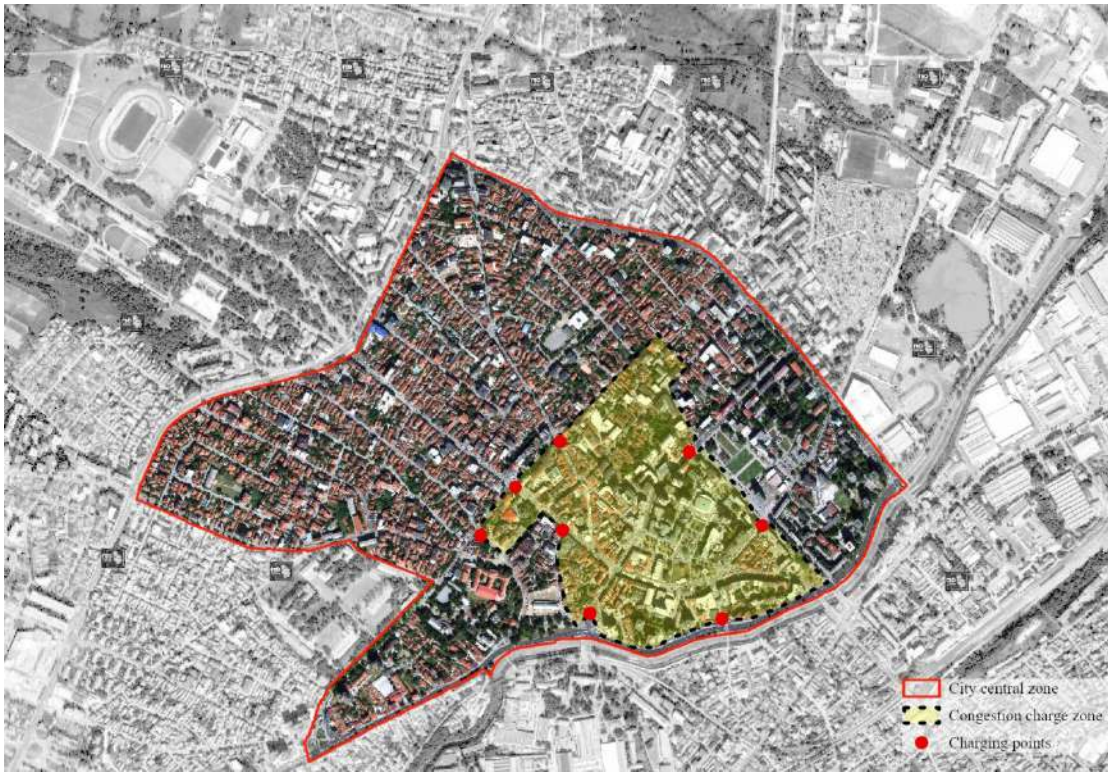
Until the 1960s, urban road planning was predominantly handled by traffic engineers who paid little attention to pricing policy. However, in recent decades, the situation has changed significantly, and many cities around the world have introduced various forms of congestion charges. Notably, congestion charge systems in cities with well-developed public transport systems (such as Stockholm, Singapore, and London) performed best. This link between the availability of efficient public transport and the effectiveness of congestion charges is evident. Thomson noted long ago that public transport functions as a "safety valve" for traffic congestion (Thomson, 1977). Investments in public transport complement congestion charges, enabling the movement of users who abandon car use.

Congestion charge systems are most often applied during peak hours when it is possible to divert a significant portion of commuting traffic to public transport systems (Lehe, 2019). Combining congestion charges and parking charges has achieved the best results in solving traffic congestion problems.

Singapore is considered the world's best example of implementing measures to limit motor vehicle use. The system of congestion charges was introduced in 1975, quite innovatively, in the form of permits that vehicle owners had to buy to enter the central city zone. The effects were visible very quickly. In just one year, the number of cars entering the central zone during peak hours decreased from 43,000 to 11,000 (Seah, 1980), and the speed of vehicle movement doubled (Chin, 1996). In ten years, this system managed to reduce the annual growth rate of motorization from 4.2% to 2.8% (Timilsina and Dulal, 2010). Guided by Singapore's pioneering effort, many European cities have introduced congestion charge systems that quickly led to numerous positive effects. The average speed of movement and the number of trips by public transport increased, while the time spent in traffic, emission of local and global pollutants, transport volume, and traffic accidents decreased.

In the case of Kragujevac, congestion charges will be introduced for a smaller part of the central zone. For the entries to the zone where charges will be applied, a total of eight strategic points are suggested. These would cover the restriction of unit 7 (to Zorana Đinđića Street), unit 6 (to Zorana Đinđića Street and Janka Veselinovića Street), and unit 5 (complete, assuming the cancellation of automobile traffic in Vuka Karadžića Street after the extension of Daničićeva Street, the "blue line" of public transport). In this way, entries to the part of the central zone will be completely controlled with minimal expenditures and infrastructure investments.

Figure 22. Congestion charge zone in the city of Kragujevac



Source: City of Kragujevac, elaborated by authors

5.8. Scenario analysis – Cost benefit analysis (CBA)

A cost-benefit analysis (CBA) aims to quantify all the costs and benefits of a proposed project or policy in monetary terms. Initially, all the costs and benefits related to the proposed action were listed. For costs and benefits ordinarily measured in monetary units, reliable estimates were obtained. For those not ordinarily measured in monetary units, due to budgetary and time constraints, as well as the unavailability of primary data, transferred values or expert opinions were used instead of nonmarket valuation techniques. Finally, all the costs and benefits were summed under a range of scenarios, and total costs were compared to total benefits to obtain a policy recommendation (Harris and Roach, 2018).

Cost-benefit analyses were conducted for scenarios 1, 2, and 3. Although it would be ideal to include a baseline scenario in a cost-benefit analysis for comparison purposes, it was possible to proceed without it due to the unavailability or unreliability of much-needed data in this case. As noted, "most cost-benefit analyses are incomplete to some extent" (Harris and Roach, 2018).

A 10-year period was chosen for the cost-benefit analysis, a widely accepted practice for most infrastructure and transportation projects. This standard timeframe aligns with typical planning and funding cycles and is reasonable considering the operational lifespan of many key elements.

The discount rate represents the time value of money and reflects the opportunity cost of capital. Given the nature of the policies and international recommendations, a 4% discount rate was deemed appropriate. Although, for Serbia, the reference interest rate set by the National Bank of Serbia typically suggests a discount rate for public project evaluations ranging from 6% to 8%, a lower discount rate was chosen for two main reasons: it favors future generations and aligns with sustainable development goals. Additionally, the European Commission often recommends a social discount rate of around 3% to 5% for public investments in EU countries (Serbia is a candidate country for EU membership).

The expected average inflation rate in Serbia over the next 10 years is projected to be around 2-3% per year, aligning with targets set by the National Bank of Serbia (NBS) (https://www.nbs.rs/). Therefore, real discount rates that reflect projected inflation will be used to avoid underestimating future values.

Table 151. Scenarios – Costs and benefits

Scenario 1 – "Green baby steps"	**Scenario 2 – "Moderate transition"**	**Scenario 3 – "(Almost) sustainable mobility"**
Main measures: 1. Introduction of three lines of electric buses (free service) that will operate in central zone of Kragujevac and partly substitute conventional existing buses.	**Main measures:** 1. Introduction of three lines of electric buses (free service) that will operate in central zone of Kragujevac and partly substitute conventional existing buses. 2. Revoking a number of parking spaces on the streets and partly substituting them with garage spaces which will have a higher parking fee	**Main measures**: 1. Introduction of three lines of electric buses (free service) that will operate in central zone of Kragujevac and partly substitute conventional existing buses. 2. Revoking a number of parking spaces on the streets and partly substituting them with garage spaces which will have a higher parking fee. 3. Implementation of congestion charges in a smaller part of a central zone which suffers from heaviest congestions and is in the same time economically and practically viable for this type of policy.
Potential costs: - The initial investment required to acquire the electric buses. - Installation of charging stations and related infrastructure. - Modifications to existing bus depots to accommodate electric buses. - Regular maintenance of electric buses and charging stations. - Battery disposal costs. - Cost of electricity for charging the buses. - Training for drivers and maintenance staff to handle electric buses. - Loss of income due to free electric buses service.	**Potential costs in addition to scenario 1:** - Expenses for building new parking garages or modifying existing structures. - Costs associated with acquiring land or repurposing existing land for garage construction. - Demolition Costs: Costs of removing existing street-level parking infrastructure and preparing the site for new use. - Ongoing costs for maintaining the new parking garages, including security, cleaning, and repairs. - Costs related to operating the garages, including staffing, utilities, and technology for automated systems. - - Potential Loss of Revenue: Initial decrease in parking revenue if the higher fees discourage use, until a balance is achieved.	**Potential costs in addition to scenario 1 and scenario 2**: - Installation of cameras, sensors, and other equipment necessary for monitoring and enforcing congestion charges. - Costs associated with installing signs and information boards to inform drivers about the congestion charge zone and fees. - Ongoing costs for maintaining the monitoring and payment systems. - Costs associated with ensuring compliance, including administrative expenses for issuing fines and handling disputes. - Hiring and training staff to manage the congestion charge system. - Public Awareness Campaigns: Expenses for campaigns to inform the public about the new policy. - Short-term economic impact on businesses within the congestion charge zone due to changes in customer behaviour.

Potential benefits:	**Potential benefits in addition to scenario 1:**	**Potential benefits in addition to scenario 1 and scenario 2:**
- Significant reduction in greenhouse gas emissions. - Significant reduction in - air pollutants (e.g., NOx, PM). - Lower noise pollution. - Lower incidence of respiratory and cardiovascular diseases due to improved air quality. - Lower operational costs over time compared to conventional buses, due to cheaper energy costs and maintenance. - Energy Efficiency: Electric buses are more energy-efficient, leading to cost savings. - Employment opportunities in the installation and maintenance of electric bus infrastructure. - Increased use of public transport: Free services can attract more users and reduce car dependency and traffic congestion. - Accessibility and fairness: Free transport services make public transport accessible to all citizens regardless of socio-economic status.	- Higher fees for garage parking can generate more revenue compared to on-street parking. - Reduced street-level parking can enhance the visual appeal of the streets, potentially increasing property values. - Freed-up street space can be repurposed for green areas, bike lanes, pedestrian zones, or other community-beneficial uses. - Lower congestion from cars searching for parking spaces can improve traffic flow. - Reduction in emissions from vehicles circling for parking, contributing to improved air quality. - Increased Business Activity: Improved accessibility and aesthetics can attract more foot traffic to local businesses. - Enhanced Public Spaces: More available space for public amenities, parks, and social areas, improving quality of life. - Improved Air Quality: Less traffic congestion can lead to better air quality, reducing respiratory problems among residents. - Increased Physical Activity: Enhanced pedestrian and cycling infrastructure can encourage healthier lifestyles.	- Direct revenue from the charges levied on vehicles entering the congestion zone. - Decreased traffic congestion, leading to improved travel times and reduced vehicle operating costs. - Reduction in greenhouse gas emissions and air pollutants due to decreased traffic and smoother traffic flow. - Better air quality can lead to a reduction in respiratory and cardiovascular diseases. - Encouragement of walking, cycling, and the use of public transportation can contribute to better public health. - Improved travel times can lead to increased productivity for businesses and individuals. - Property Value Increases: Potential increase in property values due to reduced congestion and improved environmental quality. - Improved urban environment and reduced noise pollution can enhance the overall quality of life for residents. - Equity Improvements: Revenue from congestion charges can be reinvested in public transportation and infrastructure, benefiting the wider community.

Source: Author's estimation

Of course, a number of the mentioned costs and benefits, especially external costs and benefits, cannot be reliably calculated, while for some others only a rough estimate is possible. Those costs and benefits for which reliable monetary values could not be determined based on similar studies, contact with experts and employees of public institutions in Kragujevac, governmental reports, vehicle manufacturers, utility providers, and relevant literature were omitted from the cost-benefit analysis. It represents a kind of limitation but also direction of possible future research.

Scenario 1: Introduction of three lines of electric buses (free service) that will operate in central zone of Kragujevac and partly substitute conventional existing buses

Explanation and assumptions about costs

Bearing in mind the results of the survey and field research, the best policy for the introduction of electric buses in the central zone was formulated. To achieve high-capacity occupancy, which directly influences electricity consumption per passenger kilometre travelled, and considering that the road network in the central area of Kragujevac is narrow with limited room for expansion, the decision was made to use electric buses with lower capacity. These are typically smaller in size compared to standard buses, making them suitable for intra-city routes, and other applications where manoeuvrability and lower passenger capacity are advantageous. Bearing in mind the lowest possible price as well as the desired characteristics, the model selected is the BYD eBus-7, with a maximum capacity of 26 passengers. The technical characteristics are as follows: battery capacity 174kWh, battery technology LFP and charging system is Plug-in charging (CCS) with a maximum range of around 240km.[58] Based on the length of the three new routes, the desired frequency of about 7 minutes, and the working hours of nearly 19 hours to fit into the existing system (with first departures around 4 a.m. and last around 11 p.m.), the estimation is that 18 electric buses are needed.

Considering the technical characteristics of the selected electric bus model, our estimate is that 10 charging stations are needed[59] Furthermore, there is no need to build or modify to existing bus depots to accommodate electric buses because they can support an additional number of vehicles. For heavy-duty applications like buses, battery life expectancy typically range from 5 to 10 years depending on usage patterns. Since the decision is to have a fleet of 18 buses, it is assumed that the battery will be replaced every 10+ years, so this cost will not be included in the CBA.

Maintenance costs for electric buses can range from 0.11 EUR to 0.17 EUR per km, which includes routine servicing and battery management[60]. Assuming an average bus speed in the Kragujevac central zone of around 20 km/h and working hours of 19 hours on all three new routes, the buses will travel about 380 km daily per route.

As for charging stations, DC fast chargers were chosen, which are used for Level 3 charging and offer much faster charging times. Maintenance costs for DC fast chargers often range from 900 EUR to 2,700 EUR per charger per year.[61]

For calculating the cost of electricity for charging the buses, a few pieces of data are needed. One of the data is energy efficiency i.e. the energy consumption rate of the bus, usually measured in kWh per kilometer (kWh/km). For our chosen bus model energy efficiency of approximately 1.2 kWh/km under standard operating conditions.[62] A standard charger efficiency of around 90% will be assumed, as some energy is lost during the charging process. As for the electricity rate in Serbia for commercial or industrial consumers it typically ranges between 0.07 EUR and 0.10 EUR per kWh depending on various circumstances.[63]

Since three buses will be operating on each route at all times, the daily cost of electricity for charging the fleet of 3 buses, each traveling 380 km per day with the given assumptions, is around 129 EUR. For all three routes total price will be 387 EUR daily.

To determine the costs of training for drivers and maintenance staff to handle electric buses, the first step is to calculate the number of drivers needed. Assuming 3 shifts and 9 buses in operation for 19 hours, while accounting for continuous operation, days off, vacations, and potential sick leave, approximately 38 drivers will be needed to cover all shifts. According to industry standards and reports, approximately **8 maintenance staff members** will be needed to adequately maintain a fleet of 18 electric buses, covering daily, weekly, and monthly maintenance tasks[64]. According to our calculations based on industry standards and relevant sources[65] total estimated costs can vary greatly and for our 38 drivers and 8 maintenance staff will range from **20,000 EUR to 100,000 EUR**, depending on the level of training required.

It can be assumed that there will be no significant loss of income due to the free electric bus service, as it will not replace entire existing lines but will cover parts of the city previously without public transport.

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[58] https://bydeurope.com/byd-ebus-k7

[59] https://afdc.energy.gov/, https://www.energy.gov/eere/vehicles/reports-and-publications

[60] https://www.nrel.gov/

[61] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf

[62] https://bydeurope.com/byd-ebus-k7

[63] https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Electricity_price_statistics,https://www.eps.rs

[64] https://www.nrel.gov/docs/fy21osti/80022.pdf

[65] https://www.nrel.gov/docs/fy21osti/80022.pdf

Explanation and assumptions about benefits

About 40% of the total daily mileage of diesel-powered vehicles is in the central zone, which is a total of about 3,400 km for a working day. Based on the calculations, it is assumed that approximately 7.5% of this amount will be shortened and substituted with the introduction of new routes using electric buses. The average annual mileage on line 4 is 54,745.15 km, on line 3 it is 234,878.45km and on line 15 it is 293,281.60km. Approximated and expected reduction will be 16,423 km on line 4, 47,000km on line 3 and 29,300km on line 15 yearly.

Table 152. Pollutant emission per km

	CNG	ED	ED
Bus line	**3**	**15**	**4**
PM10 (gr/km)	0.236772	0.19674	0.11034
PM2.5 (gr/km)	0.126033	0.09946	0.05497
CO (gr/km)	1.226432	1.9636	1.14252
CO2 (kg/km)	1.672907	1.06709	0.57236
NO2 (gr/km)	0.231749	0.56294	0.34807
NOx (gr/km)	5.793716	5.62947	3.4807

Table 153. Reduction of pollutants emission per year

	CNG	ED	ED	
Bus line	**3**	**15**	**4**	**Total**
PM10 (gr)	11,128.28	5,764.48	1,812.11	18,704.9
PM2.5 (gr)	5,923.55	2,914.18	902.77	9,740.5
CO (gr)	57,642.3	5,7533.48	18,763.6	133,939.4
CO2 (kg)	78,626.63	31,265.74	9,399.87	119,292.2
NO2 (gr)	10,892.2	16,494.14	5,716.35	33,102.7
NOx (gr)	27,2304.7	16,4943.5	5,7163.54	494,411.7

Table 154. Cost of reducing emissions of pollutants

	Cost (EUR/gr)	Total reduction of pollution	Cost of pollution per year in EUR
PM10 (gr)	0.087000	18,704.9	1,627.33
CO (gr)	0.000035	133,939.4	4.69
CO2 (kg)	0.056000	119,292.2	6,680.36
NO2 (gr)	0.030000	33,102.7	993.08
NOx (gr)	0.004400	494,411.7	2,175.41

The cost of noise pollution per kilometre travelled by a diesel bus can be difficult to quantify objectively, as it depends on various factors. According to study of the European Commission (European Commission, 2020), the cost of noise pollution from road transport can vary widely but typically falls within the range of 0.01 EUR to 0.03 EUR per vehicle-kilometre. This estimate includes health impacts, property value depreciation, and other social costs associated with noise. Given that diesel buses are generally louder than smaller vehicles, the upper end of this range might be more applicable.

The average fuel consumption of public transport buses in Kragujevac is 42 liters of diesel (in Serbia it's called euro diesel, EURO 5 standard) per 100km. Average price of euro diesel in Serbia is 1.8 EUR per liter.

Further, current disease Incidence of respiratory and cardiovascular diseases in Serbia is 350 and 700 per 100,000 people annually, respectively (https://www.batut.org.rs/). For other necessary data, some assumptions must be made due to the unavailability or unreliability of precise data for Serbia, to our knowledge. Concentration-response functions (CRFs) will be used to estimate the reduction in disease incidence due to reductions in PM2.5, based on relevant studies (Pope et al. 2002). It is assumed that the cost per case for respiratory disease is around 5,000 EUR and the cost per case for cardiovascular disease is around 10,000 EUR, based on common healthcare expenditure data (https://www.who.int/). Using all our other data rough estimates are: total economic benefit for respiratory diseases is around 26,000 EUR per year, and total economic benefit for cardiovascular diseases is around 105,000 EUR per year. Of course, this is incomplete economic assessment of health benefits but still provide us with some much needed data.

The costs of other pollutants are estimated as follows. For NO_2 estimated costs are in the range of 0.01 EUR to 0.05 EUR per gram due to healthcare costs and reduced quality of life from respiratory and cardiovascular diseases (https://www.eea.europa.eu/data-and-maps/figures/nitrogen-dioxide-annual-limit-values-for-the-protection-of-human-health). As for CO_2 since the environmental and social cost of one kilogram of CO_2 varies significantly depending on the specific carbon pricing mechanism and regions, costs are assumed according to the EU Emissions Trading System (ETS), which currently prices CO_2 at around 56 EUR per ton (https://carbonpricingdashboard.worldbank.org/compliance/price). Costs for CO, NOx and PM10 are based on values reported by Meyers (Meyers, 2021)

It's important to note that these values represent a broad range, as the actual costs can depend significantly on local healthcare costs, pollution levels, population density, etc.

CBA 1

A. Present Value of Costs

1. **Initial Investment Costs** (Year 0):
    - Electric Buses: 3,600,000 EUR
    - Charging Stations: 700,000 EUR
    - Training: 60,000 EUR
    - Total Initial Investment: 4,360,000 EUR
2. **Annual Costs**:
    - Maintenance: 348,642 EUR+18,000 EUR=366,642 EUR/year
    - Electricity: 141,255 EUR/year
    - Total Annual Costs=366,642 EUR/year+141,255 EUR/year=507,897 EUR/year
3. **Present Value of Annual Costs:**
    - PV of Annual Costs= 4,443,737 EUR

Present Value of Benefits

1. **Annual Benefits**:
    - Environmental Benefits: 1,627.33 + 4.69 + 6,680.36 + 993.08 + 2,175.41 = 11,481.87 EUR/year
    - Health Benefits: 26,000 + 105,000 = 131,000 EUR/year
    - Operational Savings: 70,564.7 EUR/year
    - Noise Pollution Reduction: 74,460 EUR/year
    - Total Annual Benefits=11,481.87+131,000+70,564.7+74,460=287,506.57EUR/year
2. **Present Value of Annual Benefits**:
    - PV of Annual Benefits=287,506.57×(1−(1+0.0146)−100.0146)=287,506.57×8.7514=2,515,795EUR

B. Net Present Value (NPV)

NPV=2,515,795EUR−8,803,737EUR=−6,287,942EUR

However, it is crucial to consider the non-monetary benefits and long-term sustainability advantages that might not be properly and fully captured in economic analysis.

Scenario 2. Revoking a number of parking spaces on the streets and partly substituting them with garage spaces which will have a higher parking fee

Explanation and assumptions about costs and benefits

In addition to scenario 1, new policies introduced in scenario 2, also, have their costs and benefits. To sum it up, a total of 475-575 PS are planned to be revoked, with 400 PS to be compensated—considering that two garages with 200 PS each are currently being built to replace the existing parking lots that collectively have 160 PS. So, 75-175 PS will be revoked and 400 will be substituted with GS. In this instance, there will be no initial Investment - costs of construction of garage spaces, since construction works began early and are coming to an end. The current **street parking fee is** 0.3 EUR in zone 1 and 0.4 EUR in zone 2 and proposed garage parking fee (for new garages) will be 0.6 EUR per hour. Based on the current situation regarding garage lots in Kragujevac estimated annual operating costs are following - maintenance cost per garage space: 50 EUR/year, security and staffing per garage space: 100 EUR/year, utilities per garage space: 20 EUR/year.

For environmental and social benefits, a reduction in emissions and congestion costs valued at 5,000 EUR/year will be assumed. Considering the typical impacts observed in other studies and the proportion of the city's parking capacity affected by the policy changes (3.4% of the total parking capacity lowered and 10.9% of the total capacity substituted with higher fees parking). For example, a study by the Victoria Transport Policy Institute found that reducing parking spaces and increasing fees can reduce vehicle miles travelled and emissions by 10-30% in urban areas.[66] The reduction in emissions and congestion depends on reduction in cruising for parking and higher parking fees that might discourage car usage and encourage the use of alternative transportation, further reducing emissions.

<u>**CBA 2**</u>

C. Present Value of Costs

1. **Annual Operating Costs**
   - Maintenance cost per garage space: 50 EUR/year
   - Security and staffing per garage space: 100 EUR/year
   - Utilities per garage space: 20 EUR/year
   - Total Annual Operating Cost=170×400=68,000 EUR/year
2. **Present Value of Annual Costs:**
   - PV of Annual Costs =595,895.2

D. Present Value of Benefits

1. **Revenue from Parking Fees**
   - Annual Revenue from Street Parking=125×0.35×365=15,937.5 EUR
   - Annual Revenue from Garage Parking (difference)=400×0.25×365=36,000 EUR
   - Net Annual Revenue Increase=20,062.5 EUR
2. **Environmental and Social Benefits**
   - Reduction in emissions and congestion costs valued at 5,000 EUR/year.
3. **Present Value of Annual Benefits**

66 https://www.vtpi.org/vmt_red.pdf

- PV of Annual Revenue Increase= 191,853 EUR
- PV of Environmental and Social Benefits=43,757 EUR
- Total PV of Benefits=235,610 EUR

E. Net Present Value (NPV)

NPV=235,610 −595,895.2=−360,285.2 EUR

Scenario 3. Implementation of congestion charges in a smaller part of a central zone which suffers from heaviest congestions and is in the same time economically and practically viable for this type of policy

Explanation and assumptions about costs

Regarding the choice between cameras and physical toll booths, although the analysis of local factors and consultation with stakeholders slightly favour the selection of physical toll booths, the decision has been made to proceed with installing cameras (Automatic Number Plate Recognition - ANPR) primarily due to lower costs and efficiency. Taking into account the size of congestion charge zone and traffic flow each entry and exit point would require at least one ANPR camera to capture vehicle license plate data effectively. Costs of ANPR Camera System, including ANPR camera cost and average installation cost, can vary greatly and range from 2,000 EUR to 4,000 EUR. Total operations and maintenance costs of cameras are estimated as 500 EUR per camera per year (lower than in other cases partly because of significantly lower labour costs in Serbia compared to EU[67].

Explanation and assumptions about benefits

Our pricing structure is designed to target the busiest times when congestion is highest (set to discourage unnecessary trips into congested areas), aiming to reduce traffic and improve air quality during those hours.

To determine an appropriate congestion charge for Kragujevac, average income levels and the goals of reducing congestion and improving air quality must be considered. Given an average income of 776 EUR (91,000 din) and compared to other cities like London or Stockholm, it was decided that an appropriate congestion charge for Kragujevac might start with a modest fee, such as 2 EUR per entry into congested areas during peak hours (weekdays, 07 a.m. – 10 a.m.). Later, it can be corrected in accordance with the set goals. Outside of peak hours, including weekends, the congestion charge does not apply.

Since data on vehicle ownership (320 per 1,000 people), average travel time (15 minutes), and average distance of a trip (5-8 km) are available, but precise and specific data on traffic volumes and congestion are not, major assumptions must be made, and the numbers will be based on the experience of other similar cities.

Regarding travel patterns, taking into account employment distribution, retail centers' locations, residential densities, and public transport availability, it can be somewhat safely estimated that roughly 60% of automobiles enter the central zone for work, shopping, or other activities on a daily basis. Projected impact of implementation of congestion charge can be based on experience of London (number of vehicles entering the zone decreased by approximately 15-20% which resulted in rough **reduction in congestion** of 15%) (https://tfl.gov.uk/modes/driving/congestion-charge) and that of Stockholm (number of vehicles entering the zone decreased by approximately 20-25% which also resulted in rough **reduction in congestion** of 15%) (https://skatteverket.se/servicelankar/otherlanguages/inenglishengelska/individualsandemployees/congestiontax.4.32a87cee16d2b11f30e440f.html).

The average automobile in Kragujevac, due to its older age and the prevalence of diesel engines, tends to have a higher environmental impact compared to the average vehicle in EU. The impact includes higher CO_2 emissions,

67 https://www.vitronic.com/en-us/traffic-technology/automatic-number-plate-recognition, https://www.nortechcontrol.com/solutions/vehicle/automatic-number-plate-recognition-anpr

NOx and PM2.5 and PM10. An older diesel vehicle might emit around 0.5-1.0 g/km of NOx, and around 160-200 g/km of CO_2[68].

Travel time savings are calculated **according to projected reduction in congestion** of 15%. To value the total travel time savings per day, a monetary value needs to be assigned to the time saved. This is commonly done using the Value of Time, which varies depending on whether the time saved is for work-related travel or leisure travel. For the sake of this analysis, a common estimate for the Value of Time in Europe of around 15 EUR per hour for an average traveler can be used[69].

CBA 3

F. Present Value of Costs

1. **Initial Investment Costs** (Year 0):

   1. ANPR Camera Installation Costs:

      - Total installation cost = 48,000 EUR

   2. **Annual Operation and Maintenance Costs:**

      - Total annual operation and maintenance cost = 8,000 EUR

G. Present Value of Benefits

1. **Revenue from Congestion Charges:**

   - Annual revenue (assuming 260 operational days per year): = 11,960,000 EUR

2. **Environmental Benefits:**

   - Annual CO2 reduction: 1,764.36 tonnes
   - Monetary value of CO2 reduction: 6,680.36 EUR per year
   - Annual NOx reduction: 7.3515 tonnes
   - Monetary value of NOx reduction: 2,175.41 EUR per year

3. **Travel Time Savings:**

   - Savings per Trip: 2.25 minutes
   - Total Travel Time Savings per Day: 64,800 minutes/day
   - Value of Time Saved: 15 EUR per hour
   - Annual Monetary Value of Time Saved: 4,212,000 EUR
   - Total Annual Benefits: 16,180,855.77 EUR

H. Net Present Value (NPV):

NPV = 149,417,616 EUR

Table 155. NPV for three scenarios

	NPV
Scenario 1	**–6,287,942 EUR**
Scenario 2	**–6,648,227.2 EUR** (–6,287,942 EUR –360,285.2 EUR)

68 https://www.clcv.org/storage/app/media/ICCT-Report-Emissions-Diesel-cars-Europe.pdf, https://single-market-economy.ec.europa.eu/sectors/automotive-industry/environmental-protection/emissions-automotive-sector_en.

69https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Hourly_labour_costs, https://www.destatis.de/Europa/EN/Topic/Population-Labour-Social-Issues/Labour-market/EU_LabourCostPerHourWorked.html

Scenario 3	**142,769,388.8 EUR** (−6,287,942 EUR −360,285.2 EUR **+** 149,417,616 EUR**)**

Source: Author's calculation

Of course, this analysis does not exhaust all the benefits, especially external ones. Also, complementary and synergistic effects of policies proposed is not considering here. So, reasonable caution should be exercised when interpreting the results of this CBA. However, based only on those included in the CBA, it can be concluded that, in contrast to the first two scenarios (which show a negative NPV), Scenario 3 shows a significantly positive NPV. A positive NPV indicates that the project's benefits exceed its costs when discounted to present value. This suggests that Scenario 3 is financially viable, and policies proposed should be implemented.

Next step could include sensitivity analysis to examine how changes in key variables or assumptions affect the NPV for every scenario.

Table 156. Selected data used for evaluating costs and benefits included in CBA*

Number of electric buses	18
Number of charging stations (DC Fast Chargers)	10
Price of electric bus (BYD eBus-7)	200,000 EUR
Price of charging stations including installation	70,000 EUR
Regular maintenance of electric buses	0.14 EUR per km
Regular maintenance of charging stations	1,800 EUR per charger per year
Distance travelled by electric bus, per every of three routes	380km per day
Electricity rate in Serbia	0.085 EUR per kWh
Cost of electricity for charging the buses	387 EUR per day
Training for drivers and maintenance staff to handle electric buses	60,000 EUR
Reduction of kilometres travelled by diesel buses	255 km per day
Reduction in PM10 (gr)	18704.87982 per year
Reduction in PM2.5 (gr)	9740.50131 per year
Reduction in CO (gr)	133939.38996 per year
Reduction in CO_2 (kg)	119292.23428 per year
Reduction in NO_2 (gr)	33102.69861 per year
Reduction in NOx (gr)	494411.6591 per year
Cost of reduction in PM10 in EUR	1627.33 per year
Cost of reduction in CO in EUR	4.69 per year
Cost of reduction in CO_2 in EUR	6680.36 per year
Cost of reduction in NO_2 in EUR	993.08 per year
Cost of reduction in NOx in EUR	2175.41 per year
Cost of noise	0.03 EUR per km
The average fuel consumption of public transport buses in Kragujevac	42 liters of diesel per 100km.
Average price of euro diesel in Serbia	1.8 EUR per liter.
Current Disease Incidence of respiratory diseases in Serbia	350 per 100,000 people annually
Current Disease Incidence cardiovascular diseases in Serbia	700 per 100,000 people annually
Total economic benefit for respiratory diseases caused by PM2.5 reduction	26,000 EUR per year
Total economic benefit for cardiovascular diseases caused by PM2.5 reduction	105,000 EUR per year
Street parking fee	0.35 EUR per hour
Garage parking fee	0.6 EUR per hour

Number of revoked parking spaces	125
Number of replaced street parking spaces with garage parking spaces	400
Annual Revenue from Street Parking (reduced number)	27,375 EUR
Annual Revenue from Garage Parking (increased number)	146,000 EUR
Number of charging points	8
Number of ANPR cameras	16
Costs of ANPR camera with installation	3,000 EUR
Congestion fee	2 EUR
Total operations and maintenance costs of cameras	500 EUR per camera per year
Vehicle ownership	320 per 1,000 people
Average travel time	15 minutes
Average distance of a journey	6.5km
Average CO_2 emission per automobile in Kragujevac	180 g/km
Average NO_x emission per automobile in Kragujevac	0.75 g/km
Estimated number of vehicles entering the central zone	28,800 per day
Estimated number of vehicles entering the central zone (after implementation of congestion charge)	23,000 per day
Decreased number of vehicles entering the zone	20%
Projected reduction in congestion	15%
Value of time	15 EUR per hour

* If not indicated differently in the text, for data with a range of values, the mean value was used

5.9. Conclusions and recommendations

At this moment, it is evident that the research will lead to positive developments in the planning and introduction of new public transport systems in Kragujevac. Moreover, discussions with representatives of other local communities indicate that similar methodologies may be adopted in those areas as well. The significant possibilities that this kind of system opens up motivate both space users and managers to embrace it enthusiastically. Based on the findings so far, the recommendations point towards the fastest and most effective change of the public urban transport system in the researched territory.

There is no doubt that the existing problems in the central area of the city are largely related to the current functioning of the public city transport system. Therefore, changing the system implies a fundamental change in philosophy, not only in traffic management but also in the way of life in the inner-city core. This shift will necessitate numerous other actions that will ultimately lead to a better ecological and socio-economic situation. These actions include changes in urban planning parameters, setting limit values for pollutants, ensuring transparency of pollution measurement results, improving public health, and generally enhancing the quality of life.

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Next steps

The research cases and socio-economic assessment of cost and benefits of each intervention promoting just green transition suggests that there are commonalities between the findings, although they are not comparable per se:

In Albania four scenarios were analyzed, with Scenario 3 (Build Anew) emerging as the most ambitious and potentially rewarding; but Scenario 2 (Harvesting Renewables and Rainwater) offering a good balance between investment and returns.

In Bosnia and Herzegovina four scenarios were presented for two case studies (Zenica and Banovići). Scenario 2 (Partial dismissal of workers with transition into employment) appears most favorable, minimizing negative impacts on employment and fiscal effects. Scenarios 3 and 4 (full dismissal of workers) have the most severe negative impacts.

In North Macedonia the Scenario 2- Closing, Decommissioning, JT Displaced labour assistance, & RES Energy substitution was the most convenient and realistic, in terms of economic and financial feasibility.

In Serbia only 1 scenario had a positive NPV, namely 'Implementation of congestion charges in a smaller part of a central zone' which suffers from heaviest congestions and is in the same time economically and practically viable for this type of policy

In Montenegro three scenarios were analyzed, with Scenario 1 (25% recycling rate and alternative fuel production) considered most favorable. It shows positive economic indicators and balances economic viability with environmental benefits and realistic implementation.

These results will be further discussed and elaborated in a series of co-assessment workshops at regional level, and a few stakeholder meetings at local level. Subsequently an updated version of the report will be designed, incorporating new knowledge created after the research stage, and enhanced results.

Monitoring green transition through case-study research

The knowledge produced in the other tasks of WP4 will be distilled and used to propose a framework for continuous monitoring and assessment of the impacts of green transition in the WB. This framework will propose indicators for monitoring, and will also connect to the SDG targets. The framework is useful to the exploitation of the project results beyond its lifetime, and will be part of the proposal for green transition partnership. A summary of preliminary indicators developed in this stage can be found as an Annex (specific Zenodo open access link are listed below)

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Annexes

Monitoring framework for Just Green Transition indicators in WB (excel)

To download: https://zenodo.org/records/13141829

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