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Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety
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Sustainable Energy and Climate Action Plan of Vrnjačka Banja municipality (SECAP) for period until 2030

Vrnjačka Banja municipality, December 2025.

CRP CENTAR ZA RAZVOJ I PODRŠKU
FORS MONTENEGRO

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Sustainable Energy and Climate Action Plan (SECAP) of Vrnjačka Banja municipality for period until 2030 is prepared within the project „Green Kick“ implemented by the Centre for Development and Support CRP from Tuzla, Bosnia and Herzegovina, in partnership with Smart kolektiv association from Belgrade, Serbia and the Foundation for the Development of Northern Montenegro from Nikšić. The project is a part of the European Climate Initiative (EUKI) (https://www.euki.de/en).

EUKI is a project financing instrument of the German Federal Ministry for the Environment, Climate Protection, Nature Conservation and Nuclear Safety (BMUKN). The EUKI call for project ideas was implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The overarching goal of EUKI is to encourage climate cooperation within the European Union (EU) in order to reduce greenhouse gas emissions.

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CONTENT

LIST OF ABBREVIATIONS

BAU	Business As Usual
BEI	Baseline Emission Inventory
RS	Republic of Serbia
CRP	Centre for Development and Support
DRAS	Disaster Risk Analysis System
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIB	European Investment Bank
ESCO	Energy Service Company
EU	European Union
FSC	Forest Stewardship Council
GCF	Green Climate Fund
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IDEEAA	Agency for identification documents, registers and data exchange
IPCC	Intergovernmental Panel on Climate Change
ISEE	
JKP	Energy efficiency information system
JLS	Local self-government
JPP	Public private partnership
JZU	Public Health Institution
KfW	Kreditanstalt für Wiederaufbau
LED	Light Emitting Diode
MEI	Monitoring Emission Inventory
MZ	Local Community
RCM	Regional Climate Model
RVA	Risk and Vulnerability Assessment
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nation Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorological Organisation

1 INTRODUCTION

1.1 Covenant of Mayors for Climate and Energy

Solving the problems related to climate change is one of the highest priorities of the European Union, which has already set very clear goals in this area for reducing energy consumption and related greenhouse gas emissions. Bearing in mind that more than half of total greenhouse gas emissions are created in urban areas where up to 80% of the total amount of energy is consumed, and that local authorities have a key role in mitigating and adapting to climate change, the European Union launched the "Covenant of Mayors" initiative in 2008 to encourage local authorities to achieve and exceed the climate and energy goals of the European Union. The goal of the Covenant of Mayors was to reduce greenhouse gas emissions for at least 20% by 2020. The success of this initiative soon exceeded all expectations, and the Covenant of Mayors soon became the world's largest voluntary initiative of local energy and climate activities aimed at reducing energy consumption and associated greenhouse gas emissions. One of the obligations of the signatories of this covenant was the development and implementation of the *Sustainable Energy Action Plan (SEAP*).

In 2015, after the European Union determined new goals for reducing greenhouse gas emissions by 2030 and new goals related to urgent and inevitable adaptation to already existing climate changes, this initiative grew into the "Covenant of Mayors for Climate and Energy". Local communities, signatories of this initiative, commit themselves to actions that will achieve a reduction of greenhouse gas emissions initially for at least 40%, and now for 55% by 2030. The goal of this initiative is to unite different levels of government, relevant organizations, agencies and associations, and citizens for the purpose of accelerated joint action aimed at mitigating climate change and strengthening local capacities for adapting to climate change.

In 2017, this initiative grew into the "Global Covenant of Mayors for Climate and Energy", a global movement that currently gathers over 13,000 signatories, local self-governments (LSGs) from 144 countries from Europe, Asia, Africa and America. All signatories share a common vision for 2050, which includes:

- implementation of decarbonisation of the local area, thus contributing to limiting the average global temperature rise below 2°C, ideally to 1.5°C, in accordance with the international climate agreement reached at the United Nations conference on climate change, held in Paris in December 2015[1];
- capacity building of the local community to adapt to the inevitable effects of climate change;
- enabling access to safe, sustainable and affordable energy for all citizens, which will contribute to improving the quality of life and increasing energy security.

The signatories of the Agreement undertake to:

- reduce CO2 emissions (and possibly other greenhouse gases) in its area for at least 55% by 2030 compared to the base year, through increased energy efficiency and use of renewable energy sources;
- increase resilience to climate change by applying the principle of climate change adaptation;
- propose solutions for the current topic of energy poverty, as well as key measures that enable a
- just transition,
- exchange experiences, results and good practices with other local and regional authorities in the European Union and beyond, in the context of the Covenant of Mayors; and
- create the Sustainable Energy and Climate Action Plan - SECAP within a maximum of two years from the date of accession to the Covenant of Mayors for Climate and Energy, and develop associated reports on implementation of the Action Plan.

In order to achieve a harmonized approach to planning and possibility of comparing the achieved results of the implementation of action plans, this initiative has prepared various types of support (instructions, recommendations, web-tools) that make it easier for the signatories of the Covenant to make plans, implement the planned measures and report on the achieved results.

1.2. Sustainable energy and climate action plan

[1] https://unfccc.int/most-requested/key-aspects-of-the-paris-agreement

Sustainable Energy and Climate Action Plan - SECAP is a key document showing how the signatories of the Covenant of Mayors for Climate and Energy will meet their duties determined for 2030. This action plan must include the following key elements:

- Assessment of the situation in terms of greenhouse gas emissions on the entire territory of the local community in the selected base year[2], which are quantified by the Baseline Emission Inventory (BEI);
- Assessment of current risks and exposure of the local community to climate change, and its capacity to adapt to climate change (Risk and Vulnerability Assessment - RVA);
- Long-term vision and goals until 2050, achievable at the local level, Climate Change Mitigation, i.e. for reducing greenhouse gas emissions, for the local community's adaptation to already existing climate changes, and for reducing energy poverty - as a key measure to ensure a just transition and equal access to affordable, safe and sustainable energy for all citizens;
- Local community measures to mitigate climate change, which will achieve the set goal of reducing greenhouse gas emissions by 2030;
- Measures of the local community in the field of climate change adaptation, which will achieve the set goal of strengthening the capacity of the local community to adapt its most vulnerable socio-economic sectors to the greatest risks that climate change brings by 2030;
- Local community measures to reduce energy poverty, which will ensure the improvement of energy efficiency in low-income households by 2030 and improve access to affordable and sustainable energy sources, through integrated support measures (e.g. energy reconstructions, subsidies, advisory programs and social innovations).
- Institutional, organizational, financial and control mechanisms for implementation of planned measures and monitoring of achieved results.

For each local community, joining this initiative represents joining an active community of local self-governments that have committed themselves to the continuous improvement of the living conditions of their citizens and dedicated work to achieve the vision of decarbonizing their territory, adapting to climate change and providing sustainable and safe energy available to all their residents.

Vrnjačka Banja municipality joined the Covenant of Mayors in 2024. In the beginning of 2024 local authorities applied to the *Public call for selection of local self-governments for the preparation of a Sustainable Energy and Climate Action Plan (SECAP).* This call was launched as part of a project that the Centre for Development and Support CRP from Tuzla in Bosnia and Herzegovina is implementing in partnership with the Foundation for the Development of Northern Montenegro from Nikšić and the Smart Kolektiv from Belgrade, Serbia, titled "Green Kick". The project is a part of the European Climate Initiative (EUKI)[3]. EUKI is a project financing instrument of the German Federal Ministry for the Environment, Climate Protection, Nature Conservation and Nuclear Safety (BMUKN). EUKI's call for project proposals was implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The overarching goal of EUKI is to encourage climate cooperation within the European Union (EU) in order to reduce greenhouse gas emissions.

The application was approved, and in this way technical and financial support was provided for preparatory actions and the development of this Action Plan. The next important step in confirming the commitment to the principles and practices of sustainable energy development and adaptation to climate change was made when the decision-making authority made the decision to accede to the Covenant of Mayors for Climate and Energy and develop a Sustainable Energy and Climate Action Plan.

[2] The baseline year is the selected reference year, in relation to which the goal of reducing greenhouse gas emissions in 2030 will be determined and the achieved results will be quantified.
[3] https://www.euki.de/en/

2 SUMMARY

Vrnjačka Banja is located in Raško district, in the valley of West Morava, at the foot of Goč mountain, known for its thermal springs and wooded hills. This position at the crossroads of the roads to Kruševac and Kraljevo makes it an important tourist and balneology centre of central Serbia.

The 2011 census recorded 27,527 inhabitants, while the 2022 census recorded 25,065, with a downward trend in smaller settlements

The climate combines continental and submontane elements: winters are harsh with abundant snow, summers are moderately warm, with rainfall evenly distributed, but with a pronounced spring peak. The mountainous framework reinforces local variations. Climate projections for the period 2030–2050. indicate warming, shorter snow periods and more frequent intense rains in spring, which can change the hydrological regime of Morava and the conditions for balneal tourism.

Climate change in Serbia is already affecting seasonal patterns. For Vrnjačka Banja, this implies the need for long-term strategies. SECAP prioritizes mitigation and adaptation as key steps to ensure community resilience in a changing climate environment.

The creation of SECAP included an analysis of energy consumption and CO_2 emissions, an assessment of vulnerability to climate change, an assessment of the percentage of energy-poor households, and definition of measures to reduce CO_2 emissions, measures to adapt to climate change and measures to alleviate energy poverty. This summary presents the main results of the process, and shows the following main activities:

i. ***Determining key elements of SECAP***

The key elements of SECAP are defined in accordance with the methodological recommendations of the Covenant of Mayors for Climate and Energy, and include:

Scope of SECAP: SECAP refers to the entire geographical or administrative territory of the LSG in question, which is under its jurisdiction as a signatory to the Covenant of Mayors.

The year 2015 was chosen as the **baseline year**, and the main criterion for this choice was the availability of input data required for the calculation of CO_2 emissions.

SECAP covers the **time period** until 2030. As part of this Action Plan, **a control inventory of CO_2 emissions for 2024** compared to the base year was made, in order to determine the emissions' reduction achieved so far and to determine the remaining obligations to reduce CO_2 emissions in relation to the goal set in this document for 2030.

SECAP includes measures to mitigate the consequences of climate change, measures to adapt to climate change and measures to combat energy poverty.

When making the baseline and control inventory, only CO_2 emissions were considered, namely: (i) direct emissions, which are the result of energy consumption that physically takes place on the territory of the municipality; (ii) indirect emissions, which refer to the consumption of network energy (electricity) where the production facilities may be located outside the LSG territory, but its consumption takes place on its territory.

For making the inventory of emissions, **a methodological approach based on activities** was chosen, where the inventory includes all direct and indirect CO_2 emissions that are the result of activities where energy is consumed on the territory of LSGs.

The following sectors of **final energy consumption** were considered:

- The building sector, with three sub-sectors: (1) public buildings owned by LSGs, (2) public buildings not owned by LSGs and (3) residential buildings;
- Transport sector, with three sub-sectors: (1) vehicles in the jurisdiction of LSGs; (2) public transport in the territory of LSGs; and (3) private and commercial vehicles, registered in the area of LSGs;
- The public lighting sector, which includes the entire network of public lighting in the LSG.

ii. ***Determining the long-term vision of sustainable development of LSGs, and goals in the field of climate change mitigation and climate change adaptation***

Bearing in mind the biggest climate and energy problems faced by LSGs, in this Action Plan, which for the first time unites the areas of climate change mitigation and adaptation to their consequences, and energy poverty, **a long-term vision of the city's sustainable future** is determined:

„In 2050, Vrnjačka Banja is a green and smart centre of sustainable development, where natural resources are used responsibly, energy is produced from renewable sources, and the environment is clean and protected. The municipality is a climate-resistant and energy-efficient community, which successfully implements a fair energy transition, alleviates energy poverty and provides high standards of quality of life for all citizens."

The goals set in this Action Plan, which make the path to implementation of the vision and are aligned with other strategic development goals of the LSG, are:

- reducing CO_2 emissions for at least 55% by 2030 compared to the emissions inventory from the base year;
- reducing negative impacts of climate change on the population and the economy by 2030;
- alleviating energy poverty through the establishment of criteria, mapping of energy-poor households and implementation of energy efficiency measures in that category.

iii. *Collection of input data for the analysis of past energy consumption in the considered sectors, and making a CO_2 emissions' inventory in the base and control year*

In this phase of work, calculation of CO_2 emissions in the base year from all considered sectors and sub-sectors, as well as the total base inventory of emissions, which combines emissions from all sectors, was performed. At the same time, the appropriate final energy consumption calculation was first performed, while the CO_2 emissions were obtained by multiplying the obtained energy with the appropriate emission factors for individual energy sources. After that, emissions from all the mentioned sectors were calculated for the control year 2024, taking into account all the changes (decrease or increase in energy consumption, etc.) that happened in the mentioned period.

Comparison of final energy consumption in the obtained baseline and control inventory shows that the final energy consumption in the area of LSGs in the control year 2024 14,93% lower than the consumption in the baseline year. The presentation of changes in total energy consumption and consumption in the considered sectors, as well as the share of individual sectors in the total final energy, in the period from the base year to the control year, is given in the following table and diagram.

ENERGY CONSUMPTION SECTORS	BASELINE INVENTORY in 2015.		CONTROL INVENTORY in 2024.		ACHIEVED REDUCTION IN ENERGY CONSUMPTION	
	Final energy [MWh]	Share of individual sectors [%]	Final energy [MWh]	Share of individual sectors [%]	Final energy [MWh]	Reduction of consumption per sectors [%]
BUILDING AND PUBLIC LIGHTING						
Public buildings owned by LSG	2.696,19	0,32	3.141,48	0,44	-445,29	-16,52
Public buildings not owned by LSG	1.268,91	0,15	857,56	0,12	411,35	32,42
Residential buildings	738.562,78	87,39	605.129,91	84,17	133.432,88	18,07
Public lighting	3.353,05	0,40	1.771,01	0,25	1.582,04	47,18
TRANSPORT						
Vehicles under the jurisdiction of LSG	69,36	0,01	448,57	0,06	-379,21	-546,70
Public transport	2.842,74	0,34	3.006,17	0,42	-163,43	-5,75
Private and commercial vehicles	96.318,25	11,40	104.550,45	14,54	-8.232,20	-8,55
TOTAL	845.111,27	100,00	718.905,14	100,00	126.206,14	14,93%

Table 2-1 Comparison of total final energy consumption and consumption per considered sectors in the baseline and control year

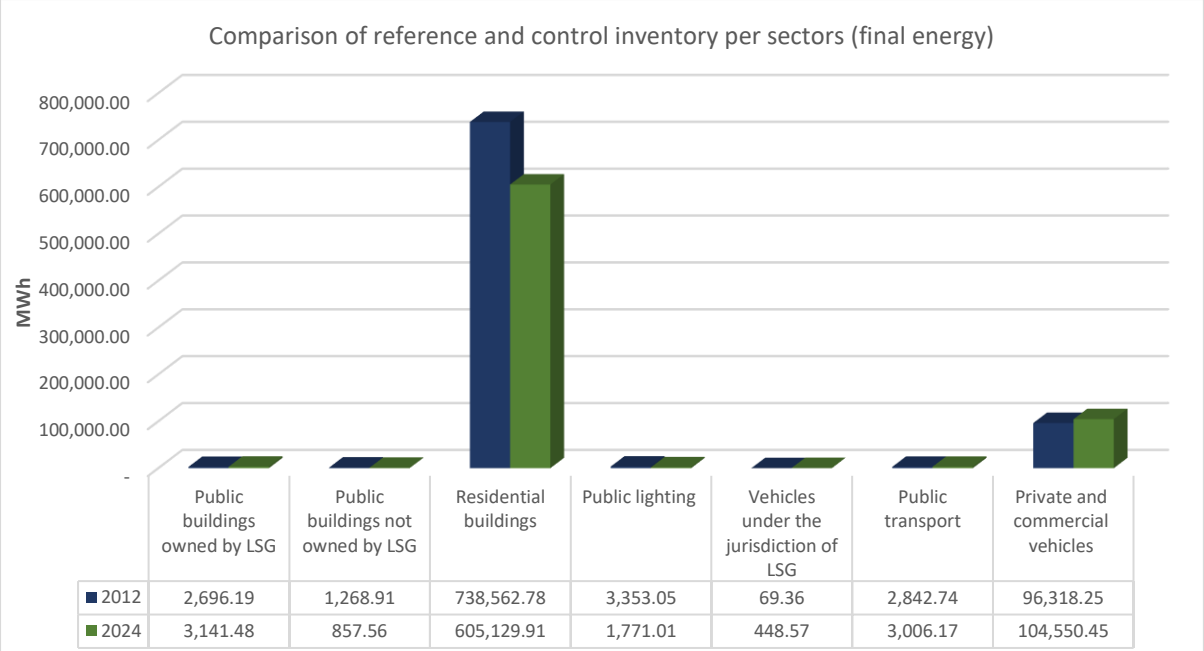

Diagram 2-1 Graphical overview of changes in final energy consumption per considered sectors in the baseline and control year

It is evident that in the mentioned period the largest reduction in energy consumption was achieved in the building sector, especially in the residential buildings sub-sector, where energy consumption decreased by 133,432.88 MWh by the control year 2024, or by 18.07% compared to the baseline year. The main reason for this progress is the willingness of citizens to implement energy efficiency measures and use more efficient heating systems, which was recorded by surveying households during the input data collection phase.

Comparison of CO_2 emissions in the baseline and control inventory shows that CO_2 emissions in the control year 2024 are 29,21% less than the emissions in the baseline year. A presentation of changes in total CO_2 emissions and the share of individual sectors in total emissions, in the period from the baseline year to the control year, are given in the following table.

ENERGY CONSUMPTION SECTORS	BASELINE INVENTORY in 2015.		CONTROL INVENTORY in 2024.		ACHIEVED REDUCTION IN CO_2 EMISSIONS	
	CO_2 emissions [tCO_2]	Share of individual sectors %]	CO_2 emissions [tCO_2]	Share of individual sectors [%]	CO_2 emissions [tCO_2]	Change of CO_2 emissions per sectors [%]
BUILDING AND PUBLIC LIGHTING						
Public buildings owned by LSG	920,63	0,40	911,87	0,56	8,76	0,95
Public buildings not owned by LSG	279,65	0,12	194,29	0,12	85,36	30,53
Residential buildings	198.729,49	86,84	130.990,47	80,86	67.739,03	34,09
Public lighting	3.375,73	1,48	1.946,34	1,20	1.429,39	42,34
TRANSPORT						
Vehicles under the jurisdiction of LSG	18,26	0,01	116,87	0,07	-98,60	-539,88
Public transport	759,01	0,33	802,65	0,50	-43,64	-5,75
Private and commercial vehicles	24.756,70	10,82	27.033,78	16,69	-2.277,08	-9,20
TOTAL	228.839,47	100,00	161.996,25	100,00	66.843,22	29,21%

Table 2-2: Comparison of total CO_2 emissions and emissions from considered sectors in baseline and control year

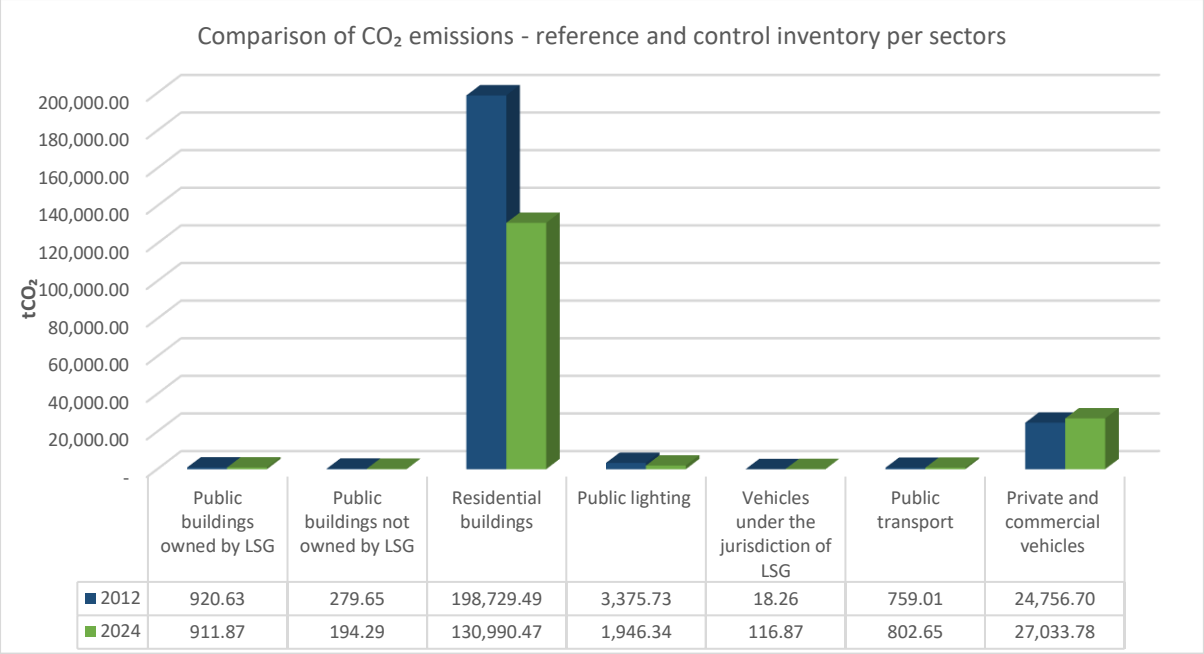

Diagram 2-2: Graphical overview of CO_2 emission changes from considered sectors in baseline and control year

Between the baseline year and the control year, the largest reduction in emissions was achieved in the buildings sector—specifically within the residential sub-sector, where CO_2 emissions decreased by 67,739.03 tCO_2 (or 34.09%) compared to baseline-year levels. The primary drivers of this reduction were the switch to more environmentally friendly heating fuels and the implementation of energy efficiency measures on residential building envelopes. The preceding table also shows an overall emissions reduction of 29.21% for this period relative to the baseline year; this figure is 25.79% less than 55% reduction target set for 2030.

iv. *Making a plan of measures to achieve the goals set in the field of climate change mitigation, i.e. reducing CO_2 emissions*

In accordance with the results of the above calculations, energy efficiency measures have been identified in all considered sectors, the implementation of which will reduce CO_2 emissions in the LSG area for more than 55% compared to emissions in the baseline year. Since the largest share in CO_2 emissions still belongs to the residential buildings sub-sector, the greatest attention was paid to this sub-sector when developing the plan. The list of all planned measures is presented in the following table, while detailed descriptions and technical characteristics for each measure are given within the related sub-title.

Inter-sectoral measures	
MS-1	Continuous education of relevant LSG employees and associated public companies on legal obligations in the field of systematic energy management
Measures to reduce CO_2 emissions from the building sector	
Measures for residential building sub-sector	
SZ-1	Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency
SZ-2	Energy reconstruction of the outer envelope on individual residential buildings
SZ-3	Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings
SZ-4	Installation of photovoltaic (PV) systems on individual residential buildings
Measures for sub-sector of public buildings owned by LSG	
JZO-1	Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels and electricity are used as heating energy

Measures for sub-sector of public buildings not owned by LSG	
JZD-1	Participation in the integrated energy reconstruction of public buildings not owned by LSGs that use fossil fuels as heating energy
Measures to reduce CO_2 emissions from transport sector	
Measures in sub-sector of vehicles under the jurisdiction of LSG	
SG-1	Procurement of electrical vehicles under the competence of LSG
Measures in sub-sector of private and commercial vehicles	
SP-1	Promotion of sustainable mobility and reduction of private vehicle use

Table 2-3: Energy efficiency measures for achievement of set goal of reducing CO2 emissions by 2030

v. *Projection of total CO_2 emission inventory for scenario with planned measures*

The following table gives a comparative overview of the total baseline inventory of CO_2 emissions for all considered sectors of final energy consumption, and emission inventory projections in 2030 for the aggregate scenario that includes the continuation of current trends without more intensive participation of LSGs and with the effects of planned measures in the considered sectors. The table also contains indicators of the percentage of reduction of CO_2 emissions in 2030 compared to the base year in each sector and sub-sector, as well as the total percentage of reduction of CO_2 emissions in the period from the baseline year to 2030.

SECTORS	CO_2 emissions [tCO_2]		Reduction of CO_2 emissions in 2030 compared to the baseline year 2015 [%]
	2015.	2030.	
BUILDING AND PUBLIC LIGHTING			
Public buildings owned by LSG	920,63	604,86	34,30
Public buildings not owned by LSG	279,65	27,90	90,02
Residential buildings	198.729,49	74.376,36	62,57
Public lighting	3.375,73	1.655,77	50,95
TRANSPORT			
Vehicles under the jurisdiction of LSG	18,26	88,03	-382,00
Public transport	759,01	471,56	37,87
Private and commercial vehicles	24.756,70	24.241,70	2,08
TOTAL	**228.839,47**	**101.466,18**	**55,66**

Table 2-4: Comparative overview of total baseline inventory of CO_2 emissions and projection of emission inventory in 2030

According to these projections, the total annual CO_2 emissions until 2030 for the scenario that includes the effects of planned measures and the effects of the continuation of current trends are 101.466,18 tCO_2, which, compared to the emissions in the baseline year, **represents a reduction in total emissions of 55,66%, thus exceeding the indicative goal of reducing CO_2 emissions of at least 55% by 2030.**

vi. *Climate Change Adaptation*

The second phase of the Action Plan development was the assessment of danger, exposure and capacity of LSG to adapt to existing and future climate changes, which included the following steps:

i. Determining the hazards of the climate change consequences, which are relevant for this LSG;

ii. Determining the main current and future characteristics of each identified hazard (probability of occurrence, expected change in intensity, time period of action);

iii. Determining the socio-economic and natural sectors that are most exposed to the identified hazards (buildings, transport, energy, water supply, waste management, land use plans, agriculture and forestry, environment and biodiversity, health, civil protection and emergency services, tourism, education, information and communication technologies), and their level of threat (high, moderate, low);

iv. Determining the most vulnerable target groups within each identified hazard; and

v. Determining the capacity of LSGs to adapt to identified hazards, which implies determining the main categories of these capacities (existence of appropriate public services; availability of socio-economic stakeholders; existence, compliance and implementation of legal regulations; availability of physical resources; and availability of knowledge, methodologies, studies, early warning systems, and the like).

Numerous hazards caused by climate change have been identified in the area of the LSG, including: extremely high temperatures, droughts and water shortages, and heavy rainfall – rain and river floods. Based on consultations with team members and advisory group members for development of this plan, taking into account the analyses and risk assessment studies conducted, as well as hazards that occurred in the previous period, it was determined that the leading risks in this area are heavy rainfall in the form of rain and river floods, extremely high temperatures, droughts and water shortages.

vii. *Development of a plan of measures to achieve the goals set in the field of climate change adaptation*

In a response to the results of this assessment, 6 measures of climate change adaptation were identified, including:

- Measures for adaptation to flood hazards (2 measures);
- Measures for adaptation to extremely high temperature hazards (1 measure);
- Measures for adaptation to drought and water shortage hazards (1 measure);
- Measures for adaptation to climate change hazards (2 measures).

The list of all planned measures, detailed descriptions and technical characteristics for each measure are given in separate tables within the related sub-title.

viii. *Energy poverty within LSG*

Energy poverty in Serbia is a key element of a just energy transition and an increasingly important part of the SECAP process, especially considering that there is still no official, operational definition or national methodology for measuring this phenomenon in the country. Although the status of "energy vulnerable customer" is regulated, it includes only socially vulnerable categories, while SECAP applies a broader European methodology according to which a household that spends more than 10% of its income on energy is considered energy poor.

Data for 2024 show that the average household in Serbia already reaches this threshold, so a stricter criterion of 15% was applied in the analysis in order to more precisely identify the most vulnerable households. Based on this methodology, it is estimated that at least 40% of households in Serbia are affected by energy poverty, which is comparable to regional indicators and indicates a serious structural problem.

SECAP foresees long-term goals and measures until 2030 and 2050, including institutional reforms, targeted subsidies and improvement of energy efficiency, treating energy poverty as a strategic part of climate and social policy.

ix. *Development of a financial and dynamic plan and mechanisms for implementation and financing of the Action Plan*

The comparison of CO_2 emissions from the baseline and control inventory clearly shows that in the period from the base year to the control year, significant efforts were made to reduce energy consumption in all considered sectors, and thus to reduce CO_2 emissions. The performed calculations and analyses also show that the set goals are realistic and that Vrnjačka Banja municipality can achieve them without any problems by implementing the planned measures.

To achieve the first goal, the Action Plan envisages the implementation of 9 measures aimed at reducing energy consumption and reducing the associated CO_2 emissions from all considered sectors of final energy consumption. To achieve the second goal, the Action Plan envisages the implementation of 6 measures aimed at strengthening the city's capacity to adapt to the existing and future consequences of climate change. The third goal refers to alleviating energy poverty through support programs, improving energy efficiency in households and improving access to energy for vulnerable population groups, and to achieve it, the implementation of 6 measures is foreseen.

The following table shows the total value of investments required for implementation of the planned measures, which amounts to 3.181.586 EUR, of which 1.424.586 EUR is intended for measures to reduce CO_2 emissions, 1.615.000 EUR for climate change adaptation measures, and 142.000 EUR for programs to alleviate energy poverty. By implementing these investments, the LSG would achieve all the set goals and significantly improve sustainable, climate-resistant and socially just development.

Segment	Investment (EUR)
Energy efficiency measures to alleviate climate changes	1.424.586
Climate change adaptation measures	1.615.000
Measures to alleviate energy poverty	142.000
TOTAL	**3.181.586**

Table 2-5 Total investment planned per SECAP

The establishment of an appropriate institutional mechanism for implementation, monitoring and control of the implementation of planned measures and reporting on the achieved results and goals, as well as the use of financial mechanisms available to local self-governments, is an additional guarantee for achieving the set goals and rapidly approaching the set vision. This Action Plan will be used as a key document in the process of planning operational programs for the next financial period in the field of energy efficiency and climate change adaptation. Progress in the implementation of SECAP will be monitored through regular updating of the control inventory and reporting in accordance with the requirements of the Covenant of Mayors.

3. ACTION PLAN DEVELOPMENT METHODOLOGY

The methodology used in the making of the *Sustainable Energy and Climate Action Plan* for the period until 2030 (SECAP) is based on the following key principles:

i. Following the guidelines and recommendations given in the guidelines for preparation of this document[4], created by the Covenant of Mayors in cooperation with the *Joint Research Centre of the European Commission*[5];

ii. Use of input data from official publicly available sources, in combination with data collected in the process of creating SECAP by the working team and advisory group for creating SECAP, and citizens;

iii. Use of institutional and individual knowledge, experiences and good practices, which the members of the working team and advisory group for the preparation of this document acquired in the implementation of other activities in the field of sustainable energy and climate;

Expert technical support in development of SECAP provided by the *Centre for Development and Support (CRP)*[6] from Tuzla.

Centre for Development and Support from Tuzla, Bosnia and Herzegovina, in partnership with **Smart kolektiv** from Belgrade, Serbia and the **Foundation for the Development of Northern Montenegro** from Nikšić, leads the preparation of Sustainable Energy and Climate Action Plans (SECAP) for selected LSGs within the **"Green Kick"** project. The selected LSGs received support for the development of SECAP in the form of technical assistance, which includes provision of advisory services and hiring of experts for preparation of documents, who will work closely with the LSG teams. During this process, activities will be organized for employees in the local elf-governments regarding capacity building, such as trainings, workshops or seminars.

3.1. Methodology for implementation of SECAP development process for period until 2030.

The overall SECAP development process included the following main phases:

i. Preparatory activities aimed at initiating the SECAP development process and

ii. Development of the SECAP document in the required format

An overview of the main activities implemented in the SECAP development process is given in the following table:

Phase	Activities
Preparatory activities	• Achieving political consent for the creation and implementation of SECAP; • Involvement of all relevant LSG departments and institutes in development of SECAP; • Ensuring the support of interested parties and general public for development and implementation of SECAP
Process of document development	• Determining the key elements of SECAP and the methodology for performing analyses and calculations; • Analysis of the current situation in the LSG: ○ Analysis of the legal framework that directs the activities of LSG in the field of energy and climate change; ○ Making a baseline and control inventory of greenhouse gas emissions;

[4] https://eu-mayors.ec.europa.eu/en/New-SECAP-Guidebooks-to-help-municipalities-step-up-their-climate-action
„Part 1 – SECAP process, step by step towards low-carbon and climate-resilient cities by 2030“:
(http://publications.jrc.ec.europa.eu/repository/bitstream/JRC112986/jrc112986_kj-na-29412-en-n.pdf;
„Part 2 - Baseline Emissions Inventory (BEI) and Climate Change Risk and Exposure Assessment (RVA)“:
(http://publications.jrc.ec.europa.eu/repository/bitstream/JRC112986/jrc112986_kj-nb-29412-en-n.pdf), i
„Diol 3 – Part 3 - Policies, key activities, key actors, good practices for climate change mitigation and adaptation, and funding for SECAP implementation “

[5] Joint Research Centre (JRC), https://ec.europa.eu/info/departments/joint-research-centre_hr

[6] http://crp.org.ba/

	○ Assessment of the risk and exposure of the subject area to climate change; • Defining a long-term vision and setting goals in the area of: (a) climate change mitigation, (b) climate change adaptation, c) energy poverty mitigation; • Making a plan of measures to achieve the goal set in the area of climate change mitigation , i.e. reducing greenhouse gas emissions; • Making a plan of measures to achieve the goal in the area of climate change adaptation; • Preparing the final *SECAP document for the period until 2030*

Table 2-6: Overview of key stages and activities in the SECAP development process

3.1.1. Preparatory activities to start the SECAP development process

Achieving political consent for the creation and implementation of SECAP

A key prerequisite for creating a high-quality SECAP and for its successful implementation is clearly expressed support for the entire process by the local administration. This support was formalized by the *Decision on accession to the Covenant of Mayors for Climate and Energy* and creation of a *Sustainable Energy and Climate Action Plan*, made by the Municipal Assembly. After that the mayor signed the accession form to the *Covenant of Mayors for Climate and Energy*, whereby Vrnjačka Banja municipality acceded to the Covenant of Mayors for Climate and Energy.

Involvement of all relevant LSG departments and institutes in development of SECAP

By Mayor's decision a Team was formed to develop a *Sustainable Energy and Climate Action Plan*. This team was composed of employees of relevant services and administrative bodies as well as external associates. The tasks of the Action Plan Development Team were:

- collection and analysis of data necessary for the creation of a baseline and control inventory of emissions, assessment of climate risks and vulnerabilities, and ensuring the appropriate involvement of the main stakeholders;
- determining the long-term vision and goals that support the vision, presenting them to the main stakeholders, and ensuring their approval by the political structures of the government;
- participation in the development of the plan: defining policy and measures in accordance with the vision and goals, determining the budget, sources and mechanisms of financing measures, deadlines, indicators and responsibilities;
- obtaining consent to the proposed plan from the political structures of the government;
- establishing a partnership with key stakeholders relevant to the development and implementation of the plan;
- submission of the Action Plan through the website of the Covenant of Mayors, and presentation of the Plan to the public.

Ensuring the support of interested parties and general public for development and implementation of SECAP

Participation of the largest possible number of interested parties and general public is an essential prerequisite for the making a high-quality SECAP and for its successful implementation. Therefore, by decision of the Mayor, *an Advisory Group for development of Sustainable Energy and Climate Action Plan* was established. This group was composed of representatives of institutions, organizations and companies from relevant fields. The tasks of the advisory group were:

- collecting and analysing data necessary for the development of baseline and control emissions inventories, assessing climate risks and vulnerabilities, and ensuring appropriate involvement of key stakeholders;
- establishing a long-term vision and goals that support the vision, presenting them to key stakeholders, and ensuring their approval by political authorities;
- participating in the development of the plan: defining policies and measures in line with the vision and goals, determining the budget, sources and mechanisms for financing measures, timelines, indicators, and responsibilities;
- obtaining approval for the proposed plan from political authorities;
- establishing partnerships with key stakeholders relevant to the development and implementation of the plan;

- delivering the Action Plan via the Covenant of Mayors website, and presenting the Plan to the public.

The team members actively participated in SECAP development, especially through a series of sector-oriented workshops where they significantly contributed to the quality of the Action Plan with their knowledge and experience. They also participated in the creation of measures for individual sectors included in this Action Plan.

The implementation of the preparatory phase for commencement of the SECAP development process is presented in the following Diagram:

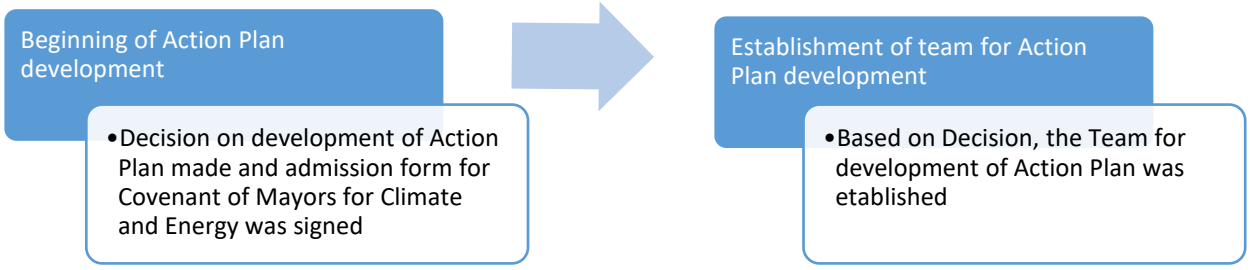

Diagram 3-3: Timeframe for implementation of preparatory actions for the commencement of SECAP development process

3.1.2. Creating a SECAP document in the required format

The SECAP development process for the period until 2030 started in mid-2024 and lasted until the end of 2025, and included the following key activities:

i. Determining the key elements of SECAP (baseline year, time period, relevant sectors, types of measures, etc.) and methodology for performing the required analyses and calculations;
ii. Analysis of the current situation in the area of LSG:
   - o Making a baseline and control inventory of greenhouse gas emissions;
   - o Assessment of risk and exposure of the area to climate change;
   - o Analysis of the legal framework that guides the activities of LSG in the field of energy and climate change;
iii. Determining a long-term vision and setting goals in the area of (a) climate change mitigation, (b) climate change adaptation, and c) energy poverty;
iv. Development of a plan of measures to achieve the goal set in the field of climate change mitigation, i.e. reducing CO_2 emissions;
v. Development of a plan of measures to achieve the goal set in the field of climate change adaptation;
vi. Preparing the final SECAP document *for the period until 2030.*

Deadline for implementation of the mentioned activities of Action Plan development is presented in the following diagram:

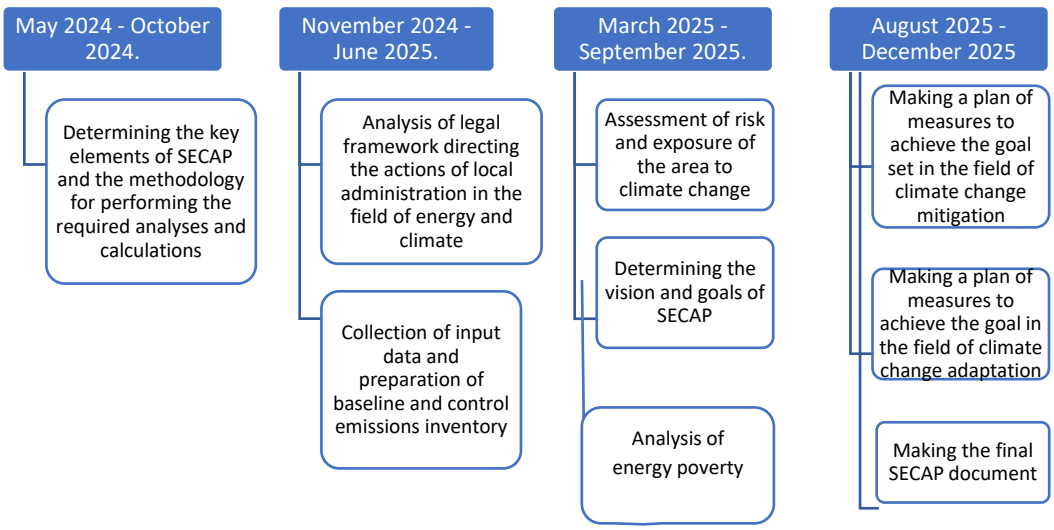

Diagram 2-4: Deadline for implementation of activities on development of SECAP document

3.2. Determining keys elements of SECAP and methodology for performing calculations and analyses

3.2.1. Key elements of SECAP

In accordance with the applied methodology, the Action Plan Development Team in the first phase of work defined all the key elements of SECAP, which directly determine the methodology for performing all necessary calculations and analyses. Presentation of these elements is given in the following table.

Key elements	Selected methodological approach to SECAP development
SECAP scope (covered territory and competence)	SECAP refers to the entire geographical or administrative territory of the LSG in question, which is under its jurisdiction as a signatory to the Covenant of Mayors.
Baseline year	In accordance with the methodological recommendations of the *Covenant of Mayors for climate and energy*, the year 2015 was chosen as the baseline year, and the main criterion for this choice was the availability of input data required for the calculation of CO_2 emissions.
Time period	SECAP covers the time period until 2030. As part of this SECAP, a control inventory of CO_2 emissions for 2024 compared to the base year was made, in order to determine the emissions' reduction achieved so far and to determine the remaining obligations to reduce CO_2 emissions in relation to the goal set in this document for 2030.
Categories of considered measures	a. Climate change mitigation measures; b. Climate change adaptation measures; c. Energy poverty alleviation measures.
The main types of greenhouse gas emissions included in the baseline and control emissions inventory	a. Direct emissions, which are the result of energy consumption that physically takes place on the territory of LSG; b. Indirect emissions, which refer to the consumption of network energy (electricity), where facilities for its production may be located outside the territory of the LSG, but its consumption takes place in that territory.
Types of considered greenhouse gases	Only CO_2 emissions were considered in this SECAP
Adopted approach for making CO_2 emissions inventory	While making SECAP, activities-based methodological approach was chosen, whereby the inventory of emissions includes all direct and indirect CO_2 emissions as a result of activities leading to energy consumption in the territory of LSG.
Considered sectors of energy consumption	Building sector, with three sub-sectors: i. Public buildings owned [7] by LSG; i. Public buildings not owned by LSG, in fact public buildings owned by higher authority levels[8], located within the target area; ii. Residential buildings[9]; Transport sector, with three sub-sectors: i. Vehicles under jurisdiction of LSG ; ii. Public transport within LSG; iii. Private and commercial vehicles registered within LSG; Public lighting sector including the entire public lighting network within the LSG.

Table 2-7: Overview of key elements and methodological approach in the SECAP development process

[7] The term "owned" used here, in addition to ownership, also includes the term "in jurisdiction", because it may happen that in some cases the ownership of the building in which a public institution under consideration is located is not fully resolved. For all of the above, the term "owned" used in the name of this subsector should be understood as "in ownership or jurisdiction".

[8] Ibid.

[9] This subsector includes all types of residential buildings represented in the area of LGUs, which in accordance with the terminology used in the National Typology of Residential Buildings of Serbia

3.2.2. Making baseline[10] and control[11] inventory of greenhouse gasses emissions

The first step in determining goals in the area of climate change mitigation is determining the baseline state, that is, the Baseline Emission Inventory (BEI) in the considered energy consumption sectors. **The baseline inventory of CO_2 emissions, which represents the level of annual CO_2 emissions in the baseline year, is obtained as a product of data on energy consumption in the baseline year in the considered sectors, and corresponding emission factors for energy sources used in these sectors in the baseline year.**

In accordance with the methodological guidelines of the Covenant of Mayors for Energy and Climate, the SECAP goal for 2030 in the area of climate change mitigation is defined as a reduction of emissions by at least 55% compared to the amount of emissions in the set baseline year.

However, the baseline year set in SECAP is 2015, while this document was made in 2025. To determine the progress so far in reducing greenhouse gas emissions, that is, the extent of the reduction of emissions so far in the period from the base year till the end of 2024, it was necessary to determine the so-called Monitoring Emission Inventory (MEI) for 2024. **This control inventory, which represents the annual level of CO_2 emissions in the control year, is determined in principle as the difference between the baseline inventory of emissions and the amount of emissions reduction that is the result of energy efficiency measures implemented in the period from the baseline to the control year.** The stated amount of emission reduction was obtained as a product of the amount of energy savings achieved by the application of energy efficiency measures in the considered sectors, and the corresponding emission factors for the energy used.

3.2.2.1. Input data collection methodology for calculation of energy consumption in the considered sectors in baseline and control year

The most important step for making a reliable baseline and control inventory of emissions was input data collection for all considered sectors and subsectors, which were then used to calculate energy consumption.

The necessary input data were collected in the following ways:

i. Data collection from local sources, which primarily included:
   - Data collection through household surveys; and
   - Collection of data available within the competent services of LSGs and relevant public enterprises, by filling in appropriate questionnaires;

ii. Using data from various official and publicly available sources, such as:
   - Statistics Agency of Serbia[12];
   - *Census of population, households and apartments in Serbia[13],* conducted in 2022;
   - *Typology of public buildings in Serbia[14];*
   - Records (monthly and annual inspections) of all registered vehicles in Serbia[15].

<u>Building sector:</u>

Input data for the subsectors of public buildings owned by LSG and public buildings not owned by LSG were collected through questionnaires that requested the following data for buildings constructed before the baseline year:

- *general information about the building* (name of the institution using the building, address, ownership, whether the institution is located within a residential building, purpose of the building, year of construction);
- *information about construction characteristics of building in the base year* (floor plan area, internal height of floors, total number of floors, total number of heated floors, total heated area, external walls – material, total thickness, thermal insulation – thickness, external joinery – windows and doors

[10] Baseline CO_2 emissions inventory is a numerical overview of CO_2 emissions in a selected baseline year.
[11] Control CO_2 emissions inventory is a numerical overview of CO_2 emissions in a selected control year.
[12] https://www.stat.gov.rs/
[13] https://www.stat.gov.rs/sr-Latn/oblasti/popis
[14] https://www.arh.bg.ac.rs/wp-content/uploads/201415_docs/SAS_EEZA_publikacije/National_Typology_of_residential_buildings_in_Serbia.pdf
[15] Municipalities and regions – Archive (RZS Serbia), https://www.stat.gov.rs/sr-cyrl/oblasti/saobracaj-i-telekomunikacije/registrovana-vozila/

(frame material, total area), ceiling slab towards the attic/pitched roof (material, thermal insulation – thickness), floors towards the ground/towards the unheated space (thermal insulation, thickness);

- *information about energy characteristics of building* (heating method and energy sources used);
- *information about energy efficiency measures implemented in the building in the period from the base to the control year, which may include*:
    - warming the building envelope - installing thermal insulation on the façade *(surface, thickness)*, replacing external joinery – windows and doors *(frame material surface)*, installing thermal insulation in ceiling and/or roof *(surface, thickness)*;
    - replacing the existing heating system and/or energy sources with a new environmentally friendly heating system.

At the same time, a list of public buildings constructed in the period from the base to the control year was made, which contains general information for each building (name of the institution using the building, address, ownership, year of construction, is the building located in the residential building, purpose of the building), and its current condition: building construction characteristics - external walls - material, total thickness, thermal insulation - thickness, external joinery - windows and doors (frame material, total area), ceiling slab towards the attic/pitched roof (material, thermal insulation - thickness), floors towards the ground/towards the unheated space (thermal insulation, thickness) and energy characteristics of the building (heating method and energy sources used).

Input data on energy consumption for **residential buildings** subsector were collected as follows:

i. Data on the total number of residential buildings in the LSG area, and on their total heated area, were taken from the *Census of Population, Households and Dwellings in Serbia* conducted in 2022;

ii. The data required for calculation of energy savings achieved in this subsector through the implementation of energy efficiency measures in the period from the baseline to the control year 2024 were collected through a household survey. For the needs of the survey, a statistical sample was determined with a confidence level of 95% and a deviation interval of 6,78%, which included 209 households in individual and collective housing buildings. After conducting the initial survey, a control survey was also conducted to confirm the credibility of the data obtained. The following data were collected for each household surveyed:

    - *general information about their housing unit*[16] (type of residential building in which the housing unit is located, year or period of construction of the building);
    - *information about the construction and energy characteristics of the housing unit* (dimensions of the housing unit, heating method and energy sources used);
    - *information about household electricity consumption* (number, type and age of electrical appliances, average monthly electricity costs), and information about photovoltaic system installations;
    - *information about energy efficiency measures implemented in the period from the base to the control year,* which may include warming the building envelope (installing thermal insulation on the facade, roof and/or ceiling, replacing external joinery)*;* and replacing the existing heating system and/or energy sources with a new environmentally friendly heating system.

<u>Transport sector</u>

Input data for the transport sector in Serbia were taken from official statistical publications and professional sources at the national and international level. The publication "Annual Statistics of Traffic, Storage and

[16] In the context of this survey, the term "residential unit" can mean: (a) a family house (detached house and terraced house), and (b) a condominium apartment, which is located in one of the buildings from the category of collective housing (smaller residential buildings, residential buildings in a row / town block, large residential blocks / residential slats, and skyscrapers).

Connections" of the Statistics Institute of the Republic of Serbia[17] was used as the main source, from which the data on total number of registered vehicles per type in the base and control year in LSGs were taken, with additional information on the vehicle fleet under the jurisdiction of the local self-government provided by the competent municipal service. Data on the structure of vehicles per type of fuel (gasoline, diesel, LPG, hybrid, electric vehicles) were taken from the EUROSTAT[18] database, while distribution of registered vehicles per EURO ecological categories was determined based on available analyses of the ecological characteristics of the vehicle fleet in Serbia and the region.[19] Information on the vehicle age was taken from the "Report on the state of the environment based on indicators" of the Environmental Protection Agency (EPA)[20], which includes the age structure and trends in the import of used vehicles in Montenegro. Since data on the annual distance travelled for Montenegro are not available, the values of the Croatian Vehicle Centre[21]were used, taken due to the similarity of the vehicle fleet, vehicle usage patterns and driving conditions. Climate parameters relevant to the assessment of fuel consumption and engine efficiency - humidity and temperature - were taken from the website of the Institute for Hydrometeorology and Seismology of Montenegro[22] and from the World Bank Climate Knowledge Portal[23], which provide historical data on temperatures and climate indices for the territory of Serbia.

Public lighting sector

The main source of information and data for this sector was data submitted by local self-governments. While making this document, the following input data were collected for the public lighting sector in the LSG area: general data on the public lighting system, structure of the public lighting electrical network, average daily operating hours, total number of lamps in the system, method of lamp operation management, annual system maintenance costs (current/investment), and annual electricity consumption and costs of the electrical energy system.

3.2.2.2. Methodology for determining energy consumption in the considered sectors in the baseline and control year

Building sector

The final energy required for heating in public buildings in the baseline year is obtained as the product of the following parameters:

i. **Total heated area of the buildings considered (m^2)** determined for the baseline year, obtained by analysing the collected input data. This area is classified per purpose of public buildings and per the types of energy sources used for their heating (natural gas, heating oil, fossil fuel – lignite and brown coal).

ii. **Specific annual energy required for heating public buildings - $Q_{hnd,nd,spec}$($kWh/m^2/year$),** which is obtained on the basis of data from a questionnaire containing general, construction and mechanical characteristics of the building, and in accordance with the Guideline on minimum energy efficiency requirements for buildings.

The required final energy for heating in the considered public buildings in the control year 2024 was obtained by reducing the required final energy determined for the base year, by the amount of energy savings achieved by energy efficiency measures that were implemented in these buildings in the period from the base to the control year. At the same time, the additional required final heating energy for public buildings that were built in the same period within Vrnjačka Banja municipality was also taken into consideration. The following data were used to calculate the energy savings:

[17] https://www.stat.gov.rs/
[18] https://ec.europa.eu/eurostat/web/main/data/database
[19] World Bank. (2024). Transport Inputs to the Western Balkans Green Growth Narrative: Strategic Actions for a Greener and More Efficient Transport Sector. International Bank for Reconstruction and Development / The World Bank. December 2024.
[20]https://epa.org.me/wp-content/uploads/2022/07/izvjestaj-o-stanju-zivotne-sredine-u-crnoj-gori-na-bazi-indikatora-2017-2020-sa-akcionim-planom-za-unapredenje-stanja-zivotne-sredine-sa-predlogom-mjera-za-period-2022-2025-godina.pdf
[21] Croatian Vehicle Center (CVH): Average annual distance traveled per vehicle type, https://cvh.hr/gradani/tehnicki-pregled/statistika/
[22] https://www.meteo.co.me/page.php?id=40&utm_
[23] https://climateknowledgeportal.worldbank.org/country/montenegro/climate-data-historical

- collected input data on energy efficiency measures implemented in public buildings in the period from the base year to the control year; presented in the *Appendix 1 – List of public buildings within LSG*, and

Final energy savings in the building sector were calculated using the methodology prescribed in the following regulations in the field of energy efficiency in buildings:

i. Guideline on methodology to determine energy savings as a result of implemented energy efficiency measures („Official Gazette of RS“ number 20/23) [24] Appendix 1 - *Methodology for calculating energy savings in final consumption using the "bottom-up" method*, according to which energy savings are obtained as a result of implemented energy efficiency measures. In further text, the term "MVP methodology" will be used for this methodology“.
ii. *Guideline on energy efficiency of buildings* ("Official Gazette of RS", 61/11)[25].

The required final energy for heating in the sub-sector of **residential buildings** in the baseline year was obtained on the basis of the following values:

I. **Heated area** of residential buildings included in the survey, obtained on the basis of input data on dimensions, number of floors, percentage of heated area and other relevant data; and

II. **Specific annual energy needed for heating residential buildings - Q_{hnd} (kWh/m^2/year),** determined according to the *National Typology of Residential Buildings of Serbia* for each individual surveyed residential building and based on data on the type and period of construction, and multiplied by the efficiency of the heating system.

The total amount of final energy for baseline year was obtained by transposing the amount of final energy required calculated for the housing units covered by the survey to the entire housing stock of the local government, by applying the ratio of the heated area of the surveyed residential buildings to the heated area of all residential buildings in the local government area according to the relevant population census.

The needed final energy for heating in the sub-sector of residential buildings in the control year 2024 was obtained by reducing the needed final energy determined for the base year, by the amount of energy savings achieved in the entire sub-sector by implementing energy efficiency measures in the period from the base to the control year. This amount of savings was obtained by transposing the amount of energy savings calculated for residential units covered by the survey to the entire housing stock of the local government, by applying the ratio of the heated area of surveyed residential buildings to the heated area of all residential buildings within this LSG.

As in the case of public buildings, the energy savings for residential units included in the survey were obtained:

- Using the necessary data contained in the *National Typology of Residential Buildings of Serbia*;
- Using the methodology prescribed in the Guideline on methodology to determine energy savings as a result of implemented energy efficiency measures (“Official Gazette of RS” number 20/23) / *Appendix 1* - Methodology for calculating energy savings in final consumption using the "bottom-up" method, and in the Guideline on Energy Efficiency of Buildings, stipulated by the Law on planning and construction ("Official Gazette of RS", No. 72/2009 and similar).

Transport sector

The calculation of energy consumption in the base and control years in the transport sector was carried out using the COPERT program (version 5.8)[26], a standard tool of the European Union for calculation of energy

[24] https://pravno-informacioni-sistem.rs/eli/rep/sgrs/ministarstva/pravilnik/2023/20/5
[25] https://pravno-informacioni-sistem.rs/eli/rep/sgrs/ministarstva/pravilnik/2011/61/6
This methodology contains a series of equations that are used for direct calculation of energy savings for each implemented project, that is, a measure of energy efficiency. These equations are based on simple algebraic relations that basically represent the difference between the required energy before and the required energy after the implementation of energy efficiency measures

consumption and greenhouse gas emissions in transport sector, and for official reporting in these areas. In addition to the input data, the collection of which is described in the previous chapter, the input data on the calorific value of the fuel and combustion efficiency were already incorporated into the COPERT program, and it was not necessary to collect them separately.

Regarding the determination of energy consumption in the **public lighting sector**, only electricity measured and calculated at the level of the entire public lighting system was considered.

3.2.2.3. Methodology for calculation of the baseline and the control inventory of CO2 emissions in considered sectors

The baseline inventory of CO_2 emissions was obtained as a product of the needed final energy determined for the considered sectors in the base year, and the corresponding emission factors for the used energy sources.

The control inventory of CO_2 emissions was obtained as a product of the needed final energy determined for the considered sectors in the control year, and the corresponding emission factors for the used energy sources.

While making the emissions inventory for the **building sector**, CO_2 emissions from energy sources used for heating residential and public buildings in LSG were considered, namely: electricity, fossil fuels – lignite and brown coal, heating oil, natural gas and wood biomass, i.e. firewood. In a certain number of residential buildings, households often use a combination of these energy sources for heating.

The software tool COPERT 5.8 was used to make the emissions inventory for the **transport sector**, which for the purpose of calculating emissions according to European standards, uses the structure and number of vehicles, the distance travelled during one year, the average speed of movement on different sections of the road, data on the external temperature and air humidity, and the corresponding emission factors for the fuels used.

While making the inventory of emissions for the **public lighting sector**, only indirect emissions resulting from the consumption of electricity in these systems were considered, while direct emissions resulting from the combustion of energy sources such as natural gas and the like do not exist.

Emission factors used to determine the baseline and control inventory of CO_2 emissions

In accordance with the guidelines of the Covenant of Mayors for Climate and Energy, universal emission factors from the database of the Intergovernmental Panel on Climate Change (IPCC) [27] were used to calculate CO_2 emissions from the considered energy consumption sectors. The exception is electricity, for which the emission factor for Serbia was taken[28] as well as district heating, which for the emission factor for Serbia[29] was taken.

The emission factors for the considered energy sources used in the area of LSG are given in the following table.

[26] https://www.emisia.com/utilities/copert/ COPERT is used as an excellent tool for planning and research in the transport sector in national, regional and local frameworks, and for creating relevant daily, monthly and annual estimates that are fully harmonized with the legislation of the European Union and the requirements of relevant international conventions

[27] https://www.ipcc.ch/

[28] The emission factor of electricity is calculated based on the share of renewable and non-renewable energy sources in total electricity production.

[29] The electricity emission factor is calculated based on the share of renewable and non-renewable energy sources in total electricity production. The CO_2 emission factor for electricity differs between the baseline year, 2024 and 2030, and is based on the CoM GHG Emission Factors for National Electricity published by the JRC (also known as the National and European Emission Factors for Electricity – NEEFE), as well as applicable national regulations and observed trends. For the baseline year, the value of 1.007 tCO_2/MWh was applied according to the CoM recommendations, for 2024 the factor was taken from the Rulebook on final energy conversion factors into primary energy and carbon dioxide emission factors ("Official Gazette of the Republic of Serbia", No. 111/2021 and 6/2023), while for 2030 a projection of the emission factor of 0.935 tCO_2/MWh was used, based on the trend of the factors from the CoM base and the national rulebook, assuming an increase in the share of renewable energy sources in the total energy mix by 2030.

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ENERGY SOURCE	CO_2 emission factor for baseline year [t/MWh]
Natural gas	0,202
Heating oil	0,267
Lignite	0,364
Brown coal	0,341
Wood biomass[30]	0,133
Diesel	0,267
Motor gasoline	0,249
Liquefied petroleum gas	0,227
Electricity	1,007

Table 2-8: Emission factors for energy source used within LSG

3.2.2.4. Methodology for assessing risks, exposure and capacity of LSG to adapt to climate change

The assessment of hazards posed by climate change and exposure to these hazards, as well as the assessment of the LSG capacity to adapt, was carried out according to the guidelines from the Manual for the Development of the Action Plan for Sustainable Energy and Climate Action Plan , utilizing the appropriate electronic tool available to the signatories on the Internet platform of the Covenant of Mayors for Climate and Energy. The basic steps provided by this tool are:

i. Determining the hazards of the climate change consequences, which are relevant for this LSG;
ii. Determining the main current and future characteristics of each identified hazard (probability of occurrence, expected change in intensity, time period of action);
iii. Determining the socio-economic and natural sectors that are most exposed to the identified hazards (buildings, transport, energy, water supply, waste management, land use plans, agriculture and forestry, environment and biodiversity, health, civil protection and emergency services, tourism, education, information and communication technologies), and their level of threat (high, moderate, low);
iv. Determining the most vulnerable target groups within each identified hazard; and
v. Determining the capacity of LSGs to adapt to identified hazards, which implies determining the main categories of these capacities (existence of appropriate public services; availability of socio-economic stakeholders; existence, compliance and implementation of legal regulations; availability of physical resources; and availability of knowledge, methodologies, studies, early warning systems, and the like).

The input data and information that were needed during the performance of the aforementioned assessments were collected from the following sources:

- Knowledge and experience of team and advisory group members for development of this action plan, collected through appropriate workshops and consultations; contribution of the advisory group members, who provided precise and specific information related to the impact of natural hazards on a number of key sectors such as healthcare, education, civil protection, etc., was of key importance;
- Relevant strategic and planning documents of LSG (*Development strategy of Vrnjačka Banja municipality for period 2023-2030.*[31]), etc.;
- Digital climate atlas of Serbia[32];

[30] The emission factor applied for baseline year is 0.403 tCO2/MWh, while for control years 2024 and 2030 it is 0.153 tCO2/MWh. This change occurred due to the fact that in the baseline year in Tuzla Canton the criteria for sustainable firewood production were not yet met, so for that period this energy source was classified in the category of unsustainable wood mass, for which the specified emission factor was prescribed. In the middle of 2011, the Public Enterprise Forests of Tuzla Canton completed certification process and received FSC certificate issued by the Forest Stewardship Council, which confirms that this enterprise meets the criteria of sustainable forest management in Tuzla Canton and sustainable wood production. Considering that private forests occupy about 38% of the area of the total forest fund in the territory of Tuzla Canton, and that they do not have an FSC certificate, management of private forests cannot be considered sustainable.

[31] *https://www.vrnjackabanja.gov.rs/images/clanak/3511/dokumenta/plan-razvoja-opstine-vrnjacka-banja-2023-2030.pdf*

[32] https://atlas-klime.eko.gov.rs/

- Republic hydrometeorological institute of Serbia[33];
- National climate change adaptation plan of Serbia[34]
- The first interim updated report of the Republic of Serbia within the United Nations Framework Convention on Climate Change 2016 (UNFCCC) [35];
- The second interim updated report of the Republic of Serbia within the United Nations Framework Convention on Climate Change 2023 (UNFCCC) [36];
- The second national report on climate change[37];

3.2.2.5. Assessment of energy poverty within LSG

Energy poverty in Serbia represents an important challenge of a just energy transition and a key element of the SECAP process, especially due to the lack of an official national definition and measurement methodology. Although the status of "energy vulnerable customer" is regulated, it includes only socially vulnerable categories, while SECAP applies a broader European methodology according to which a household that spends more than 10% of its income on energy is considered energy poor.

Data for 2024 show that the average household in Serbia already reaches this threshold, so a stricter criterion of 15% was applied in the analysis in order to more precisely identify the most vulnerable households. Based on this methodology, it is estimated that at least 40% of households in Serbia are affected by energy poverty, which is comparable to regional indicators and indicates a serious structural problem associated with the low energy efficiency of the housing stock and rising energy costs, and requires planned and targeted measures at the local level.

4. VISION OF SUSTAINABLE FUTURE OF VRNJAČKA BANJA MUNICIPALITY AND RELATED GOALS

VISION of Vrnjačka Banja municipality

In 2050, Vrnjačka Banja is a green and smart center of sustainable development, where natural resources are used responsibly, energy is produced from renewable sources, and the environment is clean and protected. The municipality is a climate-resistant and energy-efficient community, which successfully implements a fair energy transition, alleviates energy poverty and provides high standards of quality of life for all citizens.

The set vision, compatible with the obligations accepted by Vrnjačka Banja municipality as a signatory of the Covenant of Mayors for Climate and Energy, reflects the desired state in future, emphasizes the commitment of LGU to sustainable energy development and adaptation to climate change, and implementation of a just energy transition, in accordance with the principles of the Covenant of Mayors for Climate and Energy. In accordance with the recommendations of the Covenant of Mayors, the goals of the Action Plan were determined, namely:

- a goal related to mitigating the consequences of climate change; and
- a goal related to climate change adaptation
- a goal related to a just energy transition

The goals set in this Action Plan, are:

- **reducing CO_2 emissions for at least 55% by 2030 compared to the emissions inventory from the base year;**

[33] https://www.hidmet.gov.rs/
[34] https://www.klimatskepromene.rs/wp-content/uploads/2017/04/NAP-UNDP-2015.pdf
[35] https://www.klimatskepromene.rs/wp-content/uploads/2017/04/E-version_FBUR-engleski-2016-1.pdf
[36] https://unfccc.int/sites/default/files/resource/Second%20Biennial%20Update%20Report%20of%20the%20Republic%20of%20Serbia.pdf
[37] https://unfccc.int/documents/637782?utm_source=chatgpt.com

- **reducing negative impacts of climate change on the population and the economy by 2030;**
- **alleviating energy poverty through the establishment of criteria, mapping of energy-poor households and implementation of energy efficiency measures in that category.**

5. CLIMATE CHANGE MITIGATION

Vrnjačka Banja municipality is located in the central part of the Republic of Serbia, in the Raška District, and covers an area of about 239 km², with tourism and spa and health potentials playing a dominant role in the spatial and economic development of this area, given that Vrnjačka Banja is one of the most famous spa resorts in the country.

According to the 2011 Census, the municipality of Vrnjačka Banja had 27,527 inhabitants, while the 2022 Census recorded 25,065 inhabitants, which indicates a demographic decline trend characteristic of many local communities in Serbia faced with migration and an aging population

5.1. Calculation of baseline inventory of CO_2 emissions

5.1.1. CO_2 emissions in baseline year from building sector

Calculation of the baseline inventory of CO_2 emissions in this sector included buildings from all three considered sub-sectors – public buildings owned by LSG, public buildings not owned by LSG, and residential buildings. This budget covers all public buildings that were built before the baseline year and that were in operation that year. During input data collection process, a total of 16 such buildings, 14 owned by LSG and 2 owned by higher authority levels were registered. The list of these buildings with all collected input data is given in *Appendix 1 - List of public buildings in the area of LSG.* As far as residential buildings are concerned, this budget for the baseline year covers all residential buildings in the LSG area, which according to the Population Census were built by the baseline year.

5.1.1.1. CO_2 emissions in baseline year from sub-sector of public buildings owned by the LSG

Total heated area of 14 public buildings owned by LSG was obtained based on the collected input data on their general, construction and energy characteristics. Values of the obtained heated areas for this building sub-sector, classified according to the purpose of buildings and the energy sources used for their heating in the baseline year, are given in the following table.

HEATED AREA [m²]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	181,00	1.294,00	677,35	677,35	2.829,70
	EDUCATION	-	-	3.223,91	3.223,91	6.447,81
	HEALTH	-	-	-	-	-
	SPORT	-	-	634,15	634,15	1.268,29
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	-	-	-	-
TOTAL PER ENERGY SOURCE		181,00	1.294,00	4.535,40	4.535,40	10.545,80

Table 2-9 Heated area of public buildings owned by LSG in baseline year

Total heated area of buildings in this subsector is 10,545.0 m². The table shows that the largest share of the total area is occupied by buildings in the field of education, followed by buildings in the field of preschool education and sports. It is also evident that the largest area of buildings in this subsector is heated using coal (lignite and brown coal), while heating oil and natural gas are represented to a much lesser extent.

The following table provides an overview of the required final energy for heating public buildings owned by LSG in the baseline year, which was obtained by multiplying the values of specific annual energy consumption by the actual heated area of the building A_k, thus obtaining the total required energy for heating $Q_{h,nd}$ (kWh).

FINAL ENERGY [MWh]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	53,01	254,94	255,80	255,80	819,55
	EDUCATION	-	-	736,28	736,28	1.472,56
	HEALTH	-	-	-	-	-
	SPORT	-	-	202,04	202,04	404,08
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	-	-	-	-
TOTAL PER ENERGY SOURCE		53,01	254,94	1.194,12	1.194,12	2.696,19

Table 2-10: Final energy required for heating public buildings owned by LSG in the baseline year

Total final energy required for heating buildings in this subsector in the base year is 2,696.19 MWh. It is evident from the table that the largest share of this energy is related to coal (lignite and brown coal), while the share of heating oil and natural gas is significantly smaller. The representation of energy sources for heating is shown in the Diagram below.

Total CO_2 emissions from this subsector of buildings in the baseline year were obtained as the product of the final energy required for heating and the corresponding emission factors. The obtained values are given in the following table.

CO_2 EMISSIONS [tCO_2]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	10,71	68,07	93,11	87,23	259,11
	EDUCATION	-	-	268,01	251,07	519,08
	HEALTH	-	-	-	-	-
	SPORT	-	-	73,54	68,89	142,44
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	-	-	-	-
TOTAL PER ENERGY SOURCE		10,71	68,07	434,66	407,19	920,63

Table 2-11: Annual CO_2 emissions from sub-sector of public buildings owned by LSG in baseline year

The total calculated value of annual CO_2 emissions from this subsector in the base year was 920.63 tCO_2. The table shows that the largest share of CO_2 emissions from this subsector came as a result of the use of coal (lignite and brown coal). Heating oil and natural gas had a significantly smaller contribution to total emissions, whose share in the structure of CO_2 emissions from this subsector was significantly lower. Share of the considered energy sources in total emissions from this subsector in the base year is shown in the following Diagram.

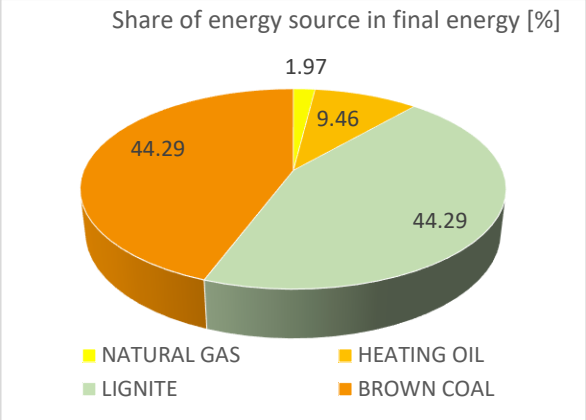


Diagram 2-5 Share of the considered energy sources in final energy required for heating public buildings owned by LSG in the baseline year

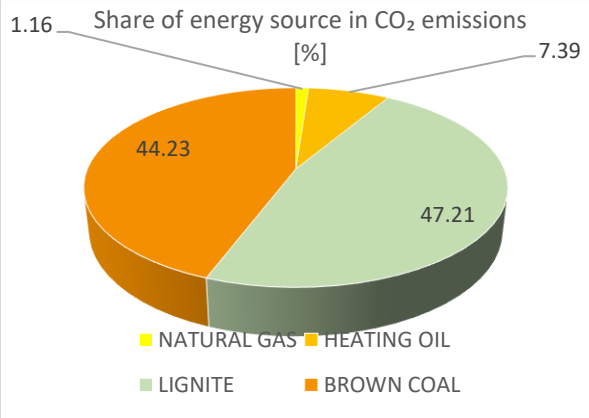


Diagram 2-6 Share of considered energy sources in annual CO_2 emissions from the public buildings sub-sector owned by LSG in the baseline year

2.1.1.1 CO_2 emissions in baseline year from sub-sector of public buildings not owned by LSG

The total heated area of 2 public buildings that are not owned by the LSG, and are located on its territory, was obtained based on the collected input data on their general, construction and energy characteristics. The values of the obtained heated surfaces for this sub-sector of buildings, classified according to the purpose of the buildings and the energy sources used for their heating in the baseline year, are given in the following table.

HEATED AREA [m²]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	-	-	-	-	-
	EDUCATION	-	-	-	-	-
	HEALTH	6.150,00	-	-	-	6.150,00
	SPORT	-	-	-	-	-
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	2.500,00	-	-	2.500,00
TOTAL PER ENERGY SOURCE		6.150,00	2.500,00	-	-	8.650,00

Table 2-12: Heated area of public buildings not owned by LSG in the baseline year

Total heated area of buildings in this subsector is 1,268.91 m². It is evident from the table that the largest share of the total area is occupied by buildings in the healthcare sector, which are heated using natural gas. Buildings intended for full-day stay have a smaller share in the total area and heating oil is used for their heating.

The following table provides an overview of the required final energy for heating public buildings that are not owned by LSG in baseline year, which was obtained by multiplying the values of specific annual energy consumption by the actual heated area of the building A_k, which resulted in total required energy for heating $Q_{h,nd}$(kWh). By dividing the total required energy by the efficiency of the heating system η, the required final energy $Q_{f,nd}$(kWh) was calculated.

FINAL ENERGY [MWh]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	-	-	-	-	-
	EDUCATION	-	-	-	-	-
	HEALTH	909,37	-	-	-	909,37
	SPORT	-	-	-	-	-
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	359,54	-	-	359,54
TOTAL PER ENERGY SOURCE		909,37	359,54	-	-	1.268,91

Table 2-13: Required final energy for heating public buildings that are not owned by LSG in baseline year

Total required final energy for heating buildings in this sub-sector in the baseline year amounts to 1,268.91 MWh. It is evident from the table that the largest share of this energy consumption is related to natural gas, while heating oil participates with a smaller share.

Total CO_2 emissions for the sub-sector of public buildings that are not owned by LSG in the baseline year, obtained as a product of the required final energy for heating and the corresponding emission factors, are given in the following table

CO_2 EMISSIONS [tCO_2]						
TYPE OF ENERGY SOURCE		FOSSIL FUEL				TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
PURPOSE OF BUILDING	PRE-SCHOOL EDUCATION	-	-	-	-	-
	EDUCATION	-	-	-	-	-
	HEALTH	183,66	-	-	-	183,66
	SPORT	-	-	-	-	-
	CULTURE	-	-	-	-	-
	OFFICE BUILDINGS	-	-	-	-	-
	FULL-DAY STAY	-	96,00	-	-	96,00
TOTAL PER ENERGY SOURCE		183,66	96,00	-	-	279,65

Table 2-14: Annual CO_2 emissions from the public buildings sub-sector not owned by LSG in baseline year

Total calculated value of annual CO_2 emissions from this subsector of buildings in the baseline year was 279.65 tCO_2. The table shows that the largest share of CO_2 emissions in this subsector is the result of natural gas consumption, while emissions resulting from heating oil consumption have a smaller share in the total emissions of the subsector.

The share of the considered energy sources in total emissions from this subsector in the baseline year is shown in the following Diagram.

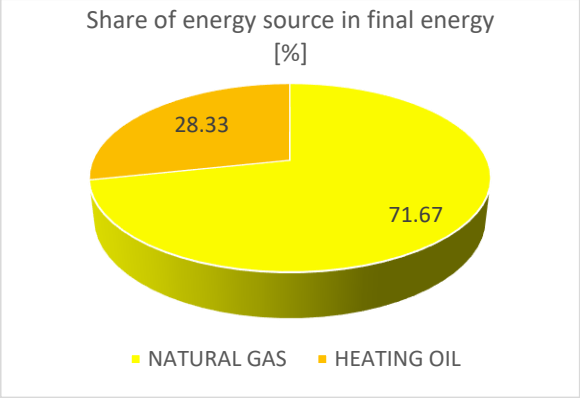


Diagram 2-7 Share of considered energy sources in the required final energy for heating public buildings owned by LSGs in baseline year

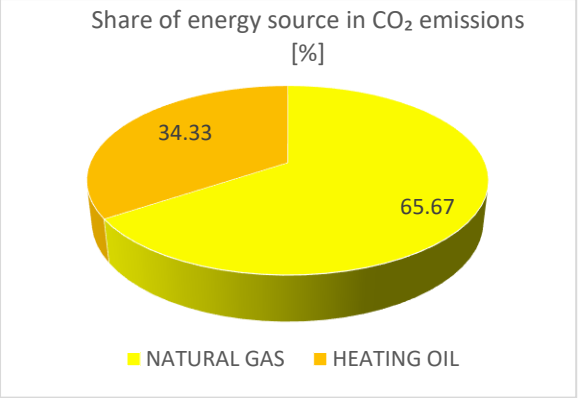


Diagram 2-8 Share of considered energy sources in annual CO_2 emissions from the subsector of public buildings owned by LSGs in baseline year

5.1.1.2. CO_2 emissions in baseline year from residential building subsector

Baseline inventory of CO_2 emissions was obtained as a product of the required final energy determined for considered sectors in the baseline year, and the corresponding emission factors for used energy sources.

The required energy for heating in **public buildings** in the baseline year is obtained as the product of the following values:

i. **Heated area** of residential buildings considered (m^2) determined for the baseline year, obtained based on the input data on dimensions, floor, percentages of heated area and other relevant data; and

i. **Specific annual energy required for heating residential buildings - Q_{hnd} (kWh/m^2/year)**, which is determined according to the *National typology of the residential buildings of Serbia* for each surveyed residential building, based on data on type and construction period, multiplied by the efficiency of the heating system all types of public buildings.

Total amount of final energy for the baseline year was obtained by transposing the amount of final energy required calculated for the housing units covered by the survey to the entire housing stock of LSG, applying the ratio of the heated area of surveyed residential buildings to the heated area of all residential buildings in LSG area according to the relevant population census.

The following table gives an overview of final energy required for heating residential buildings in the area of LSG, classified per energy sources used.

TYPE OF ENERGY SOURCE	ELECTRICITY	FOSSIL FUEL				RENEWABLE SOURCES	TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	NATURAL GAS	
CONSUMPTION PER ENERGY SOURCE	63.891,23	20.401,11	-	98.570,62	98.570,62	457.129,20	738.562,78

Table 2-15: Required final energy for heating residential buildings in baseline year

Total energy required for heating buildings in this subsector in the baseline year was 738,562.78 MWh. The table shows that the largest share (around 61.89% of this energy) was related to biomass, most often heating wood and pellets, followed by less represented energy sources, brown coal, lignite, electricity and natural gas, while heating oil is not represented. The percentage share of the represented energy sources is shown in the diagram below.

Total CO_2 emissions from residential buildings subsector in the baseline year, obtained as the product of final energy required for heating residential buildings and corresponding emission factors, are shown in the following table.

TYPE OF ENERGY SOURCE	ELECTRICITY	FOSSIL FUEL				RENEWABLE SOURCES	TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	NATURAL GAS	
CONSUMPTION PER ENERGY SOURCE	64.323,38	4.120,21	-	35.879,71	33.612,58	60.793,61	198.729,49

Table 2-16: Annual CO2 emissions from residential buildings subsector in baseline year

The total calculated value of annual CO_2 emissions from the residential buildings subsector in the baseline year is 198,729.49 tCO_2. This table shows that in the total emissions from this subsector, the largest share is from coal emissions (34.97% lignite and brown coal together), followed by electricity, biomass and natural gas, which is significantly lower than other energy sources. The percentage participation of the considered energy sources in the total emissions from this sub-sector is shown in the following Diagram.

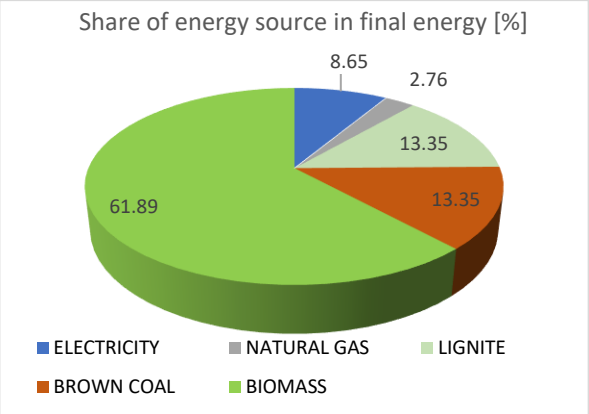


Diagram 2-9: Share of considered energy sources in final energy for heating residential buildings in the baseline year

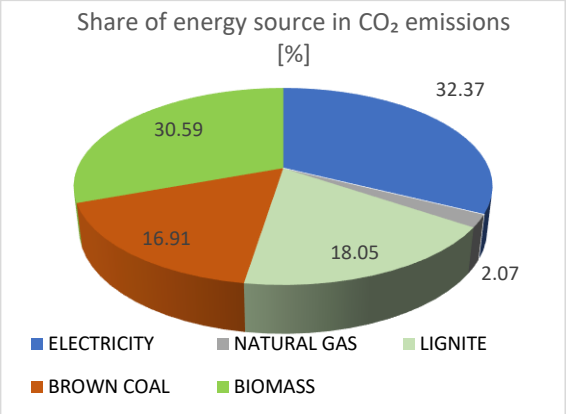


Diagram 2-10: Share of considered energy sources in CO2 emissions from residential buildings sub-sector in baseline year

5.1.2. CO_2 emissions in baseline year from transport sector

The transport sector of the LSG in question in the baseline year included a total of 8,326 vehicles classified into 5 categories: private vehicles, buses, commercial vehicles, freight vehicles, and motorcycles and mopeds. Of the total number of vehicles, the largest share (85.90%) was private vehicles, followed by commercial vehicles with 7.57%, motorcycles and mopeds with 4.42%, freight vehicles with 1.90%, and buses with 0.20%.The structure of the transport sector in the baseline year according to vehicle categories is shown in the following table and Diagram.

VEHICLE CATEGORY	NUMBER OF VEHICLES
PRIVATE VEHICLES	7.167
BUSES	17
COMMERCIAL VEHICLES	632
CARGO VEHICLES	158
MOTORCYCLES AND MOPEDS	369
TOTAL	8.343

Table 2-17: Number of vehicles in baseline year

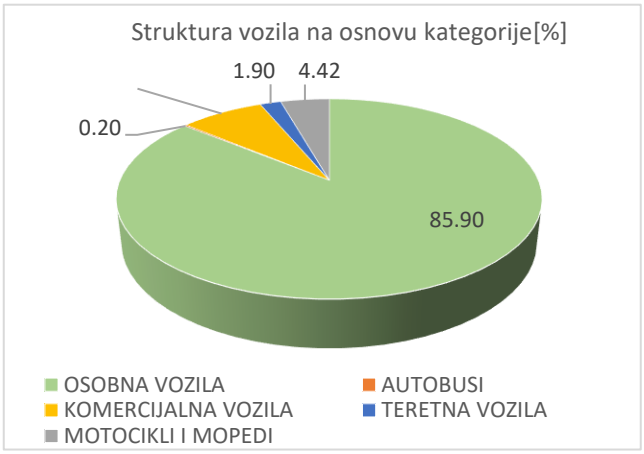


Diagram 2-11: Structure of vehicles in transport sector per vehicle

per category ***category in baseline year***

Of total number of registered vehicles, the largest number (99.71%) belongs to the subsector of private and commercial vehicles, while public transport participates with 0.20%, and the subsector of vehicles under the jurisdiction of LSG with 0.08%. The aforementioned structure is shown in the following table and diagram

VEHICLE CATEGORY	NUMBER OF VEHICLES
PRIVATE AND COMMERCIAL VEHICLES	8.319
PUBLIC TRANSPORT	17
VEHICLES UNDER JURISDICTION OF LSG	7
TOTAL	8.343

Table 2-18: Number of vehicles in baseline year per observed subsectors of transport sector

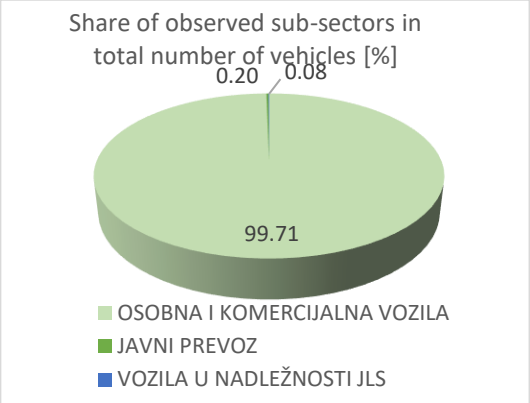


Diagram 2-12: Share of vehicles in observed subsectors of transport sector in baseline year

CO_2 emissions from motor vehicles depend on numerous parameters, the main ones being fuel quality, engine and vehicle design, driving mode, meteorological conditions, engine maintenance and its age, and others.

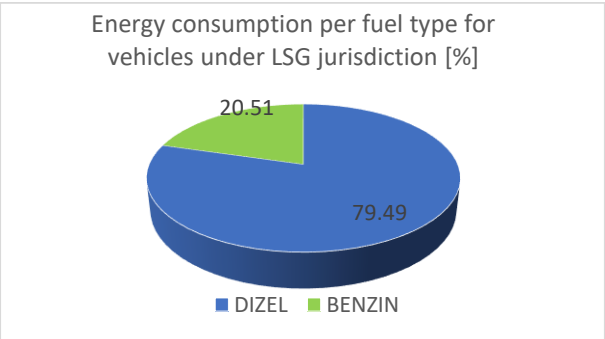
5.1.2.1. CO_2 emissions in baseline year from subsector of vehicles under jurisdiction of LSG

According to available data, the vehicle fleet owned by LSG included 7 vehicles in the baseline year. The following Table provides an overview of final energy consumption and associated CO_2 emissions in the vehicle subsector under the jurisdiction of LSG in the baseline year.

FUEL	VEHICLES UNDER JURISDICTION OF LSG	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	55,14	14,72
GASOLINE	14,23	3,54
TOTAL	**69,36**	**18,26**

Table 2-19: Annual energy consumption and CO_2 emissions for vehicles under jurisdiction of LSG in baseline year

The table shows that in this subsector in the baseline year a total of 69.36 MWh of energy was consumed, of which 55.14 MWh or 79.49% of the energy was produced from diesel fuel, and 14.23 MWh or 20.51% from petrol. Of the total 18.26 tCO_2 from this subsector, the combustion of diesel into the atmosphere produced 14.72 tCO_2 or 80.60% of the total emissions, while the remaining 3.54 tCO_2 or 19.40% was produced from gasoline combustion. These ratios are also shown in the following diagrams.



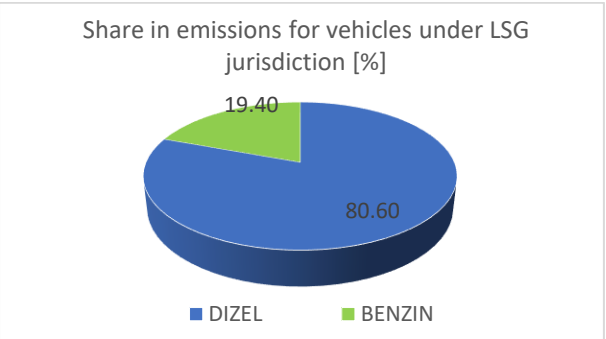


Diagram 2-13: Energy consumption in the subsector of vehicles under LSG jurisdiction in the baseline year per fuel type

Diagram 2-14: Share of fuel type in CO_2 emissions from subsector of vehicles under LSG jurisdiction

5.1.2.2. CO_2 emissions in baseline year from subsector of public transport vehicles

Public transport in the LSG area in the baseline year was carried out by buses and taxis. Within this subsector, only bus traffic was considered, while taxis were included in the private and commercial vehicles subsector. Public transport in the LSG was carried out with a total of 17 buses. The following table provides an overview of final energy consumption and associated CO_2 emissions of vehicles from this subsector in the baseline year.

FUEL	PUBLIC TRANSPORT	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	2.842,74	759,01

Table 2-20: Annual energy consumption and CO2 emissions for the sub-sector of public transport in baseline year

The table shows that in the baseline year all buses used diesel as fuel, and that year 2,842.74 MWh of energy was consumed, which caused annual emissions of 759.01 tCO_2.

5.1.2.3. CO_2 emissions in baseline year from subsector of private and commercial vehicles

In the subject area, a total of 8.343 vehicles were registered in the baseline year, of which 8.326 were private and commercial vehicles. The largest number of vehicles fell into environmental categories lower than EURO 1, so the largest number of vehicles (29.74%) belonged to the environmental category of conventional vehicles and vehicles that were manufactured before the introduction of EURO categories, i.e. before 1992. An overview of the number of vehicles per environmental categories is given in the following table and Diagram.

PRIVATE AND COMMERCIAL VEHICLES		
ENVIRONMENTAL CATEGORY	NO. OF VEHICLES	SHARE [%]
CONVENTIONAL	2.476	29,74
EURO 1	661	7,94
EURO 2	950	11,41
EURO 3	2.082	25,01
EURO 4	1.338	16,07
EURO 5	541	6,50
EURO 6	278	3,34
TOTAL	8.326	100,00

Table 2-21: Number of private and commercial vehicles in baseline year per environmental category

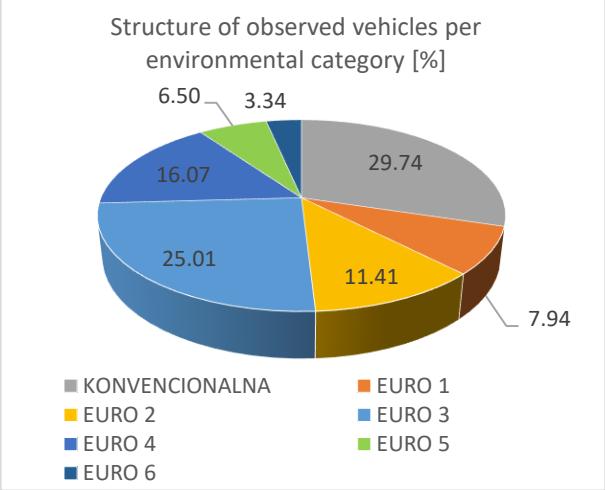


Diagram 2-15: Structure of private and commercial vehicles in baseline year per environmental category

An overview of total energy consumed in the baseline year in this subsector and the associated CO_2 emissions is given in the following table.

FUEL	PRIVATE AND COMMERCIAL VEHICLES	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	46.941,05	12.533,26
GASOLINE	46.127,80	11.485,82
LIQUEFIED PETROLEUM GAS	3.249,40	737,61
TOTAL	**96.318,25**	**24.756,70**

Table 2-22: Annual energy consumption and CO2 emissions for the sub-sector of private and commercial vehicles in the baseline year

In the baseline year, a total of 96,318.25 MWh of energy was consumed in this subsector, of which 46,941.05 MWh or 48.74% came from diesel, 46,127.80 MWh or 47.89% from gasoline, and 3,249.40 MWh or 3.37% from liquefied petroleum gas. The combustion of these fuels released 24,756.70 tCO_2 into the atmosphere, of which 12,533.26 tCO_2 or 50.63% came from the combustion of diesel, 11,485.82 tCO_2 or 46.39% from the combustion of gasoline, and 737.61 tCO_2 or 2.98% from liquefied petroleum gas. These ratios are also shown in the following diagrams.

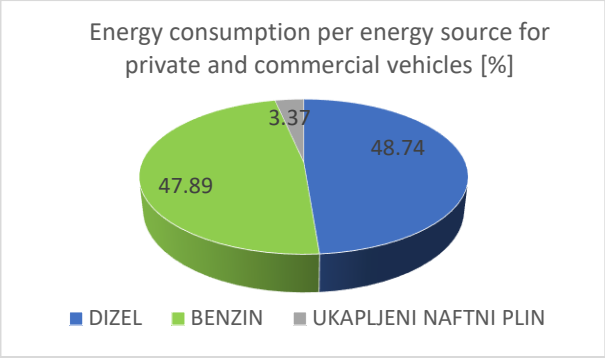


Diagram 2-16: Energy consumption in private and commercial vehicles subsector in baseline year per fuel type

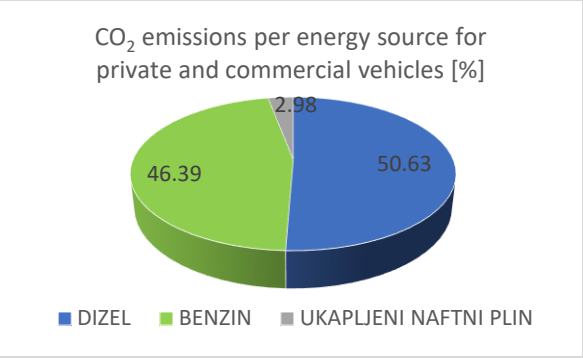


Diagram 2-17: Share of observed fuel type in CO_2 emissions from private and commercial vehicles subsector in baseline year

5.1.3. CO_2 emissions in baseline year from public lighting sector

The public lighting system in the baseline year included 6,392 lighting fixtures with a total installed power of 799 kW, with the exclusive presence of low-efficiency discharge light sources. The average daily operating time of lighting during the year was about 11.5 h/day. Calculation of the baseline inventory of CO2 emissions included all lighting fixtures within the public lighting system in the baseline year. CO_2 emissions from this sector refer to indirect emissions resulting from electricity consumption, while direct emissions resulting from the combustion of fuels do not exist. An overview of the total amount of electricity consumed in the baseline year in this sector and the associated CO_2 emissions is given in the following table.

FUEL TYPE	FINAL ENERGY [MWh]	EMISSION [tCO_2]
ELECTRICITY	3.353,05	3.375,73

Table 2-23: Annual energy consumption and CO_2 emissions for public lighting sector in baseline year

Total measured annual electricity consumption at the system level was 3,353.05 MWh, and the total annual associated indirect CO_2 emissions were 3,375.73 tCO_2. Specific annual electricity consumption per lamp is 524.57 kWh/year, and specific annual CO_2 emissions are 0.53 tCO_2/year

5.1.4. Total baseline inventory of CO_2 emissions

5.1.4.1. Total final energy in baseline year in all observed sectors

The following table shows the total final energy in the baseline year in all considered sectors of energy consumption and for all considered energy sources.

ENERGY SOURCE	BASELINE INVENTORY - FINAL ENERGY [MWh]							
	BULDING SECTOR AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Electricity	-	-	63.891,23	3.353,05	-	-	-	67.244,27

ENERGY SOURCE	BASELINE INVENTORY - FINAL ENERGY [MWh]							
	BULDING SECTOR AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Electricity	53,01	909,37	20.401,11	-	-	-	-	21.363,50
Natural gas	254,94	359,54	-	-	-	-	-	614,47
Heating oil	-	-	-	-	55,14	2.842,74	46.941,05	49.838,93
Diesel	-	-	-	-	14,23	-	46.127,80	46.142,02
Motor	1.194,12	-	98.570,62	-	-	-	-	99.764,74
Lignite	1.194,12	-	98.570,62	-	-	-	-	99.764,74
Brown coal	-	-	457.129,20	-	-	-	-	457.129,20
Biomass	-	-	-	-	-	-	3.249,40	3.249,40
Liquefied petroleum	2.696,19	1.268,91	738.562,78	3.353,05	69,36	2.842,74	96.318,25	845.111,27

Table 2-24: Baseline inventory of final energy from all observed sectors

Share of observed sectors and energy sources in total final energy is given in the following Diagrams.

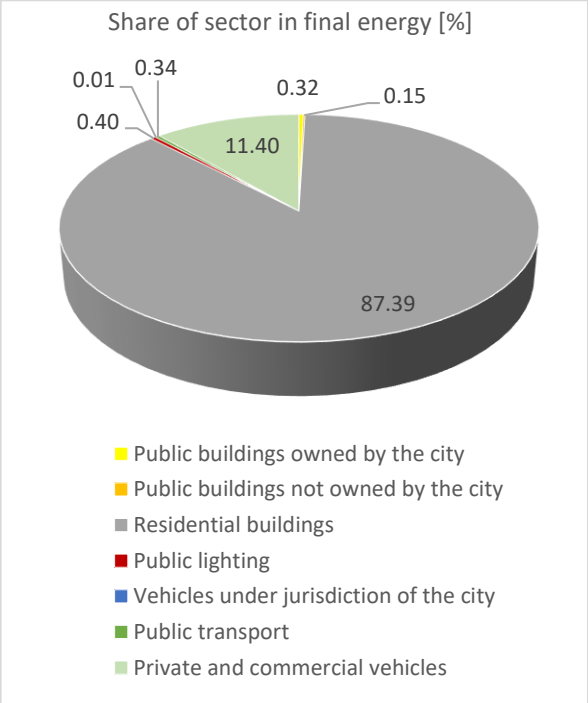


Diagram 2-18: Share of observed sectors in total final energy in baseline year

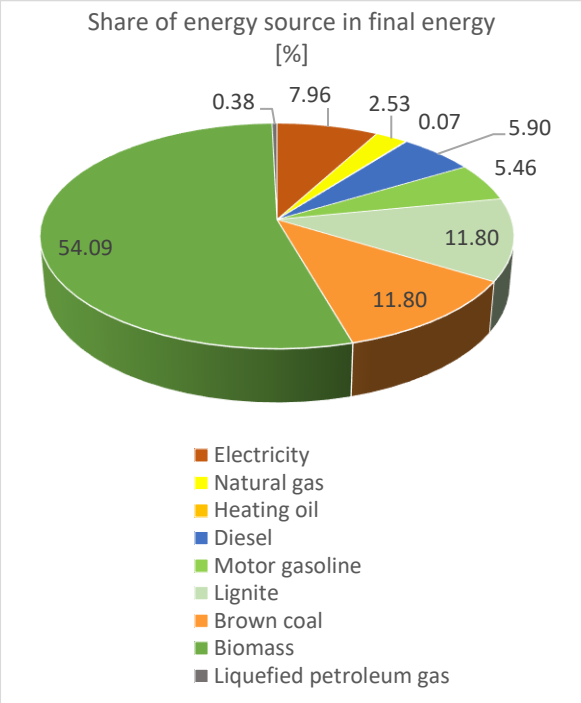


Diagram 2-19: Share of observed energy sources in total final energy in baseline year

Total final energy included in the baseline inventory amounts to **845.111,27** MWh. From the table and diagram above, it is evident that the following two subsectors have the largest participation in final energy:

i. **residential buildings**, with 738.562,78 MWh which is 87,39% of total final energy from all sectors; and

ii. **private and commercial vehicles**, with 96.318,25 MWh or 11,40% of total final energy of all sectors.

Other sub-sectors participate in total final energy to a much smaller extent, namely public lighting with 0,40%, public transport with 0,34%, public buildings owned by LSG with 0,32%, public buildings not owned by LSG with 0,15% and vehicles under jurisdiction of LSG with 0.01%.

The largest share in total final energy is accounted for by buildings that use wood biomass as an energy source, with 457,129.20 MWh (54.09%). The dominant energy sources are also lignite and brown coal, with 99,764.74 MWh each (11.80% share), electricity with 67,244.27 MWh (7.96%), diesel fuel with 49,838.93 MWh (5.90%), gasoline with 46,142.02 MWh (5.46%), natural gas with 21,363.50 MWh (2.53%), while other energy sources have a significantly smaller share.

5.1.4.2. Total CO_2 emissions in baseline year in all observed sectors

The following table shows total CO_2 emissions resulting from total final energy consumption in the baseline year in all considered sectors.

ENERGY SOURCE	BASELINE INVENTORY - FINAL ENERGY [MWh]							
	BULDING SECTOR AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Electricity	-	-	64.323,38	3.375,73	-	-	-	67.699,11
Natural gas	10,71	183,66	4.120,21	-	-	-	-	4.314,57
Heating oil	68,07	96,00	-	-	-	-	-	164,06
Diesel	-	-	-	-	14,72	759,01	12.533,26	13.306,99
Motor gasoline	-	-	-	-	3,54	-	11.485,82	11.489,36
Lignite	434,66	-	35.879,71	-	-	-	-	36.314,37
Brown coal	407,19	-	33.612,58	-	-	-	-	34.019,78
Biomass	-	-	60.793,61	-	-	-	-	60.793,61
Liquefied petroleum	-	-	-	-	-	-	737,61	737,61
TOTAL PER SECTORS	920,63	279,65	198.729,49	3.375,73	18,26	759,01	24.756,70	228.839,47

Table 2-25: Baseline inventory of CO2 emissions from all observed sectors of final energy consumption

Share of certain sectors and energy sources in total CO_2 emissions is shown in the following Diagrams.

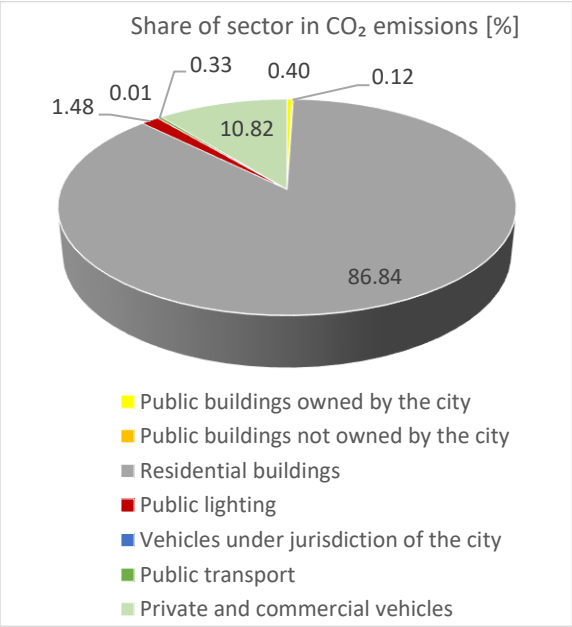


Diagram 2-20: Share of observed sectors in total CO_2 emissions in baseline year

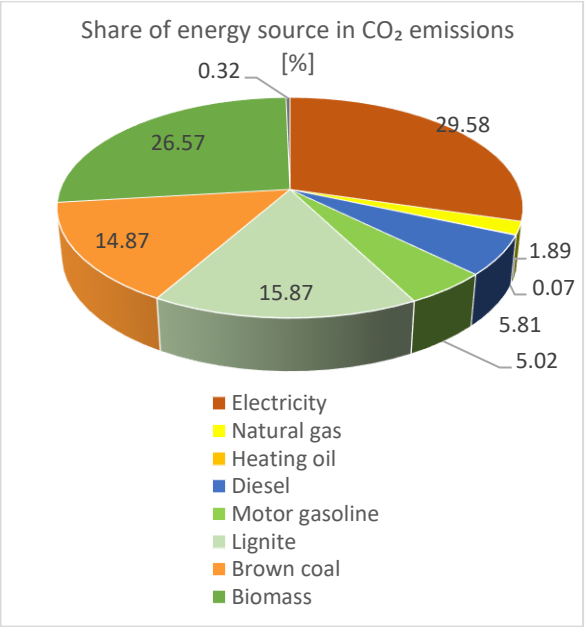


Diagram 2-21: Share of observed energy sources in total CO_2 emissions in baseline year

Total baseline inventory of CO_2 emissions is **228,839.47 tCO_2**. From the previous Diagrams it is evident that the **largest source of emissions is the residential buildings subsector with 198,729.49 tCO_2, which represents 86.84% of emissions from the total baseline inventory of CO_2, followed by the private and commercial vehicles subsector with 24,756.70 tCO_2, or 10.82% of the total baseline inventory of emissions.** Other subsectors participate to a much lesser extent.

Energy source with the largest share in CO_2 emissions is electricity with 67,699.11 tCO_2, which represents a 29.58% share in the total baseline emissions inventory. In addition to electricity, the energy sources with a dominant share in CO_2 emissions are coal with 70,334.14 tCO_2, which represents 30.74% of emissions from the total baseline inventory, namely lignite with 36,314.37 tCO_2 (15.87% share) and brown coal with 34,019.78 tCO_2, or 14.87%, biomass with 60,793.61 tCO_2 (26.57% share), diesel fuel with 13,306.99 tCO_2 (5.81% share) and motor gasoline with 11,489.36 tCO_2 (5.02% share), while other energy sources have a negligible share. Emissions from electricity, biomass and coal (lignite and brown coal) are most prevalent in the residential buildings subsector, while in the private and commercial vehicles subsector, the highest CO_2 emissions are from the consumption of diesel and motor gasoline.

5.2. Calculation of control inventory of CO_2 emission in 2024

The control inventory of emissions represents the annual level of CO_2 emissions in the control year 2024, and is determined as difference between the baseline inventory of emissions for the baseline year and the amount of emissions reduction as a result of energy efficiency measures implemented in the period from the baseline to the control year. The stated amount of emission reduction was obtained as a product of the amount of energy savings achieved with application of energy efficiency measures in the specified period in the considered sectors, and the corresponding emission factors for used energy sources. The purpose of making a control inventory of emissions is to determine the LSG's progress so far in reducing greenhouse gas emissions, that is, to determine the remaining amount of emissions reduction in relation to the set goal of reducing CO2 emissions by at least 55% by 2030 compared to the baseline year.

5.2.1. CO_2 emissions in control year from building sector

Bearing in mind that there are significant differences between sub-sector of public and sub-sectors of residential buildings regarding the availability of data on energy efficiency measures implemented on buildings in the observed period from the baseline to the control year, different approaches were used to collect them. As stated in the previous chapters, data for public buildings were most often collected directly from the management of the institutions that use these buildings, while for the collection of relevant data for residential buildings, a survey was first conducted on a statistical sample of households, owners of residential units.

5.2.1.1. CO_2 emissions in control year from subsector of public buildings owned by LSG

The control inventory of CO_2 emissions includes a total of 15 buildings within this subsector. Of that number, 14 buildings were built before the baseline year, while 1 new building was built in the period from the baseline to the control year.

The first step in determining the required final energy for heating public buildings from this sub-sector in the control year 2024 was the **determination of energy savings achieved in the period from the baseline to the control year by implementing energy efficiency measures on these buildings**. Of a total of 14 buildings from this sub-sector that were considered within the framework of determining the baseline inventory of emissions, certain energy efficiency measures were implemented in all buildings during that period. Implemented insulation measures on the external envelope (external walls/facade, roof/ceiling and replacement of external openings) of public buildings owned by LSG are shown in the following table.

MEASURES ON THE OUTER ENVELOPE OF PUBLIC BUILDINGS OWNED BY VRNJAČKA BANJA MUNICIPALITY IMPLEMENTED IN THE PERIOD FROM THE BASELINE YEAR 2015 TO THE CONTROL YEAR 2024	
Surface of thermo-insulated outside walls (m^2)	Surface of replaced outside joinery (m^2)
1.1113,00	1.165,63

Table 2-26: Summarized overview of energy efficiency measures implemented in the period from baseline to control year on the outer envelope of public buildings owned by LSG

The following table summarizes the measures of replacement of the existing heating systems with more efficient systems and replacement of the existing fossil energy sources with more environmentally friendly energy sources, which have been implemented in this building sub-sector

CHANGES IN HEATING SYSTEM OF PUBLIC BUILDINGS OWNED BY VRNJAČKA BANJA MUNICIPALITY IMPLEMENTED IN PERIOD FROM BASELINE 2015 TO CONTROL 2024			
WAY OF HEATING – ENERGY SOURCE		NO.OF BUILDINGS	HEATED AREA (m²)
BEFORE MEASURES	AFTER MEASURES		
CENTRAL – WOOD AND COAL	CENTRAL - PELLET	6	4.785,29
INDIVIDUAL STOVE - WOOD AND COAL	CENTRAL – WOOD AND COAL	4	1.902,18
CENTRAL – HEATING OIL	CENTRAL - GAS	1	1.294,00
	TOTAL	11	7.981,47

Table 2-27: Summary of energy efficiency measures implemented in the period from baseline to control year on the heating systems of public buildings owned by LSG

Final energy savings in the control year, achieved in relation to the situation in the baseline year, were obtained on the basis of these input data on implemented energy efficiency measures, using MVP methodology. According to this methodology, the basis for calculating annual final energy savings achieved by measures on the outer envelope of buildings is the difference between the value of the heat transfer coefficient of a certain part of the outer envelope of the building (outside wall/facade, roof/ceiling and outside joinery) before and after implementation of energy efficiency measures. For the heat transfer coefficient before implementation of the measures, the reference values of the coefficients were taken from the MVP Methodology, while the heat transfer coefficient after implementation of the measures is defined by the minimum allowed coefficient according to the *Guideline on minimum requirements for energy efficiency of buildings.*

Calculation of energy savings achieved by the mentioned improvements on heating systems was also performed using the MVP methodology. In the calculation of the savings achieved by the implementation of this type of measure, the reference and actual number of degree-days of heating depending on the climate zone to which the building belongs, the efficiency of the previous and new heating system for the appropriate heating method, and the energy used for heating were taken into account.

The following Table gives an overview of final energy savings for the sub-sector of buildings owned by LSG, achieved in the period from the baseline to the control year through implementation of the above energy efficiency measures.

FINAL ENERGY SAVINGS IN 2024 COMPARED TO BASELINE YEAR 2015. [MWh]					
ENERGY SOURCE	FOSILNA GORIVA				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
FINAL ENERGY [MWh]	-1.085,54	20,45	323,37	323,37	-418,35

Table 2-28: Final energy savings for heating public buildings owned by LSG achieved in the control year by implementing energy efficiency measures

The following step in determining the final energy required for heating public buildings from this subsector in the control year was to determine the **total energy required for heating new buildings from this subsector, which were built in the period from the baseline to the control year.** This energy was obtained as the product of the total heated area of the considered new buildings, which amounted to a total of 165,00 m^2, and the corresponding values of the specific annual energy required for heating public buildings – Q_{hnd} (kWh/m2) for specific types of newly constructed buildings. By dividing the total energy required by the heating system efficiency η, the final energy $Q_{f,}$(kWh) was calculated. An overview of the final energy required for heating one new public building is given in the following table.

NEW PUBLIC BUILDINGS BUILT IN THE PERIOD FROM THE BASELINE YEAR 2015 TO THE END OF 2024 – FINAL ENERGY [MWh]		
ENERGY SOURCE	FOSSIL FUEL	TOTAL

	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
FINAL ENERGY [MWh]	26,94	-	-	-	26,94

Table 2-29: Needed final energy for heating new public buildings owned by LSG, built in the period from baseline year to control year

The following Table provides a complete overview of the budget for the final energy required for heating buildings owned by LSG in the control year, showing the results of all necessary budgeting steps.

FINAL ENERGY [MWh]					
VRSTA ENERGENTA	FOSSIL FUEL				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
BUILDINGS CONSTRUCTED BEFORE THE BASELINE YEAR - FINAL ENERGY IN THE BASELINE YEAR	53,01	254,94	1.194,12	1.194,12	2.696,19
BUILDINGS CONSTRUCTED BEFORE THE BASELINE YEAR – SAVINGS GENERATED IN THE PERIOD BASELINE – CONTROL YEAR WITH EE MEASURES	1.085,54	-20,45	-323,37	-323,37	418,35
NEW BULDINGS CONSTRUCTED IN THE PERIOD BASELINE – CONTROL YEAR - FINAL ENERGY IN THE CONTROL YEAR	26,94	-	-	-	26,94
FINAL ENERGY IN 2024 [MWh]	1.165,49	234,49	870,75	870,75	3.141,48

Table 2-30: Final energy required for heating public buildings owned by LSG in the control year

Total final energy needed for heating buildings from this sub-sector is 3.141,48 MWh. It is evident from the table that the largest share of this energy refers to the use of coal, with equal share of lignite and brown coal, with total of about 55%, followed by natural gas with about 37%, while heating oil has the lowest share in total final energy consumption of about 8%. The percentage of share of the energy sources for heating is shown in the diagram below.

Total CO_2 emissions from this sub-sector in the control year were obtained as a product of the required final energy for heating in the control year and the corresponding emission factors. The obtained values are given in the following table.

CO2 EMISSIONS [tCO_2]					
ENERGY SOURCE	FOSSIL FUEL				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
CO_2 EMISSIONS [tCO_2]	235,38	62,61	316,95	296,93	911,87

Table 2-31: Annual CO_2 emissions from subsector of public buildings owned by LSG in control year

Total calculated CO_2 emissions for the sub-sector of public buildings owned by LSG in the control year amount to 911,87 t. The largest share of total CO_2 emissions comes from the use of coal, with equal share of lignite and brown coal totalling about 67%, followed by emissions from natural gas use (approximately 26%), while CO_2 emissions from heating oil consumption account for the smallest share, at around 7%.The percentage share of the considered energy sources in total emissions from this sector in the control year is shown in the following diagram.

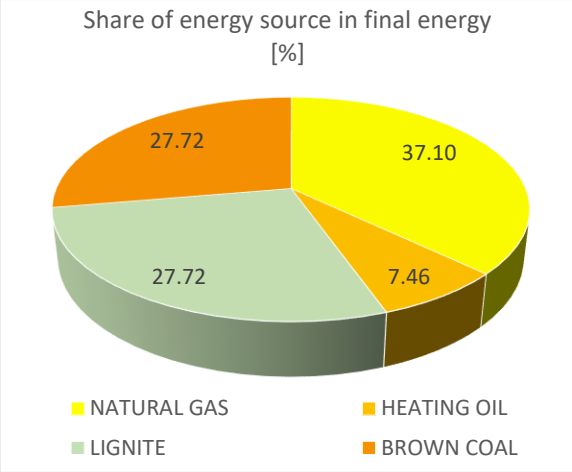


Diagram 2-22: Share of considered energy sources in final energy needed for heating public buildings owned by LSG in the control year

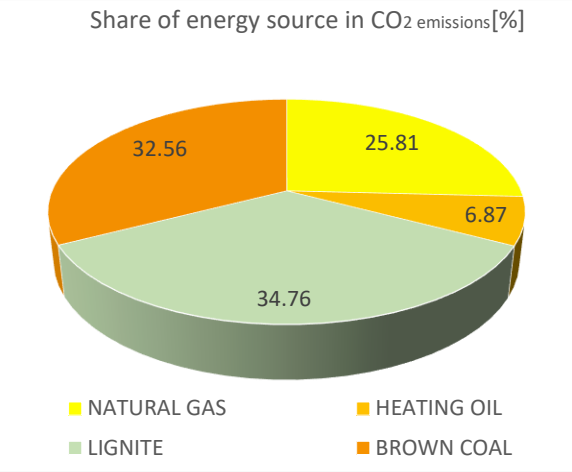


Diagram 2-23: Share of considered energy sources in annual CO_2 emissions from the sub-sector of public buildings owned by LSG in the control year

5.2.1.2. CO_2 emissions in control year from subsector of public buildings not owned by LSG

The control inventory of CO_2 emissions covers a total of 2 buildings within this sub-sector. Both buildings were constructed prior to the baseline year, and no new buildings were constructed in this sub-sector between the baseline and control year. CO_2 emissions for this sub-sector were calculated in the same manner as those for the sub-sector comprising public buildings owned by LSG. The first step in determining the final energy required for heating these public buildings during the control year was **to calculate the energy savings achieved between the baseline and control year through implementation of energy efficiency measures**. Of the 2 buildings in this sub-sector considered during the establishment of the baseline emissions inventory, energy efficiency measures were implemented on one building during this period. The measures implemented to insulate the building envelope (outside walls/facade, ceiling/roof, and outside joinery) of these public buildings are presented in the table below, whereas no measures regarding heating systems were implemented in this sub-sector.

MEASURES ON OUTSIDE ENVELOPE OF PUBLIC BUILDINGS NOT OWNED BY VRNJAČKA BANJA MUNICIPALITY IMPLEMENTED IN THE PERIOD FROM BASELINE YEAR 2015 TO THE END OF CONTROL YEAR 2024		
Surface of thermo-insulated outside walls (m^2)	Surface of thermo-insulated ceiling/roof (m^2)	Surface of replaced outside joinery (m^2)
1.556,35	1.920,00	1.515,65

Table 2-32: Summarized overview of energy efficiency measures implemented in the period from baseline to control year on the outer envelope of public buildings not owned by LSG

Final energy savings in the control year, achieved relative to the baseline year, were calculated based on input data regarding implemented energy efficiency measures using the MVP methodology, in the same manner as for the sub-sector of public buildings owned by local self-government units. The following table provides an overview of final energy savings for the sub-sector of buildings not owned by LOSG, achieved between the baseline year and the control year through the implementation of energy efficiency measures.

FINAL ENERGY SAVINGS IN 2024 COMPARED TO BASELINE YEAR 2015. [MWh]					
ENERGY SOURCE	FOSSIL FUEL				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
FINAL ENERGY [MWh]	376,16	-	-	-	376,16

Table 2-33: Final energy savings for heating public buildings not owned by LSG achieved in the control year by implementing energy efficiency measures

The following Table provides a complete overview of the budget for the final energy required for heating buildings not owned by LSG in the control year, showing the results of all necessary budgeting steps.

FINAL ENERGY [MWh]					
ENERGY SOURCE	FOSSIL FUEL				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
BUILDINGS CONSTRUCTED BEFORE THE BASELINE YEAR - FINAL ENERGY IN THE BASELINE YEAR	909,37	359,54	-	-	1.268,91
BUILDINGS CONSTRUCTED BEFORE THE BASELINE YEAR – SAVINGS GENERATED IN THE PERIOD BASELINE – CONTROL YEAR WITH EE MEASURES	-376,16	-	-	-	-376,16
FINAL ENERGY IN 2024 [MWh]	533,21	359,54	-	-	892,75

Table 2-28: Final energy required for heating public buildings not owned by LSG in the control year

Total required final energy for heating buildings from this sub-sector is 892.75 MWh. It is evident from the table that the largest share of the final refers to the consumption of natural gas, which participates with approximately 60%. The remaining part of consumption is heating oil, with a share of about 40%.

Total CO_2 emissions from this sub-sector in the control year were obtained as a product of the required final energy for heating in the control year and the corresponding emission factors. The obtained values are given in the following table.

CO_2 EMISSIONS [tCO_2]					
ENERGY SOURCE	FOSSIL FUEL				TOTAL
	NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	
CO_2 EMISSIONS [tCO_2]	107,69	96,00	-	-	203,68

Table 2-29: Annual CO_2 emissions from subsector of public buildings not owned by LSG in control year

Total calculated CO_2 emissions for the subsector of public buildings not owned by LSG in the control year amount to 203.68 tCO_2. The largest share of total CO_2 emissions comes from the use of natural gas, with a total share of around 53%. The remaining emissions are caused by the consumption of heating oil, with a share of around 47%.

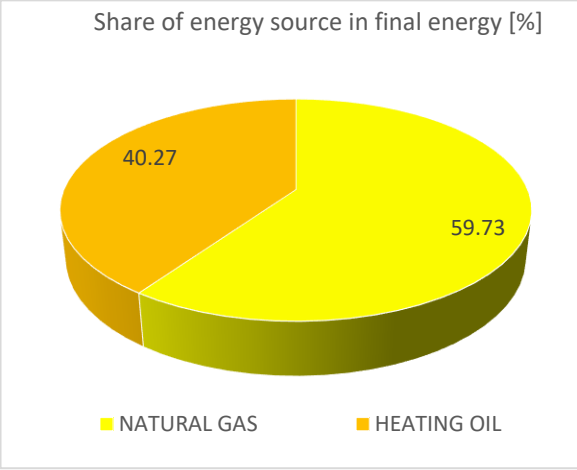


Diagram 2-24: Share of considered energy sources in final energy needed for heating public buildings not owned by LSG in the control year

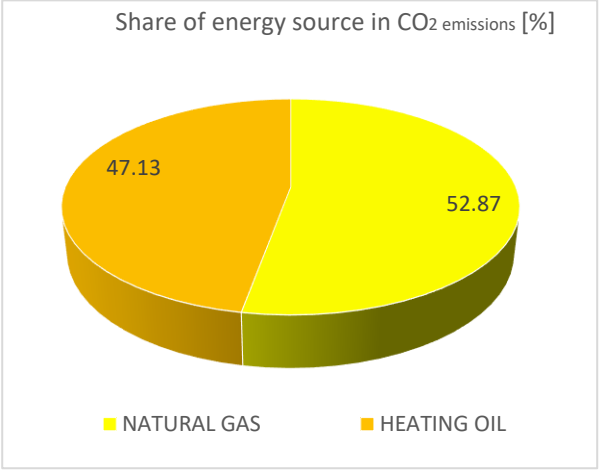


Diagram 2-25: Share of considered energy sources in annual CO_2 emissions from the sub-sector of public buildings not owned by LSG in the control year

5.2.1.3. CO_2 emissions in control year from subsector of residential buildings

When determining the required final energy for heating residential buildings in the control year 2024, **energy savings achieved in this subsector in the period from the baseline year to the control year through the implementation of energy efficiency measures** were first determined. Data on implemented measures were

obtained based on the results of a survey conducted on a statistical sample of 209 households. A summary of energy efficiency measures implemented in the period from the base to the control year in housing units owned by the surveyed households is given in the following tables.

The survey showed that the largest number of households do not have a central heating system with a boiler for heating their living units; instead, they use a combination of coal and firewood, as well as wood biomass (firewood or pellets), as fuel sources. The survey also indicated a certain willingness among citizens to adopt more environmentally friendly fuel sources and heating systems. During the observed period, 39 surveyed households (19% of the total number of participants) changed their heating method—most often by switching to a more efficient heating system—while 33 households (16%) changed their fuel sources.

IMPLEMENTED ENERGY EFFICIENCY MEASURES	NUMBER OF HOUSING UNITS
Replacement of outside joinery - DOORS	101
Replacement of outside joinery - WINDOWS	95
Thermal insulation of outside walls	47
Thermal insulation of ceiling/roof	23
Change of heating method	39
Change of energy source	33

Table 2-34: Summary of energy efficiency measures from the survey sample in the period from baseline to control year

Regarding the renovation of the outside envelope of housing units (thermal insulation of walls and ceiling/roof, replacement of joinery), the survey showed that at least one measure was implemented in 131 housing units, which is 62.68% of the total number of housing units covered by the survey. In 57.42% of housing units, outside joinery (doors or windows) was replaced, in 22.49%, thermal insulation of walls was installed, and in 11.00%, thermal insulation of the ceiling/roof was installed.

The final energy savings in the control year, achieved within the considered 209 housing units in relation to the situation in the baseline year, were obtained by applying the MVP methodology based on these input data on the implemented energy efficiency measures. The final energy savings in the control year, achieved at the level of the entire sub-sector of residential buildings, were determined by transposing the energy savings determined for the 209 considered units to the entire sub-sector of residential buildings. This transposition was carried out by multiplying the final energy savings achieved in the considered sample with the ratio of the total heated area of all 209 considered housing units and the total useful heated area of the entire sub-sector of residential buildings. The results of this calculation are presented in the following table.

ENERGY SOURCE	ELECTRICITY	FOSSIL FUEL				RENEWABLE SOURCES	TOTAL
		NATURAL GAS[38]	HEATING OIL	LIGNITE	BROWN COAL	BIOMASS	
CONSUMPTION PER ENERGY SOURCE	52.272,03	- 64.746,67	-	22.452,59	22.452,59	101.002,33	133.432,88

Table 2-35: Final energy savings for heating of residential buildings generated in the control year with implementation of energy efficiency measures

The table shows that the energy efficiency measures implemented in this sub-sector in the period from the baseline to the control year resulted in a saving of 133.432,88 MWh of the required final energy for heating.

The following table provides an overview of the entire calculation of the required final energy for heating in this subsector.

ENERGY SOURCE	ELECTRICITY	FOSSIL FUEL				RENEWABLE SOURCES	TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	BIOMASS	
Final energy in baseline year	63.891,23	20.401,11	-	98.570,62	98.570,62	457.129,20	738.562,78

[38] *Negative sign indicates an increase in the use of this energy compared to the baseline year*.

Savings generated in the period BASELINE – CONTROL year with EE measures	52.272,03	- 64.746,67	-	22.452,59	22.452,59	101.002,33	133.432,88
FINAL ENERGY in 2024.	11.619,20	85.147,78	-	76.118,03	76.118,03	356.126,87	605.129,91

Table 2-36: Final energy in MWh per energy source in subsector of residential buildings in the control year

The total final energy required for heating residential buildings in the area of the LSG is 605.129,91 MWh. The table shows that the largest share of energy is biomass, 58.85%, while other energy sources are significantly less represented. The percentage participation of the considered energy sources in the final energy of the sub-sector of residential buildings is shown in the diagram below.

Total CO_2 emissions from this subsector in the control year were obtained as a product of the required final energy for heating in the specified year and the corresponding emission factors. The obtained values are shown in the following table.

ENERGY SOURCE	ELECTRICITY	FOSSIL FUEL				RENEWABLE SOURCES	TOTAL
		NATURAL GAS	HEATING OIL	LIGNITE	BROWN COAL	BIOMASS	
CONSUMPTION PER ENERGY SOURCE	12.769,50	17.196,45	-	27.706,96	25.956,25	47.361,31	130.990,47

Table 2-37: Annual CO_2 emissions from subsector of residential buildings in the control year

Total calculated CO_2 emissions from the subsector of residential buildings in the control year amount to 130.990,47 tCO_2. Coal (lignite brown coal together) has the largest share in the total emission. The participation of the considered energy sources in the total emissions from this sector in the control year is shown in the diagram.

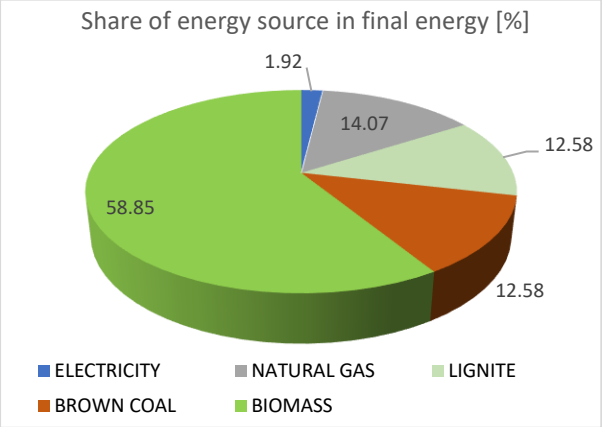


Diagram 2-26: Share of considered energy sources in the required final energy for heating residential buildings in the control year

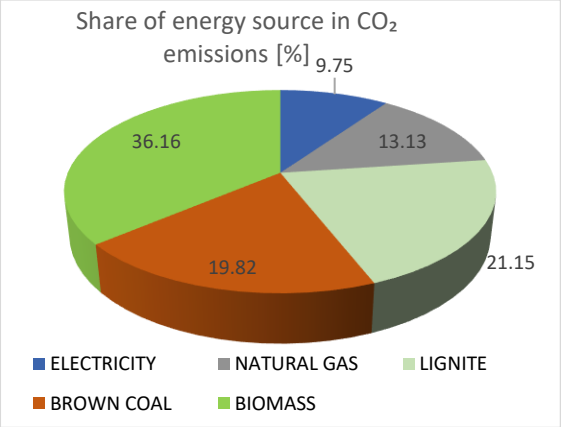


Diagram 2-27: Share of considered energy sources in annual CO2 emissions from the residential buildings subsector in the control year

5.2.2. CO_2 emissions in control year from transport sector

In 2024, the transport sector in the area of LSG includes a total of 11.615 vehicles, where the largest part (82.56% of the total number) refers to private vehicles, followed by commercial vehicles with 7,76%, motorcycles and mopeds with 4.83%, trucks with 1,94% and buses with 0.22%. The transport structure according to vehicle categories is shown in the following table and diagram.

VEHICLE CATEGORY	NO.OF VEHICLES
PRIVATE VEHICLES	9.903
BUSES	25
COMMERCIAL VEHICLES	901
FREIGHT VEHICLES	225
MOTORCYCLES AND MOPEDS	561
TOTAL	11.615

Table 2-38: Number of vehicles in control year per their category

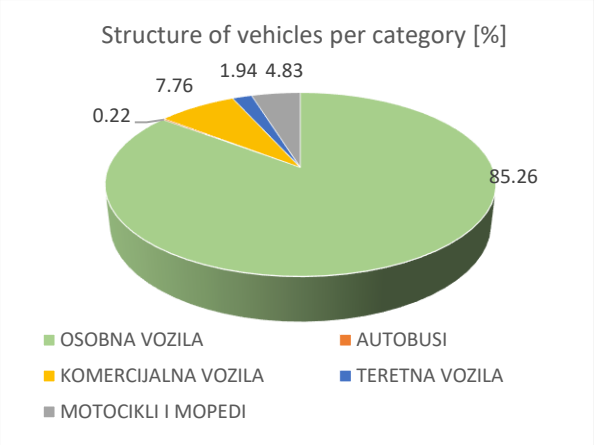


Diagram 2-28: Structure of vehicles in transport sector in control year per vehicle category

As in the case of the baseline inventory of CO_2 emissions, the transport sector is divided into the following sub-sectors in the budget of the control inventory: vehicle fleet under the jurisdiction of LSG, public transport, and private and commercial vehicles.

VEHICLE CATEGORY	NO.OF VEHICLES
PRIVATE AND COMMERCIAL	11.552
PUBLIC TRANSPORT	25
VEHICLES UNDER JURISDICTION OF MUNICIPALITY	38
TOTAL	11.615

Table 2-39: Number of vehicles in control year per considered subsectors

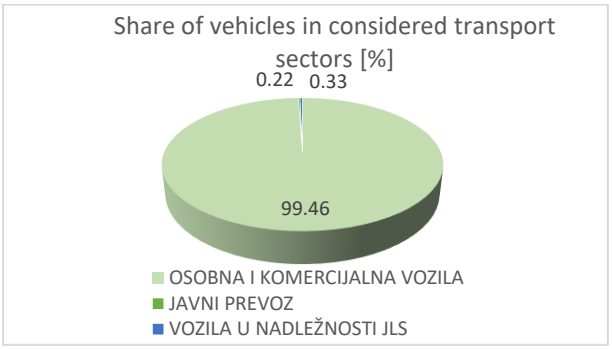


Diagram 2-29: Share of vehicles from certain sectors in control year

Of total number of vehicles registered in the LSG area, in the control year the largest number of registered vehicles (99.46% of the total number) belonged to the subsector of private and commercial vehicles, while the subsector of vehicles under the jurisdiction of LSG accounted for 0.33% and public transport vehicles accounted for 0.22%.

5.2.2.1. CO_2 emissions in control year from sub-sector of vehicles under LSG jurisdiction

In the control year, the fleet owned by the LSG consists of a total of 38 vehicles, which includes passenger vehicles and combined vehicles that are mostly owned by public companies and institutions founded by the LSG. According to the available data, out of the total number of vehicles, 27 vehicles use diesel and 11 gasoline. The following table provides an overview of final energy consumption and associated CO_2 emissions from this subsector.

ENERGY SOURCE	VEHICLES UNDER JURISDICTION OF LSG	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	287,37	76,73
GASOLINE	161,20	40,14
TOTAL	**448,57**	**116,87**

Table 2-40: Energy consumption and CO_2 emissions for vehicles under jurisdiction of LSG in control year

The table shows that in this subsector in the control year a total of 448.57 MWh of energy was consumed, of which 287.37 MWh or 64.06% of the energy consumed was produced from diesel fuel, and 161.20 MWh or 35.94% from gasoline. Of the total 116.87 tCO_2 from this subsector, the combustion of diesel generated 76.73

t or 65.65% of the total emissions, while the remaining 40.14 tCO_2 or 34.35% was generated from the combustion of gasoline. These ratios are shown in the following Diagrams.

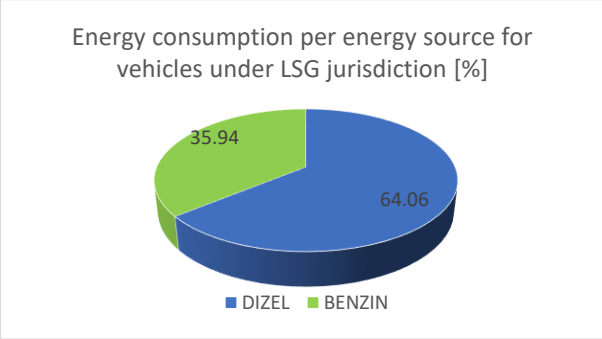


Diagram 2-30: Energy consumption per energy sources in the sub-sector of vehicles under LSG jurisdiction in the control year

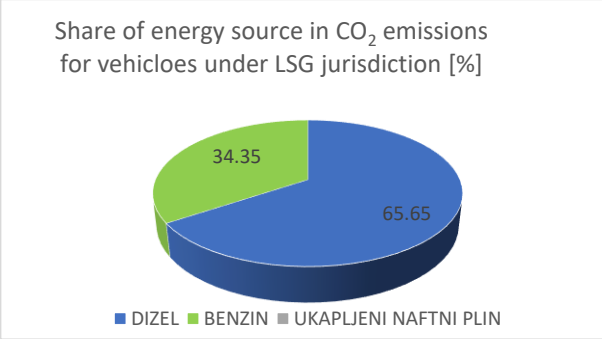


Diagram 2-31: Share of considered energy sources in CO2 emissions from the sub-sector of vehicles under LSG jurisdiction in the control year

5.2.2.2. CO_2 emissions in control year from public transport subsector

In the control year, public transport of passengers in the territory of this LSG is carried out by 25 buses. In the control year, public transport buses burned a total of 3.006,17 MWh and caused emissions of 802,65tCO_2, which is also shown in the following table.

ENERGY SOURCE	PUBLIC TRANSPORT	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	3.006,17	802,65

Table 2-41: Total annual energy consumption and CO2 emissions for public transport subsector in control year

CO_2 emissions in control year from subsector of private and commercial vehicles

Within the area of this LSG, a total of 11.615 vehicles were registered in the control year, of which 11.590 were private and commercial vehicles. The structure of these vehicles in relation to their environmental categories is shown in the following table.

PRIVATE AND COMMERCIAL VEHICLES		
ENVIRONMENTAL CATEGORY	NUMBER OF VEHICLES	SHARE [%]
CONVENTIONAL	430	3,71
EURO 1	794	6,85
EURO 2	794	6,85
EURO 3	3.175	27,39
EURO 4	3.477	30,00
EURO 5	1.463	12,62
EURO 6	1.457	12,57
TOTAL	11.590	100,00

Table 2-42: Number of private and commercial vehicles in control year per environmental categories

It is noticeable that the largest number of vehicles (over 80% of the total number) falls into the environmental categories EURO 3, EURO 4 and EURO 5, in contrast to the situation in the baseline year when the majority were vehicles produced before the establishment of the EURO categories, which now account for only 3.71% of the total number of vehicles. The structure of vehicles from this subsector in the control year according to environmental categories is shown in the following diagram.

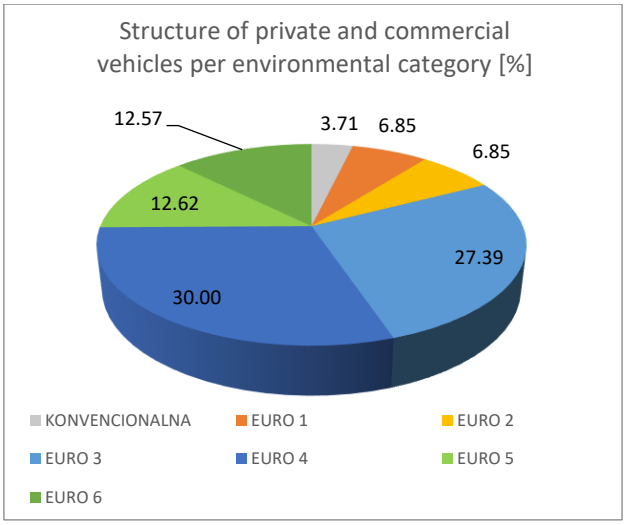


Diagram 2-32: Structure of vehicles from subsector of private and commercial vehicles according to environmental categories in the control year

The following table shows energy consumption and associated CO_2 emissions per individual fuels in the control year for the private and commercial vehicle subsector.

ENERGY SOURCE	PRIVATE AND COMMERCIAL VEHICLES	
	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
DIESEL	56.187,72	15.002,12
GASOLINE	47.914,08	11.930,61
LIQUEFIED PETROLEUM GAS	416,96	94,65
NATURAL GAS	31,68	6,40
TOTAL	**104.550,45**	**27.033,78**

Table 2-43: Energy consumption and CO_2 emissions for private and commercial vehicles in the control year

The table shows that a total of 104,550.45 MWh was consumed in the subsector of private and commercial vehicles in the control year, 56,187.72 MWh or 53.74% from diesel fuel, 47,914.08 MWh or 45.83% from gasoline, 416.96 MWh or 0.40% from liquefied petroleum gas, and 31.68 MWh or 0.03% from natural gas. The combustion of these fuels released 27,033.78 tCO_2 into the atmosphere, of which 15,002.12 tCO_2 or 55.49% was generated by the combustion of diesel, 11,930.61 tCO_2 or 44.13% by the combustion of gasoline, 94.65 t CO_2 or 0.35% by the combustion of liquefied petroleum gas, and 6.40 tCO_2 or 0.02% by the combustion of natural gas. These ratios are also shown in the following Diagrams.

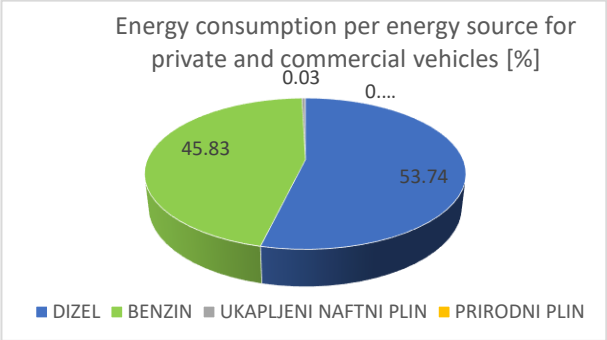


Diagram 2-33: Energy consumption per energy source for private and commercial vehicles in the control year

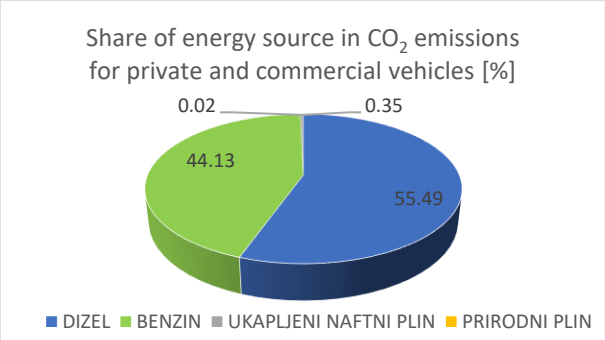


Diagram 2-34: Share of energy source in CO2 emissions from private and commercial vehicles subsector in the control year

5.2.3. CO_2 emissions in control year from public lighting sector

Compared to the baseline year, the installed power of public lighting was reduced from 799 kW to 422 kW by replacing low-efficiency light sources with new high-efficiency LED lighting, but the number of lighting fixtures increased from 6,392 to 7,032 through the effects of network expansion. The average daily operating time of lighting fixtures during the year is still 11.5 h/day, and the total measured annual consumption at the system level in 2024 is 1,771.01 MWh. In terms of the structure of light source types, compared to the baseline year when low-efficiency discharge light sources were exclusively represented, in the control year 100% of lighting is made up of high-efficiency LED light sources.

The calculation of the control inventory of CO_2 emissions includes all lighting fixtures within the public lighting system. CO_2 emissions from this sector relate to indirect emissions resulting from electricity consumption, while direct emissions resulting from fuel combustion (gas, other) do not exist.
The annual savings in electricity consumption resulting from replacing lamps with discharge light sources with highly efficient LED lamps during the baseline period - 2024 were taken into account, as well as the effects of expanding the public lighting network. An overview of the total amount of electricity consumed in the control year in this sector and the associated CO_2 emissions is given in the following table

ENERGY SOURCE	FINAL ENERGY [MWh]	EMISSIONS [tCO_2]
ELECTRICITY	1.771,01	1.946,34

Table 2-44: Total annual energy consumption and CO_2 emission for public lighting sector in the control year

Total measured annual electricity consumption at the system level was 1,771.01 MWh, and the total annual associated indirect CO_2 emissions were 1,946.34 tCO_2. Specific annual electricity consumption per lamp is 251.85 kWh/year, and specific annual CO_2 emissions are 0.28 tCO_2/year

5.2.3.1. Total control inventory of CO_2 emissions

5.2.3.2. Total final energy in control year in all considered sectors

The following table shows the total consumption in the control year in all considered sectors of LSG energy consumption, and for all considered energy sources.

CONTROL INVENTORY – FINAL ENERY [MWh]								
ENERGY SOURCE	BUILDING AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Electricity	-	-	11.619,20	1.771,01	-	-	-	13.390,20
Natural gas	1.165,49	533,21	85.147,78	-	-	-	31,68	86.878,17
Heating oil	234,49	359,54	-	-	-	-	-	594,02
Diesel	-	-	-	-	287,37	3.006,17	56.187,72	59.481,25
Gasoline	-	-	-	-	161,20	-	47.914,08	48.075,29
Lignite	870,75	-	76.118,03	-	-	-	-	76.988,78
Brown coal	870,75	-	76.118,03	-	-	-	-	76.988,78
Biomass	-	-	356.126,87	-	-	-	-	356.126,87
Liquefied petroleum gas	-	-	-	-	-	-	416,96	416,96
TOTAL PER SECTORS	3.141,48	892,75	605.129,91	1.771,01	448,57	3.006,17	104.550,45	718.940,32

Table 2-45: Control inventory of final energy for all considered sectors

Share of the considered sectors and energy sources in total final energy is shown in the following diagrams.

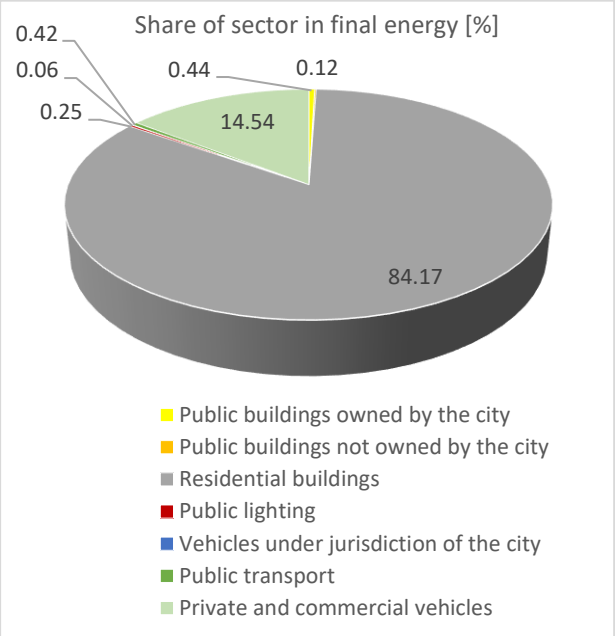


Diagram 2-35: Share of considered sectors in total final energy in control year

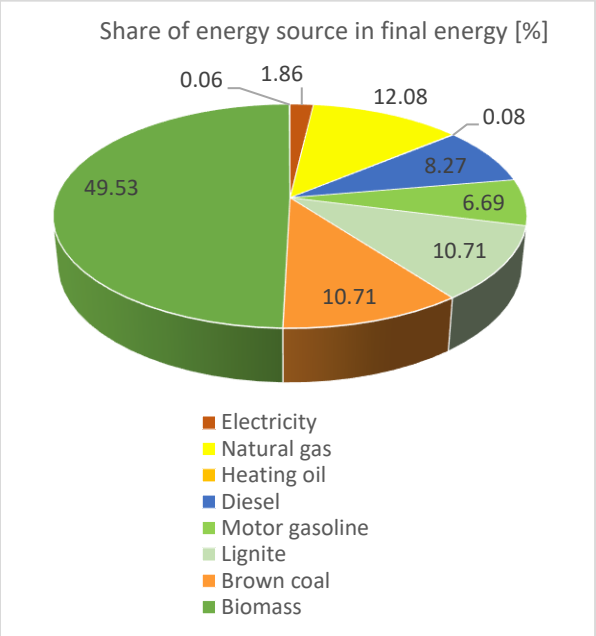


Diagram 2-36: Share of considered energy sources in total final energy in control year

Total final energy covered by the control inventory is **718.940,32** MWh. It is evident that in the control year, the following sectors or sub-sectors have the largest share in the total final energy:

i. **residential buildings**, with 605.129,91 MWh, which represents 84,17% of the total final energy in all sectors; and

ii. **private and commercial vehicles**, with 104.550,45 MWh or 14,54 % of the total final energy in all sectors.

Other sectors and subsectors participate to a much smaller extent, namely public buildings owned by LSG with 0.44%, public transport with 0.42%, public lighting with 0.25%, public buildings not owned by LSG with 0.12%, and vehicles under the jurisdiction of LSG with 0.06%. The energy source with the largest share in total final energy is biomass with 356,126.87 MWh (49.53%). Natural gas has a significant share with 86,878.17 MWh (12.08%), lignite and brown coal with 76,988.78 MWh (10.71% share each), followed by diesel fuel with 59,481.25 MWh (8.27% share), motor gasoline with 48,075.29 MWh (6.69%) and electricity with 13,390 MWh (1.86%). Energies obtained from heating oil and liquefied petroleum gas are insignificant and participate with 0.08% and 0.06%, respectively.

5.2.3.3. Total CO_2 emissions in control year from all considered sectors

The following table shows the total CO_2 emissions resulting from the consumption of total final energy in the control year.

CONTROL INVENTORY OF CO_2 EMISSIONS [tCO_2]								
ENERGY SOURCE	BUILDING AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Electricity	-	-	12.769,50	1.946,34	-	-	-	14.715,83
Natural gas	235,38	107,69	17.196,45	-	-	-	6,40	17.545,91
Heating oil	62,61	96,00	-	-	-	-	-	158,60
Diesel	-	-	-	-	76,73	802,65	15.002,12	15.881,49
Gasoline	-	-	-	-	40,14	-	11.930,61	11.970,75

CONTROL INVENTORY OF CO_2 EMISSIONS [tCO_2]								
ENERGY SOURCE	BUILDING AND PUBLIC LIGHTING				TRANSPORT			TOTAL PER ENERGY SOURCE
	Public buildings owned by the city	Public buildings not owned by the city	Residential buildings	Public lighting	Vehicles under jurisdiction of the city	Public transport	Private and commercial vehicles	
Lignite	316,95	-	27.706,96	-	-	-	-	28.023,92
Brown coal	296,93	-	25.956,25	-	-	-	-	26.253,17
Biomass	-	-	47.361,31	-	-	-	-	47.361,31
Liquefied petroleum gas	-	-	-	-	-	-	94,65	94,65
TOTAL PER SECTORS	911,87	203,68	130.990,47	1.946,34	116,87	802,65	27.033,78	162.005,65

Table 2-46: Control inventory of CO_2 emissions from all considered final energy consumption sectors

The share of the considered sectors and energy sources in total CO_2 emissions is shown in the following diagrams.

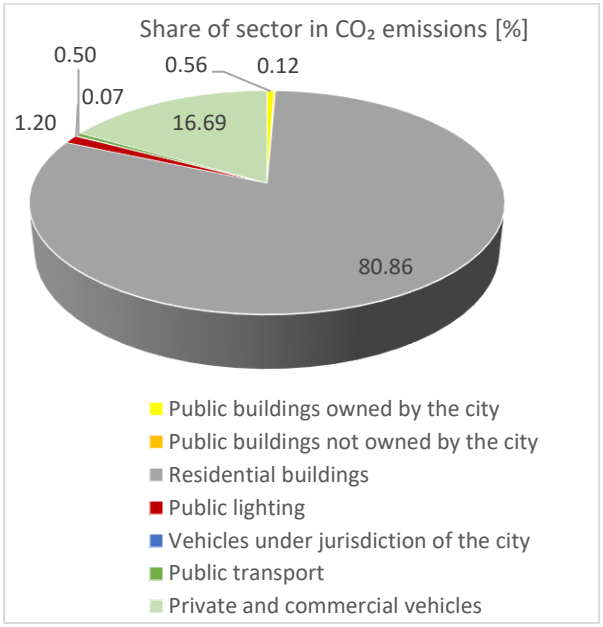


Diagram 2-37: Share of considered sectors in total CO_2 emissions in control year

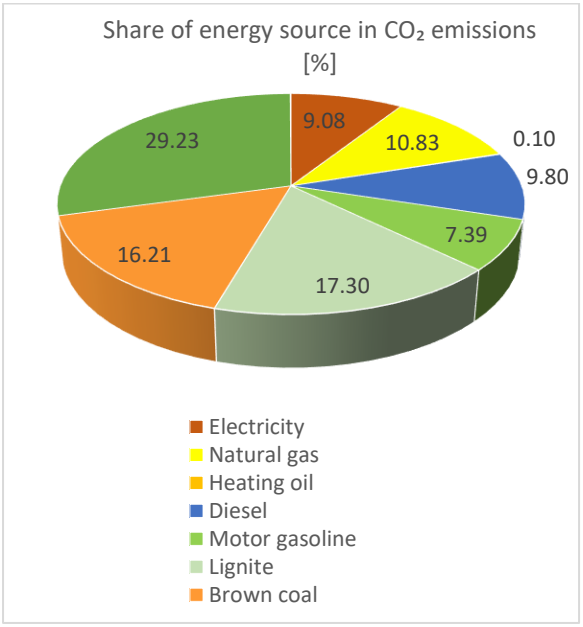


Diagram 2-38: Share of considered energy sources in total CO_2 emissions in control year

Total control inventory of CO_2 emissions is **162,005.65 tCO_2**. It is evident from the presented Diagrams that in the control year, the largest source of CO_2 emissions is the **residential buildings subsector with 130,990.47 tCO_2, or 80.86% of the total emissions from the control inventory, and the private and commercial vehicles subsector with 27,033.78 tCO_2, or 16.69% of the total emissions from the control inventory**. Other subsectors participate in a significantly smaller volume, namely public lighting with 1.20%, public buildings owned by LSG with 0.56%, public transport with 0.50%, public buildings not owned by LSG with 0.13%, and vehicles under the jurisdiction of LSG with 0.07%.

The energy source with the largest share in CO_2 emissions is coal with a total of 54,277.09 tCO_2 or 33.50% (of which lignite with 28,023.92 tCO_2 or 17.30% share and brown coal with 26,253.92 tCO_2 or 16.21% share in total CO_2 emissions), followed by biomass with 47,361.31 tCO_2 or 29.23%, natural gas with 17,545.91 tCO_2 or 10.83%, diesel fuel with 15,881.49 tCO_2 (9.80%), electricity with 14,715.83 tCO_2 indirect emissions or 9.08% share, while gasoline contributes with 11,970.75 tCO_2 (7.39%). The buildings sector is the main source of CO_2 emissions from coal and biomass. The residential buildings sub-sector records emissions from coal in the total amount of 53,663.21 tCO_2, while emissions from biomass are 47,361.31 tCO_2. Emissions from diesel fuel are

most prevalent in the transport sector, in the private and commercial vehicles sub-sector (15,002.12 tCO2), followed by emissions from motor gasoline of 11,930.61 tCO2.

5.3. Reduction of CO_2 emissions achieved in the period from baseline year 2015 to control year 2024

5.3.1. Changes in share of the considered sectors in total final energy consumption in the period from baseline year to control year

Comparison of final energy consumption in the obtained baseline and control inventory shows that the final energy consumption in the area of LSG in the control year 2024 is 14,93% lower compared to the consumption in the baseline year. Overview of changes in total energy consumption and consumption in the considered sectors and the share of individual sectors in total final energy, in the period from the baseline year to the control year, is given in the following table and diagram.

ENERGY CONSUMPTION SECTORS	BASELINE INVENTORY in 2015.		CONTROL INVENTORY in 2024.		ACHIEVED REDUCTION IN ENERGY CONSUMPTION	
	Final energy [MWh]	Share of individual sectors [%]	Final energy [MWh]	Share of individual sectors [%]	Final energy [MWh]	Change of consumption per sectors [%]
BUILDING AND PUBLIC LIGHTING						
Public buildings owned by LSG	2.696,19	0,32	3.141,48	0,44	-445,29	-16,52
Public buildings not owned by LSG	1.268,91	0,15	892,75	0,12	376,16	29,64
Residential buildings	738.562,78	87,39	605.129,91	84,17	133.432,88	18,07
Public lighting	3.353,05	0,40	1.771,01	0,25	1.582,04	47,18
TRANSPORT						
Vehicles under the jurisdiction of LSG	69,36	0,01	448,57	0,06	-379,21	-546,70
Public transport	2.842,74	0,34	3.006,17	0,42	-163,43	-5,75
Private and commercial vehicles	96.318,25	11,40	104.550,45	14,54	-8.232,20	-8,55
TOTAL	845.111,27	100,00	718.940,32	100,00	126.170,95	14,93%

Table 2-47: Comparison of total final energy consumption and consumption per sectors in baseline and control year

It is evident that in the mentioned period, the biggest reduction in energy consumption was achieved in the building sector in absolute values, especially in the sub-sector of residential buildings, in which energy consumption decreased by 133.432,88 MWh by the control year 2024, or by 18,07% compared to the baseline year. The main reason for this progress is the willingness of citizens to implement energy efficiency measures and use more efficient heating systems, which was recorded by surveying households in the phase of input data collection.

The survey results showed that in the period from the baseline year to the control year, 62,68% of respondents implemented at least one energy efficiency measure on the envelope of their housing unit (replacement of doors and windows, thermal insulation of walls and/or ceilings). In the observed period, 33 surveyed households (16% of the total number of survey participants) changed energy sources, while 39 surveyed households (19% of the total number of survey participants) changed the heating method, most often switching to a more efficient heating system.

Energy consumption in public buildings owned by LSG decreased by 376,16 MWh (29,64%), mostly due to the implementation of energy efficiency measures (energy renovation of the building envelope). In the subsector of public buildings owned by local governments, energy consumption increased by 445.29 MWh, or 16.52%, compared to the baseline year, as a result of the construction of new facilities and changes in the type of fossil fuel in some existing buildings.

In transport sector, an increase in total energy consumption was recorded, primarily as a result of an increase in the number of vehicles in the private and commercial vehicles subsector, where energy consumption in the control year increased by 8,232.20 MWh, or 8.55% compared to the baseline year. Given that data on the number of vehicles in the public transport subsector were taken from the available registers of registered vehicles by LSG, the number of public transport vehicles increased in the control year, and a slight increase in energy consumption was recorded by 163.43 MWh, or 5.75%. In the vehicles subsector under the jurisdiction of LSG, an increase in energy consumption was recorded compared to the baseline year by 379.21 MWh or 546.70%, which is directly related to the increase in the number of vehicles in this subsector from 7 to 38 units.

In the public lighting sector, the reduction in energy consumption during the control year resulted from the replacement of 100% of existing discharge light sources with new, high-efficiency LED light sources, representing a consumption decrease of 1,582.04 MWh, or 47.18%, compared to the baseline year.

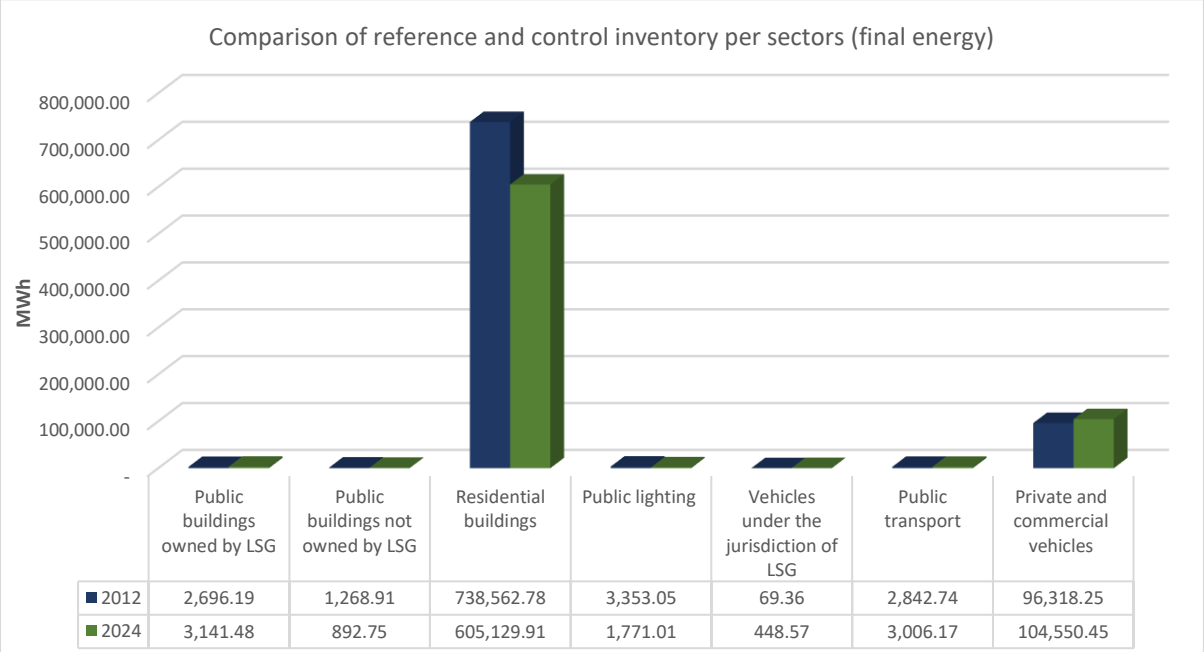


Diagram 2-39: Graphical overview of changes in final energy consumption per considered sectors in baseline and control year

5.3.2. Changes in share of considered sectors in total CO_2 emissions in period from baseline to control year

Comparison of CO_2 emissions in the baseline and control inventory shows that CO_2 emissions in the control year 2024 are 29,21% less than the emissions in the baseline year. Overview of changes in total CO_2 emissions and the share of individual sectors in total emissions, in the period from the baseline year to the control year, are given in the following table.

ENERGY CONSUMPTION SECTORS	BASELINE INVENTORY in 2015.		CONTROL INVENTORY in 2024.		ACHIEVED REDUCTION IN CO_2 EMISSIONS	
	CO_2 emissions [tCO_2]	Share of individual sectors %]	CO_2 emissions [tCO_2]	Share of individual sectors [%]	Emissions CO_2 [tCO_2]	Change of CO_2 emissions per sectors [%]
BUILDING AND PUBLIC LIGHTING						
Public buildings owned by LSG	920,63	0,40	911,87	0,56	8,76	0,95
Public buildings not owned by LSG	279,65	0,12	203,68	0,13	75,97	27,17
Residential buildings	198.729,49	86,84	130.990,47	80,86	67.739,03	34,09
Public lighting	3.375,73	1,48	1.946,34	1,20	1.429,39	42,34

TRANSPORT						
Vehicles under the jurisdiction of LSG	18,26	0,01	116,87	0,07	-98,60	-539,88
Public transport	759,01	0,33	802,65	0,50	-43,64	-5,75
Private and commercial vehicles	24.756,70	10,82	27.033,78	16,69	-2.277,08	-9,20
TOTAL	228.839,47	100,00	162.005,65	100,00	66.833,83	29,21%

Table 2-48: Comparison of total CO_2 emissions and emissions from considered sectors in baseline and control year

In the period from the baseline year to the control year, the largest reduction in the amount of emissions was achieved in the building sector, especially in the sub-sector of residential buildings, where CO_2 emissions decreased by 67.739,03 tCO_2 i.e. by 34,09% compared to the situation in the baseline year. The transition to the use of more environmentally acceptable energy sources for heating, and implementation of energy efficiency measures on the envelopes of residential buildings, are the biggest reasons for this reduction in emissions.

In public buildings not owned by LSG, CO_2 emissions are 75.97 tCO_2 or 21.17% lower than in the baseline year, due to the implementation of energy efficiency measures on the building envelope. In the period from the baseline to the control year, energy efficiency measures on the building envelope were implemented in one public building not owned by LSG (replacement of 1,515.65 m^2 of outside joinery, thermal insulation of the ceiling/roof 1,920.00 m^2 and thermal insulation of 1,556.35 m^2 of outside walls).

CO_2 emissions from the subsector of public buildings owned by LSG in the control year are 8.76 tCO_2 or 0.95% lower than in the baseline year, due to energy efficiency measures on the building envelope. In the period from the baseline year to the control year, energy efficiency measures on the envelope were implemented on 11 public buildings owned by LSG (replacement of 1,165.63 m^2 of outside joinery and thermal insulation of 1,113.00 m^2 of outside walls).

In transport sector, an increase in CO_2 emissions was recorded in the private and commercial vehicles subsector, by 2,277.08 tCO_2, or 9.20%, primarily as a result of an increase in the number of vehicles in the observed period. In the public transport subsector, an increase in CO_2 emissions was recorded by 43.64 tCO_2, which is associated with an increase in the recorded number of registered buses in the area of the LSG in the control year. In the subsector of vehicles under the jurisdiction of LSG, the increase in CO_2 emissions is accompanied by an increase in energy consumption.

In the public lighting sector, the decrease in CO_2 emissions in the control year is accompanied by a decrease in energy consumption, and emissions were reduced by 1,429.39 tCO_2, or 42.34% compared to the baseline year.

The comparison of CO_2 emission values in the considered sectors in total baseline and control inventory is shown in the following diagram.

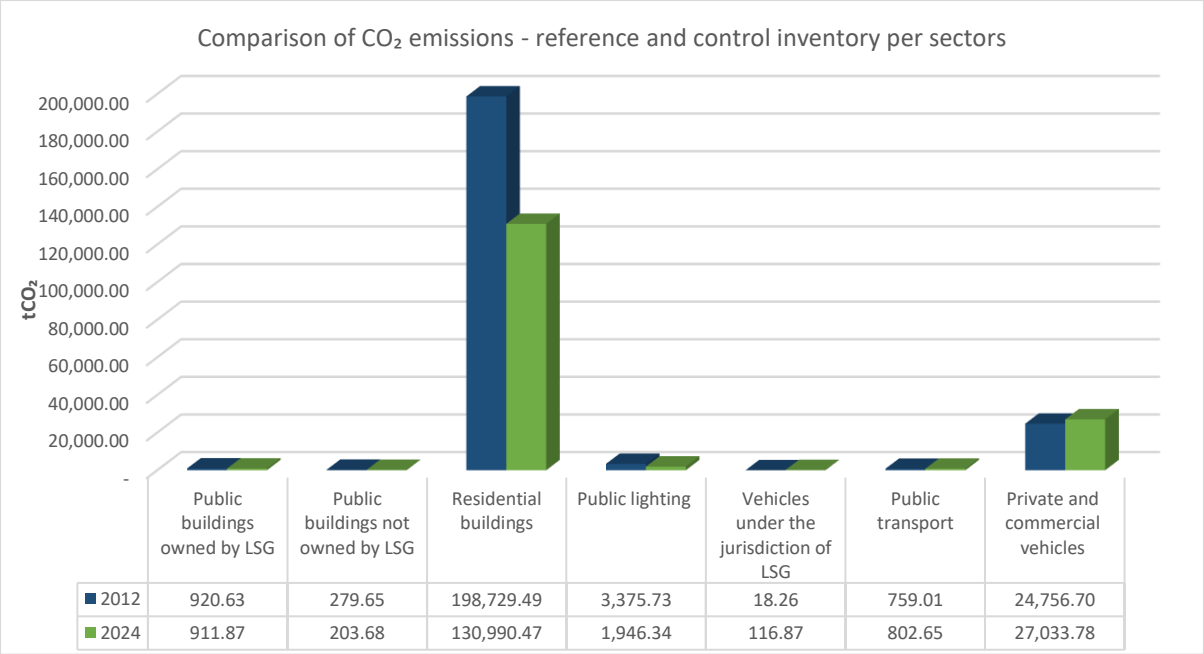


Diagram 2-40: Graphical overview of changes in CO_2 emissions from considered sectors in baseline and control year

5.4. Plan of measures of Vrnjačka Banja municipality to achieve the set goal of reducing CO_2 emissions by 2030

From calculations and analyses discussed in the previous chapters, it is obvious that **by far the largest share in CO_2 emissions, both in the base year and in the control year, is the subsector of residential buildings.** Regardless their reduction by 34,09% in this period, CO_2 emissions from the housing sector are extremely high (130.990,47 tCO_2), which far exceeds emissions from any other sector and subsector. For this reason, when making the plan of measures to reduce CO_2 emissions until 2030, the greatest attention was paid to the sub-sector of residential buildings, in which all the planned measures are of key importance. It is important to point out that the planned cross-sectoral measure MS-1 (*Continuous education of relevant employees of LSG and associated public companies on legal obligations in the field of systemic energy management*) is of key importance for the successful implementation of measures planned for all sectors and subsectors, including residential buildings. The list of all planned measures is shown in the following table.

Inter-sectoral measures	
MS-1	Continuous education of relevant LSG employees and associated public companies on legal obligations in the field of systematic energy management
Measures to reduce CO_2 emissions from the building sector	
Measures for residential building sub-sector	
SZ-1	Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency
SZ-2	Energy reconstruction of the outer envelope on individual residential buildings
SZ-3	Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings
SZ-4	Installation of photovoltaic (PV) systems on individual residential buildings
Measures for sub-sector of public buildings owned by LSG	
JZO-1	Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels and electricity are used as heating energy
Measures for sub-sector of public buildings not owned by LSG	
JZD-1	Participation in the integrated energy renovation of public buildings not owned by LSG that use fossil fuels as heating energy
Measures to reduce CO_2 emissions from transport sector	
Measures in sub-sector of vehicles under the jurisdiction of LSG	
SG-1	Procurement of electrical vehicles under the jurisdiction of LSG
Measures in sub-sector of private and commercial vehicles	
SP-1	Promotion of sustainable mobility and reduction of private vehicle use

Table 2-49: Energy efficiency measures of LSG for achievement of set goal of reducing CO_2 emissions by 2030

5.4.1. Intersectoral measures

Measure No.	**MS-1 /Key measure**
Name of measure	**Continuous education of relevant LSG employees and associated public companies on legal obligations in the field of systematic energy management**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Organisations and companies licenced to provide training in this segment.

Implementation period	2026 – 2030.
Saving (MWh)	n/a
Reduction of emissions (tCO2)	n/a
Total investment (EUR)	25.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • Budget of the Republic of Serbia; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The aim of the measure is to continuously strengthen the existing institutional capacities of LSG and public enterprises founded by Vrnjačka Banja municipality, for systematic energy management in all sectors of final energy consumption in the municipality (building, public lighting, transport, utility systems, etc.). The education topics relate to the legal obligations of local self-governments, prescribed by: a. *Law on energy efficiency and rational energy use (Official Gazette of RS, number 40/21)* [39] *and Guideline on energy management system obligors* („Official Gazette of RS", No. 59/2022) [40] which regulates: • Structure, content and characteristics of the comprehensive *Information System of Energy Management of Serbia (ISEM),* defined as a mandatory tool for energy management*;* • Obligation to collect, enter, process and submit data for various categories of data holders, including local self-governments, and reporting methods; • Responsible persons of data carriers (in which case the responsible person of local self-governments is the mayor/chief), and the obligation to appoint and perform duties of energy associates, energy managers and energy manager coordinators. *b. Guideline on the methodology for determining energy savings as a result of implemented energy efficiency measures („Official Gazette of RS", No. 20/23)* [41]*, which regulates:* • Methodology for monitoring and determining savings per sectors of final energy consumption (buildings, public lighting, transport, services, etc.); • Calculation of energy savings using the "top-down" and "bottom-up" methods; • Obligation to annually submit data and reports on the level of savings achieved through the ISEM system. The aforementioned training will be carried out through presence of appointed energy managers, coordinators, managers and associates at mandatory training sessions organized by Eko fund of the Republic of Serbia, as well as organization of additional training by LSGs, which will be provided by licensed companies for relevant employees of LSGs and public enterprises.

5.4.2. Measures to reduce CO_2 emissions from the building sector

5.4.2.1. Measures for residential building sub-sector

Measure No.	**SZ-1 / Key measure**
Name of measure	**Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Civil society organisations;

[39] https://pravno-informacioni-sistem.rs/eli/rep/sgrs/skupstina/zakon/2021/40/4/reg
[40] https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2022/59/3
[41] https://pravno-informacioni-sistem.rs/eli/rep/sgrs/ministarstva/pravilnik/2023/20/5

Measure No.	SZ-1 / Key measure
Name of measure	**Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency**
	• Local communities of the Municipality; • Ministry of environmental protection.
Implementation period	2026. – 2030.
Saving (MWh)	n/a
Reduction of emissions (tCO2)	n/a
Total investment (EUR)	15.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • State-level budget; • Eko fund of the Republic of Serbia; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The measure includes informing the public about importance of energy efficiency as a way to reduce the impact of climate change, and encouraging citizens to implement energy efficiency measures in their housing units. This measure has a dual objective: • Motivating citizens to participate in public calls of various government levels within the framework of energy reconstruction measures for individual housing buildings provided for by this document in the residential buildings subsector, while providing technical support to applicants and selected users; • Encouraging citizens to independently implement energy efficiency measures in their housing units, both in individual houses and in condominiums or collective housing buildings. The most important topics of education are: possible energy efficiency measures in residential buildings (on the building envelope; energy-efficient heating, cooling, air conditioning and lighting; energy production from renewable sources; energy-efficient appliances); energy and financial effects of these measures; availability of materials and equipment on local market; financing conditions for citizens; purpose of energy audits and certification and availability of these services; etc. All topics will be presented in an accessible and understandable way for citizens, through activities such as: i. TV and radio shows (educational series on energy efficiency, contact programs with experts); ii. active communication via the Municipality's web portal with a special section "energy efficiency for citizens" and accompanying Facebook profiles; iii. educational workshops for citizens; iv. regular events "Energy Efficiency Days of Vrnjačka Banja municipality" in public spaces, with a presentation of new technologies; v. production and distribution of information brochures and leaflets at the counters and info desks of the Municipality and public institutions

Measure No.	SZ-2 / Key measure
Name of measure	**Energy reconstruction of the outer envelope on individual residential buildings**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Owners of individual residential buildings (family houses) included in the measure • Civil society organisations; • Local communities of the Municipality; • Ministry of civil engineering, transport and infrastructure; • Ministry of mining and energy; • Ministry of environmental protection.
Implementation period	2025-2030.
Saving (MWh)	3.113,95

Measure No.	SZ-2 / Key measure
Name of measure	**Energy reconstruction of the outer envelope on individual residential buildings**
Reduction of emissions (tCO2)	414,16
Total investment (EUR)	168.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • State-level budget; • Eko fund of the Republic of Serbia; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB, etc.) • Own funds of owners of individual residential buildings included in the measure.
Short description of measure / comments	The aim of the measure is to reduce the total energy consumption and associated CO_2 emissions in individual residential buildings through the improvement of their thermal insulation characteristics. The measure may include the following activities (individually or in appropriate combinations): • Installation of thermal insulation of external walls; • Installation of thermal insulation of the roof, and/or ceiling, and/or floors; • Replacement of existing exterior joinery (windows and doors) with joinery with high energy characteristics. This measure involves the development of financial mechanisms for co-financing households with about 50% of total investment amount through a public call, in the first year as a pilot project, with continuity until 2030. This includes, on an annual basis, the energy reconstruction of the outer envelope of 20 individual residential buildings with an average heated area of about 100m^2/building, i.e. a total of 120 buildings by 2030. Note: Of 20 residential buildings annually included in this measure, from 2027, 5 buildings are included in a special measure in the energy poverty segment, and this co-financing is 90% of the total investment, therefore the investment in this measure is reduced by that amount, while the total energy savings and emission reductions are shown in this table.

Measure No.	SZ-3 / Key measure
Name of measure	**Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Owners of individual residential buildings (family houses) included in the measure • Civil society organisations; • Local communities of the Municipality; • Ministry of environmental protection; • Ministry of mining and energy.
Implementation period	2025-2030.
Saving (MWh)	6.646,42
Reduction of emissions (tCO2)	678,04
Total investment (EUR)	264.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • State-level budget; • Eko fund of the Republic of Serbia; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB, etc.) • Own funds of owners of individual residential buildings included in the measure.

Measure No.	SZ-3 / Key measure
Name of measure	**Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings**
Short description of measure / comments	This measure involves co-financing households through a public call for proposals with approximately 50% of total investment amount, in the first year as a pilot project, with continuity until 2030. The measure includes activities (individually or in appropriate combinations) to improve the energy characteristics of existing or purchase of new heating systems, as follows: 1. Improving the efficiency of heat generators and replacing energy sources, i.e. replacing existing fossil fuel boilers with high energy efficiency biomass boilers, or with heat pumps; 2. Optimizing and rationalizing the distribution pipe network, pumping systems, safety and control equipment of the central heating system, such as replacing central heating pumps with new electronically controlled pumps; improving the system's regulation and management devices; installing low-temperature heating systems and high-temperature cooling systems (floor heating and ceiling cooling, combined with a ventilation system, passive cooling systems and induction devices), etc.; Installing pellet boilers enables the transition to renewable biomass fuel, replacing fossil fuels and significantly reducing air pollution and greenhouse gas emissions. Heat pumps use natural heat from the environment for efficient heating and hot water preparation, eliminating direct combustion and contributing to cleaner and quieter system operation. Both systems improve household energy independence and support sustainable resource use while reducing dependence on imported energy sources. The calculation of presented energy savings and CO_2 emission reductions by 2030 is based on the replacement of fossil fuel boilers with pellet boilers in 20 residential buildings, as well as the replacement of fossil fuel boilers with heat pumps/air conditions also in 10 residential buildings, which includes a total of 180 buildings by 2030. Note: Out of 20 residential buildings annually included in the pellet boiler installation measure, from 2027, 5 buildings are included in a special measure in the energy poverty segment, namely co-financing with 90% of the total investment, therefore the investment in this measure is reduced by that amount, while the total energy savings and emission reductions are shown in this table.

Measure No.	SZ-4 / Key measure
Name of measure	**Installation of photovoltaic (PV) systems on individual residential buildings**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Owners of individual residential buildings (family houses) included in the measure • Civil society organisations; • Local communities of the Municipality; • Ministry of mining and energy; • Ministry of environmental protection.
Implementation period	2025-2030.
Saving (MWh)	776,08
Reduction of emissions (tCO2)	852,92
Total investment (EUR)	90.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • State-level budget; • Eko fund of the Republic of Serbia; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB, etc.) • Own funds of owners of individual residential buildings included in the measure.

Measure No.	SZ-4 / Key measure
Name of measure	**Installation of photovoltaic (PV) systems on individual residential buildings**
Short description of measure / comments	The measure includes installation of rooftop photovoltaic power plants on individual houses, using highly efficient monocrystalline or polycrystalline panels that convert sunlight into electricity for the household's own needs. In addition, it includes installation of a grid converter that ensures a safe connection to the public grid and enables the transfer of excess energy produced. Through a public call, households will have the opportunity to co-finance approximately 50% of total investment amount, in the first year as a pilot project, with continuity until 2030. All activities are aimed at reducing dependence on fossil sources, lower electricity bills and contributing to local production of clean energy. The measure includes the following activities (individually or in appropriate combinations): • Installation of rooftop photovoltaic power plants (monocrystalline or polycrystalline panels, efficiency ≥ 20%); • Installation of on-grid converter with MPPT controller and protection; • Connection to the distribution network according to the operator's rules; Calculation of the shown energy savings, CO_2 emission reductions and total investment by 2030 implies the installation of photovoltaic power plants on 5 individual houses per year, which by 2030 includes a total of 30 houses.

5.4.2.2. Measures for sub-sector of public buildings owned by LSG

Measure No.	JZO-1
Name of measure	**Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Institutions located in buildings included in the measure; • Civil society organisations and local environmental associations; • Ministry of mining and energy of the Republic of Serbia; • Ministry of civil engineering, transport and infrastructure of the Republic of Serbia;
Implementation period	2026-2030.
Saving (MWh)	344,94
Reduction of emissions (tCO2)	307,01
Total investment (EUR)	686.586
Possible funding sources for implementation of measure	• Budget of the Municipality; • Budget of the Republic of Serbia; • Fund for improvement of energy efficiency; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.); • International and local finance institutions (EBRD, KfW, EIB, etc.)
Short description of measure / comments	M The measure includes the integrated energy reconstruction of 15 public buildings owned by LSG, in which fossil fuels are used as heating energy, which includes: a. Energy reconstruction of the building envelope (installation of thermal insulation on external walls, roof, and/or ceiling, and replacement of existing external joinery (windows and doors) with joinery of high energy characteristics); and b. Replacement of existing heating system with new ones of higher energy efficiency Planned measures: • installation of thermal insulation on the facade (a total of 4.012,64 m^2 of facade); • installation of thermal insulation on the ceilings (a total of 9.068,49 m^2 of ceilings); • Replacement of 423,42 m^2 of exterior joinery;

Measure No.	JZO-1
Name of measure	**Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Institutions located in buildings included in the measure; • Civil society organisations and local environmental associations; • Ministry of mining and energy of the Republic of Serbia; • Ministry of civil engineering, transport and infrastructure of the Republic of Serbia;
Implementation period	2026-2030.
Saving (MWh)	344,94
Reduction of emissions (tCO2)	307,01
Total investment (EUR)	686.586
	• Replacement of the existing boilers/stoves using fossil fuels with the more energy efficient ones The list of all buildings proposed for this measure, with their main construction and energy characteristics (areas and prices for the facade, ceiling and joinery as well as price of a new energy efficient heating system), can be found in *Appendix 1 - List of public buildings owned by LSGs with proposed measures.*

5.4.2.3. Measures for sub-sector of public buildings not owned by LSG

Measure No.	JZD-1
Name of measure	**Participation in integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Other relevant departments of the Municipality; • Institutions located in buildings included in the measure; • Civil society organisations and local environmental associations; • Ministry of mining and energy of the Republic of Serbia; • Ministry of civil engineering, transport and infrastructure of the Republic of Serbia;
Implementation period	2026-2030.
Saving (MWh)	604,88
Reduction of emissions (tCO2)	166,38
Total investment (EUR)	31.000
Possible funding sources for implementation of measure	• Budget of the Municipality; • Budget of the Republic of Serbia; • Fund for improvement of energy efficiency; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.); • International and local finance institutions (EBRD, KfW, EIB, etc.)
Short description of measure / comments	The measure includes the integrated energy reconstruction of 2 public buildings that are not owned by LSGs, in which fossil fuels are used as heating energy, which includes: a. Energy reconstruction of the building envelope (installation of thermal insulation of external walls, roof, and/or ceiling, and replacement of existing external joinery (windows and doors) with joinery of high energy characteristics); and b. Replacement of existing heating system with new ones of higher energy efficiency Planned measures:

Measure No.	JZD-1
Name of measure	Participation in integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy
	• replacement of existing heating system with the one of higher energy efficiency The list of all buildings proposed for this measure, with the price of a new energy efficient heating system, can be found in *Appendix 2 - List of public buildings that are not owned by LSGs with proposed measures.*

5.4.3. Measures to reduce CO2 emissions from transport sector

5.4.3.1. Measures in sub-sector of vehicles under the jurisdiction of LSG

Measure No.	SG-1
Name of measure	Procurement of electrical vehicles under the competence of LSG
Responsible for measure implementation	General administration department
Partners in implementation	• Relevant department of LSG; • Public utility companies and institutions founded by Vrnjačka Banja municipality; • Department for urbanism, civil engineering, property-legal and residential affairs, • Private sector and suppliers of solar and e-mobility equipment.
Implementation period	2029.-2030.
Saving (MWh)	110,79
Reduction of emissions (tCO2)	28,84
Total investment (EUR)	120.000
Possible funding sources for implementation of measure	• Budget of LSG; • Ministry of environmental protection of the Republic of Serbia; • Own funds of public utility companies and institutions included in the measure
Short description of measure / comments	The first step in implementation of this measure is the adoption of a decision that will regulate the purchase of new electric vehicles, so that all new vehicles to be purchased by LSG will have reduced CO_2 emissions. Planned energy savings and reduction of CO_2 emissions, as well as the value of total investment, are based on the assumption that by 2030, 2 vehicles that are directly owned by LSG will be replaced by new electric vehicles with reduced greenhouse gas emissions. The goal of this measure is primarily the promotion of electric vehicles and the presentation of examples of good practice to the public. As part of this measure, construction of one solar charging station for electric vehicles with a capacity of two charging stations (grid-tied system) is planned, which will use energy from renewable sources to charge official vehicles, with the possibility of connecting other electric vehicles owned by citizens or local institutions. This way, the LSG sets an example of good practice in the application of clean technologies and actively contributes to the reduction of CO_2 emissions from the transport sector, as well as to the promotion of the green mobility concept

5.4.3.2. Measures in sub-sector of private and commercial vehicles

Measure No.	SP-1

Name of measure	Promotion of sustainable mobility and reduction of private vehicle use
Responsible for measure implementation	General administration department
Partners in implementation	• Department for physical planning, environmental, property-legal and residential affairs; • Department for economy and social affairs; • Ministry of science, technological development and innovations; • Ministry of civil engineering, transport and infrastructure; • Ministry of environmental protection; • Public enterprises and transport companies; • Civil society organisations
Implementation period	2026.–2030.
Saving (MWh)	2.587,75
Reduction of emissions (tCO2)	623,01
Total investment (EUR)	25.000
Possible funding sources for implementation of measure	• Budget of LSG; • International development organisations (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB, etc.)
Short description of measure / comments	The measure includes informing and educating citizens about the importance of reducing the use of private vehicles in everyday traffic, and encouraging the use of sustainable forms of mobility - public transport, bicycles, walking and electric vehicles. The aim of this measure is **to reduce CO_2 emissions from the transport sector and promote sustainable transport habits** among the population, employees of public institutions and business entities. The measure has a multiple objective: • Increase citizens' awareness of the impact of transport on air pollution and climate change, • Motivate the population to use public transport and other environmentally friendly means of movement; • Promote the purchase and use of energy-efficient and electric vehicles, both in the public and private sectors. The most important activities planned by this measure include: i. The organization of annual events **"Day without cars"**, with the temporary closing of central streets for motor traffic and the promotion of walking, cycling and public transport; ii. Implementation of **informational and promotional campaigns** through local media, social networks and public areas about the benefits of sustainable mobility; iii. Establishment of an "**info corner for green mobility"** on the LSG web-portal, with information on available public lines, subsidies and opportunities for purchasing ecological vehicles; iv. Organization of **public forums, educational workshops and promotional events** in cooperation with local schools, transporters and the civil sector. The measure directly contributes to SECAP's goals by reducing the consumption of fossil fuels in transport sector, improving air quality and developing a culture of responsible, environmentally conscious movement.

5.4.4. Climate, energy and financial effects of planned measures to reduce CO_2 emissions with a dynamic plan for the implementation of measures

The plan of measures to mitigate the consequences of climate change consists of a total of 9 measures. The plan envisages measures to reduce CO_2 emissions from buildings and transport sectors. The reduction of CO_2 emissions will be achieved by 2030 by implementing the planned measures to mitigate the consequences of climate change.

As a result of the implementation of the planned energy efficiency measures, annual CO_2 emissions in the area of the local government will be reduced by a total of 3.070,35 tCO_2 by 2030. The measures are mostly focused on reducing CO_2 emissions in the buildings sector, but their implementation will lead to significant reductions in CO_2 emissions in other sectors as well.

The following table summarizes the climate, energy and financial effects of all planned measures to mitigate the consequences of climate change.

Measure reference	NAME OF MEASURE	Investment (EUR)	Reduction of emissions (tCO_2)	Energy savings (MWh)
Inter-sectoral measures				
MS-1	Continuous education of relevant LSG employees and associated public companies on legal obligations in the field of systematic energy management	25.000	-	-
Measures to reduce CO_2 emissions from the building sector				
Measures for residential building sub-sector				
SZ-1	Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency	15.000	-	-
SZ-2	Energy reconstruction of the outer envelope on individual residential buildings	168.000	414,16	3.113,95
SZ-3	Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings	264.000	678,04	6.646,42
SZ-4	Installation of photovoltaic (PV) systems on individual residential buildings	90.000	852,92	776,08
Measures for sub-sector of public buildings owned by LSG				
JZO-1	Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy	686.586	307,01	344,94
Measures for sub-sector of public buildings not owned by LSG				
JZD-1	Participation in integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy	31.000	166,38	569,70
Measures to reduce CO_2 emissions from transport sector				
Measures in sub-sector of vehicles under the jurisdiction of LSG				
SG-1	Procurement of electrical vehicles under the competence of LSG	120.000	28,84	110,79
Measures in sub-sector of personal and commercial vehicles				
SP-1	Promotion of sustainable mobility and reduction of private vehicle use	25.000	623,01	2.587,75
TOTAL		**1.424.586**	**3.070,35**	**14.149,63**

Table 2-50: Financial framework and effects of implementation of climate change mitigation measures

It is necessary to provide **1.424.586 EUR** for implementation of all planned measures. Funds from the LSG budget will be used to finance the measures, as well as external sources of financing, which are presented in more detail in the chapter – *Funding mechanisms for implementation of the sustainable energy and climate action plan.*

Implementation dynamics of measures to mitigate the consequences of climate change is shown in the following table.

Measure reference	NAME OF MEASURE	Investment (EUR)	Implementation period					
			2025	2026	2027	2028	2029	2030
Inter-sectoral measures		**25.000**						
MS-1	Continuous education of relevant LSG employees and associated public companies on legal obligations in the field of systematic energy management	25.000						
Measures to reduce CO_2 emissions from the building sector		**1.254.586**						
Measures for residential building sub-sector		537.000						
SZ-1	Informing the public about the necessity of mitigating climate change and continuous education of citizens about practical aspects of energy efficiency	15.000						
SZ-2	Energy reconstruction of the outer envelope on individual residential buildings	168.000						
SZ-3	Improvement of the energy characteristics of existing and installation of new energy efficient heating systems in individual housing buildings	264.000						
SZ-4	Installation of photovoltaic (PV) systems on individual residential buildings	90.000						
Measures for sub-sector of public buildings owned by LSG		686.586						
JZO-1	Integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy	686.586						
Measures for sub-sector of public buildings not owned by LSG		31.000						
JZD-1	Participation in integrated energy reconstruction of public buildings owned by LSGs in which fossil fuels are used as heating energy	31.000						
Measures to reduce CO_2 emissions from transport sector		**145.000**						
Measures in sub-sector of vehicles under the jurisdiction of LSG		120.000						
SG-1	Procurement of electrical vehicles under the competence of LSG	120.000						
Measures in sub-sector of personal and commercial vehicles		25.000						
SP-1	Promotion of sustainable mobility and reduction of private vehicle use	25.000						
TOTAL		**1.424.586**						

Table 2-51: Implementation dynamics of climate change mitigation measures

5.5. Projection of CO_2 emissions' reduction by 2030 for scenario including planned measures

When modelling this scenario of reducing CO_2 emissions until 2030, the cumulative effects of existing trends in the considered sectors and subsectors were taken into account, without intensive participation of LSG; as well as the systematic implementation of planned energy efficiency measures aimed at mitigating climate change. Below is a presentation of projections of final energy consumption and associated CO_2 emissions until 2030 per individual sectors, and collectively for all considered sectors.

5.5.1. Projection of CO_2 emissions from building sector for scenario including planned measures

When determining the projection of CO_2 emissions in 2030 from the sub-sector of **public buildings owned by LSG and public buildings not owned by LSG,** the fact that the energy renovation of these buildings requires systematic planning and large financial investments, in which the LSG itself must participate to a large extent, was taken into account. For this reason, energy consumption in 2030 for the scenario without additional LSG measures in these subsectors would remain at the level of energy consumption in 2024, as well as the corresponding CO_2 emissions.

When determining the projection of the required final energy for heating in the **sub-sectors of public buildings** and associated CO_2 emissions, only the effects of planned energy efficiency measures were taken into account, because energy consumption (and thus CO_2 emissions) in the absence of intensive participation by LSG would remain at the level of energy consumption and CO_2 emissions determined for the year 2024. The results of this calculation are presented in the following table.

PUBLIC BULDINGS	ENERGY CONSUMPTION [MWh]			EMISSIONS [tCO_2]		
	2015.	2024.	2030.	2015.	2024.	2030.
PUBLIC BULDINGS OWNED BY LSG						
Scenario including measures	2.696,19	3.141,48	2.796,54	920,63	911,87	604,86
PUBLIC BULDINGS NOT OWNED BY LSG						
Scenario including measures	1.268,91	892,75	323,05	279,65	203,68	37,30

Table 2-52: Projections of annual final energy consumption and CO_2 emissions until 2030 for the scenario with planned measures - subsectors of public buildings

By implementing the integrated energy renovation of 15 public buildings owned by LSG (measure JZO-1), annual energy consumption will be reduced by 344.94 MWh, and CO_2 emissions by 307.01 tCO_2, so for this scenario, the total annual final energy consumption in this subsector in 2030 will be 2,796.54 MWh, and annual CO_2 emissions 604.86 tCO_2. With participation of LSG in the integrated energy renovation of 2 public buildings not owned by LSG (measure JZD-1), annual energy consumption would be reduced by 569.70 MWh, and CO_2 emissions by 166.38 tCO_2, so the total annual final energy consumption at the level of the entire subsector of public buildings not owned by LSG in 2030 would be 323.05 MWh, and the total annual CO_2 emissions would be 37.30 tCO_2.

The basis for determining the projection of CO_2 emission reductions by 2030 from the **residential buildings subsector** was the current trend of emission reductions, determined by the willingness of citizens to invest in energy efficiency measures in their residential units on their own initiative, reduced by the impact of new residential buildings built in the coming period, the trend of population emigration, and the lower purchasing power of the remaining households that have not yet implemented energy efficiency measures. In addition to the calculated continuation of the trend, the effects of planned systemic measures that include technical and financial support to owners of residential units (key measures SZ-1, SZ-2, SZ-3, SZ-4) are also included. The implementation of the above measures and the continuation of the trend will result in a total reduction in final energy by 64.460,16 MWh, or a reduction in CO_2 emissions by 56.614,11 tCO_2. The results of this calculation are presented in the following table.

RESIDENTIAL BUILDINGS	ENERGY CONSUMPTION [MWh]			EMISSIONS [tCO_2]		
	2015.	2024.	2030.	2015.	2024.	2030.
Scenario including measures	738.562,78	605.129,91	540.669,75	198.729,49	130.990,47	74.376,36

Table 2-53: Projections of annual final energy consumption and CO2 emissions until 2030 for the scenario including planned measures - residential buildings subsector

5.5.2. Projection of CO_2 emissions from transport sector for scenario including measures

The vehicle market, the habits and living standards of the population, and improvements to the transport infrastructure that contribute to better and more efficient transport flow and thus to the reduction of CO_2 emissions have the greatest influence on the trend of emissions from the transport sector. At the end of 2022, the Government of the Republic of Serbia adopted the Air Protection Program in the Republic of Serbia for the period 2022-2030, which set a clear strategic framework for improving air quality and modernizing the fleet. The program envisages a gradual restriction of the import of vehicles with lower emission standards, while at the same time introducing incentive mechanisms for the replacement of older vehicles with more modern and environmentally friendly models. The planned measures include a ban on the import of vehicles with engines that do not meet modern emission requirements (Euro 3 and Euro 4), as well as a phased extension of restrictions to vehicles with the Euro 5 standard, which creates the basis for accelerated renewal of the vehicle fleet and reduction of harmful gas emissions. Special emphasis is placed on encouraging the replacement of older diesel vehicles with vehicles that meet the Euro 6 standard, with the possibility of including gasoline vehicles in the support system. It is expected that the full implementation of these measures in the coming period will significantly contribute to the reduction of emissions of pollutants and CO_2 from transport, the improvement of air quality in urban areas, as well as the harmonization of national legislation with European standards and goals of the green transition. The program represents an important step towards the long-term sustainable development of the transport sector and the creation of a favourable framework for the further application of energy and climate policy measures. Bearing in mind that the average age of vehicles registered in the territory of this LSG is 16 years, and that only about 25% of vehicles are of EURO category 5 and above, it can be expected that as a result of this ban, the efficiency of vehicles will improve significantly in the coming period.

Calculation of CO_2 emissions for the scenario including measures, the implementation of which is implemented by the LSG, took into account, in addition to the effects of energy efficiency measures themselves, the trend of CO_2 emissions in the past period from the baseline to the control year, and the trend of increasing the number of vehicles in the coming period on the one hand and increasing the efficiency of vehicles on the other. The results of this calculation are shown in the following table.

TRANSPORT	ENERGY CONSUMPTION [MWh]			EMISSIONS [tCO_2]		
	2015.	2024.	2030.	2015.	2024.	2030.
Scenario including measures	99.230,35	108.005,18	87.314,54	25.533,97	27.953,29	24.801,29

Table 2-54: Projections of annual final energy consumption and CO_2 emissions until 2030 for the scenario including planned measures - transport sector

Total annual final energy consumption in transport sector in 2030 will amount to 87.314,54 MWh, and the total annual CO_2 emissions will be 24.801,29 tCO_2.

5.5.3. Projection of CO_2 emissions from public lighting sector for scenario including planned measures

The public lighting system in 2024 includes 7,032 lamps, and the structure of the light sources themselves exclusively includes highly efficient LED light sources. Accordingly, no additional measures are foreseen in the public lighting sector within the framework of the development of this plan. The following Table shows projections of annual final energy consumption and CO_2 emissions until 2030 for the scenario with planned measures for the public lighting sector

PUBLIC LIGHTING	ENERGY CONSUMPTION [MWh]			EMISSIONS [tCO_2]		
	2015.	2024.	2030.	2015.	2024.	2030.
Scenario including measures	3.353,05	1.771,01	1.771,01	3.375,73	1.946,34	1.655,77

Table 2-55: Projections of annual final energy consumption and CO_2 emissions until 2030 for the scenario including planned measures - public lighting sector

Total annual energy consumption at the level of the entire system in 2030 for this scenario would amount to 1,771.01 MWh/year, and the total annual CO_2 emission at the system level would be 1,655.77 tCO_2/year[42].

If additional opportunities for financing measures in this sector are created in the coming period, additional savings in electricity consumption and reduction of CO_2 emissions can be achieved by introducing a higher level of management - managing the operating time and number of active lighting fixtures in certain periods (especially at night), or by introducing central remote control (telemanagement).

5.5.4. Projection of total inventory of CO_2 emissions for scenario including planned measures

The following table provides a comparative overview of the total base inventory of CO_2 emissions for all considered sectors of final energy consumption, and projections of the inventory of emissions in 2030 for the scenario with the effects of the planned measures. The table also contains indicators of the percentage reduction in CO_2 emissions in 2030 compared to the baseline year in each sector and sub-sector, and the total percentage reduction in CO_2 emissions.

SECTORS	CO_2 emissions [tCO_2]			Reduction of CO_2 emissions in 2030 compared to baseline year 2015. [%]
	2015.	2030.	Reduction of CO_2 emissions compared to baseline year 2015.	
BUILDING AND PUBLIC LIGHTING				
Public buildings owned by LSG	920,63	604,86	315,77	34,30%
Public buildings not owned by LSG	279,65	37,30	242,35	86,66%
Residential buildings	198.729,49	74.376,36	124.353,14	62,57%
Public lighting	3.375,73	1.655,77	1.719,96	50,95%
TRANSPORT				
Vehicles under the jurisdiction of LSG	18,26	88,03	-69,77	-382,00%
Public transport	759,01	471,56	287,45	37,87%
Private and commercial vehicles	24.756,70	24.241,70	514,99	2,08%
TOTAL	**228.839,47**	**101.475,58**	**127.363,89**	**55,66%**

Table 2-56: Percentage reduction of CO2 emissions within the considered sectors and subsectors until 2030 for the scenario with planned measures

According to these projections, the total annual CO_2 emissions in 2030 for the scenario including the effects of the planned measures amounts to 101.475,58 tCO_2, which compared to the emissions in the baseline year represents a **reduction in total emissions of 55.66%, *thus exceeding the indicative goal of reducing CO_2 emissions by at least 55% by 2030.*** Total reduction of CO_2 emissions by 2030 compared to the situation in the baseline year amounts to 127.363,89 tCO_2. The biggest share in this reduction is the building sector, primarily the subsector of residential buildings with 124.353,14 tCO_2 or 97,64% of total emissions.

[42] Reduction of CO_2 emissions by 2030, albeit without an additional reduction in electricity consumption, is the result of the projection of the CO_2 emission factor for electricity in Serbia for 2030. This projection is based on the assumption of an increase in the share of renewable energy sources in the total energy mix, which leads to a decrease in the average emission factor of electricity.

6. CLIMATE CHANGE ADAPTATION

The climate of an area in a certain period of time is defined as a set of average or expected values of meteorological elements and phenomena. It is usually said that the climate of an area is influenced by the overall climate system, which is made up of atmosphere, hydrosphere, cryosphere, soil and biosphere, and that climate is only an external manifestation of complex and non-linear processes within the climate system that have their own dynamics and interaction.

Thirty-year data sets are used for climate assessment. While the earth's climate has always changed, in the past it was subject only to natural influences, and in the last 100 years it has been changing much faster, primarily due to human activity.

Climate changes is one of the key challenges for the Republic of Serbia, considering their impact on the environment, economy, society and politics. The effects are already visible, and without appropriate measures their future consequences will be serious. According to the **National Climate Change Adaptation Program for the period 2023–2030**, the Republic of Serbia is warming faster than the global average (an increase of 1.8°C compared to the world average of 1.1°C). Extreme weather events since 2000 have caused damages of about 6.8 billion euros - of which about 70% originates from droughts and high temperatures, and a significant part from floods. Annual losses from fires, droughts and floods clearly indicate the vulnerability of society.

The consequences of climate change particularly affect water resources, ecosystems, energy infrastructure, human health and agriculture - the most sensitive sector. Agriculture accounts for about **7.5% of GDP** and employs a significant part of the population, while changes in temperature and precipitation directly affect productivity. According to IPCC projections, by the end of the century, the average annual temperature is expected to increase by **2.4 to 4°C** compared to the period 1961-1990, depending on the scenario and region. Such changes will have far-reaching effects on agriculture, forestry, land and water management - sectors that are key to GDP, employment and rural development.

Changes in distribution of rainfall can also affect the production of electricity, which without adequate adaptation could burden the existing capacities. The vulnerability of the Republic of Serbia stems from its geographical position, sectors affected by climate risks and limited capacities for adaptation. While mitigation measures affect long-term development, **adaptation** is crucial for reducing the risk and sensitivity of society and the economy, as well as for recognizing the opportunities that climate change can bring.

6.1. Analysis of climate and climate changes within Vrnjačka Banja municipality

6.1.1. Current climate changes registered in the Republic of Serbia

Negative consequences of climate change are already visible in the Republic of Serbia. All previous reports related to climate change[43,] which our country prepares as a signatory to the United Nations Framework Convention on Climate Change[44], confirm that these changes will occur more and more intensively by the end of the 21st century. Analyses of temperature changes and precipitation regimes in the period from 1961 to 2020 show a trend of a significant increase in temperature in all areas of our country, an increase in the number of warm days and the frequency of extremely high temperatures, a decrease in the number of cold days and a lower frequency of extremely low temperatures, as well as a trend of a slight increase in annual precipitation with simultaneous significant changes in annual distribution of precipitation. Changes in annual

[43] *The first national report of the Republic of Serbia in accordance with the United Nations Framework Convention on Climate Change : https://unfccc.int/documents/640134*
The second national report of the Republic of Serbia in accordance with the Framework Convention of the United Nations : https://unfccc.int/documents/640134
Third National Report and Second Biennial Report on Greenhouse Gas Emissions of the Republic of Serbia in accordance with the United Nations Framework Convention: https://unfccc.int/documents/640134
The fourth national report of the Republic of Serbia in accordance with the United Nations Framework Convention on Climate Change :https://unfccc.int/sites/default/files/resource/NAP_Serbia_2024.pdf
[44] United Nations Framework Convention on Climate Change – UNFCCC (engl.) https://unfccc.int/process-and-meetings/the-convention/history-of-the-convention/convention-documents

temperatures and annual precipitation in the Republic of Serbia, obtained by comparing the period 1971–2000 compared to the period 1986–2005[45] are shown in the following picture.

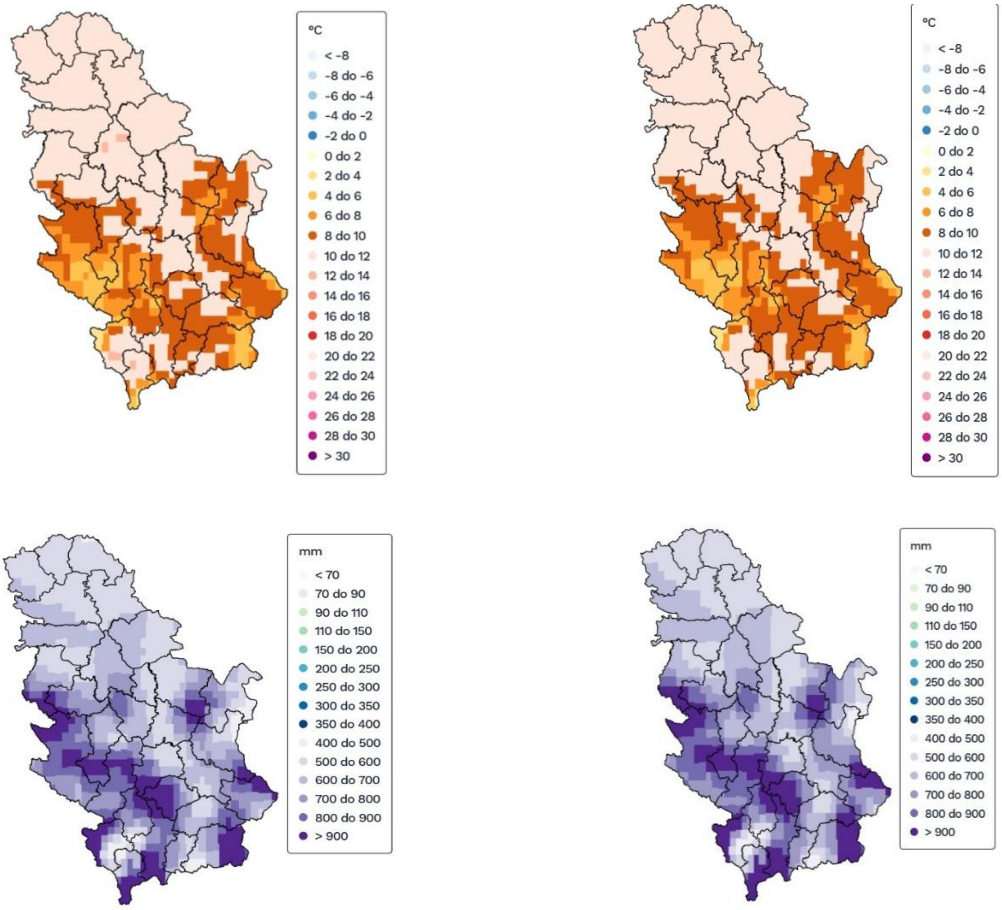


Figure 0-1 : Changes in annual temperatures and annual precipitation in Serbia, obtained by comparing the period 1971–2000 compared to the period 1986–2005.

The climate of Serbia is influenced by its geographical position, geology, relief, vegetation and proximity to the Mediterranean, with extreme factors such as subtropical and polar air masses, cyclones, anticyclones and influences from the Atlantic, Mediterranean, Adriatic and Asian continents. The relief creates three main types of climate: continental temperate (northern and central parts), mountainous (high mountains, plateaus and canyons) and modified Mediterranean (southern parts). The north has warm summers and cold winters; the south has warm summers and wet winters. In recent decades, they show a constant increase in temperature, especially in summer (June-August), with more warm days and fewer cold days. Long-term precipitation does not show strong changes, but spring/summer have fewer rainy periods, while winter has more; winters have less snow, affecting spring/summer water availability. Future scenarios predict warming of up to 4°C and precipitation reduction of up to 30% by 2100 without mitigation.

Air temperature and precipitation: Analysis of data from 1961–2014 shows a steady annual increase in temperature, especially in the last 30 years, under the influence of greenhouse gases and urban heat islands (UHI) from reduced green areas, increased vehicles, industry and energy needs - causing higher urban temperatures. Fewer cold days in the trend at stations. Projections for 2011–2100 compared to 1971–2000 under RCP8.5, A2 and A1B scenarios show continued warming: RCP8.5 (1.6–2°C by 2040, 5.4–5.6°C by 2100); A2 (1°C by 2040, 2.4°C by 2070, 4°C by 2100); A1B (1.2°C by 2040, 2–2.2°C by 2070, 3.6–3.8°C by 2100). Precipitation from 1961–2014 show stagnation/slight increase annually, but seasonal shifts (changes in

[45] *Source*: *The second national report of Serbia in accordance with the framework convention of the United Nations*

spring/autumn, more heavy rains increasing the risk of flooding in the lowlands) and more wet/extremely wet days. Projections: RCP8.5 (+5% by 2040, -20% by 2100); A2 (+5%/stagnation until 2040, -10–20% thereafter); A1B (-10% by 2040, -20% by 2100).

Vulnerability to climate change: Climate change affects the socio-economic factors of Serbia, with future effects on economy and society. Adaptation minimizes the consequences for vulnerable groups and sectors, many of which are crucial for development. Agriculture (7.5% of GDP, 20% of employment, key to rural food security) is the most affected, vulnerable to droughts/extreme rains, poor soil and reduced usable land. Since 1990, extreme weather events have caused billions in damage, hampering development.

6.1.1.1. *The increase in the average annual temperature in the area of* Vrnjačka Banja municipality *so far*

Based on data from the Republic Hydrometeorological Service of the Republic of Serbia (RHZS) and climate studies for central Serbia, including the Raška Administrative District where Vrnjačka Banja is located, the average increase in the mean annual temperature in the period 1981–2010 compared to the reference period 1961–1990 is approximately +0.4°C to +0.6°C. This increase is in line with the national average of about +0.4°C, indicating more pronounced climate change in the area with an altitude of about 210 meters. The long-term annual temperature increase since the mid-20th century has reached about +0.06°C per decade, which represents a total increase of about 1.2°C over a time interval of about 65 years.

Vrnjačka Banja is located in the central part of Serbia, in the Raška District, in the Vrnjačka River Valley, surrounded by the hilly relief of Šumadija and Western Serbia with an altitude of 200 to 400 meters above sea level. The area has a characteristic microclimate favourable for spa activities, with an average annual temperature of about 10-11°C in the lower parts, influencing local climate trends. It is surrounded by the slopes of the Goč and Jastrebac mountains, which contribute to specific conditions for climate change.

Based on the available RHZS data and regional averages for the Raška Administrative District, Table 6-1 shows the mean annual temperatures for three key climatic periods in Vrnjačka Banja, clearly indicating the consequences of climate change through an increase in average temperatures.

An overview of average monthly and average annual temperatures for typical periods is given in the following table:

Average monthly and annual air temperatures (°C) in the area of Vrnjačka Banja municipality			
Month	1961-1990 (Normal RHMZ)	1991-2014 (Approximate average)	2015-2023 (Approximate average)
January	-1.5	-0.8	-0.3
February	-0.5	0	0.3
March	4.5	5.2	5.8
April	10.2	10.8	11.2
May	16	16.5	16.8
June	19.5	20.2	20.7
July	21.7	22.5	22.9
August	21.4	22.1	22.6
September	17.2	17.8	18.2
October	11	11.6	12
November	5	5.6	5.9
December	0.5	1	1.3
Average ANNUAL	10.2	10.9	11.3

Table 0-1: Mean monthly and annual air temperatures (°C) in the area of Vrnjačka Banja municipality

According to data from the Republic Hydrometeorological Service of Serbia (RHZS) and international climate databases, the average annual temperature in the Novi Pazar area in the period 2015–2023 was around 12.2°C, which shows a slight increase compared to the earlier period 1991–2014 (around 11.8°C) and a more significant increase compared to the period 1961–1990 (around 11.0°C). This change of approximately +1.2°C is particularly reflected in warmer winters and summer months with more frequent waves of high temperatures, such as July 2022 and 2023 with average temperatures above 25°C. The data are adjusted for the altitude of Novi Pazar (~580 m) and location specifics, as well as based on daily measurements from local meteorological stations. These trends confirm an overall warming of around +1.2°C compared to the 1961–1990 climate normal, which is consistent with broader European and global climate change.

This increase in annual average temperature values clearly indicates climate change with consequences for the local ecosystem, agriculture and energy, and confirms previous predictions about warming in southwestern Serbia.

The following diagram shows temperature changes for characteristic periods per month for characteristic periods.

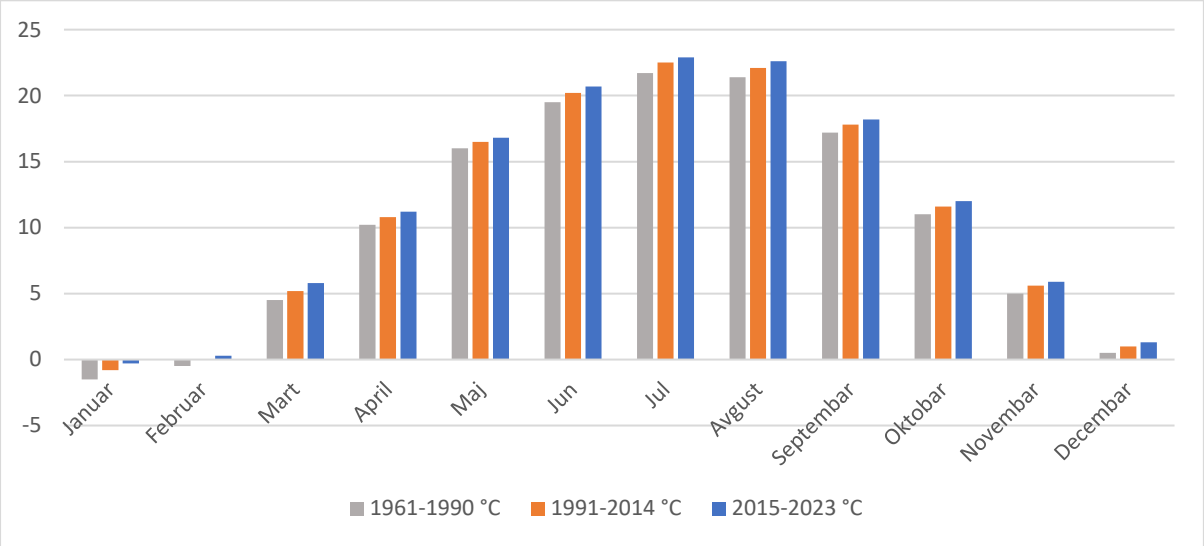


Diagram 0-1: Comparison of mean temperature for the area of Vrnjčka Banja municipality for the periods 1961-1990, 1991-2014 and 20151-2023.

According to data from the Republic Hydrometeorological Service of Serbia (RHZS), in the Vrnjačka Banja area, there was a moderate increase in the average monthly temperature in the period from 1961 to 2023. The most pronounced increase in temperature was observed during the summer months (June–August), with an increase of about 1.1–1.2°C, while the winter months (December–February) recorded an increase of about 1.3°C. Overall, the average annual temperature in the territory of the Vrnjačka Banja municipality increased by approximately 1.1°C during this period.

The increase in temperature in the last few years is particularly evident, with the average annual temperature for 2020 and 2021 being around 11.3°C, while in 2023 it reached approximately 11.4°C. These data indicate climate change affecting local weather conditions with more pronounced warming throughout the year, especially in the summer and winter months. Summer temperatures, especially in July, now often exceed 22.5°C, confirming the warming trend.

These trends reflect local climate conditions in the Vrnjačka Banja area and the increase in temperatures that is in line with broader European and global climate change. Such developments have significant implications for the local ecosystem, tourism and energy.

The following diagram presents the average annual temperatures for previous periods, taken from the nearest reference measuring station.

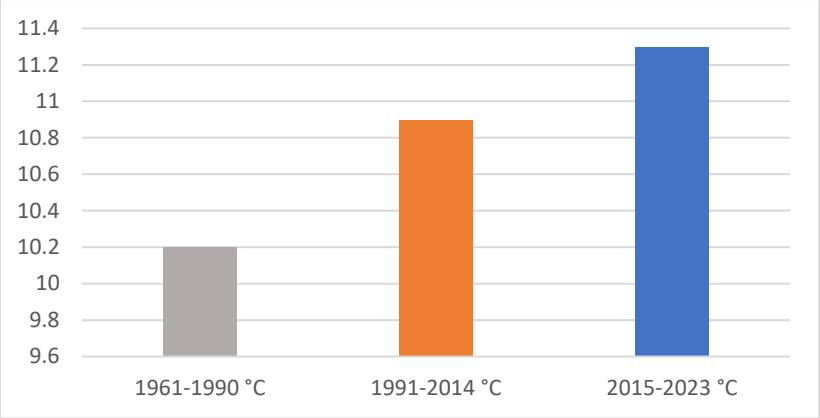


Diagram 0-2: Mean annual temperatures in the area of Vrnjačka Banja municipality

Looking at the data for the last five years in the Vrnjačka Banja area[46], it is important to point out that the deviations of the average annual air temperature are significantly above the standard normal value for the period 1961–1990, which is about 10.2°C. The largest deviations at the Vrnjačka Banja measuring station are recorded the following year in relation to that normal: about 1.1°C for 2019, 1.0°C for 2020, 0.9°C for 2022 and 1.2°C for 2023. In the period from 2020, very warm and extremely warm months were registered: June, July and August 2020, June and July 2021, June, July and August 2022, as well as July and August 2023. On the other hand, very cold and extremely cold months were recorded in April 2021, October and November 2022.
Based on data from the Republic Hydrometeorological Institute of the Republic of Serbia and analysis of climate trends in Vrnjačka Banja, a continued increase in temperatures can be expected, with this trend intensifying. The mean annual temperature increased from around 10.2°C in the period 1961–1990 to approximately 11.3°C in the period 2015–2023, indicating significant warming. This increase is changing temperature and precipitation patterns, predicting increasingly frequent climate extremes that may have a negative impact on the economy, tourism and society of Vrnjačka Banja.

6.1.1.2. Changes so far in quantity of precipitation within Vrnjačka Banja municipality

The territory of Vrnjačka Banja municipality is characterized by a temperate continental precipitation regime, with peak precipitation intensity occurring between May and October. The winter months - particularly January and February - experience lower precipitation levels, which often fall as snow during this time of year. According to data from the Republic Hydrometeorological Service of Serbia (RHZS), the average annual precipitation in Vrnjačka Banja for the 1961–1990 period was approximately 620 mm. Seasonal and annual variations in precipitation have been observed in subsequent periods, while data from 2015 to 2023 indicate a slight upward trend in total precipitation - an increase of a few percent - compared to the reference period. The most significant increase was recorded during the spring and summer months, a trend that may heighten the risk of local flash floods.

These climate changes necessitate adequate water resource management to mitigate negative impacts on the local economy, tourism, and infrastructure in Vrnjačka Banja. Continuous monitoring and precise analysis of climate data are crucial for adaptation and for planning the municipality's sustainable development in the future.

A comparison of average monthly and annual precipitation levels in the Vrnjačka Banja municipality for the periods 1961–1990, 1991–2014, and 2015–2023 is presented in the following table and diagram:

Mean and average monthly and annual rainfall in Vrnjačka Banja municipality (mm)			
Month	1961-1990	1991-2014	2015-2023
January	40	42	43
February	32	34	35
March	38	39	41
April	45	46	48

[46] https://www.hidmet.gov.rs/data/klimatologija/latin/leto.pdf

May	65	67	70
June	80	82	85
July	70	72	75
August	60	62	64
September	55	57	59
October	50	52	54
November	45	47	49
December	40	42	44
Annual total	620	635	663

Diagram 0-3: Comparison of average monthly and annual rainfall for the area of Vrnjačka Banja municipality for the periods 1961-1990, 1991-2014, 2015-2023

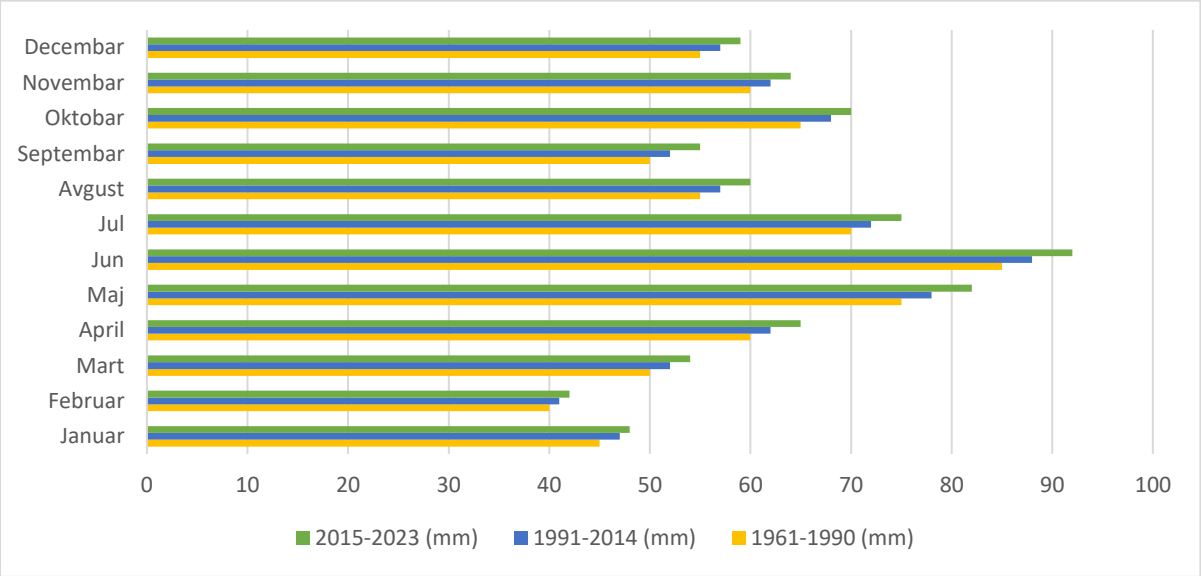


Diagram 0-4: Comparison of monthly rainfall for the area of Vrnjačka Banja municipality for the periods 1961-1990, 1991-2014, 2015-2023.

The analysis of the average monthly and annual precipitation in Vrnjačka Banja in the period from 1961 to 2023 shows slight changes and a trend of a slight increase in total precipitation in the recent period. Considering the seasonal distribution, precipitation is most pronounced in the spring and summer months (May–October), while the winter months (January–February) are drier with precipitation predominantly in the form of snow. Such trends indicate increased humidity and relatively stable precipitation, but at the same time increased seasonal variability is also observed, especially in the summer months.

The data is based on official sources from the Republic Hydrometeorological Service of Serbia (RHZS) and studies on climate change at the local level.

The following diagram shows the differences in average monthly precipitation between annual periods:

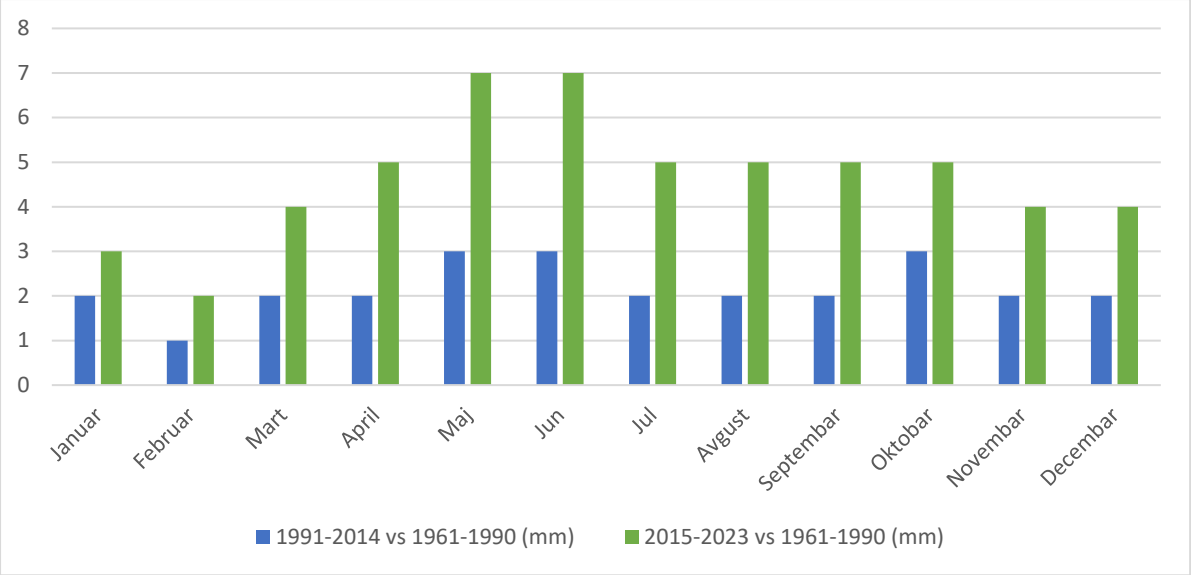


Diagram 0-5: Difference in average monthly rainfall (mm) in the area of Vrnjačka Banja municipality in the period 1961-1990, 1991-2014 and 2015-2023.

Precipitation amounts have been gradually increasing in recent periods compared to the baseline period 1961-1990, which may indicate changes in climate patterns. This tendency of increasing precipitation by months, as well as annually, has significant implications for planning and adaptation to climate conditions in Vrnjačka Banja, especially in the context of water resources management, tourism and urban infrastructure systems. Monitoring these statistics allows for better adaptation of local protection measures and sustainable development in the context of climate change.

From 1990 to 2024, Vrnjačka Banja experienced significant climate challenges, including increased risk of flooding due to changes in the amount and distribution of precipitation, as well as other weather events such as severe storms and droughts. In recent decades, extremes have been recorded that required urgent protection and adaptation measures, such as the rehabilitation of watercourses, the modernization of sewage systems, and the strengthening of regional cooperation.

6.1.2. Estimates of future climate change in the area of Vrnjačka Banja municipality

Significant changes in climate conditions can be expected in the Republic of Serbia in future, especially in case of scenarios that do not include appropriate climate change mitigation measures. Estimates of future climate change are based on projections of greenhouse gas emissions that take into account the parameters of future demographic, social, economic and technological development at global and regional level. If global greenhouse gas emissions maintain the recorded trend of the last few decades, the climate of the Republic of Serbia could become warmer on average compared to the climate conditions of the mid-twentieth century, with undesirable changes in intensity and frequency of extreme precipitation and other climate phenomena.

Regional Climate Models (RCM) are used to assess climate changes in certain areas. These models are the most frequently used tools for regionalization of the results of global climate models and assessment of changes in regional climate conditions in future depending on different scenarios of a possible increase in greenhouse gas concentrations. The Climate Atlas of the Republic of Serbia[47], i.e. the results of the climate scenario A1B for the territory of the Republic of Serbia made within the framework of the EBU-POM[48] regional model, was used to present the climate conditions in future for the area of this LSG.

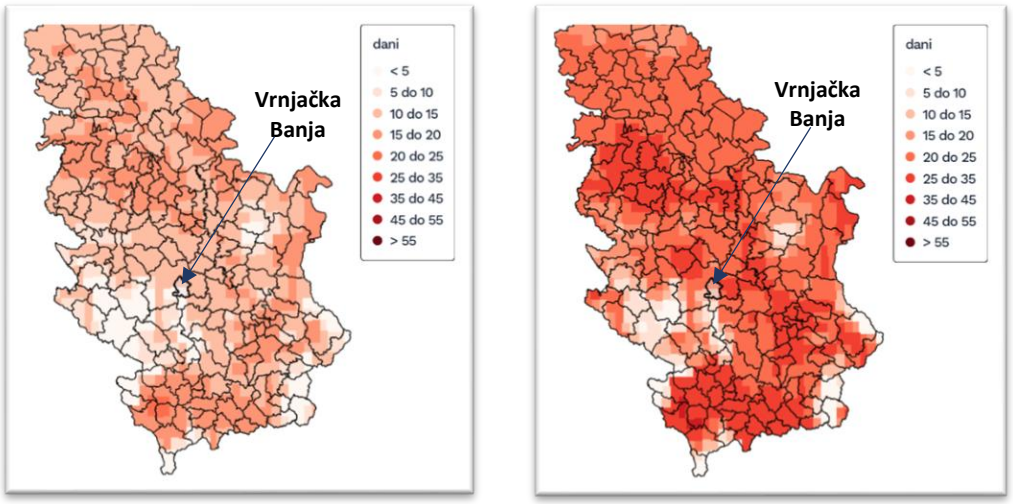
[47] https://atlas-klime.eko.gov.rs/

[48] Scenario A1B, in relation to concentration of greenhouse gases characterized as an "intermediate" scenario, is defined by the special report of the Intergovernmental Panel on Climate Change (IPCC) on emission scenarios (Nakicenovic and Swart, 2000), in which the possible future emissions of greenhouse gases are given as a consequence of future technological, social and economic development, based on human activities. A1B assumes a balanced mix of technology and the use of basic resources, with technological advances that allow avoiding the use of only one energy source. The implications of this possible development of society in future will be reflected in greenhouse gas emissions ranging from very intensive emissions to the possibility of decarbonizing emissions.

6.1.2.1. Assessment of the future increase in the mean annual temperature in the area of Vrnjačka Banja municipality

Based on the data of the Republic Hydrometeorological Institute, and the Second and Third National Reports of the Republic of Serbia on climate change, it can be predicted that air temperatures will continue to rise and that this growth will become increasingly intense. The rise in temperature causes the limits of temperature and precipitation regime to shift. An increase in temperature extremes is also predicted, which can have a significant negative impact on the economy and society.

The following diagram shows the average annual temperatures for the considered scenario A1B for two time horizons, 2011–2040 and 2041–2070.[49]



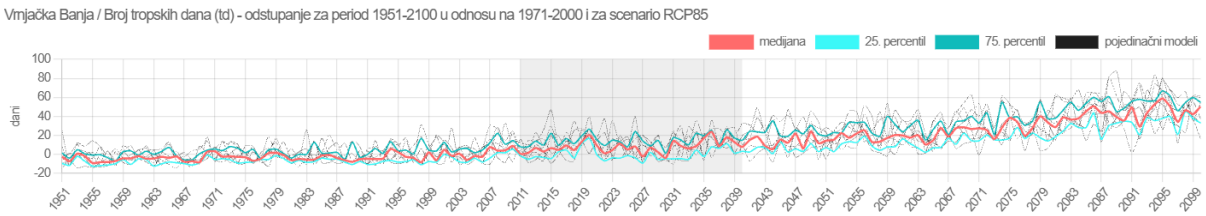
2011-2040 **2041-2070**

Figure 0-2: Mean annual temperature for the period 2011-2040 (left) and 2041-2070 (right) according to the A1B scenario

The territory of Vrnjačka Banja municipality[50] is characterized by climate trends that show an increase in the average annual temperature, which is in line with global climate change. According to available projections and data from the Republic Hydrometeorological Service of Serbia for the period 2021–2040, the average annual temperature in Vrnjačka Banja is expected to reach values of around 11.5°C to 12.0°C, while a further increase to over 12.3°C is predicted for the period 2041–2070.

Rising temperatures have already led to more frequent heat waves, longer dry periods and more intense extreme weather events, such as severe storms and flash floods, which are affecting local tourism, water resources and urban infrastructure in Vrnjačka Banja. These trends require adaptation measures and improvements in the resilience of the local system to climate change.

An addition to this projection is the Diagram for Vrnjačka Banja Municipality showing the increase in the number of tropical days for the period 1951 - 2100 compared to the period 1971-2000 shown below:



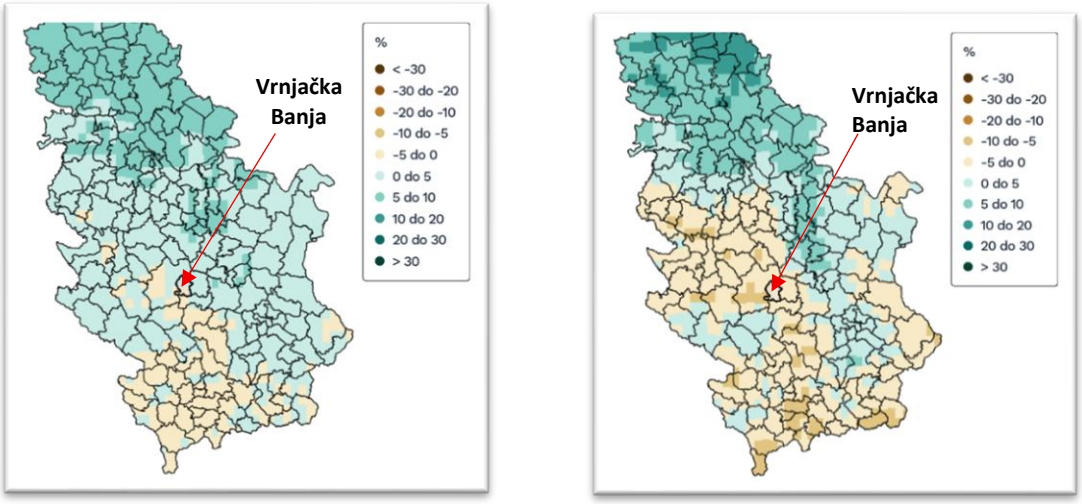
[49] Source: The work of the expert team based on the Climatic Atlas of Serbia - temperature and precipitation

[50] https://drive.google.com/file/d/1k7naD3s7d4GIa-fy1Y_8yoWGuZzw1Ncv/view

Diagram 0-6: Vrnjačka Banja municipality showing the increase in number of tropical days for the period 1951-2100 compared to the period 1971-2000.

6.1.2.2. Estimate of future changes in the amount of precipitation in the area of Vrnjačka Banja municipality

The following figures show annual precipitation amounts for two time periods 2011-2040 and 2041-2060:



2011-2040 **2041-2070**

Figure 0-3: Annual precipitation for the period 2011-2040 (left) and 2041-2060 (right) according to scenario A1B.

An addition to this projection is the diagram of Vrnjačka Banja municipality showing precipitation for the period 1951 – 2100 compared to the period 1971-2000.

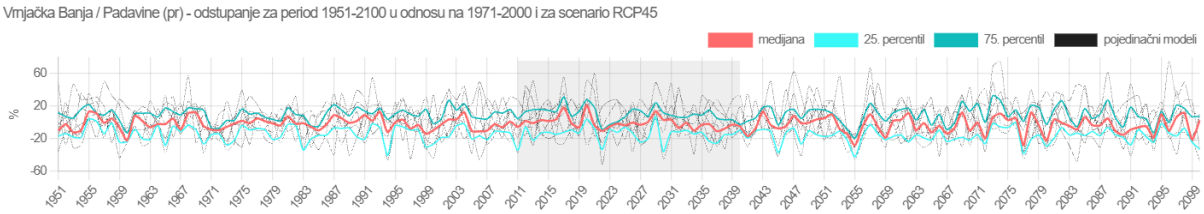


Diagram 0-7: Vrnjačka Banja municipality with a display of precipitation for the period 1951 – 2100 compared to the period 1971-2000.

6.2. Assessment of hazards, exposure and capacity of Vrnjačka Banja municipality to adapt to climate changes

6.2.1. Assessment of hazards from climate change consequences within Vrnjačka Banja municipality

In the area of Vrnjačka Banja municipality[51], numerous hazards have been identified as a consequence of climate change, including: extremely high temperatures, heavy rainfall (rain), floods (river floods), droughts and insufficient water supplies.

Local development and strategic documents, together with risk analyses and maps, integrate an approach to managing these risks, with an emphasis on sustainable development and adaptation to new climate conditions. Measures such as the modernization of sewage systems, rehabilitation of watercourses, hail control and increased regional cooperation in the prevention and rehabilitation of natural disasters can be highlighted.

This information was confirmed from sources of the Republic Hydrometeorological Institute of Serbia, local newspaper reports on weather disasters and official websites of Vrnjačka Banja municipality.

The assessment results of the identified hazards from the consequences of climate change in the area of Vrnjačka Banja municipality are given in the following table:

Hazards	Characteristics of hazards				
	Current characteristics		Future characteristics		
	Hazard probability	Impact of hazard	Anticipated change of intensity	Anticipated change of frequency	Time period
Extremely high temperatures	Medium	High	Increase	Increase	Risk in medium term period
Heavy rainfall – rain	Medium	High	No change	No change	Risk in medium term period
Floods and sea level rise - river floods	Medium	High	No change	No change	Risk in long term period
Droughts and insufficient quantities of water	High	High	Increase	Increase	Risk in long term period

Table 0-2: Characteristics of identified hazards from the climate change consequences in the area of Vrnjačka Banja municipality

6.2.2. Assessment of sector vulnerability to hazards identified within Vrnjačka Banja municipality

In this assessment the following socio-economic sectors in Vrnjačka Banja area were considered from the perspective of exposure to hazards caused by climate change[52]:

[51] https://www.vrnjackabanja.gov.rs/

[52] The above definitions are taken from the methodological documents of the Covenant of Mayors for Climate and Energy

- ⇒ Buildings - refers to all (municipal or city, residential, tertiary, public and private) buildings or groups of buildings permanently constructed or erected on their sites;
- ⇒ Agriculture and forestry - includes land categorized/intended for use in agriculture and forestry, as well as related organizations and industries. It includes livestock farming, fruit growing, vegetable growing, beekeeping, horticulture and other forms of production and services in agriculture and forestry in a specific area;
- ⇒ Civil protection and emergency services - refers to the activities of civil protection and emergency services for or on behalf of public administration (e.g. civil protection organizations, police, firefighters, ambulances, emergency medical services), and includes management and reduction of local disaster risks (staff training, coordination, equipment, development of emergency plans, etc.);
- ⇒ Water supply - refers to water supply service and its related infrastructure. It includes water consumption and waste and storm water management systems such as sewerage and drainage systems and filters (that is, the processes by which waste water is brought to a state that meets environmental standards;
- ⇒ Health - refers to geographical distribution of dominant pathogenic conditions (allergy, cancer, respiratory diseases, heart diseases, etc.); it includes information on the effects on health (biomarkers, reduced fertility, epidemics) or human well-being (fatigue, stress, post-traumatic stress disorder, death, etc.) that are directly (air pollution, heat waves, drought, severe floods, ozone above ground, noise, etc.) or indirectly (food/water quality, genetically modified organisms, etc.) related to environmental quality. It also includes health services department and related infrastructure (e.g. hospitals);
- ⇒ Energy production and distribution - refers to energy supply services and related infrastructure (networks for the production, transport and distribution of all types of energy). It includes coal, crude oil, liquefied natural gas, raw material for refineries, additives, petroleum products, gases, renewable fuels, as well as water, electricity and heating;
- ⇒ Tourism – refers to the activities of persons who travel to and stay in places outside their usual place of residence, for a period not exceeding one year, for leisure, business and other reasons not related to the performance of any activity for which they would receive remuneration in the destination they are visiting.

In the Vrnjačka Banja area, most sectors are threatened by floods, including: construction, agriculture and forestry, civil protection and emergency services, water supply, tourism, etc. The level of impact of floods on these sectors is high.

Vrnjačka Banja has been repeatedly exposed to natural disasters in the form of floods, caused by heavy rainfall and torrents of local watercourses, with the most significant incidents recorded in June 2023, April 2014 and June 2017, when emergency situations were declared in the municipality. In June 2023, a short-term downpour of 48.8 mm in intensity in 30 minutes led to flooding of the central parts of the settlement, including the Bridge of Love, the "Popinski borci" Primary School, the municipality building, public streets and residential buildings in the villages of Podunavci, Novo Selo and Vranesi, with the destruction of 7 bridges and damage to about 4 km of roads and an additional 11 bridges. The preliminary damage assessment indicated significant material losses, with a focus on the rehabilitation of infrastructure facilities, rebalancing the municipal budget and coordination of the Emergency Situations Headquarters in cooperation with the Hydrometeorological Institute of Serbia. A similar scenario was recorded in April 2014, when a 45-minute storm flooded the centre of Banja, collapsing 7 bridges on the central street, penetrating the Municipal Assembly and about 300 business premises, with interventions to pump water from the basement, while the floods of June 2017 affected the settlements of Gračac, Otroci and Rsavci with significant material damage. These events indicate the need to implement preventive measures, including strengthening watercourses, improving urban planning and continuous monitoring of hydrological conditions.

Floods are not a rare occurrence, but a continuous challenge that affects the safety of the population and the stability of economic activities in Vrnjačka Banja. In the last few years, measures have been taken to better manage flood risks, through local plans and cooperation with republican institutions.

Most torrential watercourses in the Vrnjačka Banja area have developed river valleys in the lower and middle reaches. The lengths and widths of river valleys are variable, depending on geomorphological and geological conditions. The main cause of floods in the Vrnjačka Banja area is that in most torrential watercourses, the dimensions of the riverbed are minimal - with a width at the bank level of 2 - 4 m and a maximum depth of 1-2 m, which causes the dimensions of the riverbed and its permeability to be incompatible with the flows of high waters. In all of the above watercourses, there is a real danger of sudden arrival of torrential waters and flooding of settlements, agricultural areas, roads and utility infrastructure. To assess the level of vulnerability of this area to the harmful effects of water, it is of particular importance to know: - the natural hydrographic

characteristics of the area (hydrological characteristics of dominant watercourses and tributaries with data on constructed protection systems and on the disposition of potentially endangered assets in relation to watercourses). - the issues of protecting assets in the coastal areas of regulated and unregulated watercourses. The basins of the tributaries of the West Morava are specific for their dense network of tributaries, with low and unstable banks, flood valleys and backfilled beds, with low water levels in summer and high or medium waters in the autumn and spring months. The opportunities offered by these watercourses are modest and insufficiently exploited. The characteristics of these watercourses impose the need for permanent flood protection, regulation of torrential watercourses and finding ways to use water for irrigation in agriculture. [53]

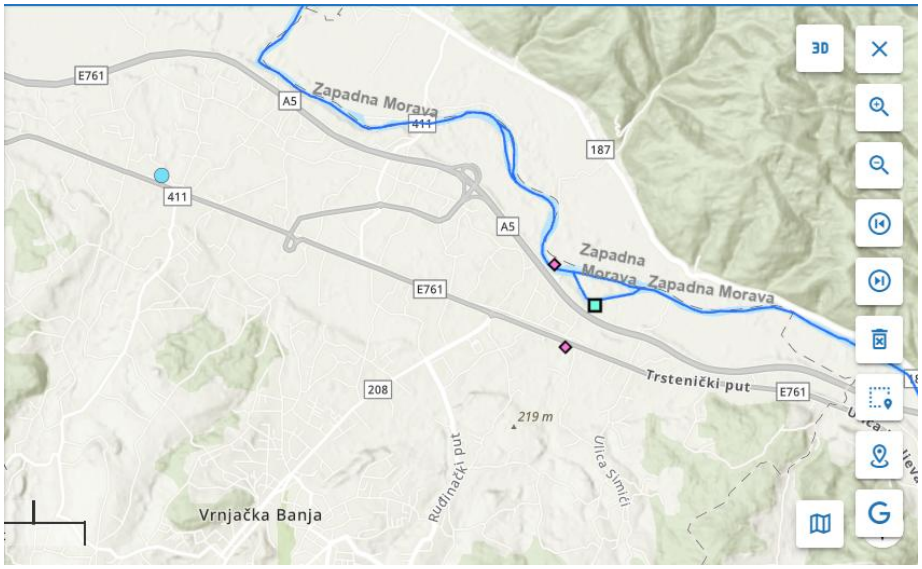


Figure 0-4: Flood vulnerability and risk maps in the Republic of Serbia [54,55]

[53] https://www.vrnjackabanja.gov.rs/images/clanak/387/dokumenta/operativni-plan-za-odbranu-od-poplava-na-teritoriji-opstine-vrnjacka-banja-za-vode-drugog-reda-za-2017godinu-.pdf

[54] СРБИЈАВОДЕ - Веб ГИС портал

[55] *https://www.srbijavode.rs/karte-ugrozenosti-i-karte-rizika-od-poplava.html*

Hazards	Threatened sectors												
	Buildings	**Transport**	**Energy**	**Water supply**	**Waste management**	**Land use plans**	**Agriculture and forestry**	**Environment and biodiversity**	**Health**	**Civil protection and emergency services**	**Tourism**	**Education**	**IT and communication technologies**
Extremely high temperatures	-	-	High (Increased consumption compared to previous years)	High (Increased water consumption compared to the previous period and increased number of days with restrictive water use regime)	-	-	High (Reduction in yield compared to previous years and reduction in plant population compared to previous years)	-	Medium (Increased number of interventions)	-	Medium (Reduced number of tourists compared to the previous period)	-	-
Heavy precipitation - Rain	Medium (Increased number of flooded buildings compared to the previous period and increased number of construction site interruptions due to difficult working conditions compared to the period without the impact of this phenomenon)	-	-	High (Increased number of days with restrictive regime in water use and increased number of water quality analyses compared to the previous period)	-	-	High (Reduced yields compared to previous years, increased investments in reclamation and restoration of agricultural, parkland and other public green damaged areas, increased number of damaged forest access roads and damaged trees)	-	-	High (Increased activity of the competent authorities)	High (Reduced number of tourists compared to the previous period and an increased number of days with seasonal interruptions)	-	-

Hazards	Threatened sectors												
	Buildings	**Transport**	**Energy**	**Water supply**	**Waste management**	**Land use plans**	**Agriculture and forestry**	**Environment and biodiversity**	**Health**	**Civil protection and emergency services**	**Tourism**	**Education**	**IT and communication technologies**
Floods – river floods	High (Increased number of flooded structures compared to the previous period, and an increased number of work stoppages at construction sites due to difficult working conditions compared to the period unaffected by this phenomenon)	-	-	High (increased number of days with restrictive regime in water use and increased number of water quality analyses compared to the previous period)	-	-	High (Reduction in yields compared to previous years increased investment in reclamation and renewal of agricultural land)	-	-	High (Increased activity of the competent authorities)	High (Reduced number of tourists compared to the previous period and increased number of off-season days)	-	-
Drought and insufficient quantity of water	-	-	-	High (Increased costs for water supply and increased number of water quality analyses compared to the previous period)	-	-	High (Reduction in yields compared to previous years increased investment in reclamation and renewal of agricultural land)	-	Low (Number of interventions)	Low (Increased activity of competent services)	High (Increased costs of operating the tourist offer/place)	-	-

Table 0-3: Vulnerability analysis of socio-economic and natural sectors from hazards caused by climate changes within Vrnjačka Banja municipality

In addition to vulnerable sectors, the entire population of the area is exposed to climate change hazards, with different levels of impact on different population categories. Floods, heavy rainfall, and especially hail are hazards that affect a large number of people, but they have a particularly negative impact on the elderly, low income population, and people with chronic diseases. Biological hazards negatively affect the entire population, but especially women, the elderly, children, young people, and marginalized groups.

6.2.3. Climate change adaptation capacities in Vrnjačka Banja municipality

Adaptive capacities refer to the system's ability to adapt to climate change (including climate variability and climate extremes), to mitigate potential harms, to take advantage of opportunities, or to cope with consequences. The capacity to adapt depends on available financial resources, human resources and adaptability, and varies depending on the hazard and sector. For example, an area that is well prepared for flood control may be unprepared for heat waves. The amount of the budget, the number of educated persons per activity, the availability or lack of data on the impact of certain hazards, methods and mechanisms of action in emergency situations, programs to preserve business continuity after the occurrence of hazards, etc., are indicators used to assess the capacity to adapt to climate change. A number of other factors contribute to

this capacity, including the experience of local administration in implementation of disaster response measures.

The climate change adaptation capacities in the area of Vrnjačka Banja municipality, in the context of this analysis, are viewed from several aspects. The following elements of adaptive capacity are considered:

- ⇒ **Existence of public services,** which implies availability and access to public services (police, fire brigade, civil protection, emergency services, etc.) that can deal with identified hazards such as floods and landslides;
- ⇒ **Existence and availability of socio-economic stakeholders,** which implies interaction between socio-economic stakeholders taking into account available resources, and level of development of social awareness and connection (e.g. level of commitment and reaction of socio-economic stakeholders from one area in case of danger);
- ⇒ **Existence, compliance and implementation of regulations, laws, regulations, procedures, etc.,** which includes the existence of institutional environment, regulations and policies (e.g. laws, preventive measures, urban development policies); leadership and competencies of local administration; staff capacity and existing organizational structures (e.g. knowledge and skills of staff, level of interaction between city/municipal services and bodies); availability of financial resources for climate actions;
- ⇒ **Existence of physical resources,** which implies availability of resources (e.g. water, land, sand, stone, etc.) and practices for their management, as well as availability of physical infrastructure and conditions for its use and maintenance in case of danger;
- ⇒ **Existence of knowledge, methodologies, assessments, studies, early warning systems, etc.,** which refers to availability of data and knowledge (e.g. methodologies, guidelines, frameworks for assessment and monitoring); availability and access to technology and technical applications (e.g. meteorological systems, early warning systems, flood control systems); and skills and abilities needed to use them and potential for innovation in case of danger.

It is evident that in the area of Vrnjačka Banja municipality, the capacities to cope with the climate change hazards are moderately developed. The medium score refers to the existence and availability of public services and socio-economic actors; the existence, compliance and implementation of regulations, laws, rules, procedures and the like; the existence of physical resources; and the existence of knowledge, methodologies, assessments, studies, early warning systems, etc. All these elements of the capacities for climate change adaptation require improvements and advancement.

6.3. Climate change adaptation measures within Vrnjačka Banja municipality

Based on the assessment of hazards, exposure and capacity to adapt to climate change, measures and activities have been identified, the implementation of which will lead to the fulfilment of the second key objective set in this Action Plan. Taking into account the natural disasters that most often occurred in Vrnjačka Banja municipality, as well as the views and assessments of the team and advisory group members for the development of the Action Plan, the proposed measures are related to hazards from *river floods, extremely high temperatures, droughts and insufficient water quantities*. In addition, some of the measures relate to *capacity building of actors in the field of protection and rescue of people and property*.

6.3.1. Measures for adaptation to flood hazards

Measure No.	**1**
Name of measure	**Long-term program of adaptation to climate change and development of an early warning system**
Responsible for measure implementation	Vrnjačka Banja municipality
Partners in implementation	• Vrnjačka Banja municipality • Republic Hydro meteorological Institute • Ministry of environmental protection
Implementation period	2025-2030
Total investment	500.000 EUR
Funding sources	• National budget • International funds for climate change adaptation
Short description of measure	Modernization of hydro meteorological and climatological infrastructure, improvement of early warning systems, education and development of infrastructure capacities for resilience to floods, droughts and heat waves.

Measure No.	**2**
Name of measure	**Prevention and rehabilitation of river floods**
Responsible for measure implementation	Ministry of environmental protection Department for emergencies
Partners in implementation	• Hydro meteorological Institute • Water management services • Local utility services
Implementation period	2025–2030
Total investment	400.000 EUR
Funding sources	• Republic funds • Local budget • International donor
Short description of measure	Making the threat maps, monitoring of river levels, construction of embankments and dams, rehabilitation of erosive areas. Reconstruction and expansion of drainage system, precipitation retention devices, capacity for rapid response, trimming and arrangement of riverbeds, cleaning of anti-erosion dams.

6.3.2. Measures for adaptation to extremely high temperature hazards

Measure No.	3
Name of measure	**Adaptation to extremely high temperatures and protection of population**
Responsible for measure implementation	Vrnjačka Banja municipality
Partners in implementation	• Republic Hydro meteorological Institute of Serbia • Local health institutions • Civil protection service • Non-governmental organisations
Implementation period	2026-2030.
Total investment	150.000 EUR
Funding sources	• Budget of the Municipality • Republic funds • EU Funds for climate adaptation • Donations
Short description of measure	Implementation of a system for early warning of extremely high temperatures, education of citizens about protection measures, greening of city areas, establishment of cooling centres in city areas with weaker infrastructure.

6.3.3. Measures for adaptation to drought and water shortage hazards

Measure No.	4
Name of measure	**Raising public awareness of importance of rational water consumption in households and impact of climate change on water**
Responsible for measure implementation	Vrnjačka Banja municipality
Partners in implementation	Public enterprises, local schools and media, non-governmental environmental organisations
Implementation period	2026-2030.
Total investment	15.000 EUR
Funding sources	• Budget of the Municipality • Republic funds • EU Funds for climate adaptation • Donations
Short description of measure	As a resource, water is one of the most sensitive to climate change effects, in terms of its availability and quality. Its availability is a growing problem, therefore any activity aimed at raising awareness of it rational use and the way climate change affects water is extremely desirable and necessary. The measure includes educational and informational activities for citizens about rational water consumption and impact of climate change on water supply. Activities include organizing workshops, lectures in schools, public campaigns, distribution of promotional materials and online information platforms. The goal is to increase the awareness of population, promote water saving and improve local practices of sustainable use of water resources. Existing communication channels and infrastructure will be used for this activity (websites, jumbo posters, posters, flyers, invoices, etc.), and new ones will be developed.

6.3.4. Other measures for adaptation to climate changes hazards

Measure No.	KEY MEASURE - 5
Name of measure	**Strengthening resilience and sustainable management of public and private forests**
Responsible for measure implementation	Vrnjačka Banja municipality and public enterprise „Šume-Goč“
Partners in implementation	• Ministry of agriculture, forest and water management of Serbia • Food and Agriculture Organization of the United Nations (FAO) • Green Climate Fund • Forest Stewardship Council (FSC)
Implementation period	2027-2030.
Total investment	250.000 €
Funding sources	• Budget of Vrnjačka Banja municipality • Ministry of agriculture, forest and water management of Serbia • International financiers and donors (EU, UNDP, and others)
Short description of measure	In the territory of Vrnjačka Banja municipality, state-owned forests are managed by the Public Enterprise for the Management of Protected Forests of Vrnjačka Banja "Šume-Goč". The total area managed by this company is 8,189.85 ha of vegetated and non-vegetated land, while the area of private forests is 3,980.00 ha. In accordance with FSC-STD-SRB-01-2023 SR (Principles 6, 7, 8, 9) and the project "Strengthening the resilience of Serbian forests to ensure the energy security of the most vulnerable, while contributing to their livelihoods and carbon sequestration (FOREST Invest)" implemented in Serbia, this measure implies the inclusion of public enterprise "Šume-Goč" as well as private forests in the area of Vrnjačka Banja in the program of sustainable management. Given that the forests currently do not have FSC certification, start the process of preparation for certification through public enterprise "Šume Goč". Also, it is necessary to make a management plan with emphasis on resilience to droughts, fires and erosion, while preserving protected zones. Organize educational workshops for forest owners, forestry engineers and employees of public enterprise Šume Goč on FSC principles and climate-smart techniques. Implement conversion of low to high forests, afforestation of degraded areas and protection of high protective values. By implementing the afforestation measure, a positive impact would be achieved both on the reduction of carbon emissions and on regulation of extreme heat. The impact of afforestation would have a positive effect on the acceptance of excess water and mitigation of the impact of raindrops on the land during heavy rainfall, which would mitigate or completely prevent the occurrence of floods and landslides, but afforestation would also have an impact on improving water quality. The entire population of the municipality would greatly benefit from the increase in forest coverage, and above all the chronically ill, due to cleaner air and a reduction in temperature extremes, both positive and negative. Newly planted forests would expand the existing capacities of the social function of forest: recreation, tourism, research, landscape protection, etc.

Measure No.	6
Name of measure	**Equipping and strengthening Civil Protection capacities**
Responsible for measure implementation	Vrnjačka Banja municipality
Partners in implementation	• Ministry of Internal Affairs – Department for emergencies
Implementation period	2026-2028.

Total investment	300.000 EUR
Funding sources	• Budget of the Municipality • Budget of the Government of Serbia – Ministry of Internal Affairs • Republic funds • International financiers and donors (EU, UNDP, and others)
Short description of measure	The Civil Protection Service plays a significant role in protection against natural and other hazards, including climate change consequence. The capacities of this service, despite all the efforts, are insufficiently equipped, primarily technically but also professionally. Implementation of this measure includes purchase of vehicles, and purchase of necessary equipment to improve the work of the service. One of the activities to be implemented as part of this measure is holding of trainings for civil protection members on contemporary methods of responding to natural and other hazards.

6.4. Financial framework and dynamics of implementation of the plan of climate change adaptation measures

The plan of climate change adaptation measures includes a total of **6 measures**. The plan envisages measures to adapt to the hazards of floods, hail, extremely high temperatures and hazards from drought and water shortage. In addition, part of the foreseen measures also apply to other measures. By 2030, the implementation of the planned measures will reduce the negative impact of climate change on the population and the economy. Climate change adaptation measures will be implemented in the period from 2025 to 2030. For implementation of all measures, it is necessary to provide **1.615.000 EUR.** Funds from the budget of Vrnjačka Banja municipality , national and regional budgets, and external funding sources determined on the basis of the review given in the *Chapter – Funding mechanisms for implementation of the sustainable energy and climate action plan* will be used to finance the measures

No.	NAME OF MEASURE	Investment (€)	Implementation of measure					
			2025	2026	2027	2028	2029	2030
Measures for adaptation to flood hazards		**900.000**						
1	Long-term program of adaptation to climate change and development of an early warning system	500.000						
2	Prevention and rehabilitation of river floods	400.000						
Measures for adaptation to extremely high temperature hazards		**150.000**						
3	Adaptation to extremely high temperatures and protection of population	150.000						
Measures for adaptation to drought and water shortage hazards		**15.000**						
4	Raising public awareness of importance of rational water consumption in households and impact of climate change on water	15.000						
Other measures for adaptation to climate changes hazards		**550.000**						
5	Strengthening resilience and sustainable management of public and private forests	250.000						
6	Equipping and strengthening Civil Protection capacities	300.000						
UKUPNO		**1.615.000**						

Table 0-4: Dynamic and financial framework of the plan for implementation of climate change adaptation measures

7. ENERGY POVERTY

Energy poverty is a complex socio-economic and energy phenomenon that is often defined as **inability of households to access a sufficient amount of energy at an affordable price to meet the basic needs of heating, cooling, lighting, cooking and using electrical appliances**. It arises when the household has to reduce energy consumption to a degree that negatively affects health, well-being and social inclusion of its members[56].

From 2022, this topic has become an integral part of the obligations for the signatories of the Covenant of Mayors for Climate and Energy through introduction of a special pillar within the reporting and monitoring system. This obligation arose from the need to include the issue of energy affordability and vulnerable households in local climate-energy plans, thus ensuring that a just transition is as important goal as reducing CO_2 emissions.[57].

The first serious discussions about the problem of energy poverty in Europe date back to the period of oil crisis in the 1970s, when the sharp rise in energy prices significantly increased the number of households that could not provide adequate heating. These events opened up the space for linking the issue of energy costs with social policy, especially in the United Kingdom. The term *fuel poverty* came into use only in 1991 thanks to Brenda Boardman, who systematically defined and operationalized it for the first time in her work *Fuel Poverty: From Cold Homes to Affordable Warmth*. The term was later expanded into the concept of energy poverty, emphasizing not only the issue of fuel costs, but also broader aspects of access to modern energy services. In the following decades, this concept developed beyond the framework of developed countries and became globally recognized as an important dimension of social inequality[58].

Energy poverty is also linked to Sustainable Development Goal 7 (SDG 7), which reads "*to ensure access to affordable, reliable, sustainable and modern energy for all*". It is precisely this that represents one of the main obstacles to the achievement of this goal, as it implies not only a lack of physical access to energy, but also situations in which energy is too expensive or is used inefficiently. Solving these problems through energy efficiency measures, greater use of renewable sources and targeted social programs is recognized as a key step in approaching the goals of SDG 7 by 2030. According to available data, around 666 million people in the world still do not have access to electricity, while approximately 2.1 billion people use traditional fuels for cooking, which has serious consequences for health and environment. Although the number of people without electricity has decreased by almost 300 million since 2015, estimates show that in 2030, about 645 million people will be without access to electricity, and that about 1.8 billion people will continue to use traditional cooking fuels. These indicators confirm that energy poverty is a global challenge that requires permanent and systematic attention[59].

In the European Union, energy poverty is recognized as a central issue of energy and climate policy. Because of its predominantly private nature, because it primarily affects households, and due to complexity of the phenomenon itself, it still remains a major challenge in the European Union. The crisis caused by the COVID-19 pandemic and the rise in energy prices have further worsened already difficult situation for many EU citizens. However, thanks to the efforts of the European Union, for the first time since 2021, a positive shift has been noted: the share of population that could not adequately heat their homes decreased from 10.60% in 2023 to 9.20% in 2024, after being at the lowest level of 6.90% in 2021. This improvement trend is the result of a combination of factors - reduction of retail prices of gas and electricity, implementation of energy efficiency measures in the member states, but also growing understanding of the problem of energy poverty and the affected groups. It is expected that the application of the newly adopted regulations, including the Directive on the energy efficiency of buildings, the Directive on energy efficiency and the Directive on renewable energy sources, will further confirm and strengthen this positive trend[Error! Bookmark not defined.].

The literature emphasizes three basic causes of energy poverty:

1. **Low income** - households with limited financial resources often spend a disproportionately large part of their income on energy.

[56]https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-poverty_en#:~:text=Energy%20poverty%20occurs%20when%20a,the%20inhabitants'%20health%20and%20wellbeing.
[57] Covenant of Mayors (2025). *Reporting Guidelines on Energy Poverty.* Brussels: Covenant of Mayors Office / European Commission.
[58] https://www.internationalaffairs.org.au/australianoutlook/the-origins-of-energy-poverty-in-europe/
[59] https://trackingsdg7.esmap.org/sites/default/files/download-documents/sdg7-report2025-0804-v11.pdf

2. **Poor energy efficiency of housing** - insufficient insulation, outdated heating systems and low efficiency of devices increase consumption and costs.
3. **High energy prices** - market volatility and rising prices of gas, electricity and solid fuels push an additional number of households into the risk of poverty[Error! Bookmark not defined.].

In recent years, energy poverty is increasingly seen as an element of a just transition. Through the Clean Energy for All Europeans package (2019) and initiatives such as the Energy Poverty Advisory Hub (EPAH), the European Union emphasizes that energy efficiency, renewable sources and decarbonisation measures must simultaneously reduce the burden of costs for the most vulnerable citizens. EPAH, in its diagnostic, planning and implementation manuals, emphasizes that the problem can only be solved by a combination of technical measures (building renovation, EE devices), social instruments (subsidies, tariffs, vouchers) and institutional support (local strategies, registers of vulnerable customers)[60,61]. New frameworks stipulate that local governments in the process of making and implementing their SECAPs also conduct an **Energy Poverty Assessment**, using a set of over 20 indicators grouped into six macro-areas (climate, housing, mobility, socio-economic factors, policy/regulatory framework and citizen participation). **The only mandatory indicator is the share of households or the population that spends more than a certain income threshold on energy**, while other indicators are chosen according to the local context. This way, within SECAP, energy poverty is not only viewed as a social issue, but also as a strategic component of climate and energy planning, which enables the harmonization of local measures with the European goals until 2030 and 2050[Error! Bookmark not defined.].

7.2. European framework and examples of good practices

In the European context, energy poverty is recognized as a multidimensional problem that includes social, economic and climate dimensions. The European Union formally included it among the priorities through the package of measures "Clean Energy for All Europeans", presented in 2016 and adopted in 2019. This package establishes three central principles: energy efficiency in the first place, global leadership in renewable energy sources and ensuring fair conditions for consumers, especially for the vulnerable and energy poor[Error! Bookmark not defined.].

The package includes eight key legal documents, including directives and regulations covering energy efficiency, renewable energy sources, internal electricity market and the Energy Union management system. Directive (EU) **2019/944** on common rules for the internal electricity market emphasizes that low incomes, high energy consumption and poor energy efficiency of residential buildings are the main risk factors, and requires member states to develop integrated measures that link social protection with energy and climate policies. The package also formally recognized and introduced the concept of renewable energy communities and citizen energy communities, which opened up space for active participation of citizens in production and use of energy[62]. According to the estimates of the European Commission, the implementation of these measures can generate annual investments of almost 180 billion euros, open up to 900,000 new jobs and increase the EU GDP by about 1%[Error! Bookmark not defined.].

The regulatory framework is complemented by the **EU Energy Poverty Observatory, EPOV**, whose role was to collect data, develop indicators and make comparative analyses among member states. Based on his experiences, **the Energy Poverty Advisory Hub (EPAH)** was established in 2021, as the main initiative of the European Commission for practical support to cities and municipalities. EPAH offers methodological tools, technical assistance and mentoring support to local authorities, and its work is structured through three guides (*Guide 1 – Diagnosis, Guide 2 – Planning, Guide 3 – Implementation*). This enables local self-government units to precisely identify energy-poor households, create action plans and implement targeted measures. At the same time, EPAH is developing a network of cities that encourages the exchange of experiences and innovative

[60] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0860
[61] https://energy-poverty.ec.europa.eu/
[62] https://eur-lex.europa.eu/eli/dir/2019/944/oj/eng

practices - from social tariffs and energy consultation centres to programs for in-depth renovation of the housing stock and local energy communities[Error! Bookmark not defined.].

Various models have been developed at national levels. **France** has established the **National Observatory for Energy Poverty (ONPE)**, which publishes annual reports and links state institutions, agencies and civil society[63]. **Spain** has adopted the **National Strategy to combat energy poverty**, within which the key instrument is the "*bono social eléctrico*", that is, a social bonus that reduces the bills of vulnerable customers, with additional mapping of the affected regions and mandatory inclusion of local plans[64]. **Portugal** adopted the **Long-Term Strategy 2021-2050**, which links combat against energy poverty with the goals of decarbonisation and energy transition[65], while **Italy** applies the "*bonus energia*" as direct financial assistance to households with low incomes[66].

Examples of good practice are also clearly visible at the local level. **Barcelona** has developed a network of energy advice centres (Punts d'Assessorament Energètic) that offer citizens free information and legal support regarding energy bills[67]. **Vienna** has combined systematic renovation of social housing with subsidies for overhead costs[68], while **Berlin** offers emergency funds to prevent disconnections from the grid and advisory services to save energy[69].

The common experience of European countries shows that successful policies require institutionalization of problems (strategies, observatories, agencies), development of targeted measures for vulnerable groups (subsidies, bonuses, priority renovation) and strong involvement of local stakeholders. The Clean Energy for All Europeans initiative has set legal and strategic framework, while the EPAH enables practical operationalization at local level. As a result, energy poverty is increasingly viewed not only as a social issue, but also as a development priority and a key element of a just energy transition by 2050.

7.3. Situation in Serbia and region

In the Republic of Serbia, there is currently no national definition or criteria for determining energy poverty, and the number of households currently facing the consequences of energy poverty is also unknown. Poverty is closely related to difficult access to modern, sustainable and affordable energy resources. Households facing financial difficulties often fall into a vicious circle of energy poverty, from which it is difficult to get out. The main challenges include low incomes, lack of knowledge and information, limited social capital, low energy efficiency of buildings and high energy prices. Such households can rarely afford to renovate their homes or purchase energy-efficient devices, especially for heating, as well as sufficient quantities of high-quality energy sources. In order to meet basic energy needs, they often chose to use cheap, low-quality and potentially dangerous energy sources, which can have a negative impact on health. Energy poverty, in addition, brings significant economic, social and health consequences for citizens.

In the existing legal framework, the status of an energy-endangered customer is defined by the ***Regulation on an energy-endangered customer*** ("Official Gazette of the RS", no. 137/2022, 46/2023), which more closely regulates which household can acquire this status, under what conditions and which rights it exercises. According to the Regulation, an energy-vulnerable customer is considered a household (single or multi-member) that has one electricity or gas meter, lives in one housing unit and meets the conditions prescribed by the criteria of material, social and health status. Criteria for obtaining the status include: total monthly household income, number of household members, property status, already achieved rights to social assistance, child

[63] https://ec.europa.eu/social/BlobServlet?docId=25972&langId=en
[64] https://ec.europa.eu/social/BlobServlet?docId=22466&langId=en
[65] https://www.eapn.eu/wp-content/uploads/2022/02/eapn-R2E-EAPN-PT-5356.pdf
[66] https://www.arera.it/consumatori/bonus-sociale
[67]https://www.energia.barcelona/en/contract-energy/contract-energy/where-can-you-find-out-all-about-them
[68] https://climateandcommunity.org/research/vienna-green-social-housing/
[69] https://www.berlin.de/en/news/7829156-5559700-hardship-fund-for-energy-debts-planned-f.en.html

allowance, right to the lowest pension, i.e. situations in which the health condition of a household member requires special energy consumption (e.g. use of medical equipment)[70].

It is important to emphasize that this regulation covers vulnerable customers in terms of social protection and privileges in energy consumption, but it is not equivalent to a broader definition of energy poverty. In Serbia, there is still no specific legal definition of a household that remains exposed to risk due to high energy costs and poor energy efficiency, and the concept of energy poverty is currently used indirectly through the category of energy-endangered customer.

The current Draft Law on Energy Efficiency and Rational Use of Energy stipulates that energy poverty is defined using three groups of criteria: low household income, high consumption of available income on energy, insufficient energy efficiency. The draft Law on Energy Efficiency and Rational Use of Energy provides for the establishment of the Energy Efficiency Administration for performance of executive and professional tasks related to financing of energy efficient use operations in accordance with this law and related regulations. One of the responsibilities of the Administration provided for in the draft law is the preparation of special programs for implementation of energy efficiency measures for energy-dangerous and other customers in order to reduce energy poverty. If this competence of the Administration is retained in the final text of the law, basic instruments will be created for implementation of informed policies in combatting energy poverty. It is necessary to: 1. adopt a national definition of energy poverty and develop indicators for monitoring measures to reduce energy poverty in accordance with European Union standards, 2. improve the instruments and methodology for collecting data relevant to monitoring energy poverty in the Republic of Serbia, 3. prepare and adopt appropriate planning document that would ensure achievement of the goal of reducing energy poverty in the Republic of Serbia, and 4. ensure the transparency of the process and the participation of interested parties in development of public policies to solve the problem of energy poverty at all levels.

Given that the availability of data on energy poverty in Serbia is limited, as in the rest of the region, an estimate of the number of households affected by this problem was made. The first step was to determine the threshold that will be used to define energy poverty.

According to the data of the Republic Institute of Statistics from the Household Consumption Survey for 2024, the average household in Serbia had a monthly income of RSD 97,705[71], i.e. RSD 1,172,460 per year, while the average annual energy costs were estimated at around RSD 120,000[72] per year. This means that, on average, households spend approximately 10% of their total income on energy. In accordance with the international standard (threshold of 10% of income), this average indicates that a typical household in Serbia can be classified in the category of energy poverty. In order to avoid too broad classification, since almost every other household would be affected by this criterion, a stricter threshold of 15% of income was applied for the analysis. This approach better reflects the real conditions in Serbia, where the living standard is lower than in the EU, but the threshold is used to enable a clearer differentiation of the most vulnerable households. Based on the distribution of income by deciles, the first three (≈ 30% of the population) clearly exceed the 15% threshold, while a significant part of the fourth decile is approaching that threshold. Therefore, it can be assumed that about 40% of households in Serbia are affected by energy poverty, which represents a working estimate that will be used for the purposes of this plan[73].

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[70] https://www.eps.rs/cir/snabdevanje/Documents/UREDBA%20O%20ENERGETSKI%20UGRO%C5%BDENOM%20KUPCU.pdf

[71] Republic Institute of Statistics. "Statistical release: Household income and consumption – 2024" [Online]. Available at: https://www.stat.gov.rs/sr-latn/vesti/statisticalrelease/?p=16928&a=01&s=0101

[72] Annual energy costs include heating and electricity costs. Heating costs are estimated at around RSD 75,500 per year for an average house with an area of 74.7 m², with a specific need for heat energy of 150 kWh/m². The assessment used the assumption that, according to the energy balance, 5% of households are heated with coal, 75% with wood, and 20% with district heating. Electricity costs are calculated on the basis of an average monthly bill of around RSD 3,700, which is approximately RSD 44,400 per year. The energy prices used for the budget were taken from available public sources on the Internet.

[73] The data were taken from the Decile Analysis of Household Consumption in the Republic of Serbia, 2019 (Team for Social Inclusion and Poverty Reduction of the Government of the Republic of Serbia, 2021), https://socijalnoukljucivanje.gov.rs/wp-content/uploads/2021/10/Decilna_analiza_2019_lat.pdf. Based on that document, and data on the growth of average earnings per household between 2019 (66,880 RSD) and 2024 (97,705 RSD), a proportional correction of income per consumer unit (+46%) was made. Data on the average number of members and consumption units per household from the same analysis were used for the calculation of earnings per household, which were retained because more recent data are not available. According to this estimate, the share of energy expenditure in income by decile is: first 32.93%, second 21.49%, third 17.03%, fourth 13.85%, fifth 11.65%, sixth 10.09%, seventh 8.98%, eighth 7.86%, ninth 6.63% and tenth 4.73%. This means that according to the classic definition of the energy poor (10% threshold) about 60% of the population of Serbia would fall into this category.

These data comply with the "Situation analysis of energy poverty: Survey of 10,000 households from Tuzla, Kalesija, Lukavac, Banovići, Živinice and Gračanica" conducted by the Centre for Ecology and Energy Tuzla, Bosnia and Herzegovina in 2021 showed that 42.90% of households allocate more than 15% income on energy, which places them in the group that needs help the most. Within that group, two subcategories were identified: the first consists of 25.70% of households that spend more than 20% of their income on energy, and the second 17.20% of households that allocate between 15% and 20%. Of particular concern is the fact that around 10% of households are in an extremely difficult situation, because they spend more than 30% of their income on energy - which makes them "very energy poor" and puts them in the category for urgent intervention[74].

Some of the identified key priorities for public policies within the framework of these analyses, which can be copied to the beginning of solving the issue of energy poverty in Serbia, include

- The need to adopt a clear definition and methodology for measuring energy poverty at the BiH level, which includes several criteria and is in line with EU approaches, and to fit into the NECP and accompanying sector documents,
- Establishing a register of energy-vulnerable households at the LSG level, which is periodically updated and linked to social services,
- Introduction of planning budget funds to solve the problem of energy poverty at the level of LSGs,
- Creation of a co-funding program for the energy rehabilitation of buildings of poor households,
- **Organization of various types of education and campaigns on the application of energy efficiency and renewable energy sources for all citizens.**

Various types of measures are applied in the Republic of Serbia, including those intended to support households affected by energy difficulties. While some of these measures are permanent, others are implemented periodically or renewed every year through the adoption of new or similar decisions on support programs. Also, these measures differ in the degree of impact on the energy efficiency of households.

Support measures for energy vulnerable households can be divided into three groups:

- Measures to improve energy efficiency and increase the use of renewable energy sources, which includes all types of measures that will ensure the implementation of household energy consumption.;
- Measures for the protection of vulnerable consumers consisting of various measures for the protection of vulnerable consumers;
- Measures to improve citizens' information, consisting of information campaigns aimed at citizens.

Also, the Law on Housing and Building Maintenance from 2016 provided a legal basis for local self-governments to, through co-financing, support activities on investment maintenance and improvement of the energy properties of private residential buildings in order to achieve the public interest.

7.4. Indicators of energy poverty within LSG

Although there is still no official national methodology for measuring energy poverty in Serbia, the **SECAP** creation process enabled the collection and structuring of certain data that can be used as an indicator, which enables comparison with European cities and harmonization of local policies with broader EU practices.

According to the *Covenant of Mayors for Climate and Energy guidelines*, energy poverty indicators are divided into **six macro-areas**:

1. **Climate factors** – measures the sensitivity of a local community to external conditions, such as the number of heating and cooling degree days (HDD) and cooling degree days (CDD). These indicators

[74]Center for Ecology and Energy. (2021). Analysis of the state of energy poverty: Survey of 10,000 households from Tuzla, Kalesija, Lukavac, Banovići, Živinice and Gračanica. Tuzla: Center for Ecology and Energy.

show how much heating or cooling load is required during the year, which directly affects the energy needs of households.

2. **Facilities/Housing** - include housing quality indicators: share of buildings in F, G and H energy classes, average energy consumption per inhabitant compared to the national average, share of renovated buildings on an annual basis, access to centralized heating and connection to the electricity distribution network. These indicators help to identify areas with poor housing conditions and a higher probability of energy poverty
3. **Mobility** - refers to access to basic services and public transport. Lack of reliable and accessible transportation can increase dependence on energy-intensive private vehicles, but also reduce the availability of social and health services for vulnerable groups.
4. **Socio-economic indicators** - include mandatory indicator of the percentage of households that spend more than a certain threshold of income on energy (e.g. 10% or 15%), as well as the share of households with debts for bills, the inability to keep the home warm or cooled, the rate of poverty, unemployment, the share of the elderly population and people with chronic diseases. These indicators provide direct insight into the vulnerability of the population
5. **Policies and regulatory framework** – include the existence of a national or local strategy for energy poverty, rent regulation and measures that protect vulnerable consumers. Introduction of these indicators is important because they show institutional readiness to solve the problem systematically
6. **Participation and raising awareness** - refers to the existence of information campaigns for vulnerable households, cooperation with local stakeholders and mechanisms for involving citizens in the processes of planning and monitoring measures.

Use of indicators enables:

- **Standardization of measurements** - comparison between different municipalities and regions in country, but also with European cities.
- **Progress monitoring** – the effect of energy efficiency measures and social policies can be measured through time series.
- **Integration with climate and energy plans** - indicators of energy poverty directly contribute to the goals of just transition and climate neutrality

It is particularly important to emphasize that the ***Covenant of Mayors for Climate and Energy*** prescribes one mandatory indicator for monitoring energy poverty: percentage of households or persons who spend a certain part of their income on energy (most often 10% or 15%). In accordance with this methodology, within the framework of this SECAP, **the share of households that spend more than 15% of their total income on energy** will be considered. This threshold was chosen based on the results of a comparison of monthly household incomes in Serbia and annual energy costs, which was previously described in the chapter **Situation of Serbia and the region.**

According to the results of the analysis for Serbia, 40% of households spend more than 15% of their total income on energy. In SECAP, the goals of gradually reducing energy poverty were set by increasing the share of households that pay less than 15% of their income for energy - to 65% by 2030, and to 85% by 2050. These goals imply a continuous improvement of approximately 1% per year, starting from 2025, with simultaneous monitoring of the progress through regular local records and available statistical sources.

Category	Indicator	Value for LSG	EU average	Goal 2030	Goal 2050
Socio-economic	Percentage of households	**60%**	**84-92%**[75]	**65%**	**85%**

[75] According to research by the Joint Research Center of the European Commission (JRC), between 8% and 16% of the population of the European Union is in a state of energy poverty, depending on the applied indicator. These indicators include different dimensions of the problem: inability to keep the home adequately warm, delay in paying energy bills, disproportionately high energy costs in relation to income, and so-called "hidden" energy poverty, which implies too low energy consumption due to forced savings. It follows that the majority of the population in the EU, i.e. between 84% and 92%, is not included in the indicators of energy poverty. Although this range cannot be directly equated with the 15% energy revenue threshold used in this analysis, it can serve as a rough reference to understand the scale of the local data problem.

indicators	spending to 15% of income on energy (%)				

Table 7-1 Percentage of households spending more than 15% of income on energy costs

Achieving these goals will require a combination of measures: subsidies for the most vulnerable, improvement of the energy efficiency of the housing stock, and targeted assistance to vulnerable groups through social and energy policies. Given that LSGs currently do not have a strategy for reducing energy poverty, the adoption of such a document is expected by 2030, which would enable alignment with EU practice and strengthen the institutional response.

7.5. Plan of energy poverty alleviation measures in Vrnjačka Banja municipality

The plan of energy poverty alleviation measures in Vrnjačka Banja municipality includes a total of 6 measures, aimed at identifying and mapping energy-poor households, strengthening the institutional and strategic framework, raising the level of energy literacy, and direct technical and financial support to households in a state of energy poverty. The planned measures combine social, informational and infrastructural interventions, with the aim of reducing energy costs, improving the quality of housing and increasing the energy security of the most vulnerable population groups.

Implementation of planned measures by 2030 is expected to significantly reduce the intensity and scope of energy poverty, improve the living conditions of households affected by this problem, as well as strengthen the capacity of local self-government for systematic and long-term solutions to the issue of energy poverty, in accordance with the principles of a just energy transition.

Measures to alleviate energy poverty will be implemented in the period from 2025 to 2030, with phased implementation in accordance with available financial and institutional capacities. For implementation of all planned measures, it is necessary to provide a total of **142.000 EUR.**

Funds for financing of the measures are planned to be provided from the budget of Vrnjačka Banja municipality, the budget of higher authority levels, as well as from external funding sources, including international development organizations and financial institutions, in accordance with the funding mechanisms described in the chapter Funding Mechanisms for Implementation of the *Sustainable Energy and Climate Action Plan.*

Measure No.	**ES-1 /Key measure**
Name of measure	**Identification and mapping the energy poor households**
Responsible for measure implementation	Centre for social welfare
Partners in implementation	• Other relevant departments of the LSG; • National Coalition for Energy Poverty Reduction; • Civil society organisations; • Local communities in LSG.
Implementation period	2026.
Saving (MWh)	n/p
Reduction of emissions (tCO2)	n/p
Total investment (EUR)	7.000
Possible funding sources for implementation of measure	• State-level budget; • International donors (UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The measure includes the development of a methodology for identification and monitoring of energy-poor households in the area of LSG. As part of the activity, home visits to around 1,000 households are planned in order to identify energy-vulnerable households and their needs, and

Measure No.	ES-1 /Key measure
Name of measure	Identification and mapping the energy poor households
	based on that, establish a unique register and database. The results will be monitored and regularly reported on changes in the energy status of the target groups. The beneficiaries of the measure are households in a state of energy poverty, where indicators of public financial support are used as criteria - such as beneficiaries of financial assistance and other social and child benefits, material benefits from the field of veterans and disability protection. The main objectives of the measure are: • Identification of energy poor households through home visits and data collection • Establishment of a single register/database with data on households and their needs • Continuous monitoring of changes in the energy status of target groups and regular reporting • Ensuring targeted and timely support measures (financial and non-financial) for energy poor households • Increasing the institutional readiness of LSG to solve the problem of energy poverty.

Measure No.	ES-2 / Key measure
Name of measure	Development of strategy for reduction of energy poverty
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Centre for social welfare; • National Coalition for Energy Poverty Reduction; • Other relevant departments of the LSG; • Civil society organisations; • Local communities in LSG.
Implementation period	2026.
Saving (MWh)	n/p
Reduction of emissions (tCO2)	n/p
Total investment (EUR)	10.000
Possible funding sources for implementation of measure	• Budget of LSG; • International donors (UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The measure includes development and adoption of the first strategic document that systematically treats energy poverty at the LSG level. The document will include an analysis of the current situation, definition of indicators, assessment of number and structure of energy-poor households, and measures and goals for the period up to 2030 and 2050. The strategy will be developed in accordance with the European framework and national/regional documents, and will serve as a key basis for planning and implementation of future support programs. **The main objectives of the measure are:** • Determine actual situation and scale of energy poverty in the area of LSG • Define indicators and methodology for monitoring and reporting • Set strategic goals and priorities until 2030 and 2050 • Connect energy efficiency measures and social policy into a single framework • Provide institutional and financial mechanism for reducing energy poverty Adoption and implementation of the Strategy will ensure institutional recognition of energy poverty, improve coordination between LSG services and social institutions, and enable more targeted and fair measures to help citizens. In the long term, the Strategy will serve as a tool to reduce the number of energy-poor households and contribute to achieving the goals of a just energy transition.

Measure No.	ES-3

Name of measure	Campaigns and education in the field of energy literacy and energy efficiency
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Electronic and printed media; • Civil society organisations; • Local communities of LSG; • National Coalition for Energy Poverty Reduction.
Implementation period	2026. – 2030.
Saving (MWh)	n/a
Reduction of emissions (tCO2)	n/a
Total investment (EUR)	7.000
Possible funding sources for implementation of measure	• Budget of LSG; • International development organisations UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The measure includes organization and implementation of public campaigns and education aimed at raising the level of energy literacy and strengthening the capacity of citizens to apply energy efficiency measures. The focus is on households affected by energy poverty, but also on general public, in order to increase awareness on the ways to reduce energy consumption, available support programs and possibilities of using renewable energy sources. The activities include: • Creation of a public campaigns and education plan, • Implementation of media appearances via TV, radio, press and social networks, • Organization of educational workshops and public events, • Engagement of NGOs and experts in the field of energy efficiency, • Creation of promotional materials (brochures, flyers, online content), • Evaluation of campaign and education results. The expected result of this measure implementation is increased information and empowerment of citizens in use of energy efficiency measures, reduction of energy costs, improvement of housing quality and contribution to environmental protection.

Measure No.	ES-4
Name of measure	**Establishment of info-centres for support to energy poor households**
Responsible for measure implementation	General administration department
Partners in implementation	• Relevant departments of LSG; • National Coalition for Energy Poverty Reduction; • Civil society organisations.
Implementation period	2027.
Saving (MWh)	n/p
Reduction of emissions (tCO2)	n/p
Total investment (EUR)	10.000
Possible funding sources for implementation of measure	• Budget of LSG; • International donors (UNDP, EU, governments and embassies of individual countries, etc.)
Short description of measure / comments	The measure implies the establishment of a local info-centre that will provide advisory and information services to households affected or threatened by energy poverty. The information centre will offer technical and administrative support, information on financing options for energy efficiency measures, support programs and use of renewable energy sources. The activities include: • Opening a local info-centre and equipping the space,

Measure No.	ES-4
Name of measure	**Establishment of info-centres for support to energy poor households**
	• Providing direct advisory services to households, • Strengthening energy literacy through informative materials and workshops, • Informing citizens about current programs and projects. The expected results are that citizens and households affected by energy poverty receive systematic informational and advisory support, that energy poverty is reduced through access to energy efficiency measures and available financial mechanisms, and that the quality of life and environmental protection are improved.

Measure No.	ES-5 / Key measure
Name of measure	**Energy reconstruction of the outer envelope of individual housing buildings for households in a state of energy poverty**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Centre for social welfare; • Relevant departments of LSG; • Owners of individual residential buildings (family houses) included in the measure; • National Coalition for Energy Poverty Reduction; • Civil society organisations: • Local communities ; • Ministry of civil engineering, transport and infrastructure; • Ministry of mining and energy; • Ministry of environmental protection.
Implementation period	2027-2030.
Saving (MWh)	0Error! Bookmark not defined.
Reduction of emissions (tCO2)	0[76]
Total investment (EUR)	72.000
Possible funding sources for implementation of measure	• Budget of LSG; • Eko Fund of the Republic of Serbia; • International donors (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB etc.) • Own funds of owners of individual residential buildings included in the measure.
Short description of measure / comments	**The goal of the measure** is to make life easier and reduce the energy poverty of the most vulnerable households by reducing their energy consumption and associated costs, while simultaneously reducing CO_2 emissions. The focus is on providing warmer, healthier and more energy-efficient homes, whereby families in a state of energy poverty will be provided with co-financing of energy reconstruction measures in the amount of up to 90% of the investment. The measure may include the following activities (individually or in appropriate combinations): • installation of thermal insulation of external walls; • installation of thermal insulation of the roof, and/or ceiling, and/or floors; • replacement of existing exterior joinery (windows and doors) with joinery with high energy characteristics. On annual basis, the energy reconstruction of the outer envelope of 5 individual housing buildings with an average heated area of about 100 m² is planned, or a total of 20 buildings by 2030.

Measure No.	ES-6 / Key measure
Name of measure	**Improvement of energy characteristics of existing and installation of new energy-efficient heating systems in individual housing buildings for households in a state of energy poverty**

[76] Efekti ušteda energije i emisija CO_2 za ovu mjeru uračunati su u sektoru mitigacije. Budući da fokus mjere nije na mitigaciji, nego na povećanju komfora i smanjenju troškova kod energetski siromašnih domaćinstava, rezultati nisu prikazani u ovom dijelu.

Measure No.	ES-6 / Key measure
Name of measure	**Improvement of energy characteristics of existing and installation of new energy-efficient heating systems in individual housing buildings for households in a state of energy poverty**
Responsible for measure implementation	Department for physical planning, environmental, property legal and residential affairs
Partners in implementation	• Centre for social welfare; • Relevant departments of LSG; • Owners of individual residential buildings (family houses) included in the measure; • National Coalition for Energy Poverty Reduction; • Civil society organisations: • Local communities of LSG; • Ministry of environmental protection; • Ministry of mining and energy;
Implementation period	2027-2030.
Saving (MWh)	0Error! Bookmark not defined.
Reduction of emissions (tCO2)	0Error! Bookmark not defined.
Total investment (EUR)	36.000
Possible funding sources for implementation of measure	• Budget of LSG; • Eko Fund of the Republic of Serbia; • International donors (UNDP, EU, governments and embassies of individual countries, etc.) • International and local finance institutions (EBRD, KfW, EIB etc.) • Own funds of owners of individual residential buildings included in the measure.
Short description of measure / comments	The aim of the measure is to reduce energy poverty through the improvement of heating systems in individual and collective residential buildings, thereby reducing energy costs for households and at the same time reducing CO_2 emissions. Special attention will be paid to vulnerable population groups, who will be provided with co-financing in the amount of up to 90% of the investment, in order to ensure access to safe, healthy and energy-efficient heating systems. The measure includes the following activities (individually or in appropriate combinations): 1. Improving the efficiency of heat generators and replacing energy sources – e.g. replacing existing fossil fuel boilers with high energy efficiency biomass boilers; 2. Optimization and rationalization of the distribution network, pump systems and regulation equipment - including replacement of pumps with new electronically regulated models, improvement of regulation devices and installation of low-temperature heating systems and high-temperature cooling systems; 3. Installation of energy efficient systems for heating, ventilation and air conditioning (HVAC systems); Calculations of foreseen savings, reduced CO_2 emission and total investments until 2030 are based on replacing fossil fuel boilers with pellet boilers in 5 residential buildings per year, which includes a total of 20 buildings by 2030

7.5.1. Implementation dynamics of the plan of energy poverty alleviation measures

Measure reference	NAME OF MEASURE	Investment (EUR)	Implementation period					
			2025	2026	2027	2028	2029	2030
ES-1	Identification and mapping the energy poor households	7.000						
ES-2	Development of strategy for reduction of energy poverty	10.000						
ES-3	Campaigns and education in the field of energy literacy and energy efficiency	7.000						

ES-4	Establishment of info-centres for support to energy poor households	10.000						
ES-5	Energy reconstruction of the outer envelope of individual housing buildings for households in a state of energy poverty	72.000						
ES-6	Improvement of energy characteristics of existing and installation of new energy-efficient heating systems in individual housing buildings for households in a state of energy poverty	36.000						
TOTAL		**142.000**						

Table 7-2 Dynamic and financial framework of implementation plan if the energy poverty mitigation measures

8. IMPLEMENTATION AND MONITORING OF THE RESULTS OF THE ACTION PLAN

8.1. Implementation of the Action Plan

Sustainable energy and climate action plan in Vrnjačka Banja municipality has a short implementation period, and therefore it is necessary to precisely plan the organizational structure of working and supervisory bodies for its successful implementation. For this reason, the LSG will form a Working Group for Energy Efficiency and Climate Change, whose task will be to implement, monitor and control implementation of measures provided for in the Action Plan.

The Working Group will be headed by a coordinator - an expert in energy management, who will manage the activities of the group and the process of creating a report on implementation of the Action Plan. The working group for energy efficiency and climate change will participate in implementation of measures and activities from the Plan, establish appropriate databases and continuously monitor energy consumption for building, transport, water supply and public lighting sectors, as well as the progress of climate change adaptation process. The working group will include representatives of all relevant departments of the LSG administration, public companies and institutions.

8.2. Monitoring and control of the implementation of the Action Plan

One of the main tasks of the Working Group for Energy Efficiency and Climate Change is monitoring and controlling the implementation of the Action Plan, which includes the following:

1. monitoring the implementation dynamics of the foreseen climate change mitigation and adaptation measures,
2. monitoring the success of the implementation of the planned measures,
3. monitoring and control of set goals for each individual measure within the Action Plan,
4. monitoring and control of achieved reductions in CO_2 emissions for climate change mitigation measures.

Successful monitoring of achieved savings in energy consumption and reduction of CO_2 emissions in various sectors and their sub-sectors, as well as reaching the set goal of the Action Plan, is achieved by creating new control inventories of CO_2 emissions, where it is important that the methodology of their creation is identical to the methodology according to which the baseline inventory of CO_2 emissions and the control inventory for the year 2024 were created.

8.3. Reporting on progress of Action Plan implementation

By acceding to the *Covenant of Mayors for Climate and Energy*, Vrnjačka Banja municipality undertook the obligation of regular reporting to the Covenant of Mayors for Climate and Energy on implemented measures and activities. Accordingly, the working group for energy efficiency and climate change will report every two years to the administrative bodies of LSG and the competent authority of the Covenant of Mayors on the results of the implementation of the planned measures.

The Covenant of Mayors created and published forms for submitting interim reports, whereby the signatories of the covenant were offered the following two options:

i. Reporting every two years;
ii. Making a report on the status of activities every two years (which does not include making of an inventory of emissions), and a complete report that is submitted every four years and which includes the status of activities and at least one control inventory of emissions.

9. FUNDING MECHANISMS FOR THE IMPLEMENTATION OF THE SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN

In order to implement climate change mitigation measures, climate change adaptation measures, and energy poverty alleviation measures that are included in this Action Plan, adequate financial resources must be provided.

To achieve the goal of reducing CO_2 emissions by 55% by 2030, the Action Plan envisages implementation of 9 measures aimed at reducing energy consumption from all considered sectors of final energy consumption. To achieve the goal of adapting to climate change, the Action Plan envisages implementation of 6 measures aimed at strengthening the capacity of LSG to adapt to existing and future consequences of climate change. The third goal refers to alleviating energy poverty through support programs, improving energy efficiency in households and improving access to energy for vulnerable groups of population, and to achieve it, the implementation of 6 measures is foreseen.

Total value of investments required for implementation of planned measures, as shown in the following table, amounts to 3.181.586 EUR , of which 1.424.586 EUR is intended for measures to reduce CO_2 emissions, 1.615.000 EUR for measures to adapt to climate change, and 142.000 EUR for programs to alleviate energy poverty. By implementing these investments, LSG would achieve all set goals and significantly improve sustainable, climate-resistant and socially just development.

Segment	Investment (EUR)
Energy efficiency measures for climate change mitigation	1.424.586
Energy efficiency measures for climate change adaptation	1.615.000
Measures for energy poverty alleviation	142.000
TOTAL	**3.181.586**

Table 0-1 Total investment planned per SECAP

Necessary funds can be mobilized from one funding source or through a combination of several sources. Currently available funding mechanisms enable various forms of assistance from domestic and international sources. Considering the current situation, decision-makers should choose optimal funding model that corresponds to the situation in the local self-government unit. An overview of the funding sources currently available to local self-government units is given in the following table.

Funding sources		Type	Way of funding
Domestic sources	Budget funds	Own funds	Grants
	Investment development institutions	Private funds	Loans with more favourable terms

	Commercial finance institutions	Private funds	Loans
	Private investors	Private funds	Funding; co-funding
International sources	International organisations, EU and bilateral cooperation funds	International funds	Technical assistance; Grants
	International finance institutions	International funds	Loans; Loans with more favourable terms

Table 0-2: Overview of available funding sources for planned measures

9.1. Domestic funding sources

i. Budget funds

A potential funding source, from which it is possible to provide funds for implementation of the Sustainable Energy and Climate Action Plan includes budget funds. When it comes to funds from the budget, it is possible to identify the following sources:

- **Budget of LSG** - through its regular operations, LSG has the possibility to include in its strategic documents the measures provided for in this document and on the basis of that plan the necessary funds in its budget.
- **Budget of higher authority levels** – In the territory of this LSG there is a certain number of public buildings that are under the jurisdiction of higher authority levels. Taking this fact into consideration, the relevant ministries have both the interest and the possibility to finance and implement programs that will contribute to the reduction of CO_2 emissions in the area of Vrnjačka Banja municipality from their own resources, but also through cooperation with other domestic and international institutions.

ii. Investment development institutions

Development banks are financial institutions that provide the possibility of closing the financial structure for implementation of measures of the Sustainable Energy and Climate Action Plan. In their credit portfolio, they usually have a special credit line intended for local self-government units.

iii. Commercial finance institutions

Several commercial finance institutions, primarily banks, operate in the area of LSG, which place funds according to market conditions. Certain banks have developed programs for funding the projects related to energy efficiency and use of renewable energy sources. Local self-governments have the option of borrowing or issuing guarantees for the timely payment of due obligations of public enterprises. Borrowing from commercial finance institutions is a tool that can provide partial or complete funding of the measures proposed in this document.

iv. Private investors

In addition to the engagement of public sector to collect funds for implementation of CO_2 reduction measures, the private sector is also a potential source of funding source. Namely, the private capital of investors is a significant source of financial resources that can be used for this purpose. The most commonly used models of using private capital for public purposes are:

- **Public private partnership (PPP)** - represents a model of pooling resources of public and private sectors for the purposes of producing public products or providing public services. Local self-government units have the option of using this model of organization of a certain job in cases where they do not have necessary resources for this or when they are unable to perform public duties independently. The primary reasons why the public sector decides on PPP include: lack of capacity and resources, lack of professional staff, high costs, high business risk, etc. On the other hand, PPP implies participation of private sector with its capacities, knowledge, skills and capital. In the aforementioned relationship, public sector defines the need and scope of a public product or service, ensures equality and prevention of abuse, while the private sector strives to ensure profitability while meeting all required conditions. PPP as a model represents a long-term contractual cooperation between a public and a private partner, whereby redistribution of business risk is mostly transferred to private partner. Projects where PPP is most often used as a model of cooperation include energy sector, health, and education.

- **ESCO model (**Eng. *Energy Service Companies*) - is a PPP model used in the field of providing energy services, which includes development, construction and funding of projects aimed at increasing energy

efficiency while simultaneously reducing exploitation and maintenance costs. This model is based on reduction of energy costs through construction of infrastructure that will enable system optimization and more efficient use of energy. The ESCO company invests its funds in implementation of measures to increase energy efficiency, and return on the investment is achieved through the savings that will arise. During the project implementation, that is, during repayment of the investment, service users pay the same amount for energy costs as they did before the project implementation. After paying off the investment, the ESCO company exits the project and the financial difference resulting from the savings is transferred to the end users, which in the long run represents an exceptional benefit for the users. The ESCO model can be applied to public companies, institutions and local self-governments, and most often for energy projects.

9.2. International funding sources

In addition to the mentioned domestic funding sources, it is also possible to use international aid funds for implementation of the measures of the *Sustainable Energy and Climate Action Plan*. Namely, international organizations, international financial institutions and agencies present in this area carry out activities aimed at protecting the environment and improving the living conditions of citizens.

i. International organisations and bilateral cooperation funds (EU, UNDP, GIZ)

In this area, there are numerous international organizations that implement programs through which they offer technical assistance as well as financial resources. By using these funds, it is possible to secure the necessary funding of the measures of this Action Plan. The programs that offer funding for the mentioned projects are limited in time, but they tend to be repeated in the same or similar form. The most significant international donors in the field of energy efficiency, use of renewable energy sources and reduction of CO_2 emissions in Bosnia and Herzegovina are:

European Union - with the instrument of pre-accession assistance **(IPA II)**, candidate countries or potential candidates for EU membership can obtain funding. IPA II is an instrument that prepares the mentioned countries for the way of using the funds, once they are part of the EU. The aforementioned pre-accession aid is applied in the spheres of democracy and governance, rule of law and legislation, competitiveness and innovation, education, employment and social change, transport, environment, climate change and energy, agricultural development and rural development.

Horizon Europe is the European Union's key funding program for research and innovation. After the decision on the mid-term revision of the Multiannual Financial Framework (MFR), the indicative amount of funding for Horizon Europe for the period 2021-2027 amounts to 93.5 billion euros. The program deals with climate change, helps to achieve the Sustainable Development Goals of the United Nations and promotes EU competitiveness and growth.

The program facilitates cooperation and enhances the impact of research and innovation in development, support and implementation of EU policies, while facing global challenges. It supports development and better distribution of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, encourages economic growth, promotes industrial competitiveness and optimizes the impact of investments within the strengthened European Research Area.

Legal entities from the EU and associated countries can participate.

UNDP is one of the largest individual donors of international support for strengthening institutional capacities in our region. Local self-government units can obtain UNDP support by applying to projects funded by UNDP independently or in partnership with other agencies. In addition to financial assistance, programs funded by UNDP also provide technical support in implementation of project activities.

German Organization for Technical Cooperation (GIZ) is an organization that works intensively on institutional strengthening of the state and making of preconditions for independent collection of funds from European funds. GIZ is present in the area of South-eastern Europe, which is why the Open Regional Fund for South-eastern Europe was created, including a fund for energy efficiency and renewable energy sources. Withdrawal of funds from the aforementioned fund is possible through international cooperation with other countries, where the right to co-financing and technical assistance is exercised.

ii. International finance institutions (EIB, EBRD, EEEF)

Numerous international finance institutions are present on our financial market, which, through favourable credit arrangements, strive to promote the importance of environmental protection and reduction of CO_2 emissions. Finance institutions through commercial banks, which have their branches all over the country, place credit funds intended for funding of energy efficiency projects and energy use from renewable sources. In a large number of cases, the mentioned credit lines also offer an incentive for investment, which is reflected in grants (grant component), technical assistance, favourable financing conditions, a grace period, etc. The leading finance institutions that in our country invest the funds needed to reduce CO_2 emissions are the European Investment Bank (EIB), the German Development Bank (KfW), the European Bank for Reconstruction and Development (EBRD) and others.

10. LEGISLATIVE FRAMEWORK

One of the important prerequisites for successful implementation of the *Sustainable Energy and Climate Action Plan* of Vrnjačka Banja municipality is its full compliance with relevant domestic and international legislation, as well as with all official documents accepted by Vrnjačka Banja municipal council.

i. International context of climate change and European Union policy

Addressing climate change is a priority for the European Union, which has already set a goal of gradually reducing greenhouse gas emissions by 2050. In this context, through the European Green Deal and the "Fit for 55" package, the EU has established a commitment to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels.

The EU's current climate and energy policy framework for the period up to 2030 includes the following key targets:

- reducing greenhouse gas emissions by at least 55%;
- increasing the share of energy from renewable sources to at least 42.5% (with an indicative target of 45%);
- significantly improving energy efficiency at the level of final energy consumption.

These targets are directly linked to obligations arising from the Paris Agreement, the primary goal of which is to keep the global temperature rise well below 2°C, while striving to limit it to 1.5°C, in line with the latest reports from the Intergovernmental Panel on Climate Change (IPCC).

At the European Union level, there is no single, specific directive or regulation that comprehensively governs climate change adaptation across all sectors. However, climate change adaptation is an integral part of the EU's binding climate framework—primarily through the European Climate Law, as well as through planning, monitoring, and reporting mechanisms within the climate and energy governance framework, and through a range of sectoral policies relevant to climate risk management (e.g., water, agriculture, infrastructure, civil protection).

A key strategic document in this area is the **European Union Strategy on Adaptation to Climate Change (2021),** which establishes a framework for systematically strengthening climate resilience and is based on three interconnected lines of action:

- Smarter adaptation: improving knowledge, data, and decision-making tools, including the enhancement and development of the European Climate Adaptation Platform (Climate-ADAPT);
- Faster adaptation: accelerating the implementation of measures and solutions to reduce risk and strengthen resilience;
- More systemic adaptation: integrating climate resilience into key sectors and policies, while supporting local actions, infrastructure resilience, and nature-based solutions.

At the international level, outside the European Union, there are several agreements that are very important for the adaptation strategy, namely:

- The *United Nations Framework Convention on Climate Change* (UNFCCC), which aims to achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system;

The *Paris Agreement on Climate Change*, reached on 4 November 2016 within the framework of the UNFCCC, which aims to limit the increase in the average global temperature to “well below” 2°C, secure food supplies, but also strengthen the capacity of countries to combat the consequences of climate change, develop new green technologies and help weaker, economically less developed parties to achieve their national emission reduction plans.

The Republic of Serbia ratified the Paris Agreement under the United Nations Framework Convention on Climate Change by adopting the Law on the Ratification of the Paris Agreement in the National Assembly of the Republic of Serbia, which was published in the "Official Gazette of the RS – International Treaties," No. 4/2017.

ii. European Union regulations and documents relevant to the development of the energy sector and renewable energy sources

The main legislative documents regulating the development of energy sector at the European Union level are:

The proposal for European Energy Policy from January 2007, which set the following main requirements until 2020: reduction of greenhouse gas emissions by 20%; increase in energy efficiency by 20%; increasing the share of renewable energy sources to 20%; and increasing the share of biofuels in traffic to 10%. These targets were then updated in line with the **2030 Climate and Energy Policy Framework** to: reduce greenhouse gases by at least 40%; increasing the share of energy from renewable sources to at least 32%; and an increase in energy efficiency by at least 32.5%. This framework was updated through **"Fit for 55" (2021),** which raised the targets to a 55% reduction in emissions by 2030, in line with the European Green Deal and the long-term goal of climate neutrality by 2050.

Clean Energy For All Europeans, November 2016; The package was implemented through the directives (RED II), but updated through REPowerEU (2022), and "State of the Energy Union 2025.", which highlights progress in renewable sources (half of electricity from renewable sources in 2024.).

A Clean Planet for all, A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy, November 2018.

European Union directives regulating the use of renewable energy sources:

- Directive (EU) 2018/2001 (RED II) and its revision via Directive (EU) 2023/2413 (RED III), setting a target of 42.50% renewable energy sources by 2030. Transposition of RED III into national laws is scheduled for 2025.

Directives of the European Union regulating directly or indirectly the use of renewable energy sources:

- The Energy Efficiency Directive (EED) (Directive 2012/27/EU), revised under the "Fit for 55" legislative package, further strengthened Member State obligations regarding the reduction of final energy consumption, the improvement of public sector efficiency, and the systematic planning of energy efficiency measures. The Directive places special emphasis on the role of public buildings and local governments as drivers of the energy transition through mandatory measures for renovation, consumption monitoring, and long-term energy savings planning.
- The Energy Performance of Buildings Directive (Directive 2010/31/EU), May 2010. Updated by Directive 2018/844 and subsequently recast by Directive 2024/1275 (EPBD revision, entered into force in May 2024), setting targets for zero-emission buildings. The EPBD highlights the importance of long-term building renovation strategies and directly influences the planning of measures within SECAPs at the local level.
- Regulation (EU) 2017/1369 of the European Parliament and of the Council establishes a framework for labelling the energy efficiency of products placed on the EU market and replaces the earlier Directive 2010/30/EU. Within this Regulation, Commission Delegated Regulation (EU) 2019/2014 and other delegated regulations from 2019 define specific requirements for energy labelling of different product categories (e.g. household appliances, refrigerators, televisions), including the transition to rescaled energy classes (A–G). From 2021, new energy classes and measurement methods came into force, and the EU is currently working on further improvement of the requirements through work plans for 2025–2030. This framework contributes to the reduction of energy consumption and greenhouse gas emissions by stimulating the market for more energy-efficient products.

iii. Legislative and regulatory framework of Serbia in the field of energy and renewable energy sources

Strategic documents at national level:

- Integrated National Energy and Climate Plan of the Republic of Serbia (INEKP / NECP) adopted by the Government of the Republic of Serbia in 2024 in accordance with obligations towards the Energy Community
- Energy Development Strategy of the Republic of Serbia until 2040 with projections until 2050 ("Official Gazette of RS", No. 94/2024),
- Climate Change Adaptation Program of the Republic of Serbia adopted by the Government of the Republic of Serbia in 2023 as a national framework for planning adaptation measures
- Low-carbon development strategy of the Republic of Serbia for the period from 2023 to 2030 with projections until 2050 ("Official Gazette of the RS", no. 46/2023)

Legal framework in the Republic of Serbia:

- Law on Energy ("Official Gazette of RS", no. 145/2014, 95/2018 - other laws, 40/2021, 35/2023 - other laws, 62/2023, 94/2024 and 109/2025 - other laws);
- Law on the use of renewable energy sources ("Official Gazette of RS", no. 40/2021, 35/2023 and 94/2024 - other law);
- Law on Energy Efficiency and Rational Energy Use ("Official Gazette of RS", No. 40/2021);
- Law on Climate Change ("Official Gazette of RS", No. 26/2021);

- Law on Planning and Construction ("Official Gazette of the Republic of Serbia", No. 72/2009, 81/2009 - corrigendum, 64/2010 - decision of the Constitutional Court, 24/2011, 121/2012, 42/2013 - decision of the Constitutional Court, 50/2013 - decision of the Constitutional Court, 98/2013 - decision of the Constitutional Court, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - other law, 9/2020, 52/2021, 62/2023 and 91/2025);
- Law on Environmental Protection ("Official Gazette of the Republic of Serbia", No. 135/2004, 36/2009, 36/2009 - other law, 72/2009 - other law, 43/2011 - decision of the Constitutional Court, 14/2016, 76/2018, 95/2018 - other law, 95/2018 - other law and 94/2024 - other law).

Bylaws and technical regulations:

- Guideline on energy efficiency ("Official Gazette of RS", no. 61/2011);
- Guideline on the deadlines, scope and method of conducting the energy audit in the energy management system, as well as the content and method of submitting extracts from the report on the conducted energy audit ("Official Gazette of RS", no. 51/2022 and 97/2025);
- Guideline on the conditions, content and manner of issuing certificates on the energy properties of buildings ("Official Gazette of RS", no. 69/2012, 44/2018 - other laws, 111/2022 and 102/2025);
- National housing typology of the Republic of Serbia

iv. Strategic documents of Vrnjačka Banja municipality

- Development Plan of Vrnjačka Banja Municipality (2023-2030)

v. Legal frameworks and strategic bases for climate planning of the EU and the Republic of Serbia

- Climate change adaptation strategy of the European Union 2013; updated in 2021.
- United Nations Framework Convention on Climate Change- UNFCCC;
- Paris Agreement on Climate Change, which has been in force since November 4, 2016, confirmed by the European Union on October 5, 2016; Republic of Serbia ratified the Paris Agreement along with the United Nations Framework Convention on Climate Change by adopting the Law on Confirmation of the Paris Agreement in the National Assembly of the Republic of Serbia, which was published in the "Official Gazette of RS - International Agreements", no. 4/2017.
- The 13th Global Sustainable Development Goal adopted by the UN within 2030 Sustainable Development Agenda as part of the 17 new Sustainable Development Goals - SDGs;
- Environmental Law („Official Gazette of RS“, No. 135/2004, 36/2009, 36/2009 – other law, 72/2009 – other law, 43/2011 - Decision US, 14/2016, 76/2018, 95/2018 – other law, 95/2018 – other law and 94/2024 – other law);
- Climate changes law („Official Gazette of RS“, No. 26/2021);
- Climate Change Adaptation Program of the Republic of Serbia adopted by the Government of the Republic of Serbia as a national strategic document for planning adaptation measures;
- Law on Water ("Official Gazette of RS No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 – other law);
- Air Protection Law ("Official Gazette of RS", No. 51/2025);
- Law on Waste Management ("Official Gazette of RS", No. 109/2025);
- Law on Planning and Construction ("Official Gazette of the Republic of Serbia", no. 72/2009, 81/2009 - corrigendum, 64/2010 - decision of the Constitutional Court, 24/2011, 121/2012, 42/2013 - decision of the Constitutional Court, 50/2013 - decision of the Constitutional Court, 98/2013 - decision of the Constitutional Court, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - other law, 9/2020, 52/2021, 62/2023 and 91/2025)

12. CONCLUSION

Bearing in mind the biggest climate and energy problems faced by Vrnjačka Banja municipality, in this Action Plan, which for the first time unites the areas of climate change mitigation and adaptation to its consequences, as well as a just energy transition and energy poverty, a long-term vision of a sustainable future is established:

„In 2050, Vrnjačka Banja is a green and smart centre of sustainable development, where natural resources are used responsibly, energy is produced from renewable sources, and the environment is clean and protected. The municipality is a climate-resistant and energy-efficient community, which successfully implements a fair energy transition, alleviates energy poverty and provides high standards of quality of life for all citizens."

The goals set in this Action Plan, which trace the path to the implementation of the vision and are aligned with other strategic development goals of the LSG, are:

- reduction of CO_2 emissions by at least 55% by 2030 compared to the emissions inventory from the baseline year;
- reducing the negative impacts of climate change on the population and the economy by 2030;
- alleviating energy poverty through the establishment of criteria, mapping of energy-poor households and implementation of energy efficiency measures in that category.

Total value of investments required for implementation of planned measures amounts to 3.181.586 EUR, of which 1.424.586 EUR is intended for measures to reduce CO_2 emissions, 1.615.000 EUR for measures to adapt to climate change, and 142.000 EUR for programs to alleviate energy poverty. By implementing these investments, the LSG would achieve all the set goals and significantly improve sustainable, climate-resistant and socially just development.

The establishment of an appropriate institutional mechanism for implementation, monitoring and control of the implementation of planned measures and reporting on achieved results and goals, as well as the use of financial mechanisms available to local self-governments, represent an additional guarantee for achieving the set goals and accelerating the approach to the set vision. LSG will use this Action Plan as a key document in the process of planning operational programs for the next financial period in the field of energy efficiency and adaptation to climate change.

Benefits from the successful implementation of this Action Plan will be multiple, both for the LSG itself and for its residents. By creating, implementing and monitoring the implementation of the Action Plan, Vrnjačka Banja municipality will:

- demonstrate its commitment to energy-sustainable development of the city based on the principles of environmental protection, energy efficiency and renewable energy sources as the basis of sustainable development in the 21st century;
- strengthen their capacities for dealing with harmful effects of climate change;
- take advantage of the opportunities for economic and social growth provided by development of a low-carbon society;
- strengthen the foundations of energy sustainable development of LSG;
- provide access to clean energy for all citizens;
- establish new financial mechanisms for initiation and implementation of energy efficiency measures and use of renewable energy sources;
- increase the quality of life of its citizens

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