NET ZERO CITIES

EU MISSION PLATFORM | CLIMATE NEUTRAL AND SMART CITIES

Climate City Contract

2030 Climate Neutrality Action Plan

2030 Climate Neutrality Action Plan of the Wroclaw City

NetZeroCities has received funding from the H2020 Research and Innovation Programmeme under the grant agreement n°101036519.

Table of Contents

Summary

Textual element
The information presented in this document is only preliminary analysis for the preparation of the Climate City Contract, as part of Wroclaw's participation in the European Commission's Climate-Neutral and Smart Cities Mission by 2030 initiative, and will be subject to further assessment and consultation with key internal and external stakeholders. The actions indicated in the document are not binding, define the city's starting point and are only a description of the method of achieving the ambitious reduction target set in the Climate City Contract. The document shows that the city is aware of the threats related to the climate crisis and the need to undertake innovative, unconventional transformational actions, the implementation of which is only possible within the framework of broad cooperation to achieve climate neutrality.

List of figures

List of tables

Abbreviations and acronyms

Abbreviations and acronyms	Definition
AP	Action Plan
BAU	Business As Usual
CEEB	Central Building Emissions Inventory
CCC	Climate City Contract
EBI/EBRD	European Investment Bank/ European Bank for Reconstruction and Development
EMAS	EcoManagement and Audit Scheme
ESG	E – Environment, S - Social responsibility, G - Corporate governance
GIS	Geographical information system
IP	Investment Plan
IPAM	Independent Project Accountability Mechanism
ISO	International Organisation for Standardisation
KOBiZE	National Centre for Emissions Management
KPI	Key Performance Indicator
MEL	Monitoring Evaluation & Learning
MPA	Climate change adaptation plan
MRV	Monitoring Reporting Verification
WP	Work Package
MWSC	Municipal Water and Sewage Company
NEEST	NetZero Emission and Environmentally Sustainable Territories
PEDs	Positive Energy Districts
PPP	Public-Private Partnership
RFIL	Government Fund for Local Investments
RSE	Regional Energy Company
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable energy and climate action plan
SMES	Small and Medium Enterprises
SPVs	Special Purpose Vehicle
SUMP	Sustainable urban mobility plan
TAT	one of the city's flagship investments in Bus and Tram Route construction to Nowy Dwor district

1 Introduction

Introduction

Wroclaw is a city that sets ambitious sustainable development goals. As the third largest city in Poland, Wroclaw is one of the key actors contributing to the implementation of the regional and national goals of a climate-neutral Lower Silesia and a climate-neutral Poland.

Wroclaw and its Functional Urban Area are a dynamically developing city in terms of economic and demographic indicators. Achieving climate goals must go hand in hand with maintaining this development. This requires a fair energy transformation in the spirit of "leaving no one behind" but also actions in the social sphere in order to reduce energy poverty. On the one hand, Wroclaw has reduced emissions from the industrial sector and, to a small extent, built environment, but transportation emissions are growing noticeably, and in recent years, emissions from the built sector have increased again due to dynamic spatial development.

Wroclaw Climate City Contract defines the portfolio of actions of the municipality and its stakeholders, impact pathways and investment plan in six areas of interest: energy (energy and heating system), **transport and mobility, built environment, waste and sewage management, green infrastructure and nature-based solutions,** and **industry.** Key actions aim to: decarbonisation of electricity and heat production, reducing electricity and heat consumption, expansion of decarbonised district heating and reduction of emissions from road traffic.

Over the last years, Wroclaw has been implementing an ambitious vision of transforming the city into a coal-free zone, where residents have access to reliable, clean, sustainable and affordable energy. Wroclaw aims to become a city that is aware, resilient, responsible and ready for the challenges of the future, that protects and develops its natural capital and ensures safety and sustainable socio-economic development for its residents. To this end, the city is active in the international forum and is an active member of European initiatives aimed at changing the energy and climate policy of cities, including the Covenant of Mayors for Climate and Energy and the International Council for Local Environmental Initiatives (ICLEI). Wroclaw is also a signatory to the open letter of the Mayors of 58 cities within the Eurocities network addressed in 2020 to the Presidents of the European Council, expressing the need to increase, with the support of the EU, emission reductions in cities to 65% by 2030.

In 2019, Wroclaw, acting under the Covenant of Mayors, prepared a Sustainable Energy and Climate Action Plan (SECAP) as a key instrument for implementing the agreement. The SECAP identified key measures that the city will undertake to achieve its climate neutrality goal. The plan also includes mapping of climate change risks and vulnerabilities, adaptation measures, emission calculations, emission reduction scenarios and impact estimates of the measures.

Based on the prepared strategic documents, city policies and action plans as well as accompanying incentive and support tools, the following activities were implemented:

- Replacing heat sources based on solid fuels (coal and its derivatives) in single-family and multi-family buildings with ecological, less emission systems based on district heating, electricity, gas or heat pumps, classified as renewable energy sources.

- Implementation of the so-called "Small RES Programme", under which municipal institutions are equipped with RES installations, thanks to which their number in Wroclaw is gradually growing every year. As a standard, newly constructed municipal facilities already meet the standards of sustainable buildings, are equipped with photovoltaics, green walls and roofs, and rainwater management installations. In addition, municipal companies' facilities are also equipped with installations for obtaining energy from renewable sources from other funds.

- Thanks to the property tax exemption system for investing your own funds in renewable energy, we are seeing a rapid increase in renewable energy in Wroclaw. In 2019-2023 alone, exemptions were granted for the amount of over PLN 29 million, which illustrates the scale of the activities.

- An agreement on the establishment of an energy cluster is planned to be signed between the city of Wroclaw and the rectors of all Wroclaw universities in October this year. This is an innovative approach on a national scale and a direct result of Wroclaw's participation in the Climate Neutral and Smart Cities Mission.

- Cooperation between the City and energy and heating companies within the so-called Decarbonisation Table. The state-owned heating company KOGENERACJA[1],which supplies district heating to the residents of Wroclaw, plans to modernise its production capacities by 2028, replacing coal fuel with gas and heat pumps. Thanks to close cooperation with the city within the aforementioned partnership, a common direction has been given to decarbonisation goals, resulting from Wroclaw's participation in the Climate Neutral and Smart Cities Mission, and a high priority has been given to supporting investments in the modernisation of district heating sources in the city.

- Implementation by FORTUM SA, the operator of district heating in Wroclaw and MWSC – the Municipal Water and Sewage Company of the innovative WROMPA project, consisting in the recovery of heat from sewage. On one of the sewage collectors, the second largest heat pump in Europe was installed. The implementation of the project will provide 5% of Wroclaw's demand for district heating.

- Development of the public transport network, including the improvement of the bus fleet with vehicles meeting the highest emission standards and electric vehicles. Currently, the Municipal Transport Company is also at the stage of testing hydrogen vehicles. Tram lines are being intensively expanded, in the last five years alone two new tram lines have been built and two more have been designed. It was also possible to sign an agreement on the development of the agglomeration railway with the Marshal of the Voivodeship, which allows the residents of Wroclaw to travel by train within the administrative boundaries of the city using a ticket for public transport. Travel by rail is the most desired means of public transport by residents, which is why over 90% of tram tracks in Wroclaw are dedicated routes to increase comfort and shorten travel time for passengers, thus increasing the attractiveness of public transport in relation to travel by individual transport.

- Expansion of the network of Park&Ride parking lots near railway stations and tram terminals to reduce the number of cars entering the city centre.

- In accordance with the Sustainable Mobility Policy, a pedestrian and bicycle programme is also being implemented, aimed at increasing the share of pedestrian and bicycle journeys. The development of so-called green ways is particularly desirable, which not only enables contact with nature during pedestrian and bicycle journeys, but also increases the thermal comfort of road users on hot days.

- Development of green areas and implementation of the strategy for the development of blue-green infrastructure and management of rainwater and meltwater. The indicator of accessibility of green areas within 300 m from the place of residence is currently 84% in Wroclaw and 94.6% for the city centre and has been gradually increasing over the last few years. Taking into account the need to reduce the Urban Heat Island effect, the "Green Revolution" programme is being implemented, consisting in the protection and strengthening of the potential of existing

[1] Wroclaw Combined Heat and Power Plants Group

greenery and areas of natural value, creating new green areas, implementing tall greenery plantings in road areas (Green Arteries) and implementing unsealing of concreted courtyards of schools and kindergartens (Gray to Green). These are activities very high in the hierarchy of needs and expectations of Wroclaw residents.

Joining the European Commission's Climate Neutral and Smart Cities Mission initiative is a continuation and reinforcement of the activities carried out so far by setting a clearly defined goal for Wroclaw. Work on the Climate City Contract allows for building a transition team, parameterizing the emission level and addressing specific tasks to specific stakeholders adequately to the contribution in generated emissions. Participation in the Cities Mission also means building a multi-level partnership at the city, regional and national level. Considering the fact that the public sector is responsible for only 7% of emissions in Wroclaw, the involvement of other stakeholders is crucial. Moreover, within the 55% of emissions from buildings, a significant part of them falls on the energy and heating sector, therefore the cooperation established within the so-called Decarbonisation Table with utilities managers, which are mostly state-owned companies implementing the goals of national policy, is an absolute foundation for the success of achieving the assumed goals.

Based on the strategic documents adopted by the Wroclaw City Council in the field of climate and energy, Wroclaw declares that it will achieve climate neutrality by 2050 at the latest. Nevertheless, taking into account the deepening climate crisis and challenges resulting from the energy crisis caused by the armed conflict in Ukraine, it is necessary to accelerate actions in this area, hence Wroclaw's participation in the Climate Neutral and Smart Cities Mission and the effort undertaken to set a path for reducing GHG emissions by 80% by 2030.

Simulations performed within the economic model show that such a scenario is possible, however, it must be borne in mind that it is highly dependent on the implementation of national policies and actions taken by energy and heating companies (state-owned companies), private entities and residents themselves (in terms of improving the energy efficiency of buildings they use), as the broadly understood city council is responsible for only 7% of all emissions.

In parallel with the work on the CCC and the economic model, a road map for achieving climate neutrality in Wroclaw is being created on behalf of the Climate and Energy Division of the Wroclaw City Office, presenting three scenarios for reducing GHG emissions: 1) a continuation scenario, 2) achievable and 3) progressive. The aim of the document is not only to collect information on generated emissions, to describe the possibilities and limitations resulting from city, regional and national policies, but also to analyse the cost-effectiveness of the Decarbonisation actions taken vs. the expected ecological effect.

The actions described in the CCC cover the entire area of the city within its administrative boundaries. We do not make any subject or subject exclusions here. One of the added values of this document is the fact that it constitutes an integration of all processes taking place in the city and overturns the stereotypical approach limited only to the formal authority of the city president. With such an approach, the goal set in the Mission of Cities would not be possible to achieve. Only a comprehensive approach and multi-level inter-sectoral partnership give a chance for the success of the entire initiative.

Based on the structure of emissions from the GHG inventory and analyses within the economic model, it can be stated that in Wroclaw, activities in 3 areas are key: production of electricity and heat, renovation of the building stock and transport. An additional area is adaptation to climate change through the development of blue-green infrastructure and protection of existing greenery and unsealing of hardened surfaces in order to minimize the UHI effect.

Wroclaw's participation in the Mission of Climate Neutral and Smart Cities was a very important step in legitimising a systemic approach to the city's climate ambitions and giving them high priority not only within Wroclaw Municipality structures but also among external stakeholders.

Building a strong internal and external mandate and precisely parameterising both the challenges related to generated GHG emissions and the needs related to their reduction was a huge challenge.

However, the effort put into the over two-year process of preparing the climate contract, in retrospect, we consider valuable and desirable.

The city has been implementing activities for Decarbonisation and sustainable development for many years. However, for a long time these were grassroots activities, implemented by units, divisions and municipal companies without systemic coordination. As a result, the city's resources and funds allocated for this purpose were not optimally used due to the lack of synergy and systemic planning. The plans and programmes created in the city were sectoral in nature.

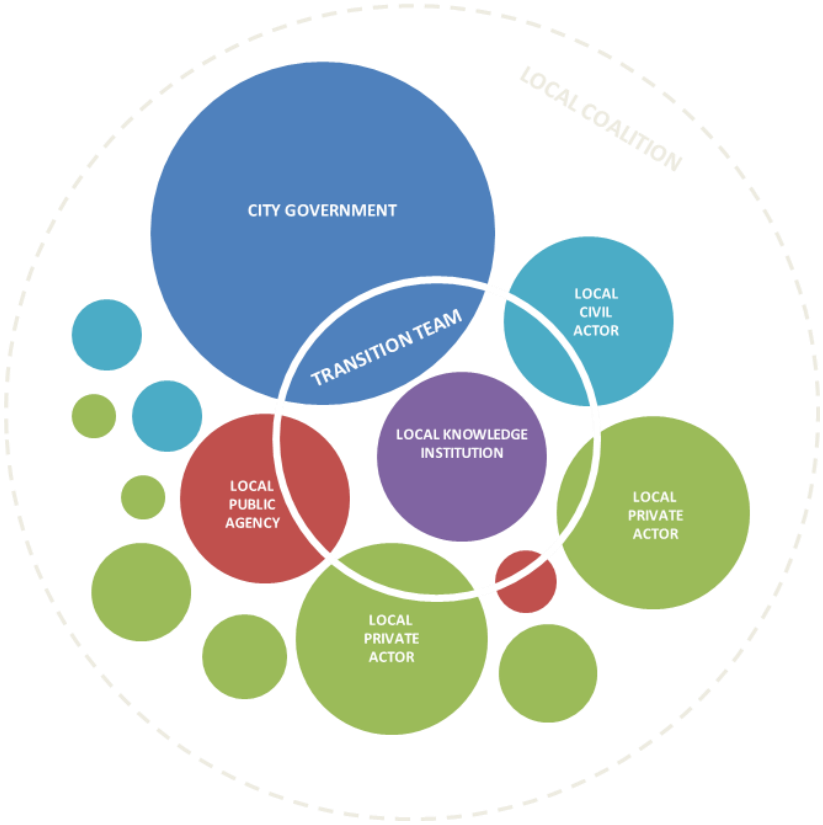

Figure 1. The scheme of local coalition during building the Wroclaw Transition Team (Net Zero Cities).

As a first step toward making the city's climate neutrality efforts systemic, the Mayor of Wroclaw established the City Mission Team in October 2022. It includes representatives of all city departments, units and companies, and meetings are cyclical in nature to ensure an adequate flow of information and a platform for cross-sectoral cooperation.

At the same time, networking outside of the office's structures has been underway with the academic community, developers, housing cooperatives, NGOs and residents. In each of the communities, a leader emerged who was the contact person and voice of his environment.

Very important was the establishment in June 2023 of a partnership for Decarbonisation of the district heating system, the so-called Decarbonisation table, which succeeded in establishing in one body an unprecedented cooperation of power companies, district heating companies, gas companies, the municipal water and sewer company, the municipal investment and environmental services and municipal planners. The declaration of joint work for the Decarbonisation of Wroclaw was of particular importance in the context of the fact that the Decarbonisation of the power and heating systems depends to a great extent on the success of achieving the assumed goal of reducing 80% of Wroclaw's GHG emissions.

An absolute breakthrough in contacts with Wroclaw companies was the Mission 1.5 Degree Wroclaw conference organized in May 2024, during which companies were invited to sign a declaration

of cooperation to achieve the goals set in the Mission and the CCC. The response and openness of Wroclaw companies to cooperation with the City exceeded our expectations and is a good prognosis for the future.

As part of building regional support for the intentions expressed in the CCC, a cooperation agreement for the climate neutrality of the city and region was signed with the Institute for Territorial Development - a structure at the provincial level corresponding to the Department of Strategy and Sustainable Development. The Institute for Territorial Development has prepared the Energy Strategy of Lower Silesia, adopted by the Voivodeship Board in 2022, which indicates the directions of energy development in the region taking into account the current challenges of climate change and the necessary energy transition activities to be carried out in accordance with the policy directions of the European Union.

The parties plan to develop cooperation in which other municipalities in the Lower Silesia region will benefit from Wroclaw's experience in determining the city's Decarbonisation path.

On the other hand, at the government level, thanks to the cooperation within the coalition of five Polish cities, it was possible during the six-month workshop to develop not only the support of the Ministry of Climate and Environment for the actions included in the CCC of Wroclaw and the city's climate ambitions, but also to build a platform for cooperation, without which the implementation of the goals described in this document would not be possible.

The work on the CCC assumed from the beginning the iterative nature of the document, especially in the context of the fact that the broad magistrate is responsible for only 7% of all GHG emissions in the city, with the remaining 93% of emissions resulting from the activities of state-owned enterprises, private companies and residents. Therefore, the transition team that has been built is crucial in further action. We assume close cooperation with all stakeholder circles to monitor the progress of the implementation of the actions assumed in the CCC, coordinate with each other and obtain synergies.

The expectation of the magistrate's role as coordinator of the entire process is already apparent, which is absolutely understandable and natural. Immediately after the completion of work on the Climate City Contract (CCC) and the Climate Neutrality Roadmap for Wroclaw, an update of the SECAP and Climate Change Adaptation Plan is planned so that all documents are consistent with each other. Both the SECAP and the MPA are adopted by resolutions of the Wroclaw City Council, which means that they are given a high profile and continue to dedicate city funds to the activities described in the CCC.

Finally, it should be mentioned that as part of the ongoing work on the Strategy of Wroclaw 2050, issues related to climate neutrality and energy security have been given a very high priority and elevated to the level of strategic goals, which will mean the need to monitor the progress of implementation of the set objectives on an annual basis.

Economic characteristics of the city

Wroclaw is the dominant centre of the Wroclaw Urban Functional Area, where higher-level functions - related to administration, business, economy and trade, culture, and science focusing on higher education and innovation of research and scientific centres - are concentrated. It is a place of transnational investment attractiveness. The city is one of the largest economic centres in the country, dominated by such industries as automotive, consumer electronics, pharmaceuticals, biotechnology, information technology, and the production of household appliances and consumer electronics. A strong position in the city's economy is occupied by services in the fields of information and communication, finance and accounting, information technology and those included in the group of professional, scientific and technical activities, as well as services related to entertainment, leisure and recreation gaining in importance.

An important role in the economy of Wroclaw is played by, having a supra-regional character, science and business parks, industrial and technological parks, as well as innovation and entrepreneurship

centres (among others: Wroclaw Industrial Park, Wroclaw Technology Park/Wroclawski Park technologiczny, Lower Silesian Science and Innovation Park, Lower Silesian Science and Technology Incubator). Also important institutions influencing the development of innovation in the city are the Wroclaw Research Centre EIT+, the Lower Silesian Academic Business Incubator, as well as academic business incubators operating at several universities. Businesses operating in Wroclaw include: 3M, GE POWER, LG Philips, Volvo, Whirlpool, Bosch, Toshiba,US PHARMACIA, WAGO ELWAG, AB, AmRest Holdings SE, Neonet, Work Service, Impel Group, Incom, PFG Urtica, Sudzucker Polska, Selena FM, KOGENERACJA., Wabco Poland. Wroclaw is also an investment destination for BPO services (Business Process Offshoring - service centres for the parent organization in accounting and finance, IT, research and development). Companies operating in this service sector include: HP, UPS, GE Money Bank or Credit Suisse. There is also a growing business services and development sector for the telecommunications industry, represented by companies such as Nokia Siemens Networks and Tieto. Due to the city's location on the Oder River, river shipyards also operate in the city.

Demographic situation

One of the factors influencing the city's development is the demographic situation and the prospects for its change. An increase in the number of residents means an increase in the number of consumers, and thus an increase in the demand for energy and its carriers - both networked and in the form of solid or liquid fuels. According to official demographic data, 673,743 residents live in Wroclaw (as of the end of 2023, the Statistics Poland). This number is steadily growing (about 7% over the period 2010 - 2023). According to the Report - Estimating the actual number of residents of Wroclaw, prepared in 2023 by the University of Wroclaw, the values determined on the basis of the population registered in public statistics do not reflect the actual state. According to the detailed analysis conducted for the purposes of the aforementioned Report, the estimated actual population was determined to be 893,506 people (as of 31/12/2022). This indicates a significant disparity between the CSO data and the data resulting from the Report - the difference is at 219,427 people.

A large impact on demographic changes is exerted by domestic and foreign migration, which has particularly gained momentum as a result of the opening of foreign labor markets. On a national scale, Wroclaw is one of the largest economic centers and the only city in the area surrounded by smaller urban and rural communities, which has a direct impact on the demography and use of the city.

Development characteristics

According to data from 2021, there are 360,200 housing units in Wroclaw, with a total area of 21.2 million square meters, located in 52,000 buildings (according to the 2021 National Census). The area of municipal buildings is about 1,560 thousand square meters. The average square meterage of one apartment is 59 m2. Residential buildings account for more than 66% of all buildings in the city.

In terms of floor area, residential buildings, built between 1918 and 1944, and objects erected between 1989 and 2002, dominate. Buildings from the first of the above-mentioned time intervals often deviate from today's standards in terms of construction solutions, partitions and energy systems. At the same time, some of the objects are under conservation protection. Objects erected in later years, until 2002, constitute the largest group of buildings. At the same time, they are characterized by very different solutions and varying degrees of thermo-modernisation.

The energy consumption of buildings, in addition to their size and year of construction, is influenced by its type. Among the most important building types are:

- Townhouses - buildings erected with traditional technology, often forming part of the development in the centre of the city, with high floors, there are often mixed heating sources, some are under conservation protection.

- Urban villas - pre-war construction characteristic of Wroclaw (examples of occurrence in the city: Grabiszynek, Zacisze, Zalesie, Karlowice district).
- Residential blocks, so called “block of flats” - buildings erected in large-panel system construction, heated in different ways, but mostly uniform within the building. Some of the buildings have undergone thermal modernisation.
- Houses of the “cube” type - a characteristic norm of single-family housing from the 1970s and 1980s occurring in the form of an intrusion in many urban areas of the city,
- Developer buildings - erected after 1990, various technologies, in large part traditional with hollow blocks. The state of insulation of the partitions depends on the technical requirements current at the date of obtaining a building permit. Heating system within a building uniform.
- Single-family buildings - erected mainly in traditional technology from hollow blocks. The state of insulation of partitions depends on the technical requirements current at the date of obtaining a building permit. A large proportion of buildings have replaced window frames, but do not have insulated external walls. Individual heating system of various types. Buildings erected after 2014 partly use modern, in today's terms, technical solutions...
- Buildings in rural character - that is, buildings expansively absorbed by the city with the shift of its borders after the war (mainly in the 1970s) covering former villages (homestead and single-family buildings).

It is estimated that residential buildings modernised to a significant degree (insulating the external envelope, replacing woodwork, modernizing the heating system) account for 10-20% of buildings. The remainder are partially or not at all modernised buildings.

The number of housing units put into use in recent years shows a high dynamics, the direct reasons for which include social (lifestyle, income growth) and geopolitical changes in recent years. Buildings constructed after 2017 are expected to achieve a high degree of energy efficiency, with the latest technical requirements in this regard coming into force in 2021. About 10,000 residential units have been put into service every year in recent years.

Buildings with a non-residential function account for approx. 33.4% of the city's total building area (about 10,660,000 square meters of floor space).

Number of buildings and usable area of all buildings located in Wroclaw :

Table 1. Number of buildings and usable area of all buildings located in Wroclaw.

Building type	Number of buildings	Estimated floor area [m^2]	Share
office buildings	1,927	2,758,694.66	8.7%
commercial and service buildings	1,995	1,407,060.29	4.4%
residential buildings	52,044	21,258,188	66.6%
educational, scientific and cultural buildings and sports buildings	1,282	1,797,145.72	5.6%
production, service and farm buildings for agriculture	7,178	493,641	1.6%
industrial buildings	1,404	1,367,247.58	4.3%
hospital and other health care buildings	339	511,109.31	1.6%
transportation and communications buildings	1,571	428,540.23	1.3%
other non-residential buildings	1,134	830,955.12	2.6%

tanks, silos and storage buildings	1,635	1 065 856,23	3.3%
TOTAL	**68,094**	**31,918,438.14**	**100%**

Within the city of Wroclaw, there are 1,117 buildings listed in the National Register of Historic Monuments and 9,511 buildings listed in the Municipal Record of Monuments. In addition to the buildings listed in the Register and Record, Conservation Protection Zones has been introduced, which also set up restrictions regarging modernisation of buildings. The total area of buildings under conservation protection in the city is 1,212,693.56 m2, which is less than 4% of the floor area of all buildings in the city.

District heating system

The city's district heating system consists of district heating networks and the heat sources supplying them. The owner of the heat distribution system is Fortum Power and Heat Power, and the source supplying the system is KOGENERACJA.

The Wroclaw district heating system consists of water district heating networks built in ring and radial systems in traditional duct and pre-insulated technology with a total length of 590 km. In 2019 - 2022 there was a significant development of the network, the total length increased by 43 km (nearly 8%). The share of the network in modern pre-insulated technology is of the order of 55%. Heat losses on Fortum's district heating network in Wroclaw in 2022 amounted to 12.4% and were practically equal to the average amount of losses from 2018 - 2021 (12.6%). The average losses in district heating companies according to the ERO report “Thermal energy in numbers - 2020” were 18.8%. Thus, the level of heat losses in 2018 - 2022 can be considered good and stable - no clear trends of change, which is favourable in a situation of systematic growth of new sections of the district heating network. Thus, under the existing conditions, one can speak of a positive trend in reducing heat losses. This trend is the result of systematic modernisation of the network (replacement of the duct network with a preinsulated one), as well as a gradual increase in the efficiency of leak detection by maintenance services.

Wroclaw's district heating system consists of a main district heating system supplied from EC Wroclaw and EC Czechnica expanded primarily in the central and southern parts of the city, as well as a local system supplied from EC Zawidawie in the area of the Psie Pole district.

The district heating system of Wroclaw currently has the status of an energy-efficient system according to the criteria described in the Energy Law Act and the EED Directive. The share of heat supplied to the district heating network, generated in renewable heat source installations (use of biomass in EC Czechnica), and usable heat generated in cogeneration exceeds the required 50%. This allows the use of aid funds for the development and modernisation of the system. The primary fuel for heat production in this system is still hard coal, which translates into a relatively high emission factor for network heat in the city. The average emission factor of heat supplied to consumers by district heating companies according to the URE report “Thermal energy in numbers - 2020” was 347.4 kgCO2/MWh (96.5 kgCO2/GJ), so Wroclaw’s - is at a similar level.

The characteristics of Wroclaw’s district heating system presented above indicate that the main determinant for achieving climate neutrality in this area is the modernisation and reconstruction of its power supply system, aimed at building low-carbon and climate-neutral heat sources for the district heating network.

Electric power system

The city's power system is made up of power grids at different voltage levels and their power sources in the form of local producers and substations that are connected to the national PSE power system. In the process of ensuring the supply of electricity to consumers in the Wroclaw area, energy

companies involved in: generation, transmission and distribution of energy participate. An important group are also trading companies, selling electricity to final consumers.

The main producer of electricity in the city is KOGENERACJA. Electricity is produced in cogeneration sources. Electricity comes from the combustion of conventional fuels (coal, heavy fuel oil) and from the combustion of biomass in a fluidized bed boiler (light fuel oil is an auxiliary fuel) and using an internal combustion engine that uses natural gas.

In the area of Wroclaw, Polish Power System Operation[2] (PSE) does not have substations and power lines. The main sources of electricity supply to Wroclaw are elements of the highest voltage power infrastructure, owned by PSE, located outside the city limits: the 400/110 kV Wroclaw and 400/110 kV Pasikurowice substations, as well as electricity sources of the mentioned enterprises and individual owners.

Public transportation system

Public transportation in Wroclaw is made up of trams, buses and railroads, the latter of which is not dependent on municipal transportation decisions. However, given the structure and richness of the railroad network within Wroclaw, it should be said that this network should become an equal component of the public transport system. And from a structural point of view, this is so - for it surrounds the entire downtown with a ring, intersecting with tram and bus routes running radially. These three elements of the public transportation system: tram, bus and rail, should form an integrated system and be the basis of a well-functioning city. At present, these are still two independently functioning systems, the integration of which is becoming one of the priorities of the provincial government. A positive first step in the process of integrating the rail and urban systems is the introduction of an integrated ticket for urban public transportation and rail transportation.

The dynamic growth of residential development on the outskirts of the city necessitates the development of public transportation, which is currently lagging behind spatial development.

Bicycle traffic

The network of bicycle routes in Wroclaw includes more than 360 km of routes of different nature: separated roads, pedestrian and bicycle paths, bicycle lanes and 99 km of routes on the dikes, which are an important element of the whole system. The low-lying and flat terrain of Wroclaw is conducive to the promotion of the bicycle as a cheap, healthy and generally accessible means of locomotion, not only in tourism and recreation, but first of all in relieving the burden on car and mass transport in everyday travel, including to work and to the place of study. Wroclaw has very favourable conditions for bicycle transportation - a warm climate, flat terrain and a well-planned urban layout. The city's assets also include an exceptionally large number of students and young people employed in modern companies that support ecological forms of transportation, and the openness of society to modern ecological trends.

In 2010, the Bicycle Policy of Wroclaw was adopted , which is part of the city's development strategy aimed at ensuring a high quality of life in the city. The policy's assumptions provide for the promotion of an efficient and clean form of transportation, such as the bicycle, which is expected to become an alternative means of transportation in the city. The main challenge of the policy is to strive for a 15% share of bicycle traffic by 2020 (in 2018, according to the Comprehensive Traffic Survey, this share was 6.3%). Adopted in 2013. Wroclaw Mobility Policy identifies the bicycle - alongside public transportation - as the basis for sustainable transportation in the city, which should be developed and promoted.

Pedestrian traffic

[2] Polskie Sieci Elektroenergetyczne S.A.

The large share of pedestrian traffic in the total number of trips in the city is one of the most important factors determining the city's friendliness to residents. Pedestrian traffic and the way it functions affect the assessment of the quality of life in the city.

In the structure of the city, it is possible to distinguish the most important areas of spatial activities relevant to pedestrian traffic. These include:

a) the centre of the city, and therein separate pedestrian zones, woonerfs, promenades along the city moat, a system of boulevards and pedestrian routes on embankments along rivers, collision-free crossings eliminating various types of pedestrian barriers,
b) residential neighbourhoods with separate neighbourhood pedestrian routes, streets in residential zones,
c) green and recreational areas, with green promenades, paths and tracts,
d) pedestrian links between the city centre, residential areas and green and recreational areas, as well as important elements of the transport system, such as interchanges.

In 2015, a coordinator for pedestrian development was appointed in Wroclaw, following the example of the coordinator for bicycle development, whose task is to ensure the comfort and high quality of infrastructure for pedestrian traffic and promote this form of travel as one of the best ways to move around the city.

Sewage and waste management

The central and southern parts of Wroclaw are dominated by a combined sewer system receiving sanitary sewage and rainwater and snowmelt, based on the historical layout of the network. In the rest of the area and in the settlements that are sewered today, there is a distribution sewer system, i.e. a separate sanitary sewer system and a rainwater drainage system. The core of the system is made up of the main sewers, the combined sewers: Oder, Sleza, Bystrzyca, South, North, West.

Due to the terrain, there are 41 municipal sewage pumping stations and 1 rainwater pumping station in the sewage collection system. Sanitary and combined sewage pumping stations pump on average, counting together with the main pumping station of the Wroclaw Sewage Treatment Plant Janowek, about 82 million m3 of sewage per year. The Wroclaw Sewage Treatment Plant Janowek is a mechanical-biological treatment plant with chemical support for the removal of phosphorus compounds.

Part of the sewage network dates back several decades and requires corrective measures. However, the programme of modernisation and reconstruction of the network, carried out by Municipal Water and Sewage Company for many years, makes it possible to provide the residents of Wroclaw with sewage collection services at an appropriately high level. The planned investment activities, in addition to the expansion of the network in the newly developing settlements, will also include the renovation and reconstruction of the main sewers, gradually increasing the safety of the system. In areas not equipped with sanitary sewerage systems, domestic sewage is mostly discharged into non-drainage tanks.

Among others, the city has the following waste management facilities - active facilities and installations related to waste collection and processing, which are:

a) a waste transfer station with a municipal waste sorting plant and an alternative fuel production line, as well as two transfer stations,

b) green waste composting plant,

c) waste processing facilities,

d) two Selective municipal waste collection points (PSZOK),

e) a landfill for sewage waste,

f) other waste collection and processing facilities operated by entities with the appropriate permits for waste collection and processing, and about 30 smaller waste processing facilities.

The majority of municipal waste is transferred to facilities located outside the city, including the Regional Installation for Municipal Waste Processing (RIPOK) facilities of the region in Rudna Wielka, Jaroszow, Kryniczno.

2 Part A – Current State of Climate Action

2.1. Module A-1 Greenhouse Gas Emissions Baseline Inventory

GHG Emissions Baseline inventory

The first step to understanding the sources and magnitude of greenhouse gas emissions in Wroclaw was to develop an emissions inventory. Wroclaw has been performing a GHG emissions inventory since 2014, which was originally linked to the adoption of the Low Emission Economy Programme. Subsequently, due to the signing of the Covenant of Mayors (CoM) by Wroclaw, this inventory also served and continues to serve the needs of SECAP[3], the Covenant of Mayors and CDP/ICLEI, as well as in the application phase for the City Mission.

The Municipality of Wroclaw reports emissions according to the GPC standard at the BASIC level, meeting the requirements of the Covenant of Mayors and the Global Covenant for Climate and Energy. Currently, the GHG inventories contain all the required data for BASIC reporting and most of the data needed at the BASIC+ level (BASIC+ reporting will be possible after making the necessary additions and changes to the inventory).

The results of the inventory have so far been used for reporting in the CoM and CDP/ICLEI as well as the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area[4] and SECAP monitoring. In the case of the CoM and CDP/ICLEI, however, this reporting was not continuous and complete due to a lack of staffing and adequate commitment to the topic of striving for climate neutrality. It was not until the participation in the City Mission that there was a renewed impetus to take a closer look at the results of the inventory and prioritise actions in terms of their impact on reducing emissions in the city.

So far, the GHG emissions inventory performed for the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area and SECAP has been the only source of information for identifying the main emission sectors in the city. However, in the course of the work in the Cities Mission, another analytical tool has emerged to identify GHG emissions, to identify the emission gap resulting from the city's actions and to indicate the relevant economic parameters of the actions. This tool is the economic model made available within the NZC. While the greenhouse gas emissions inventory only gave us information on emissions in the previous year, the economic model makes it possible to indicate future

[3] Sustainable Energy and Climate Action Plan aims to reduce carbon emissions and promote renewable energy use in Wroclaw, essential for achieving climate neutrality by 2050.

[4] This plan outlines strategies to transition the Wroclaw Functional Area to a low-emission economy through integrated territorial investments. It focuses on reducing carbon emissions, promoting renewable energy, and enhancing energy efficiency across the functional area. Crucial for achieving regional climate goals and sustainability targets.

emissions according to the so-called 'Business as Usual BAU2030' scenario and on the basis of assumptions of possible emission reduction scenarios that are most economically viable. Wroclaw, during its participation in the Cities Mission, collected the most recent input data for the model, independently of the collection of data for the inventory, and defined assumptions for activities up to 2030.

The emissions obtained in the model and the inventory differ from each other due to the type of data set used in both studies. However, the structure of emissions by sector and the proportions of these emissions remain similar in principle. Therefore, it was decided to show the results of both studies in this part of the CCC.

Greenhouse gas emissions based on the Greenhouse Gas Inventory for the Municipality of Wroclaw (2022)

Emission inventories are performed in accordance with the 'Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. An Accounting and Reporting Standard for Cities" (hereafter referred to as the GPC guidelines). The inventory principles according to the GPC are in line with the IPCC Guidelines for National Greenhouse Gas Inventories, making it possible to transfer the inventory results to the level of national GHG emission inventories performed for the UNFCCC. They incorporate the guidance provided in the guidebook 'How to develop a Sustainable Energy Action Plan (SEAP[5])'.

The inventory covers the administrative area of the municipality, which is in line with the scope of the CCC reported within the Cities Mission. A territorial approach is used for determining the GHG emissions balance (scope 1 emissions), but it is extended to include emissions resulting from electricity and heat consumption generated outside the municipality (scope 2 emissions) and those resulting from the management of waste generated in the municipality (scope 3 emissions)[6].

The inventory is performed for one full calendar year. The base year (representing a benchmark) for the GHG emission inventory, according to the assumptions adopted in the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area, is the year 1990. As the data on which the inventory is based for the year 1990 are strongly estimated and based on archival data, not always complete, they are characterised by a high uncertainty of estimation. Therefore, for the purposes of the CCC, we will refer to 2018 (as a year with data not disturbed by e.g. COVID-19 pandemic) and to 2022, for which we have the latest inventory. For these years, this is a much better estimate based on the latest available statistics.

The inventory covers all GHGs emitted in significant quantities within the administrative boundaries of Wroclaw, although it focuses on CO_2 emissions or converts them into eCO_2. Global warming potentials (GWPs) have been adopted in accordance with IPCC 5AR[7] .

The classification of emission sources is based on the division into Sectors, Subsectors and Categories. The division is based on the GPC classification, which has been adapted to the layout resulting from the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Urban Functional Area structure (some sub-sectors have been transferred to other sectors). The emission inventory was broken down into the following sectors:

- Sector I. Energy use in buildings and appliances (stationary fuel combustion) - scope 1 and 2:
  - Subsector I.1. Residential buildings,
  - Subsector I.2. Institutional, commercial buildings and facilities (including municipal facilities and public lighting)

[5] Sustainable Energy Action Plan
[6] The term 'scope' used corresponds to the English term 'scope' used in the GPC guidelines
[7] IPCC Fifth Assessment Report (AR5): Climate Change 2013: The Physical Science Basis https://www.ipcc.ch/pdf/assessmentreport/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf (p. 73-79)

  - Subsector I.4. Energy - direct emissions from energy are not included in the balance, they are reported informatively (they are included indirectly, as Scope 2 - electricity and heat use - attributing the resulting emissions to individual energy end-users).
  - Subsector I.8 Fugitive emissions from oil and gas distribution systems.
- Sector II. Transport (non-stationary fuel combustion) - scope 1 and 2:
  - Sub-sector II.1 Road transport (including public collective transport - buses),
  - Subsector II.2 Rail transport (including collective public transport - trams),
  - Sub-sector II.3 Waterborne transport,
  - Sub-sector II.4 Air transport,
  - Sub-sector II.5 Non-road transport.
- Sector III. Waste management - scope 1 and 3:
  - Sub-sector III.1 Solid waste management,
  - Subsector III.2 Biological treatment of waste,
  - Sub-sector III.4 Water and waste water management.
- Sector IV. Industry (IPPU) - scope 1 and 2:
  - Subsector I.3 Manufacturing industry and construction - combustion of fuels in industry for the production of energy for own use,
  - Subsector IV.1 Industrial production processes - direct (process) emissions,
- Sector V. Agriculture (AFOLU) - scope 1
  - Sub-sector I.5 Agriculture, forestry and fishing - scope 1 and 2
  - Subsector V.1 Livestock,
  - Subsector V.2 Land use,
  - Subsector V.3 Other sources.

The following sub-sectors were excluded from the scope (according to the methodology adopted in the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area):

- Subsector I.7 Short-term fugitive emissions from coal mining, processing, storage and transport - emissions do not occur within the city.
- Subsector I.3.b Maritime transport - emissions do not occur within the city.

Subsector IV.2 Product use - emissions not estimated - not required for BASIC reporting.

The Municipality of Wroclaw reports emissions according to the GPC standard at the BASIC level, meeting the requirements of the Covenant of Mayors Compact of Mayors and the Global Covenant for Climate and Energy. Currently, the GHG inventories contain all the required data for BASIC reporting and most of the data needed at the BASIC+ level (BASIC+ reporting will be possible after making the necessary additions and changes to the inventory).

<u>Emission factors</u>

Fixed emission factors have been used for all fuels - consistent with the inventory made for 2013 (based on the Methodology for developing the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area). The emission factors for electricity and district heating are variable over the years. This is due to changes in production technology (fuels used and generation efficiency). Therefore, for electricity and heat, year-specific factors have been applied.

Electricity

For the calculation of 2013 emissions, the official national emission factor defined by the National Centre for Emissions Management (KOBiZE) as carbon dioxide emissions per MWh of electricity produced in power plants and combined heat and power plants in 2013 was adopted. This factor is 831.50 kg CO_2/MWh[8].

[8] http://www.kobize.pl/pl/article/2014/id/569/komunikat-dotyczacy-emisji-dwutlenku-wegla-przypadajacej-na-1-mwh-energii-elektrycznej

Starting in 2016, KOBIZE publishes[9] product indicators for emissions of individual pollutants per unit of electricity production. For the emission inventory for 2014-2019, the relevant emission factor for that year (the most recent) was used. For 2022, the emission factor for 2021 was adopted (more recent data was not available at the time of preparation).

CH_4 and N_2O emission factors were assumed to be constant and invariant over time.

Table 2. Emission factors for electricity used in the GHG inventory.

Inventory year	Emission factor used [kg CO_2 /MWh].	Reference year of the emission factor	Comments
1990	1,100,000	1990	takes into account distribution losses
2013	831,500	2013	takes into account distribution losses
2014	825,412	2014	takes into account distribution losses
2015	798,000	2015	takes into account distribution losses
2016	781,000	2016	takes into account distribution losses
2017	781,000	2017	takes into account distribution losses
2018	765,000	2018	takes into account distribution losses
2019	719,000	2019	takes into account distribution losses
2020	719,000	2020	takes into account distribution losses
2021	698,000	2021	takes into account distribution losses
2022	709,000	2022	takes into account distribution losses

The increase in the value of the emission factor for electricity end-users for 2021 is due to the increase in electricity production in the country. According to information provided by KOBIZE, there was an increased demand for electricity in 2021 compared to 2020 (total consumption increased from 171.310 TWh in 2020 to 180.519 TWh in 2021) as a result of the recovery of economic activity after the Covid-19 pandemic crisis, reduced imports and increased exports of electricity. The percentage increase in CO_2 was greater than the increase in electricity generation due to, inter alia, weather-limited production from RES and reduced generation from gas-fired sources due to high gas prices and the consequent lower economic competitiveness of these units.[10]

District heating

The emission factor for district heating (heat supplied by a district heating network) is calculated as the weighted average emission factor for all major sources supplying heat to the district heating system. For installations covered by the emissions trading scheme, the emission factor is obtained from the operators of the installation - in this case it is already calculated for the heat produced in the installation (possibly including cogeneration).

[9] http://www.kobize.pl/pl/fileCategory/id/28/wskazniki-emisyjnosci
[10] https://www.kobize.pl/pl/article/aktualnosci-2022/id/2229/nowe-wskazniki-emisyjnosci-dla-energii-elektrycznej

Table 3. Emission factors for district heating used in the GHG inventory

Inventory year	Emission factor used [kg CO_2 /GJ]	Comments
1990	110	Calculation for EC Wroclaw and EC Czechnica - estimated data
2013	104	-
2014	97	-
2015	98	-
2016	107	-
2017	103	-
2018	105	-
2019	105	-
2020	102	-
2021	99	-
2022	99.6	-

Waste management

Emission factors for the management of solid (mixed) waste have been updated on the basis of the latest reports from the National Emission Inventories. Emission factors for biological treatment of waste in line with the National Inventory have been added.

Table 4. Emission factors for waste management used in the GHG inventory.

Inventory year	CH_4 emission factor - mixed waste [kg/Mg].	Emission factor CH_4 - biological treatment [kg/Mg]	Emission factor N_2O - biological treatment [kg/Mg]
1990	61,232	4	0.24
2013	35,246	4	0.24
2014	38,894	4	0.24
2015	44,554	4	0.24
2016	50,832	4	0.24
2017	50,832	4	0.24
2018	39,146	6.67	0.4
2019	39,146	6.67	0.4
2020	34,113	6.67	0.4
2021	34,807	6.67	0.4
2022	1,265	6.67	0.4

Fugitive emissions from natural gas distribution systems

Updated emission factors were used, distinguishing between the natural gas distribution network and the transmission network. The indicators were taken from the study "Inventory of methane emissions from the natural gas distribution system" (Oil and Gas Institute)[11]. The arithmetic average indicators presented in approach 3 were used: emission factor of the transmission network - 191 m^3/km/year, emission factor of the distribution network - 81 m^3/km/year.

Due to the fact that some of the basic data used in the emission inventory is made available with a considerable delay in relation to the year to which the data relates (statistical data from the Statistics

Poland, data from the Marshal's Office for the use of the environment), the emission inventory was prepared partly on the basis of historical data (data from previous years).

At the date of completion of the emissions inventory (31 May 2023), the following data for 2022 was not available:

- complete data on entities using the environment in the city - information on the type and quantity of fuels burned (Marshal's Office of Lower Silesia data),
- statistics of the Statistics Poland (complete housing data),
- Office of Rail Transport data,
- emissions from civil aviation - national greenhouse gas emissions inventory,
- emission factor for the national electricity grid for the year 2022.

The estimated error due to the use of incomplete/historical data is set at approximately +/- 5% of the total emissions from the city area.

Table 5. Summary of GHG emissions in the Municipality of Wroclaw by sub-sector for the period 1990-2022.

Emissions by sub-sector	Emissions [Mg CO_2e]									Change from base year
	1990	2015	2016	2017	2018	2019	2020	2021	2022	
Residential buildings	1,777,035	1,335,603	1,499,768	1,452,910	1,417,181	1,379,351	1,375,325	1,442,453.00	1,384,934	-22.06%
Institutional buildings, commercial buildings and equipment	583,207	1,054,596	1,145,131	1,162,780	1,219,625	1,237,166	1,051,388	1,103,873.00	1,071,493	83.72%
Public lighting	46,541	26,838	24,256	23,418	22,534	25,185	21,285	17,895.00	22,406	-51.86%
Road transport	455,476	1,014,791	1,051,632	1,099,967	1,139,908	1,172,607	953,296	1,245,368.00	1,423,677	212.57%
Rail transport	118,779	64,502	64,508	65,196	63,433	63,645	59,878	58,844.00	59,669	-49.76%
Air transport	-	141,806	189,744	190,983	216,337	214,370	6,386	119,436.00	171,628	100.00%
Industry	1,442,928	610,393	623 177	646,077	796 956	806 825	618,072	601,312.00	591,090	-59.04%
Gas distribution system	169	110	110	110	102	102	104	106.00	84	-50.30%
Waste management	390,686	16,937	16,467	18,332	19,662	19,731	22,804	25,214.00	24,595	-93.70%
AFOLU	9,064	-5,139	-5,024	-5,031	-4,448	-4,444	-5,049	-4,432.00	-5,554	-161.28%
TOTAL	**4,823,885**	**4,260,437**	**4,609,769**	**4,654,742**	**4,891,290**	**4,914,538**	**4,103,489**	**4,610,069.00**	**4,744,022**	**-1.66%**

[11] http://socket.pl/gazterm/2015-2/2014/images/prezentacje/13maja2014/INiG.ppt

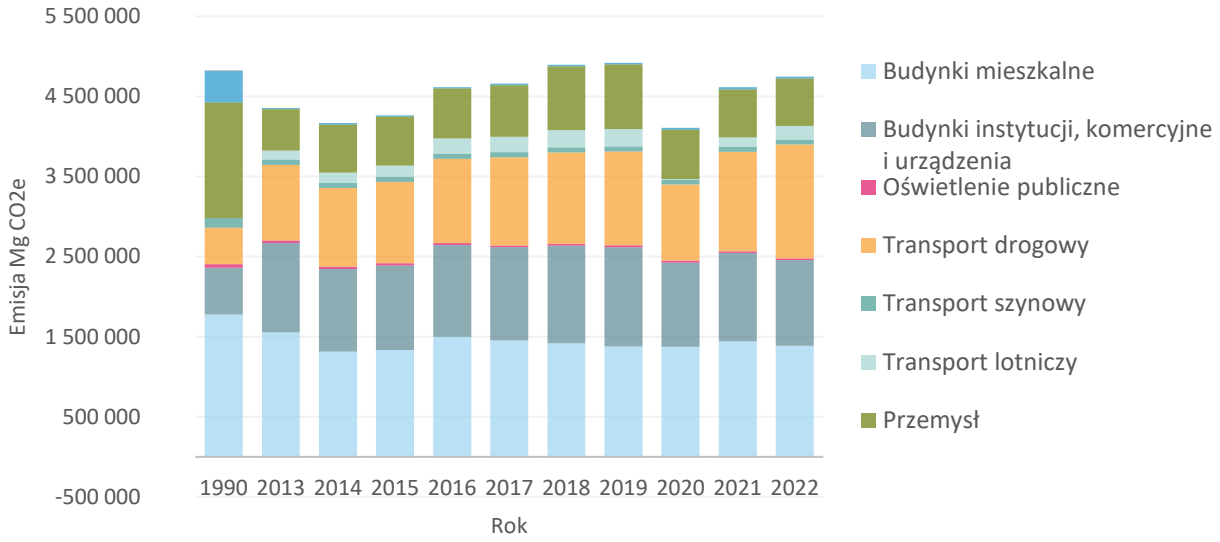

Figure 2. Summary of GHG emissions in the Municipality of Wroclaw by sub-sector for the period 1990-2022.

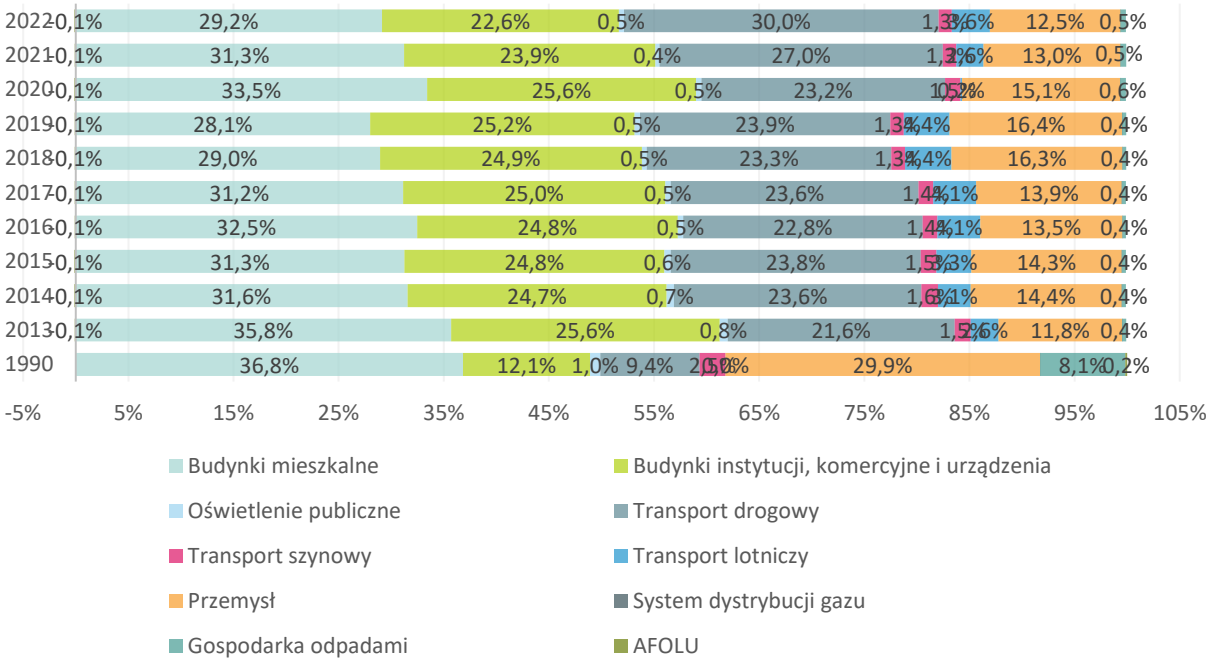

Figure 3. Summary of GHG emissions in the Municipality of Wroclaw by sub-sector for the period 1990-2022 - percentage shares of individual sectors.

During the period 1990 - 2022, the volume of emissions from the Wroclaw Municipality area has changed significantly. The energy-intensive socialist economy, the effects of which can be seen in the volume and structure of emission sources for 1990, was replaced by a modern, increasingly efficient market economy. There was a significant decrease in emissions between 1990 and 2014, followed by a significant upward trend continuing until 2020. 2020 proved to be an exceptional year - with a significant drop in emissions most likely due to the economic and movement restrictions put in place related to the COVID-19 pandemic - with emissions decreasing by more than 17% in that year compared to 2019. In 2021, the economy the economy recovered from pandemic lockdowns and emissions started to increase again, and 2022 was

marked by a further increase in emissions compared to previous years, related to both the 'rebound' effect of the economy after the pandemic and the effects of the armed conflict in Ukraine.

Total emissions

Based on the results of the inventory, it should be noted that the initially high emissions in the base year (1990 - more than 4.82 million tonnes of carbon dioxide equivalent) reached their first minimum in 2014 (just over 4.16 million tonnes), only to start rising again - by 2019, when emissions reached around 4.91 million tonnes of CO_2 e, which is 1.8% higher than the base year. In 2020, there was a sharp turnaround in this trend and emissions decreased significantly to around 4.1 million tonnes CO_2 e - the lowest level since 1990, which should be attributed primarily to the impact of the COVID-19 pandemic. In 2021, emissions increased again, but have not yet reached pre-pandemic levels, and 2022 continued the trend of increasing emissions (4.744 million tonnes CO_2 e). Currently, there are 7.04 tonnes of CO_2 e per city resident.

Table 6. Emission volumes in Wroclaw by sector in each year of emission inventories (period 1990 - 2022).

Sector	Emissions [Mg CO_2 e]								
	1990	2015	2016	2017	2018	2019	2020	2021	2022
Buildings and equipment	2,406,952	2,417,147	2,669,265	2,639,218	2,659,442	2,641,804	2,448,102	2,564,327	2,478,917
Transport	574,255	1,221,099	1,305,884	1,356,146	1,419,678	1,450,622	1,019,560	1,423,648	1,654,974
Waste management	390,686	16,937	16,467	18,332	19,662	19,731	22,804	25,214	24,595
Industry	1,442,928	610,393	623,177	646,077	796,956	806,825	618,072	601,312	591,090
Land use (AFOLU)	9,064	-5,139	-5,024	- 5,031	-4,448	-4,444	-5,049	-4,432	-5,554
TOTAL	**4,823,885**	**4,260,437**	**4,609,769**	**4,654,742**	**4,891,290**	**4,914,538**	**4,103,489**	**4,610,069**	**4,744,022**
Emissions per capita	7.50	6.60	6.70	7.31	7.29	7.63	7.64	6.39	7.04
Emission reduction compared to baseline year	**Mg CO_2 e**	**- 662,305**	**- 563,448**	**- 214,116**	**-169,143**	**67,405**	**-720,396**	**-213,816**	**-79,863**
	%	**13.73%**	**11.68%**	**4.44%**	**3.51%**	**+1.40%**	**14.93%**	**4.43%**	**1.66%**

The changes in emissions shown have their origin in several main causes:

- The emission inventory is carried out in actual values, without correction for fuel consumption and heat consumption related to the variability of the heating season
- After the political transformation, especially since Poland's accession to the European Union, the city has been developing intensively, which translates into increasing energy consumption (mainly electricity and transport fuels) and rising emissions in the tertiary, industrial and transport sectors.
- In 2020 and also, to a lesser extent in 2021, the impact of the COVID-19 pandemic on emissions became apparent.
- In 2022, the Russian-Ukrainian conflict had a significant impact on the volume of emissions, with a very large number of refugees from Ukraine arriving in the city (estimated at up to 150,000 people in 2022).

Since 1990, emissions from the industrial sector have been significantly reduced (by more than half from an initial share of less than 30% to around 12.5% today - an observed decreasing share in recent years) and waste management (from a share of around 11% to less than 0.5%). Emissions from the transport sector have increased significantly since then (a steady upward trend since 2013) from initially less than 12% share (1990) to more than % of the share in 2019, and in 2020 there was a significant decrease in emissions to 24.8%, but in 2021-2022 there was a rebound and it is now as high as 34.9%). In the buildings and facilities sector, emissions have remained more or less constant (in 2022, these emissions accounted for more than 52% of total emissions, with a decreasing trend in these sectors' share of total emissions until 2022).

The agriculture, forestry and land use sector shows no significant change in emissions, and is also characterised by a small share - absorption of emissions predominates (GHG emissions predominated in the base year).

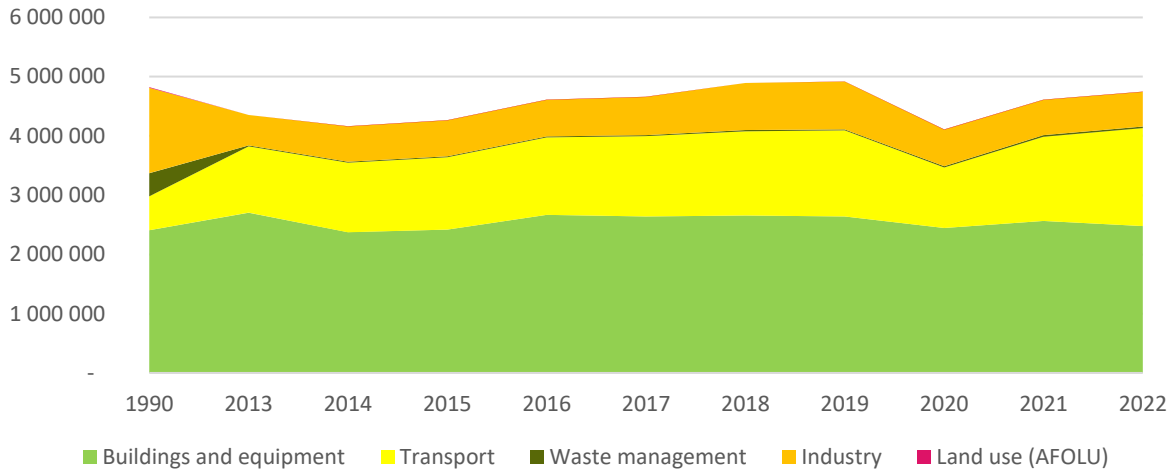

Figure 4. Changes in emissions in Wroclaw by sector in individual years of the emission inventory (period 1990 - 2022).

Analysis of emissions by sector

Energy use in buildings and equipment (including industry)

Within the subsector, services, trade and institutions stand out in particular - this subsector has shown a consistently strong upward trend, halted in 2020 by the pandemic. In 2021, there was a rebound in this subsector, while emissions are now lower than in 2019, which can be linked to an increase in the number of people working remotely. The general upward trend, halted in 2020, is related to the economic development of the city and the construction of many new office, retail and service areas (new buildings) in recent years. The use of electricity and also district heating in these buildings, which is dependent on climatic conditions, is mainly responsible for the changes in emissions in this case.

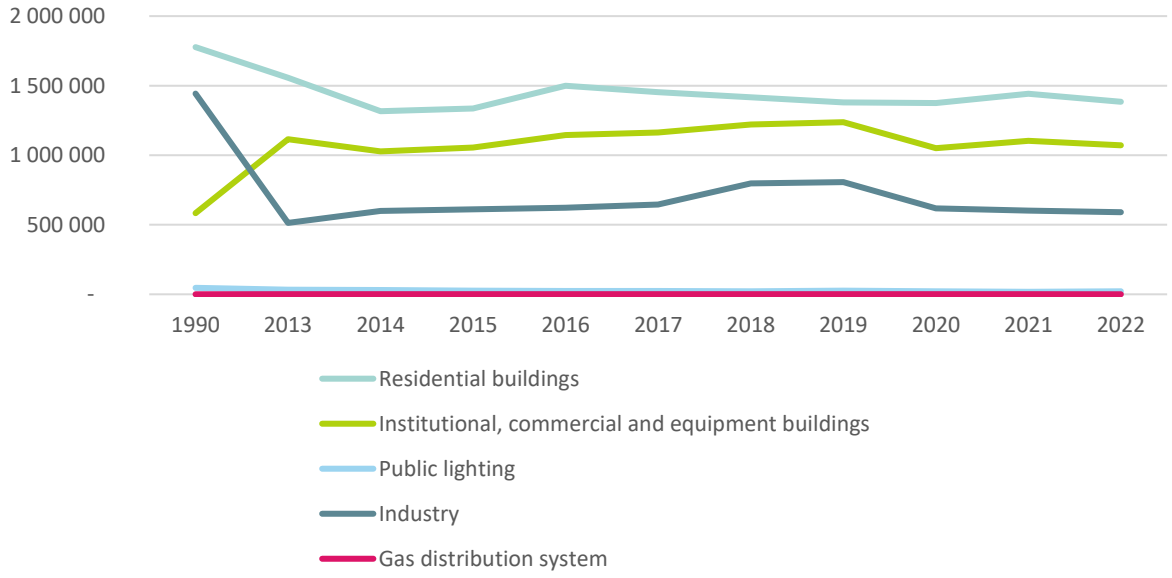

Figure 5. Changes in emissions in sub-sectors related to energy use in buildings in Wroclaw between 1990 and 2022.

In the residential sub-sector, a downward trend in emissions was evident until 2021 (a decrease of more than 18.8% compared to the base year), which was mainly due to an increase in the energy efficiency of buildings (especially thermal modernisation of multi-family buildings by housing communities and cooperatives), as well as a significant reduction in the use of coal for heating (in favour of low-carbon gas and district heating). Emissions from this subsector show a strong dependence on the number of heating degree days - in years with cold winters, emissions increase significantly - this is the reason for the increase in emissions in 2021 (more than 400 heating degree days more than in 2020).

In 2022, emissions decreased compared to 2021, due to a warmer winter and a shorter heating season (according to heat distributors). Interestingly, despite the very large number of refugees from Ukraine who stayed in Wroclaw (according to various estimates, it was between 100,000 and 150,000 people), this did not translate into significantly increased consumption of electricity and gas and other fuels, as opposed to water and waste volumes. The reception of refugees has indeed affected the entire economy of the city[12].

The residential sub-sector accounts for the second largest share of total emissions from the Wroclaw area (over 29% in 2022).

The tertiary sector shows similar changes to the residential sector - an increase in emissions until 2019, followed by a significant decrease due to the pandemic in 2020. In 2021, emissions in this sector 'rebounded', but did not reach pre-pandemic levels. In 2022, there was a decrease in emissions from the previous year. The tertiary sector currently accounts for around 22.6% of emissions from the city area.

The industry sub-sector has undergone significant changes due to the political transition of the 1990s, resulting in a reduction in emissions of over 59% in 2022 compared to the base year. Emissions in this subsector had a significant upward trend between 2018 and 2019, related to the city's continued economic development, now emissions have decreased significantly between 2020 and 2022.

Transport

Within the transport sector, the main driver of emissions growth is road and air transport. The increase in GHG emissions for road transport was up to over 157% by 2019 compared to the base year. Due to the movement restrictions introduced in 2020, emissions decreased significantly and amounted to 109% compared to the base year. In the period 2021 – 2022, there was a rebound and emissions increased to 212% of the base year level. This is now the first largest share of total emissions of the emission inventory sub-sector (30 % share in 2022).

In the case of road transport, this is associated with a steady increase in the number of cars and their use within Wroclaw - it should be noted that this is a nationwide trend. In the period 1990 - 2022, the number of vehicles registered in Wroclaw increased by more than 485% from approximately 145,000 in 1990 to 704,000 in 2022. The increased number of vehicles and traffic is also related to the Russian-Ukrainian conflict (influx of refugees from Ukraine).

In 1990, emissions from air transport were practically non-existent (minimal number of domestic connections), whereas since the mid-1990s, airport and air traffic development has taken place - particularly intense in the last few years, which translates into increased emissions. 2020 was a special year, air traffic was virtually halted - year-on-year emissions were reduced by 97%. The resumption of flights in 2021 resulted in a slight increase in aviation emissions again, and in 2022 the already normally operating airline contributed to a significant increase in emissions, which now account for around 3.4% of total emissions.

Emissions from rail transport are small (around 60,000 tonnes in 2022) and show a steady downward trend, mainly related to the decarbonisation of electricity. The number of rail connections shows an increasing trend.

[12] https://www.portalsamorzadowy.pl/finanse/ukraincy-stali-sie-mieszkancami-polskich-miast-ile-to-koszt-uje,444225.html

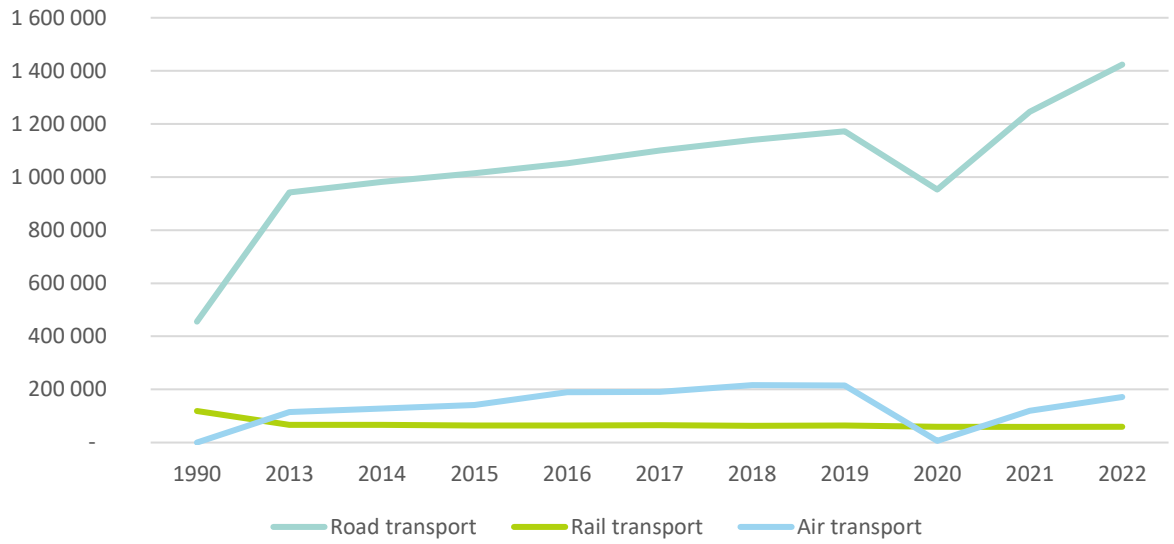

Figure 6. Changes in transport emissions in Wroclaw from 1990 to 2022.

Waste management

Between 1990 and 2022, there have been very significant changes to the waste management system - old landfills characterised by high methane emissions have been closed, and the currently operating landfills are equipped with landfill gas capture systems (biogas recovery), which significantly reduces methane emissions to the atmosphere. In addition, the amount of waste landfilled each year (due to recycling and other recovery processes) has been very significantly reduced. This has resulted in a reduction in the volume of emissions from over 390,000 tonnes to approximately 24,600 tonnes of CO_2e at present (a reduction of over 93%).

It should be noted that composting of biodegradable waste has been introduced, which influences the appearance of additional CH_4 and N_2O emissions in this sector - emissions from composting account for more than 3/4 of emissions from waste management. The waste management sector has had relatively constant emissions since 2013. The slight increase in emissions in recent years is related to the increasing amount of municipal wastewater being treated. In 2022, emissions have increased due to more waste generated in Wroclaw and managed within and outside the city limits.

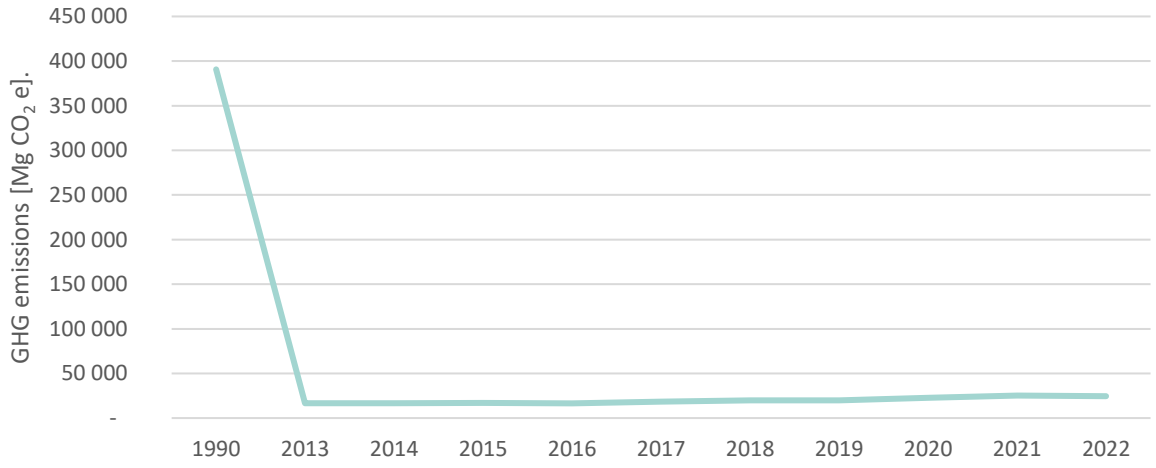

Figure 7. Changes in emissions from waste management in Wroclaw from 1990 to 2022.

Agriculture, forestry and land use

The AFOLU sector currently contributes to reducing the volume of total emissions from the Wroclaw area, thanks to the absorption of CO_2 by green areas. The magnitude of the uptake remains relatively constant (increasing with the increase in green areas – particularly in forest areas). The significantly higher emissions from the sector in 1990 were due to the higher number of livestock in the city and the more intensive fertilisation of soils. Although woodland is increasing, the built-up area is increasing, which in total reduces the CO_2 absorption capacity. The reduction in emissions is mainly due to fewer livestock within the city.

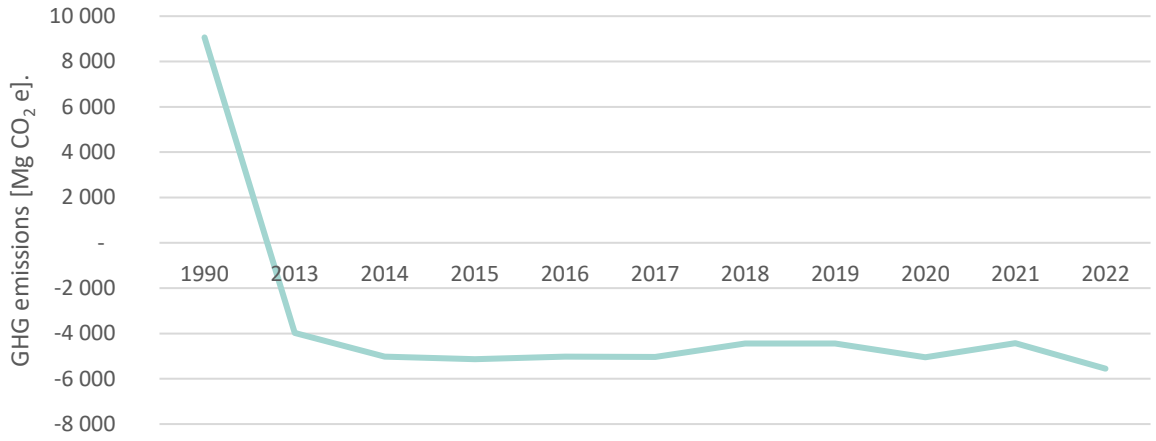

Figure 8. Changes in emissions from agriculture, forestry and land use in Wroclaw from 1990 to 2022.

Analysis of emissions by energy carrier used

Among the energy carriers used in Wroclaw, electricity has the highest consumption and the highest GHG emissions, accounting for more than 37.5% of emissions in 2022 (indirect emissions of more than 1,775 million tonnes CO_2e). The share of this energy carrier has increased since 1990 (35.7% in 1990). The increase in electricity consumption is primarily related to economic development - the increasing number of retail, service and office spaces is the main driver of growth in this case. The increase in emissions is evident even despite the increasing decarbonisation of electricity from the national energy system. However, exceptionally, electricity emissions has increased slightly in 2021.

For indirect emissions resulting from district heating, a significant increase in energy efficiency is evident. The share of heat in the volume of emissions has decreased from an initial almost 30% (1990) to about 17.7% today. The increase in heat consumption (and GHG emissions) in recent years compared to previous years is mainly due to the longer heating season (2016 and 2017, 2021), but also in part to an increase in sales related to the connection of new heat consumers.

Natural gas consumption shows a slight upward trend, reinforced in 2022, which translates into a slight increase in emissions from this fuel in recent years. This is related to the increase in the use of this fuel for home heating in recent years (as a result of the replacement of old coal-fired cookers and boilers). In 1990, natural gas was mainly used in industry and in homes for hot water, after 1990 there was a very rapid increase in the use of this fuel for domestic heating purposes.

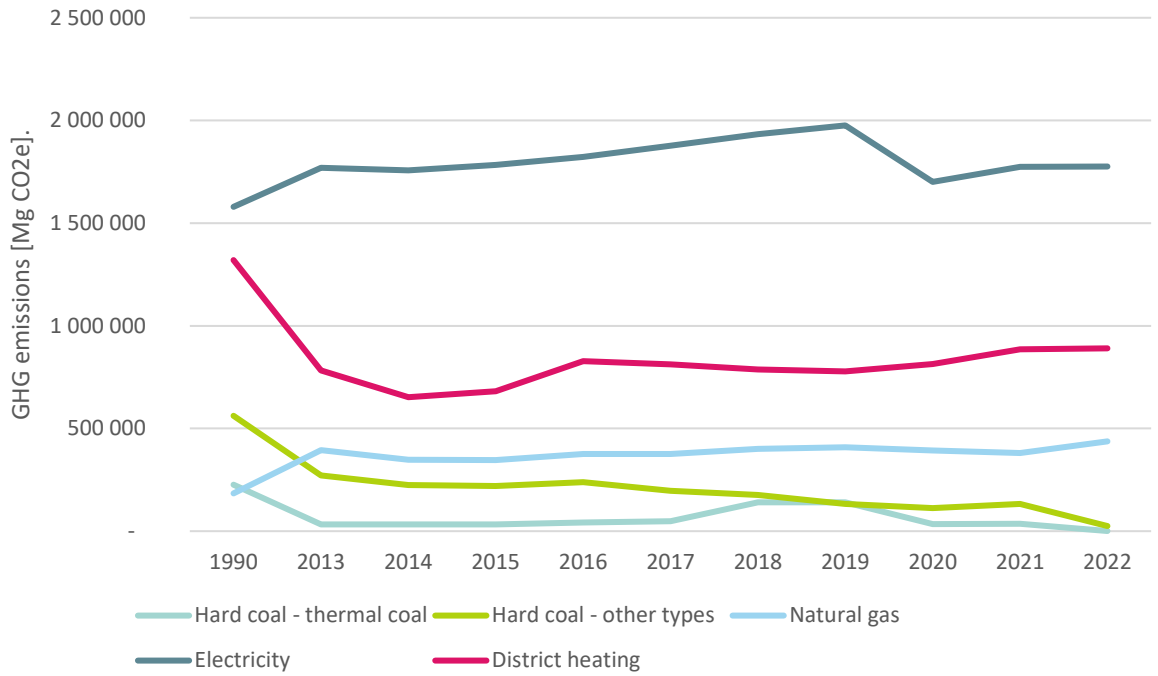

Figure 9. Changes in emissions from the use of the main energy carriers used for economic and domestic purposes in Wroclaw between 1990 and 2022.

The consumption of hard coal (especially in housing) has been on a steady downward trend, linked to the now widespread reduction in its use for heating purposes (due to the need to reduce air emissions). After 1990, there has been a very large decline in coal consumption - from almost 18% of the GHG emission volume to less than 1% today. Coal used for heating is mainly replaced by district heating and natural gas.

Other fuels (fuel oil, liquefied petroleum gas) account for a small share of total emissions and do not show much variability, although their consumption has been increasing in recent years.

For transport fuels, emissions from each fuel show a very strong upward trend, halted in 2020 by the introduced movement restrictions. Very significant is the increase in the use of petrol and diesel, which, despite being less carbon-intensive in terms of greenhouse gases, contributes much more to air pollution from particulate matter (PM10 and PM2.5) and nitrogen oxides than motor gasoline. In 2021 - 2022, there was a significant 'rebound' in post-pandemic transport fuel consumption.

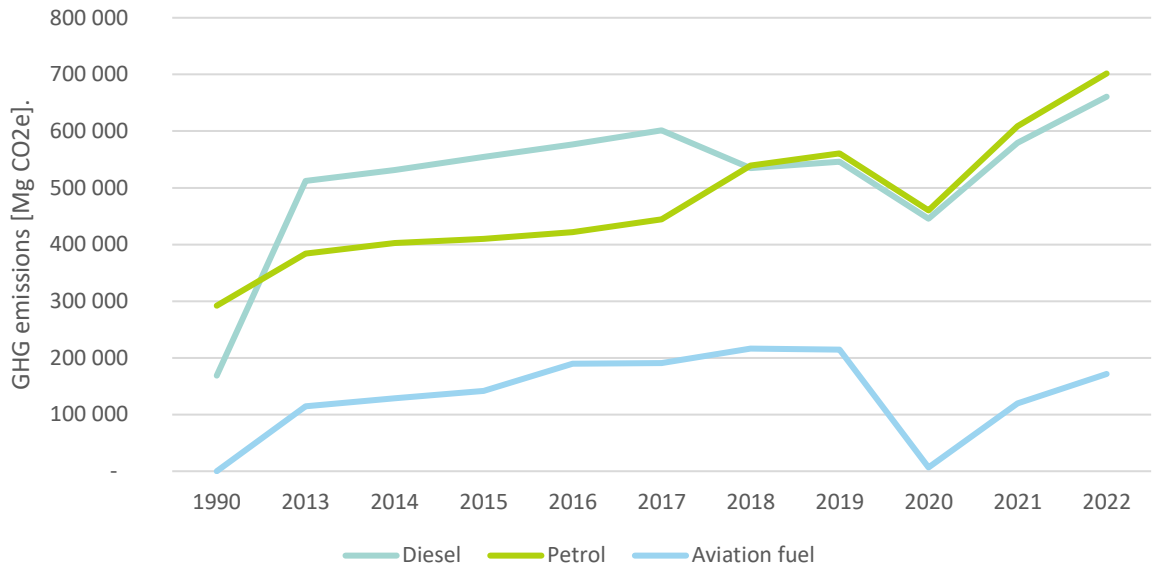

Figure 10. Changes in emissions from the use of the main transport fuels in Wroclaw between 1990 and 2022.

Summary

The main conclusions from the analysis of the emission inventories carried out so far are as follows:

1. Total GHG emissions in 2022 amounted to 4,744,022 Mg CO_2e and were 79,863 Mg CO_2e lower (1.66%) than the base year emissions estimated at 4,823,885 Mg CO_2e (1990)
2. There was a very large decrease in emissions between 1990 and 2014 (13.7%), with a slow increase in emissions since 2015. In 2020, this trend came to a sharp halt due to the economic impact of the COVID-19 pandemic, particularly evident in the industrial, services and transport subsectors. In 2021, the economy 'rebounded' and emissions started to increase again, but declined slightly in 2022
3. In 2022, the key driver of emissions growth in the city was the transport sector, which increased its share at the expense of other sectors
4. The main driver of the increase in GHG emissions in Wroclaw is transport - in order to achieve significant emission reductions (assumed in the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area), it is necessary to implement measures leading to a reduction in the use of individual motor vehicles to move around the city. The travel restrictions introduced in 2020 resulted in a significant decrease in transport emissions (16% year-on-year decrease, compared to 2019), but already in 2021 and 2022 transport emissions started to increase rapidly again (this is also related to the influx of refugees)
5. Electricity consumption shows a constant, high growth trend, which, despite the steady declining emissivity of electricity in Poland, is, after transport, the second most important factor in the growth of emissions in Wroclaw. However, this is inextricably linked to the economic development of the city
6. Coal consumption has been steadily decreasing in recent years, which is mainly related to the implementation of air protection policies (e.g. implementation of Kawka programmes) and the city's progressive district heating
7. There has been a very large decrease in emissions from the waste management sector, which is linked to the implementation of modern waste management methods - a significant reduction in landfill and the introduction of landfill gas recovery. The use of composting has slightly increased emissions in this sector

8. After 1990, air transport emissions, which were previously negligible and not included in the baseline inventory, occurred in the Wroclaw area. Air transport emissions show a strong upward trend (an increase of more than 87% in 6 years). These emissions were almost completely reduced in 2020 (down 97% year-on-year, compared to 2019) and started to return to their former level in 2021 - 2022.

Between 2018 and 2019, an intense increase in emissions from the industrial sector was marked, with an increase of more than 160,000 tonnes in 2 years (from 2016). In contrast, emissions from industry decreased in 2020, probably as a result of COVID-19. Currently, these emissions continue their downward trend.

The development of emission inventories is a process that is subject to continuous change and improvement. When data is obtained that allows emissions to be estimated with greater accuracy, it should be used to revise and update historical emissions inventories. Listed below are the inventory elements that should be subject to more detailed analysis and verification when successive emission inventories are carried out, ranked in order of relevance:

1. Back-testing of the emission inventories for 1990 and 2013 - 2021, based on the most up-to-date data available (the Statistics Poland, national emission inventories, other available data sources).
2. Application of the emission factor for electricity for 2022 (published at the end of 2023).
3. Analyse the appropriateness of developing a new model for estimating emissions from the residential sector - fuels used for home heating. The model could be developed using data from the Central Building Emissions Inventory. Data continuity may be problematic - verification of how significant the change is needed.
4. Analyse the methodology for estimating road transport emissions - the currently adopted methodology and parameters are likely to overestimate emissions from the transport sector. In particular, attention should be paid to the parameters for the number of kilometres travelled within the city.
5. Update passenger rolling stock data (emission estimates are based on 2015 model and assumptions).
6. Verify the feasibility of including rail freight in the emissions inventory (subject to data availability).
7. Analyse the appropriateness of updating the emission factors for fuels (according to the most up-to-date KOBIZE reports). In addition, analyse the rationale for dividing coal into two types.
8. Prepare a model for estimating emissions for water and wastewater management taking into account local specificities.
9. Transfer and update the emission factors in the AFOLU sector.
10. Relocate and update the method for determining emissions from industrial processes (IPPU sector).
11. Re-analysis of data for river transport - to determine whether emissions are increasing compared to the 2016 analysis.

In addition, the Municipality of Wroclaw currently reports emissions at the BASIC level in accordance with the GPC guidelines. The high level of detail in the inventory and the availability of source data make it possible to move to the BASIC+ reporting level. Achieving the BASIC+ reporting level requires:

1. Complementing the emission estimate for Subsector IV.2 Emissions from product use - a method for estimating emissions for this subsector should be developed
2. Changing the model for determining transport emissions - identifying/extracting emissions resulting from residents' travel outside the city's borders
3. Analysis of other sources in Subsector V.3
4. Inclusion of landfill biogas combustion in biogenic emissions.

To conclude the information, it is worth mentioning that as part of the inventory, in addition to the GPC standards, emissions for the SEAP/SECAP were also calculated. In this case, this value is lower than the GPC emissions and for the Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Functional Area, lower by 171,712 t CO_2 as it does not take into account emissions from air transport and the gas distribution system. In this view, the volume of GHG emissions in 2022 was - 4,572,308

t CO_2. Therefore, in the following part of the CCC when the emission gap and the actions in the action plan are described, reference is made to the value of emissions counted according to SECAP rules.

Greenhouse gas emissions based on an economic model (2024)

The economic model considers 13 sectors and sub-sectors related to greenhouse gas emissions. These are: transport (reduced demand for passenger transport, increased use of shared transport, reduction and optimisation of freight logistics, shift to public and non-motorised transport, electrification of cars, buses and freight), buildings and heating (new buildings with high energy efficiency, energy-efficient building renovation, energy-efficient lighting and appliances, decarbonisation of heating), electricity (shift to renewable energy sources), waste (increase in recycling). The model does not include actions related to the AFOLU sector as it does not significantly affect emissions reductions.

The economic model calculates the cost and carbon impact of the measures and identifies which measures in the plan provide the greatest benefit in terms of carbon dioxide emission reductions relative to the financial outlay. The model gives a social cost-benefit perspective (not restricted to city boundaries), delta OPEX and net CAPEX, and quantifies financial costs/benefits, air quality, noise and road safety.

The model includes scope 1 and 2 emissions in the economic case, as cities can often affect these emission sources. Scope 3 emissions are only included for municipal waste disposed of outside the city boundaries. This is consistent with the methodology adopted in the inventory and with the requirements of the Cities Mission.

Based on the data entered into the model, emissions were estimated for the so-called base year 2019 (it is worth noting, however, that the data in the model are not from a single period, but are rather a collection of different data from the last few years - depending on their availability). The baseline emissions estimated in this way are higher than those estimated in the inventory for both 2019 and 2022. The difference is 2.4% for 2019 and 5.9% for 2022. This implies a relatively high convergence of the results obtained.

The economic model with regard to the emission structure also shows the dominance of emissions from the buildings sector only in this view it is broken down into two components - emissions from electricity production and from its use and heat in buildings (in the case of the inventory, emissions from buildings are calculated together with emissions from electricity and heat production). In both cases it is respectively 55% according to the inventory and 58% according to the model. The second important area is transport (both in the inventory and in the model at 31%). The last sector of importance in reducing emissions is industry.

Table 7. GHG Emissions by Source Sector - Baseline Year

GHG Emissions by Source Sector - Baseline Year					
Base Year	**2019**				
Unit	t CO_2 equivalent/year				
	Scope 1	**Scope 2**	**Scope 3**	**Total**	**% of Total**
Transport	1,398,899			1,398,899	28%
Buildings & Heating	1,347,413			1,347,413	27%
Electricity		1,547,097		1,547,097	31%
Waste*			60,234	60,234	1%
Other (incl. IPPU & AFOLU)	683,091			683,091	14%
Total	**3,429,403**	**1,547,097**	**60,234**	**5,036,733**	**100%**

** Includes scope 1 Waste emissions (produced and processed in the city) and scope 3 (produced by the ci but processed outside the city border) - solid waste only; wastewater falls under "Other" sector.*

Emission factors used in the model (Emission = Activity data * Emission factor)

Table 8. Emission factors used in the model (BAU2030 scenario).

Emissions sector	Primary energy/energy source	Carbon dioxide (CO_2)
Transport	Private transport (cars) (g/km)	172
	Bus transport (g/km)	944
	Light trucks (<3.5 t) (g/km)	403
	Trucks (>3.5 t)(g/km)	563
Buildings and heating	District heating production (g/kWh)	385
	Local heating production (g/kWh)	219
Electricity	National emission factors - 2022 (g/kWh)	708

Based on the data, the model also forecasts future emissions from the city area in a continuation or business-as-usual scenario for the year 2030. According to these data, emissions could increase by almost 7%, with electricity generation being the main growth sector, while decreases could be recorded in transport and energy and heat consumption in buildings.

Table 9. GHG Emissions by Source Sector - Business as Usual (BAU) 2030.

GHG Emissions by Source Sector - Business as Usual (BAU) 2030					
Base Year	BAU 2030				
Unit	t CO_2 equivalent/year				
	Scope 1	**Scope 2**	**Scope 3**	**Total**	**% of Total**
Transport	1,195,918			1,195,918	22%
Buildings & Heating	1,324,407			1,324,407	24%
Electricity		2,222,253		2,222,253	40%
Waste*			64,855	64,855	1%
Other (incl. IPPU & AFOLU)	683,091			683,091	12%
Total	**3,203,417**	**2,222,253**	**64,855**	**5,490,525**	**100%**

** Includes scope 1 Waste emissions (produced and processed in the city) and scope 3 (produced by the city but processed outside the city border) - solid waste only; wastewater falls under "Other" sector*

The model then presents a scenario for reducing greenhouse gas emissions under certain assumptions made by the city. These assumptions should provide a scenario showing how far the city can go in its decarbonisation efforts in a very ambitious scenario, consistent with the SECAP. The values in the table below were used for the analysis. These figures show what changes in each sector would need to be undertaken to achieve a reduction in GHG emissions of at least 80% compared to 2030 emissions calculated under the BAU scenario.

Table 10. Economic Indicators by Sector.

Economic Indicators by Sector				
Sector	**Indicator**	**Indicator Unit**	**Indicator Baseline**	**Indicator Target 2030**
Transport	*Reduced motorised passenger transport need*	*% reduction by 2030*		25%
	Reduced passenger kilometres by car through shift to public & non-motorised transport	*% reduction in car passenger kilometres by 2030*		25%
	Car pooling	*average passengers per car*	1.6%	1.8%
	Electrification of cars + motorbikes by 2040	*% of fleet electrified*	0%	50%
	Electrification of buses	*% of fleet electrified*	0%	56%
	Optimisation of trucking logistics - light duty trucks (< 3.5 t)	*average utilisation of maximum load weight for light duty trucks (< 3.5t)*	30%	37%
	Optimisation of trucking logistics - heavy duty trucks (> 3.5 t)	*average utilisation of maximum load weight for heavy duty trucks (< 3.5t)*	40%	60%
	Electrification of light duty trucks <3.5 t by 2030	*% of fleet electrified*	0%	60%
	Electrification of heavy duty trucks <3.5 t by 2030	*% of fleet electrified*	0%	50%
Buildings & Heating	*Building renovation (envelope)*	*% annual renovation rate*	1.0%	3.8%
	New buildings built to top performing standard	*% of buildings built to the top standard*	1%	60%
	Efficient lighting and appliances	*% annual renovation rate*	1.0%	3.8%
	Heating technologies	*share of heating as district heating*	55%	55%
	Decarbonising district heating	*share of district heating produced using fossil fuels*	96%	40%

	Decarbonizing district heating	*share of district heating produced using electric heat pumps*	0%	60%
	Decarbonising district heating	*share of district heating produced using bio fuels*	4%	0%
	Heating technologies	*share of heating as local heating*	45%	45%
	Decarbonising local heating	*share of local heating produced using fossil fuels*	100%	20%
	Decarbonising local heating	*share of local heating produced using electric heat pumps*	0%	80%
	Decarbonising local heating	*share of local heating produced using bio fuels*	0%	0%
Electricity	*Renewable/fossil fuel electricity production*	*share of electricity produced using fossil fuels*	99%	20%
Waste	*Paper recycling*	*% recycling rate*	67%	80%
	Metal recycling	*% recycling rate*	59%	80%
	Plastic recycling	*% recycling rate*	40%	80%
	Glass recycling	*% recycling rate*	45%	80%
	Organic recycling	*% recycling rate*	31%	100%

The economic model, based on inputted contemporary data from recent years, forecasts emissions in 2030 according to the so-called BAU scenario. Therefore, the emission reductions in this case do not relate to a reduction in values relative to a base year as close as possible to the present day and the values obtained from the emission inventories held, but relate to estimated emissions in 2030. In the case of Wroclaw, this estimate of emissions in 2030 will be higher than the emissions from the adopted base year 2022 by 909,862 t CO_2e, i.e. by approximately 16%. According to the economic model, emissions in 2019 were 5,036,733 t CO_2e i.e. higher than those from the GHG inventory by 455,595 t CO_2e (9%). According to the economic model, the total emission reduction will be 4,399,000 t CO_2e and the residual emissions will remain at 1,092,000 t CO_2e.

Table 11. Emissions Gap (kt CO_2e)

Emissions Gap (kt CO2e)									
	Baseline Emissions (BAU 2030)	**Emissions Reduction Resulting from CNAP**		**Remaining Emissions**		**Residual Emissions Offsetting[1]**		**Emissions Gap (amount necessary to achieve net-zero)**	
	(Absolute value)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)
Transport	1,196	766	64%	429	36%	429	36%	0	0%
Buildings & Heating	1,324	1,266	96%	59	4%	59	4%	0	0%
Electricity	2,222	1,778	80%	444	20%	444	20%	0	0%
Waste	65	42	66%	22	34%	22	34%	0	0%
Other (incl. IPPU & AFOLU)[2]	683	546	80%	137	20%	137	20%	0	0%
Total	**5,491**	**4,399**	**80%**	**1,092**	**20%**	**1,092**	**20%**	**0**	**0%**

[1] Residual emissions consist of those emissions which can't be reduced through climate action and are being offset. Residual emissions may amount to a maximum of 20 % as stated by the Mission Info Kit.

[2] Emissions reduction target percentage for "Other" sector is assumed to be the same as for the other 4 main sectors unless updated by city. Activities and commitments to reduce these emissions are documented in the Climate Neutrality Action Plan.

It is worth noting that in building the portfolio of actions towards emission reductions in the Action Plan, the actions indicated in the sectors included in the model were used, but referred directly to emission reductions from the baseline year 2022 based on the emission inventory. The emissions gap was also calculated for the base year inventory values (presented later in the CCC).

The use of an economic model allowed us to confirm the assumption that in order to successfully achieve an 80% reduction in greenhouse gas emissions by 2030, external stakeholders need to be involved, as the municipality is responsible for only a small fraction of city-wide emissions. The model estimates this to be around 4% of direct emissions and another few percent as a manager of the transport infrastructure. On the basis of analyses for dozens of European cities that have used the economic model, this share of emissions directly dependent on the magistrate is assumed to be in the order of 7-10% of global greenhouse gas emissions from the city area.

Table 12. Capital Planning by Stakeholder - Total Investment-CAPEX (Cash Basis MEUR 2020-2030)

Capital Planning by Stakeholder - Total Investment-CAPEX (Cash Basis MEUR 2020-2030)							
Sector	**Subsector**	**Citizens**	**Businesses**	**City**	**Tranport Operators**	**Utilities**	**Total**
Transport	*Reduced motorised passenger transport need*	EUR -	EUR -	EUR -	EUR -	EUR -	EUR -
	Shift to public & non-motorised transport	EUR 66	EUR -	EUR 30	EUR 425	EUR -	EUR 521

	Increased car pooling	EUR -	EUR -	EUR -	EUR -	EUR -	EUR -
	Electrification of cars + motorbikes	EUR 137	EUR 42	EUR 4	EUR -	EUR -	EUR 184
	Electrification of buses	EUR -	EUR -	EUR -	EUR 15	EUR -	EUR 15
	Optimised logistics	EUR -	EUR -	EUR -	EUR -	EUR -	EUR -
	Electrification of trucks	EUR -	EUR 53	EUR 8	EUR 394	EUR -	EUR 454
Buildings & Heating	*Building renovations (envelope)*	EUR 911	EUR 325	EUR 65	EUR -	EUR -	EUR 1,302
	New energy-efficient buildings	EUR 48	EUR 97	EUR 16	EUR -	EUR -	162
	Efficient lighting & appliances	EUR 256	EUR 91	EUR 18	EUR -	EUR -	EUR 366
	Decarbonising heating generation	EUR 214	EUR 76	EUR 2	EUR -	EUR 52	EUR 240
Electricity	*Decarbonising electricity generation*	EUR 1,154	EUR 412	EUR 82	EUR -	EUR 543	EUR 2,191
Waste	*Increased waste recycling*	EUR -	EUR -	EUR 1	EUR -	EUR -	EUR 1
TOTAL		**EUR 2,786**	**EUR 1,097**	**EUR 225**	**EUR 834**	**EUR 491**	**EUR 5,433**
% of Total		**51%**	**20%**	**4%**	**15%**	**9%**	**100%**

2.2 Module A-2 Current Policies and Strategies Assessment

Table 13. List of relevant policies, strategies and regulations (Municipality of Wroclaw).

A-2.1: List of relevant policies, strategies and regulations	
Name	**Description & Relevance**
Local level	
Sustainable energy and climate action plan (2019)	Aims to reduce carbon emissions and promote renewable energy use in Wroclaw, essential for achieving climate neutrality by 2050.
Updating the assumptions to the plan for supply of heat, electricity and gaseous fuels in the area of City of	Ensures energy supply plans align with climate goals, focusing on sustainable heat, electricity, and fuel sources

Wroclaw (2019)	to reduce emissions.
Sustainable urban mobility plan - SUMP (2019)	Focuses on improving transportation efficiency and reducing emissions from transport, crucial for achieving sustainable urban development and climate goals.
Bicycle Policy of Wroclaw (2010)	The policy's assumptions provide for the promotion of an efficient and clean form of transportation, such as the bicycle, which is expected to become an alternative means of transportation in the city.
Wroclaw mobility policy (2013)	Specific policies and initiatives to promote sustainable transport modes, aiming to reduce traffic congestion and air pollution in Wroclaw.
Wroclaw strategy for the development of electromobility (2020)	Aims to promote the adoption of electric vehicles and charging infrastructure, reducing emissions from the transport sector in Wroclaw.
The Sustainable Development Plan for Public Mass Transport in Wroclaw (2022)	Focuses on enhancing the efficiency and sustainability of public transport systems, reducing reliance on private vehicles and lowering emissions.
Plan for Cycling Actions until 2030 (2022)	Promotes cycling as a sustainable mode of transport, aiming to increase cycling infrastructure and reduce carbon emissions from urban transport.
The Wroclaw Tram Programme for the years 2024-2032 (2022)	Focuses on expanding and modernising tram infrastructure, aiming to reduce traffic congestion and emissions in Wroclaw.
Resolution[13] regarding the introduction of restrictions and prohibitions on the operation of installations involving fuel combustion within the Municipality of Wroclaw (2017)	Introduces restrictions on fuel combustion installations in Wroclaw, crucial for improving air quality and reducing emissions.
Position[14] of the Wroclaw City Council regarding the climate emergency (2019)	Addresses urgent climate issues and outlines measures to mitigate climate change impacts in Wroclaw.
Climate Change Adaptation Plan (2019)	Plans and strategies to adapt to climate change impacts, ensuring resilience and sustainability in Wroclaw's development.
Environmental Protection Programme for years 2021-2025, with perspective to 2030 (2021)	Focuses on protecting the environment and reducing pollution in Wroclaw, contributing to climate goals and sustainability.
Wroclaw City Strategy by 2030 (2018)	Sets long-term development goals and strategies for sustainable growth and climate action in Wroclaw by 2030. New strategy is under development with perspective by 2050, issues related to climate neutrality and energy security have been given a very high priority and elevated

[13] Resolution No. XLI/1405/17 of the Lower Silesian Voivodeship Assembly dated November 30, 2017, regarding the introduction of restrictions and prohibitions on the operation of installations involving fuel combustion within the Municipality of Wroclaw

[14] Position No. XIV/4/19 of the Wroclaw City Council dated October 17, 2019, regarding the climate emergency

	to the level of strategic goals, which will mean the need to monitor the progress of implementation of the set objectives on an annual basis.
City Masterplan (2018)	Guides spatial and urban development in Wroclaw, integrating sustainability principles and climate considerations into urban planning. There is new document under development – General Plan that will replace City Masterplan
Resolution[15] regarding the principles of granting targeted subsidies to individuals for tasks aimed at improving energy efficiency through the replacement of external windows (2024)	Provides subsidies for improving energy efficiency through window replacements, contributing to reduced energy consumption and emissions.
Resolution[16] regarding the principles of granting targeted subsidies for tasks aimed at air protection, involving the permanent change from solid fuel-based heating to low-emission heating (2024)	Provides subsidies to transition from solid fuel-based heating to low-emission heating, crucial for reducing local air pollution and emissions.
Resolution[17] regarding the principles of granting targeted subsidies for tasks involving the installation of systems utilising renewable energy sources for electricity generation and energy storage systems (2024)	Provides subsidies for renewable energy systems, promoting clean energy generation and reducing reliance on fossil fuels in Wroclaw.
Resolution[18] regarding exemptions from property tax for buildings or their parts connected to photovoltaic installations, solar collectors, heat pumps, heat recovery systems, or ground heat exchangers (2024)	Grants tax exemptions for properties with renewable energy installations, incentivising green energy adoption and reducing carbon footprint.
Resolution[19] regarding exemptions from property tax for usable area of residential premises within the framework of intensifying the creation of green areas within the City of	Grants tax exemptions for residential properties to intensify green space creation, enhancing urban greenery and climate resilience.

[15] Resolution No. LXXX/2093/24 of the Wroclaw City Council dated April 18, 2024, regarding the principles of granting targeted subsidies to individuals for tasks aimed at improving energy efficiency through the replacement of external windows

[16] Resolution No. LXXX/2092/24 of the Wroclaw City Council dated April 18, 2024, regarding the principles of granting targeted subsidies for tasks aimed at air protection, involving the permanent change from solid fuel-based heating to low-emission heating

[17] Resolution No. LXXX/2095/24 of the Wroclaw City Council dated April 18, 2024, regarding the principles of granting targeted subsidies for tasks involving the installation of systems utilising renewable energy sources for electricity generation and energy storage systems.

[18] Resolution No. III/8/24 of the Wroclaw City Council dated June 6, 2024, regarding exemptions from property tax for buildings or their parts connected to photovoltaic installations, solar collectors, heat pumps, heat recovery systems, or ground heat exchangers

[19] Resolution No. XLVI/1192/21 of the Wroclaw City Council dated November 25, 2021, regarding exemptions from property tax for usable area of residential premises within the framework of intensifying the creation of green areas within the City of Wroclaw

Wroclaw (2021)	
The Strategy for Managing Stormwater and Meltwater in Wroclaw (2023)	Manages stormwater and meltwater to reduce flood risks and improve water quality in Wroclaw, crucial for climate resilience and sustainable water management.
Masterplan for the City Centre (2021)	Guides sustainable development and urban planning in Wroclaw's city centre, integrating green infrastructure and reducing urban heat island effect.
Roadmap to achieving climate neutrality by 2030, with perspective to 2050 (in preparation)	The document is intended to systematically present a diagnosis of the current situation and needs of Wroclaw in the area of climate transformation, and then, in response to these needs, present specific action plans with the identification of risks and barriers, taking into account reduction scenarios up to 2030 with perspective to 2050.
Subregional level	
Low-Emission Economy Plan for Integrated Territorial Investments of the Wroclaw Urban Functional Area (2015)	This plan outlines strategies to transition the Wroclaw Functional Area to a low-emission economy through integrated territorial investments. It focuses on reducing carbon emissions, promoting renewable energy, and enhancing energy efficiency across the functional area. Crucial for achieving regional climate goals and sustainability targets.
Sustainable Mobility Plan for the Wroclaw Urban Functional Area (2022)	Aims to improve transportation efficiency, reduce traffic congestion, and lower emissions within the Wroclaw Functional Urban Area. The plan emphasises sustainable transport modes such as public transit, cycling, and walking, contributing to enhanced urban mobility and reduced environmental impact. Essential for promoting sustainable urban development and achieving climate neutrality objectives.
Integrated Territorial Investment Strategy of the Wroclaw Functional Area for 2021-2027 (2023)	This strategy outlines priority areas and investment projects aimed at sustainable development and economic growth within the Wroclaw Functional Area from 2021 to 2027. It integrates environmental sustainability, climate resilience, and socio-economic development goals, guiding strategic investments to enhance infrastructure, energy efficiency, and environmental quality. Crucial for fostering integrated and sustainable territorial development aligned with regional and EU policies.
Regional level	
Energy strategy of Lower Silesia - directions of support for the energy sector (2022)	This strategy outlines the priorities and measures to support the energy sector in Lower Silesia. It focuses on promoting renewable energy sources, improving energy efficiency, and reducing carbon emissions. Crucial for achieving regional energy security, sustainability, and climate goals.

Transport infrastructure development plan in the Lower Silesian Voivodeship with a perspective until 2030 (2023)	The plan details investments and developments in transport infrastructure across Lower Silesia until 2030. It aims to enhance connectivity, reduce transport emissions, and improve mobility efficiency. Essential for sustainable regional development and meeting EU transport and climate targets.
Development Strategy of the Lower Silesian Voivodeship 2030 (2023)	Sets out long-term goals and development priorities for Lower Silesia until 2030. It integrates economic, social, and environmental objectives, guiding policy and investment decisions to foster sustainable growth and improve quality of life.
Resolution[20] regarding the introduction of restrictions and prohibitions on the operation of installations involving fuel combustion within the spa areas of the Lower Silesian Voivodeship (2017)	Introduces restrictions and prohibitions on fuel combustion installations within spa areas of Lower Silesia, aiming to protect air quality and environment, supporting regional environmental and health goals.
Voivodeship Environmental Protection Programme for the years 2022-2025 with a perspective until 2029 (2022)	Outlines environmental protection measures and priorities in Lower Silesia from 2022 to 2025, with a perspective until 2029. It addresses pollution reduction, conservation efforts, and sustainable resource management, contributing to regional sustainability and climate resilience.
Spatial development plan of the Lower Silesian Voivodeship (2020)	Guides spatial and urban development in Lower Silesia, balancing economic growth with environmental and social considerations. It promotes sustainable land use, infrastructure development, and spatial planning aligned with regional development goals and EU policies.
Climate neutrality action plan for the Lower Silesian Voivodship (2024)	The study aims to integrate the activities carried out in the region and take into account all areas in which local governments (both regional and local) can influence the achievement of the overarching policy objective of the Lower Silesian Voivodship, as set out in the 'Energy Strategy for Lower Silesia', which is to achieve the region's climate neutrality by 2050.
National level	
Strategy for Responsible Development to 2020 (with an outlook to 2030) (2017)	Sets out socio-economic development goals for Poland, integrating environmental sustainability and climate action. It guides policy decisions to achieve sustainable growth, improve resource efficiency, and reduce environmental impact.

[20] Resolution No. XLI/1406/17 of the Lower Silesian Voivodeship Assembly dated November 30, 2017, regarding the introduction of restrictions and prohibitions on the operation of installations involving fuel combustion within the spa areas of the Lower Silesian Voivodeship

Poland's energy policy until 2040	Provides a framework for Poland's energy sector development until 2040, focusing on energy security, diversification, and sustainability. It promotes renewable energy sources, energy efficiency improvements, and modernisation of energy infrastructure to align with EU and global energy trends.
National energy and climate plan for 2021-2030 (2019)	Outlines Poland's commitments and measures to achieve EU climate and energy targets for 2030. It includes plans for reducing greenhouse gas emissions, increasing renewable energy share, and enhancing energy efficiency across sectors.
Strategy for heating until 2030 with a perspective until 2040 (ongoing)	Sets goals and actions for improving the efficiency and sustainability of heating systems in Poland. It promotes modernisation of heating infrastructure, deployment of low-emission technologies, and reducing reliance on fossil fuels in heating.
National Urban Policy 2030 (2022)	Guides urban development policies in Poland towards sustainable, inclusive, and resilient cities. It promotes integrated urban planning, efficient land use, and sustainable infrastructure development to enhance quality of life and reduce environmental impact in urban areas.
Sustainable Transport Development Strategy until 2030 (2019)	Aims to improve transport efficiency, reduce emissions, and promote sustainable transport modes in Poland. It focuses on enhancing public transport, developing cycling infrastructure, and reducing dependency on private vehicles to achieve climate and environmental goals.
Polish Hydrogen Strategy until 2030 with a perspective towards 2040 (2021)	Sets out Poland's roadmap for developing hydrogen as a clean energy carrier. It promotes investments in hydrogen production, infrastructure, and research to support decarbonisation efforts in industry, transport, and energy sectors.
National Environmental Policy 2030 (2022)	Defines Poland's environmental protection priorities and strategies until 2030. It addresses air, water, and soil quality, biodiversity conservation, and sustainable use of natural resources, aiming to achieve environmental sustainability and resilience to climate change impacts.
Strategic adaptation plan for sectors and areas sensitive to climate change until 2020 with a perspective until 2030 (2013)	Focuses on adapting key sectors and vulnerable areas in Poland to climate change impacts. It includes measures for water management, agriculture, forestry, and infrastructure resilience, aiming to reduce climate vulnerability and enhance adaptive capacity.
Long-Term Building Renovation Strategy (2022)	Sets objectives and measures to improve energy efficiency and sustainability of buildings in Poland. It promotes renovation of existing building stock to reduce energy consumption, lower emissions, and enhance

	indoor comfort and health.
National Recovery and Resilience Plan	Details investments and reforms funded through EU recovery funds to support Poland's economic recovery and resilience post-COVID-19. It includes measures for green transition, digital transformation, and social resilience, aligning with EU's green and digital priorities.
EU level	
European Green Deal EU	Comprehensive plan by the EU to make the EU's economy sustainable by addressing climate change, biodiversity loss, and pollution. It aims to achieve climate neutrality by 2050 and promotes green technologies and investments across sectors.
European Climate Pact	Initiative to engage EU citizens, communities, and organisations in climate action and sustainability efforts. It fosters collaboration, knowledge-sharing, and commitments to reduce emissions and adapt to climate change impacts. Crucial for mobilising societal support and participation in achieving EU climate goals.
EU Covenant of Mayors for Climate & Energy	Network of local authorities committed to implementing EU climate and energy objectives. It promotes sustainable energy policies, climate adaptation measures, and local climate action plans, contributing to EU's climate and energy targets at the local level.
The package "Fit for 55"	Legislative package aimed at reducing EU greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. It includes revisions to various EU directives and regulations to promote energy efficiency, renewable energy use, and emission reductions across sectors.
Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings	EU directive setting out requirements for improving the energy performance of buildings. It promotes energy efficiency measures, renewable energy use in buildings, and contributes to reducing energy consumption and emissions in the building sector.
EU Biodiversity Strategy for 2030	Strategy to halt biodiversity loss and restore ecosystems across the EU by 2030. It aims to protect and restore biodiversity, promote nature-based solutions, and ensure sustainable use of natural resources, contributing to climate resilience and sustainability.
EU energy policy	Framework guiding EU's energy transition towards a secure, sustainable, and affordable energy system. It promotes renewable energy deployment, energy efficiency improvements, and innovation in clean technologies to reduce greenhouse gas emissions and

	enhance energy security.
REPowerEU	Initiative to accelerate the deployment of renewable energy across the EU, aiming for 40% of EU energy consumption to come from renewable sources by 2030. It supports investments in renewable energy projects and infrastructure, contributing to EU's climate and energy goals.

A-2.1: Description & assessment of policies

Impact of policies and legislation on climate neutrality

Policies at both local and national level, as well as some regulations, have to some extent a decisive influence on the dynamics of emission reduction activities. Policies and regulations are the basis for the subsequent creation of detailed operational documents (plans, programmes) and support programmes from municipal, national and European funds. Policies and regulations allow targets to be clearly defined and can significantly accelerate their implementation, but they are no substitute for action.

A good example is the legislation regulating the installation of renewable energy sources on private buildings - when legislation was introduced to benefit prosumers, around 7 000 prosumers' installations were set up in Wroclaw in a short period of time, additionally supported by tax exemptions offered by the city. However, in the last year the regulations were changed to be less favourable for prosumers and this resulted in a slowdown in the creation of further installations. Obviously, these changes were aimed at protecting the stability of transmission networks unprepared for such a development of distributed sources, but this has had a negative impact on the growth of renewable energy capacity.

The situation is similar with aid programmes - as long as they are grant-based, they are willingly used by residents (sometimes overly complicated procedures or restrictive criteria for awarding grants can be a barrier). However, in the case of repayable instruments (such as loans, credits), interest decreases significantly. From the local government's point of view, the limitation is the regulations on budget discipline or public procurement law, which often restrict the possibility of quick investment activities.

At this stage, it seems that strategic and regulatory actions in the field of energy decarbonisation, but also in the field of energy efficiency of buildings, which will reduce significant energy consumption in buildings and thus also energy costs for residents, are crucial. In addition, regulations and policies and even sector-specific strategies are needed - heating, energy, mobility, building renovation. The policies and regulations at city, regional and national level outlined above partly respond to these challenges, but require bolder targets as well as consistent implementation and funding.

Assessment of all level policies impacting Wroclaw's Climate Neutrality Ambition

Achieving climate neutrality by 2030 necessitates a comprehensive assessment of the impact and effectiveness of policies across all levels — local, regional, national, and European. These policies collectively focus on enhancing energy efficiency, promoting sustainable transport, transitioning to low-emission heating systems, and stimulating innovation in low-carbon technologies. By incentivising change and ensuring policy integration and alignment, these policies aim to significantly reduce greenhouse gas emissions. However, the path to climate neutrality is fraught with challenges that require continuous adaptation and long-term investment.

Furthermore, actions at the local level must be supported by regulations at the national and regional level that enable the implementation of energy efficiency of buildings (Building Act), facilitate investment in renewable energy sources (RES Act and policy documents), provide incentives for rapid energy decarbonisation (Energy Act and other energy regulations), contribute to the development of sustainable transport and support the NBS (Spatial Planning Law and other regulations).

Impact and Effectiveness

- **Expected Emission Reductions:** Collectively, all level policies are expected to lead to significant reductions in greenhouse gas emissions by 2030. The focus on energy efficiency improvements in buildings, promotion of sustainable transport modes, and transition to low-emission heating systems will contribute to achieving emission reduction targets.
- **Incentivising Change:** Financial incentives and subsidies for energy-efficient technologies and low-emission heating systems encourage residents and businesses to adopt sustainable practices. This approach facilitates behavioural change and accelerates the transition to a low-carbon economy.
- **Stimulating Innovation:** EU policies stimulate innovation and investment in low-carbon technologies and practices through funding mechanisms and regulatory incentives. This approach accelerates the transition to a sustainable and resilient economy while enhancing competitiveness and job creation.

Integration and Alignment

- **Policy Integration:** EU policies are aligned with international climate agreements such as the Paris Agreement, ensuring coherence and global leadership in climate action. They provide a harmonised framework that enables member states to collaborate effectively and share best practices in achieving climate neutrality. All level policies are well-integrated into Wroclaw's overall urban development and sustainability strategies. They align with national and EU-level climate targets, ensuring coherence and synergy in climate action efforts.
- **Monitoring and Adaptation:** Continuous monitoring and evaluation of policy effectiveness are crucial. Regular reviews allow for adjustments based on evolving technologies, economic conditions, and emerging environmental challenges.

Challenges and Considerations

- **Implementation Challenges:** Implementation of all level policies may face challenges such as funding constraints, regulatory complexities, and public acceptance. Addressing these challenges will require collaboration with stakeholders and effective communication of benefits.
- **Long-Term Sustainability:** Ensuring the long-term sustainability of emission reductions will require ongoing investment in renewable energy infrastructure, technology innovation, and capacity building.

Summary

In summary, the policies at all levels are crucial for steering Wroclaw towards its 2030 climate neutrality ambition. They are expected to drive substantial emission reductions through energy efficiency improvements, sustainable transport initiatives, and the adoption of low-emission technologies. Financial incentives and subsidies play a key role in facilitating this transition, while EU policies stimulate innovation and investment. Ensuring the alignment of these policies with international climate goals provides coherence and strengthens the collective effort. Despite the challenges in implementation and the need for sustained investment, these policies form a robust framework for Wroclaw to achieve its climate goals and contribute to a sustainable and resilient future.

A-2.3: Emissions gap

Achieving climate neutrality by 2030 requires a meticulous assessment of current emissions reduction efforts and the identification of additional measures necessary to bridge the emissions gap. In the context of Wroclaw, this gap refers to the difference between the city's current trajectory of emissions reductions outlined in its Sustainable Energy and Climate Action Plan (SECAP) and the level of reductions needed to meet the ambitious climate neutrality target.

Importance of Quantifying the Emissions Gap

Quantifying the emissions gap is crucial for several reasons:

- **Strategic Planning:** It provides a clear understanding of how far Wroclaw is from achieving climate neutrality by 2030 and guides the development of targeted strategies and policies.
- **Resource Allocation:** Helps prioritise investments and allocate resources effectively towards high-impact mitigation actions.
- **Policy Alignment:** Ensures that new measures proposed in the Action Plan are aligned with the specific emissions reduction goals needed to close the gap.

SECAP as a Baseline

The SECAP serves as a foundational document outlining Wroclaw's current efforts and commitments to reduce greenhouse gas emissions. It includes measures across sectors such as energy, transport, buildings, and waste management, aiming to achieve substantial reductions by 2030. The current SECAP sets the following reduction levels: by 20% by 2020, by 40% by 2030 and by 80% by 2050. However, the actions included in this programme only apply to the time horizon up to 2030. The actions planned in the SECAP should result in greenhouse gas reductions of 21% compared to the base year (in the SECAP it was 1990 - for the Action Plan it was 2022 - fortunately these values are not significantly different). However, to achieve climate neutrality, additional actions beyond those outlined in the SECAP may be required. This is all the more so because, as the emission inventories indicate, the first of the targets, a 20% reduction in 2020 compared to the base year (1990), has not been achieved.

Addressing the Emissions Gap in the Action Plan

The forthcoming Action Plan for Wroclaw will outline specific actions and policies designed to bridge the emissions gap identified through quantitative analysis. These actions will build upon existing initiatives while introducing new measures to accelerate emission reductions across the city.

The table below shows the calculation of the emissions gap taking into account the measures from SECAP. Due to the different mix of measures in SECAP, reductions from heat and power production have been added to the buildings sector in the table as this is where they are mainly consumed. The actions identified in the SECAP are dominated by reductions related to the buildings sector and heat and power production. It covers very little of the reductions from the transport or industry sectors, and does not address waste and water and wastewater management measures at all.

Of course, some of the actions in the SECAP are long term and will therefore also be part of the current action plan. It has been assumed that the actions in the action plan are counted separately from the actions from the SECAP, therefore only the reductions resulting from the action plan will be included in column 5, and together with the reductions from the existing SECAP will give the expected result of reducing greenhouse gas emissions by up to 80 per cent from the base year 2022.

In the case of emission reductions for the 2022 base year (based on the inventory), the total emission reduction should be 3,664,911 t CO2e and the residual emissions will remain at 916,228 t CO2e. In

contrast, the Climate Contract Action Plan should include emission reductions of at least 2,716,043 t CO2e to achieve the assumed reduction rate of 80% relative to the base year. In showing the emissions gap, it was assumed that the emission reductions would be distributed evenly for each sector. However, the following section shows some deviations from this assumption due to the possible interventions in each sector and their reduction potential.

Quantifying the emissions gap between current efforts outlined in the SECAP and the required reductions for climate neutrality provides a roadmap for strategic climate action planning in Wroclaw. By identifying and addressing this gap through targeted policies and investments, Wroclaw can progress towards its ambitious climate goals and contribute to global efforts in combating climate change.

The table shows the emissions in the base year 2022, the reduction target set in the Mission, i.e. an 80% reduction in CO2e emissions, the emissions on the basis of the existing SECAP, the emissions remaining to be reduced under the AP and the residual emissions, i.e. 20%. Column 4 shows the emissions by sector that should be reduced as a result of the actions proposed in the Action Plan. The actual, estimated values of emission reductions by sector in relation to the identified emissions gap are given in the table on page 91-92 in module 3.1 presenting the actions planned to be carried out.

Table 14. Emission gap based od existing policies

	(1) Baseline emissions	(2) Emissions Reduction Target 2030		(3) Emission reduction through other Action Plans (SECAP)		(4) Emissions Gap		(5) Emissions reduction through the CCC Action Plan to address the Gap		(6) Residual emissions	
	Baseline emissions (ideally not older than 2018) - referring to the inventory used for target setting	The emissions reduction target for 2030 ideally achieves a minimum 80% reduction from the baseline, as reported in Section 2 of the Commitments document of the CCC. The overall target should be absolute or net-zero (i.e. including the compensation of any residual emissions).		These are the emissions reductions that would be achieved through existing policies, and plans, outlined in Section A-2.1. Those actions are by definition not part of the action portfolio in section B. If they are fully or partially incorporated in module B-2, their associated reduction potential should be referenced in column (5) and not be included here. WARNING if the baseline is a BAU scenario: If the BAU modelling includes any of these existing measures, please also do not include the associated emissions reduction in this column as otherwise it would be double counted.		(4) = (2) – (3)		This column is used to present the already quantified emission reduction associated with the action portfolios outlined in module B-2. Ideally, this equals the gap. If the there is a difference between the reduction potential of the actions specified in module B-2 (for instance because their reduction potential has not been fully estimated or because additional measures will be identified in future iterations), the CCC AP should be explicit about this difference and explain how the difference will be closed. In principle, as long as the difference has not been addressed, it would be considered as part of the residual emissions.		(6) = (1) – (2)	
	(absolute) (t CO2e)	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**
Buildings/Heating/Electricity	2,478,830	1,983,064	80	728,715	29	**1,254,349**	51			495,766	20
Transport	1,483,345	1,186,676	80	137,438	9	**1,049,238**	71			296,669	20
Waste / water and sewage management	24,595	19,676	80	-	0	**19,676**	80			4,919	20

Industrial Process and Product Use (IPPU)	591,091	472,873	80	80,559	14	**392,314**	66			118,218	20
Agricultural, Forestry and Land Use (AFOLU)	3,277*	2,622	80	2,156	66	**466**	34			655	20
Total	**4,581,138**	**3,664,911**	**80**	**948,868**	**21**	**2,716,043**	**79**			**916,228**	**20**

* in addition to the emissions, the inventory also shows the beneficial effect of reducing emissions through greenery in the AFOLU sector. According to calculations from the inventory, greenery in the city absorbs approximately 8,830 t CO2e therefore the actual total emissions are 4,572,308 t. CO2e.

Residual emissions

With respect to residual greenhouse gas emissions, a value of 20% was assumed due to the relatively short time for potential investments and the relatively high level of baseline emissions. Unfortunately, the challenge faced by Wroclaw is significantly greater than in some of the mission cities, which is largely due to national conditions (energy mix), but also the state of the building stock in the city area (very high proportion of old buildings), or the way individual buildings are supplied with heat (ongoing process of replacing coal-fired heat sources). Simulations carried out using an economic model indicate that a key action to achieve climate neutrality is to change the way electricity and heat are produced (switching to renewable sources as much as possible). As this is mainly dependent on state-owned companies, action in this regard concerns the national level and ambitious decarbonisation plans at government level. For the time being, national plans indicate a 50% share of renewables in electricity generation and 32% in heat generation. These values are insufficient to achieve more ambitious reduction targets than 80%.

Emission gap based on an economic model

As part of our work on the climate contract, we also used an economic model to calculate the emissions gap using the BAU2030 scenario. The economic model, based on the inputted contemporary data from recent years and current emission factors (the data used in the model calculation can be found in Table 10), forecasts the emissions in 2030 according to the so-called BAU scenario. Therefore, the emission reductions shown in this case do not relate to a reduction in values from the base year, as close as possible to the present time and the values obtained from the available emission inventories, but relate to estimated emissions in 2030. In the case of Wroclaw, this estimated emission in 2030, according to the BAU scenario, will be higher than the emissions from the adopted base year by 909 862 t CO_2e, i.e. by approximately 16%. According to the economic model, emissions in 2019 were 5,036,733 t CO_2e i.e. higher than those from the GHG emissions inventory by 455,595 t CO_2e (9%). According to the economic model, the total emission reduction should be 4,399,000 t CO_2e, with residual emissions of 1,092,000 t CO_2e.

Table 15. Emissions Gap (kt CO_2e) based on economic model.

Emissions Gap (kt CO_2e)									
	Baseline Emissions (BAU 2030)	**Emissions Reduction Resulting from CNAP**		**Remaining Emissions**		**Residual Emissions Offsetting[1]**		**Emissions Gap (amount necessary to achieve net-zero)**	
	(Absolute value)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)	(Absolute value)	(% of BAU 2030)
Transport	1,196	**766**	64%	429	36%	429	36%	0	0%
Buildings & Heating	1,324	**1,266**	96%	59	4%	59	4%	0	0%
Electricity	2,222	**1,778**	80%	444	20%	444	20%	0	0%
Waste	65	**42**	66%	22	34%	22	34%	0	0%
Other (incl. IPPU & AFOLU)[2]	683	**546**	80%	137	20%	137	20%	0	0%
Total	**5,491**	**4,399**	**80%**	**1,092**	**20%**	**1,092**	**20%**	**0**	**0%**

The economic model indicates differentiated emission reductions across sectors, in particular high potential for emission reductions in the building and heating sector and electricity generation. Lower reductions are achievable in the transport and utilities sectors. It is worth noting that such significant reductions will be possible with the assumption that as much as 80% of electricity will come from renewable sources. This is significantly higher than the current plans contained in national documents (mainly the National Energy and Climate Plan to 2030 (In 2019 update of the Plan) - draft of 29.02.2024 - sent to the European Commission in March).

2.3 Module A-3 Systemic Barriers and Opportunities to 2030 Climate Neutrality

A-3.1: Description of urban systems, systemic barriers, and opportunities

Based on the inventory, it can be clearly stated that Decarbonisation of electricity and heat production for buildings and transport will be crucial for the city's climate transformation. These two main sectors (buildings/stationary energy and transport) generate over 86.5% of emissions. To achieve significant reductions, efforts must be focused on these areas. Both in the case of Decarbonisation of the construction and energy production sectors, as well as in the transport sector, actions must go at least in two directions.

Firstly, and most importantly, the method of producing electricity and heat to power buildings and transport must change. So far, the main factor of energy production, both in the national energy system and locally, are fossil fuels with high emission parameters, therefore investment activities must be aimed at the gradual elimination of fossil fuels, first of all, switching to less emission ones, and ultimately to renewable or emission-free ones. Support for renewable energy sources is also necessary in this sector. This means encouraging entrepreneurs and residents to invest in renewable energy sources, such as photovoltaic panels or wind turbines, which will help reduce emissions related to energy production at the local level.

The second important element of this process is reducing energy consumption. In the case of construction, this will concern thermal modernisation of the building fabric in order to reduce the demand for energy, especially heat. This is also particularly important in the context of reducing energy poverty. Changes in the heating and electricity production sectors result in an increase in energy prices, which translates directly into the quality of life of residents. The vast majority of the city's housing requires renovation in terms of thermal modernisation, both in municipal and private resources, as well as in relation to public buildings. Investing in projects to improve the energy efficiency of public and private buildings can deliver significant benefits in terms of both emissions reductions and maintenance cost savings.

In the case of the transport sector, the transition to electric vehicles will involve an increase in demand for electricity or energy produced from emission-free sources (e.g. hydrogen cells). This means a potential increase in emissions if it is largely produced using fossil fuels. Therefore, the development of electromobility and its positive impact on emission reductions in Wroclaw will only be possible if the energy mix changes at the national level, supported by the development of renewable sources at the local or even individual level (electric cars as energy storage for individual photovoltaics). Again, this must be linked to an increase in the share of non-vehicular transport so as to reduce this demand. The best effects in terms of emission reduction are achieved by changing the modal split to one where the share of individual transport is significantly reduced in favor of public transport. That is why the city has been taking steps to develop and promote public transport for years. Due to the significant

share of transport in emissions, investments are and will be continued in the expansion and modernisation of public transport, promoting its use and limiting individual car transport.

An important element of the energy transformation is education and involvement of local communities. This involves building awareness among residents about the importance of reducing emissions and how they can get involved. This may turn out to be crucial for the success of the activities, because, as analyzes show, private owners are mostly responsible for reducing emissions. Administrative action alone at the national, local and city levels will not be enough. Cooperation with external partners, such as non-governmental organisations, academic institutions or enterprises, can contribute to the exchange of knowledge and experiences and joint implementation of projects.

Stakeholder involvement should also apply to the entrepreneurial sector, therefore it is necessary to introduce incentive programmes for enterprises that invest in environmentally friendly technologies, which can accelerate the transformation of the industrial sector. Wroclaw is a large academic center, but also a smart up center, so it has the potential to be a leader in new Decarbonisation technologies. It is worth mentioning that Saule Technologies is a company based in Wroclaw that produces highly efficient photovoltaic cells made of perovskites.

Stakeholders are a broad and diverse group due to their power of influence and willingness to be directly involved in energy transition activities. Collaboration with stakeholders was built within the Transition Team. The stakeholder selection process focused on six main topics with the greatest impact on emissions:

- spatial development and sustainable building;
- energy (including hydrogen) and energy efficiency;
- closed loop economy;
- sustainable transport;
- blue-green infrastructure;
- social inclusion and education.

Main stakeholder categories:

Table 16. Main stakeholder categories (Own evaluation on the basis of Analiza interesariuszy. Przewodnik podsumowujący projektowanie procesu mapowania kluczowych interesariuszy w procesie miejskiej transformacji klimatycznej[21])

Public sector at national and international level:	**Public sector at provincial, district and city level:**	**Public services:**
• EU administration • ministries • fund operators at national level • national research and development centres • State companies (Polish Waters, State Forests	• voivodship offices • district offices • voivodeship conservator of monuments • fund operators at voivodship level • railway and road network managers • municipal offices and bureaus responsible for topics related to climate change • Strategy and Sustainable Development Department	• education • social welfare • culture • housing • public safety • public transport • telecommunications • energy management • Water management • Waste management • Greenery Management • Environmental protection

[21] Contractors: Fundacja Think Tank Miasto ul. Zaruby 6/22, 02-796 Warszawa thinktankmiasto.pl Joanna Mędrzecka-Stefańska Anna Wieczorek Anna Petroff-Skiba

	• Wroclaw Urban Functional Area	
Private sector: • industry (manufacturing companies and industrial parks) • services (including industry associations) • banks and financial services • large corporations • Shopping centres and large retail shops • large sports and cultural facilities (stadiums, concert halls, sports tracks, etc.) • companies with data centres, large servers • logistics companies • courier companies) • transport companies, including railways • energy, heat, gas and water suppliers • oil companies • building managers, communities, cooperatives and their associations • developers • manufacturers and suppliers of building materials and technologies • Business organisations (trade unions and associations) • Associations of small busi-nesses		**Academia:** • universities • Institute of the Polish Academy of Sciences (PAN) • research and development institutions • research stations and centres • scientists - specialists in various fields • student research clubs
Third sector: • organisations working for the protection of the environment and nature in the city • organisations promoting heritage and historical monuments • organisations promoting social or technological innovation	**Residents' representatives:** • District Councils • Local Activity Centres • Local leaders	**Media:** • **radio** • **television** • **press** • **internet portals** • **Social media groups and profiles**

• organisations promoting specialised knowledge - SARP[22], TUP[23], SAK[24] • local organisations working for the benefit of the local community		

The work on the CCC, as well as its subsequent implementation, involves continuous monitoring of progress and updating of actions. Regular stocktaking and monitoring of progress towards targets will allow actions to be adjusted in response to changing circumstances.

Main barriers and gaps identified in the city:

1. High costs and unknown scale of needs related to increasing the energy efficiency of buildings. The vast majority of emissions from the city arise from the production of energy (electricity and heat) and its consumption by buildings. According to the results of the latest GHG inventory (for 2022), in Wroclaw the dominant sector in terms of emissions is stationary energy (production of electricity and heat and its consumption by buildings), which constitutes 55% of the city's total emissions. According to current data for 2021, there are 360.2 thousand in Wroclaw. apartments with a total area of 21.2 million m^2, located in 52 thousand buildings (according to the 2021 National Census). The area of municipal buildings is approx. 1,560 thousand m^2. The average area of one apartment is 59 m^2. Residential buildings constitute over 66% of all buildings in the city. In terms of usable area, residential buildings built between 1918 and 1944 and buildings constructed between 1989 and 2002 dominate. Buildings from the first of the above-mentioned time periods often differ in their construction solutions regarding partitions and energy systems from today's standards. At the same time, some of the facilities are under conservation protection. Facilities constructed in later years, until 2002, constitute the largest group of buildings. At the same time, they are characterized by very different solutions and varying degrees of thermal modernisation. Non-residential buildings constitute approximately 33.4% of the total area of buildings in the city (approx. 10,660 thousand m^2 of usable area). The condition and energy characteristics of most of them are unknown. In Poland, the Integrated System for Reducing Low Emissions (ZONE) has recently been implemented, of which the Central Emissions Register for Buildings (CEEB) is a part, but it does not yet have enough data to estimate the scale of thermal modernisation needs for all buildings in the city. The greatest challenge to the climate transformation is posed by: buildings with unregulated ownership status, buildings in poor technical condition, buildings entered in the register of monuments or under conservation protection. Thermal modernisation of buildings is the key to achieving climate neutrality in Wroclaw. All available analyzes show that it is impossible to produce as much heat energy from renewable energy sources as is currently consumed by buildings in Wroclaw.

   Actions to take:

   a. completing data on buildings in the Integrated Low Emission Reduction System (ZONE),

   b. conducting energy audits of buildings,

[22] Polish Architects Association
[23] Society of Polish Town Planners
[24] Society of Landscape Architects

c. launching (at the EU, national and local levels) systemic financial support programmes for deep thermal modernisation of buildings and an advisory system facilitating the use of the programmes and increasing their availability.

2. **Dependence on the National Energy System (NES) and the national energy mix.** The Wroclaw local government has very limited influence on energy generation sources, which are regulated at the national level. There are energy companies operating in the city that meet 53% of the city's demand for thermal energy, are independent from the city and are not obliged to consult their development plans with the local government. The energy and heating sector in Wroclaw is based on the production of electricity and heat from fossil fuels, coal and natural gas, and partially from biomass. However, the current national energy mix is based on fossil fuels. The main fuel is coal. For example, in 2022, 66.2% of domestic heat production came from coal, and almost 16% from other fossil fuels: natural gas and fuel oil (Energy Regulatory Office - report: Thermal energy in numbers - 2022).

   Actions to take:

   a. Decarbonisation and modernisation of the national energy system,

   b. creating a local strategic partnership of the city with the main producers and suppliers of energy in the city in order to agree on joint Decarbonisation activities, including: increasing energy production from non-fossil sources (e.g. biogas), reducing energy losses on transmission networks and distribution lines, using waste energy (from industrial processes, refrigeration processes, sewage, server rooms), energy storage, increasing the sales offer of certified green energy, searching for new sources of energy supply.

3. **Limited, direct impact on the level of greenhouse gas emissions in the city.** The GHG inventory in Wroclaw shows that the share of municipal units in the emissions of the entire Wroclaw fluctuated around 10-12% (applies to emission ranges 1 and 2). This means that the vast majority of emissions are the responsibility of entities over which the local government has no direct influence.

   Actions to take:

   a. engaging the widest possible range of urban stakeholders in activities towards climate neutrality,

   b. launching (at the national, EU and local level) a broad, attractive programme of incentives (subsidies, reliefs) for residents, entrepreneurs and other municipal entities encouraging activities aimed at reducing greenhouse gases in various sectors (energy efficiency of buildings, switching to renewable energy energy sources, electromobility, etc.).

4. **Systemic barriers to the development of renewable energy sources.** The development of renewable energy sources in cities in Poland encounters many systemic barriers. These are formal and legal barriers such as: lack of stable legal regulations and long-term development strategy, which leads to investment uncertainty, the so-called "distance criterion" in the Act on investments in wind farms, which prevents the construction of windmills in densely built-up areas, the lack of legal possibilities to establish energy cooperatives in urban communes, unfavorable settlements for prosumers of electricity supplied to the National Energy System. There are also infrastructural barriers, such as restrictions for prosumers related to access to connection capacity due to the lack of appropriate infrastructure (especially in the field of transmission networks). These types of barriers discourage or even prevent investing in renewable energy. In the case of photovoltaics, they make production for self-consumption at the point of production the most profitable and it is

not profitable to produce surplus energy. In the case of wind energy, they prevent the construction of windmills in urban or suburban areas.

Actions to take:

a. legislative changes at the national level, including the reduction of the so-called "distance criterion" in the Act on investments in wind farms,

b. enabling the establishment of energy cooperatives in urban communes, a more favorable energy settlement system for prosumers,

c. creation, at the national level, of stable legal regulations and a long-term strategy for the development of renewable energy sources.

5. **Financial barriers**. Systemic transformation requires huge financial outlays that local governments cannot cover. Therefore, the most costly changes must be carried out using external funds: regional, central, EU, foreign and private. Access to current financing programmes is significantly limited by the scattering of financing programmes, complicated application procedure and rigid nature of the procedures, narrow scope of programmes (they are addressed to specific activities, comprehensive transformation activities require the use of many programmes with different application and settlement rules), lack of an appropriate number qualified staff at the Wroclaw Municipality who could process applications and implement projects, in particular statutory restrictions on local government debt, limiting the possibility of using loans.

   Actions to take:

   a. facilitating access to national and EU financing programmes by: simplifying application procedures, more comprehensive financing programmes and their modular structure enabling flexible use of various programme options, launching an advisory system supporting local governments in the process of obtaining and settling subsidies, adapting financing programmes to real needs and restrictions in EU member states.
   b. increasing the level of private capital involvement in public investments in the city by using the Public-Private Partnership (PPP) formula, the Energy Service Company (ESCO) formula, or by establishing funds dedicated to activities related to energy transformation (e.g. related to renewable energy).

6. **Unknown scale of energy poverty**. The scale of the energy poverty phenomenon is not precisely known and its proper diagnosis is not easy. This action is still being analyzed. Without detailed knowledge of the nature and scale of the phenomenon, it will be difficult to create effective support programmes.

   Key factors contributing to energy poverty are low energy efficiency in buildings, insufficient income to cover energy costs and rising energy prices. It is estimated that approximately 12% of the population in Poland is affected by this phenomenon. In Wroclaw, energy poverty is exacerbated by legal problems related to the ownership of real estate and the relatively high share of pre-war buildings, especially in the city center, which hamper significant investments in the modernisation of buildings.

   Actions to take:

   a. conducting a thorough analysis of the scale and specificity of the phenomenon of energy poverty in Wroclaw,

   b. designing public policies (at national, regional and local levels) to alleviate energy poverty by improving the energy efficiency of buildings, promoting renewable energy

sources, developing energy communities and promoting decentralized and democratized energy production and consumption,

c. elimination of legal barriers at the national level limiting the development of energy communities,

d. developing programmes of targeted financial support for low-income households,

e. substantive support in obtaining financing, appropriate investment selection and adjustment of energy community models are adapted to local conditions.

7. **Restrictions on the development of blue and green infrastructure (BGI).** The city has great potential for BZI development, but is increasingly struggling with challenges such as: lack of places for new tree plantings (mainly due to conflicts with underground infrastructure), complicated land ownership structure (open areas, valuable in terms of nature, are often outside the city's property and are not protected against development), urbanization pressure from private investors on new areas, increasingly difficult habitat conditions for plants in the city (heat waves, droughts, frosts, emergence of new pests, diseases and invasive species), many entities responsible for maintaining urban green areas .

   Actions to take:

   a. legislative changes at the national level enabling local governments to more effectively protect valuable areas against urbanization pressure and introducing quality standards for investors regarding the development of the surroundings of linear and cubature investments (e.g. regarding the quality of biologically active surface or management of rainwater on the plot),
   b. dissemination of uniform standards for the development and maintenance of green areas for all entities responsible for maintaining urban green areas (not only those managed by local governments, but also private and cooperative ones),
   c. selection of plant species with increased resistance to high temperatures, droughts and other threats.

8. **Problems with using rainwater.** Only a small part of rainwater is reused in the city, which affects the city's degree of adaptation to climate change. This is due to factors such as: dispersion of responsibility for rainwater management among various entities (in particular for managing stormwater infrastructure), high degree of sealing of the area, especially in downtown districts, lack of legal regulations and a systemic solution that would allow investors to be obliged to use solutions ensuring stormwater retention and management in the investment area, with simultaneous strong investment and urbanisation pressure on almost all areas, low level of implementation of stormwater drainage solutions, lack of general standards for rainwater retention and management.

   Actions to be taken:

   a. implementation of legislation at national level obliging investors to use solutions ensuring the retention and management of rainwater or meltwater in the investment area;
   b. intensification of actions aimed at sealing off areas of impermeable surface belonging to the city, but also encouraging private or cooperative investors to do so;
   c. intensification of educational activities aimed at property owners, cooperatives, housing communities, entrepreneurs in the field of adaptation to climate change and management of rainwater.
   d. intensifying efforts to break up urban impermeable areas, but also to encourage private investors or cooperatives to do so,

e. intensifying educational activities aimed at property owners, cooperatives, housing communities, entrepreneurs in the field of adaptation to climate change and rainwater management.

Table 17. Systems and Stakeholder Mapping.

Systems and Stakeholder Mapping			
System	Stakeholder	Stakeholder impact on the city's climate neutrality ambitions	Interest in the city's climate neutrality ambition.
National level - ministries:			
Governance and policy	Ministry of Climate and Environment	**very high** – introduces regulations and has at its disposal funds aimed at environmental and climate protection	It joins the activities of cities for climate neutrality and undertakes a number of activities to support cities and declares further systemic cooperation within the national platform, which manifests itself through an open dialogue on, m.in, barriers to achieving the pro-climate goals of cities. It provides support for programmes such as the Clean Air Programme, the Warm Apartment Programme, the Stop Smog Programme - financing the thermal modernisation of buildings and the replacement of heat sources.
	Ministry of Technology	**high** - introduces regulations and has at its disposal funds directed to climate projects	• National Recovery and Resilience Plan - new low-emission construction according to eco standards • Department of Spatial Planning - spatial planning, densification of buildings • Thermal Modernisation and Renovation Fund (FTiR) (financial instruments supporting thermal modernisation)
	Ministry of Infrastructure	**high –** introduces regulations and has funds directed at infrastructure and systemic tasks in the field of pro-climate projects; develops plans, e.g. to counteract	It joins the operation of the platform for cooperation between the government and the local government.

		water shortages or the effects of drought	
	Ministry responsible for regional policy	**very high** – introduces regulations and has at its disposal funds directed towards climate tasks	It affects the possibilities of implementing pro-climate projects and investments. • European Funds for Infrastructure, Climate, Environment Programme 2021-2027 (financial mechanisms supporting energy transition, adaptation to climate change, improvement of transport safety) • European Funds for Modern Economy Programme 2021-2027 (greening of enterprises)
Finance	Ministry of Finance	**very high** – has at its disposal external funds in Poland and creates regional and national support programmes	It defines the scope of support programmes and the allocation of EU and foreign funds for individual types of activities and beneficiaries. It has a very high potential to support both local governments and the private sector in their efforts to achieve climate neutrality. It introduces a mechanism of thermo-modernisation relief.
National level - fund operators:			
Finance	Centre for EU Transport Projects	**high** – has at its disposal funds from the European Union, intended to support infrastructure investments, including pro-climate ones in the area of road, rail, air and urban transport	It affects the development of public transport and the sustainable development of transport.
	National Fund for Environmental Protection and Water Management	**very high**	It provides funding to various entities for activities in the field of environmental and climate protection – in this way, it really supports both local governments and the private sector, the science sector. It participates in an open dialogue with local governments on supporting them in the implementation of tasks related to achieving climate

			neutrality. It conducts thematic programmes, e.g. thermal modernisation, renewable energy sources, environmental education, obtaining funds from the EU, energy-efficient construction.
National level - entities specialised in specific thematic areas and thematic research institutes:			
Technology and infrastructure	General Office of Building Control	**high**	It conducts activities in the field of technical condition control of buildings, central records of building emissions and energy efficiency of buildings.
	Motor Transport Institute	**moderate** - mainly for the implementation of emission reductions	Substantive support for public administration and the ministry responsible for the shape and condition of Polish transport. Analysis of the impact of road transport on the environment; exhaust emissions, noise, vibration tests; research on reducing fuel consumption by internal combustion engines of vehicles and machines, development of electric vehicles, including hydrogen and alternative fuels.
	Railway Research Institute	**low** - for emission reductions	Conducting research on the digitization and processing of railway traffic parameters; reducing the negative impact of rail transport on the environment.
Science	Institute of Environmental Protection - National Research Institute	**high** - in the field of know-how, expert opinions and high-quality climate analyses	Central scientific institution in the field of environmental and climate protection - a center for climate research and adaptation, subordinate to the Ministry of Climate and Environment. It cooperates with the city of Wroclaw in the field of counteracting the climate crisis.
Governance and policy	General Directorate for National Roads and Motorways (GDDKiA)	**moderate**	When implementing investment tasks, GDDKiA undertakes a number of activities related to environmental protection, which, m.in others, are aimed at counteracting climate change. When implementing investment tasks, GDDKiA undertakes a number of activities related to environmental protection, which, m.in others, are aimed at counteracting climate change.

	Polish Waters	**very high**	Polish Waters are developing planning documents, m.in. flood risk management plans and a plan for counteracting the effects of drought, which is the first such plan in Poland to include measures to increase the national water retention rate. Polish Waters prepare flood hazard and flood risk maps from flowing waters, specifying areas of special flood risk, which should also be taken into account in local spatial development plans.
National level - large enterprises and concerns and entities that associate them:			
Technology and infrastructure	TAURON[25]	**high** - emissions from heat and electricity production, emissions from buildings	A Polish company grouping companies from the energy sector. The goals that the group wants to meet are a significant increase in the share of low- and zero-emission sources in the TAURON Group's installed capacity by 2030 and a decrease in emissions for energy generation by nearly 80% and climate neutrality in 2050. Modernisation of the network in the direction supporting climate transformation.
	Polish Energy Group	**high** - emissions from heat and electricity production, emissions from buildings	• Transition plan and path to decarbonise generation and achieve climate neutrality by 2050 • Implementation of investments in low- and zero-emission energy sources and grid infrastructure.
	Polish Railway Lines	**high** - to reduce emissions from transport	On a city scale, it provides long-distance rail transport connections regionally, nationally and abroad. It contributes to the construction of the metropolitan railway network and is part of the city's transport network, improving the comfort and accessibility of public transport for residents. It pursues a policy of sustainable transport.

[25] Responsible for generation and distribution of electricity

Social	Polish Alternative Fuels Association	**high**	Implementation of projects in the area of sustainable development. Implementation of educational projects aimed at increasing public awareness in the area of sustainable mobility.
	Association of Polish Architects	**moderate**	In 2014, the Association of Polish Architects established the SARP Expert Team for Sustainable Development, whose task, in accordance with the statutory objectives of the Association, is to provide substantive knowledge in matters related to architecture and urban planning using the philosophy of sustainable development.
	Polish Chamber of Town Planners Association, Polish Town Planners Association	**high**	Protection of spatial order and high quality of the living environment of people in accordance with the principle of sustainable development.
	Polish Green Building Association	**high**	It conducts activities of radical transformation of buildings, cities and their surroundings in such a way that the way they are planned, designed, erected, used, modernised and dismantled is as sustainable as possible.
	National Association of Installation and Service Companies	**moderate**	Education in the use of solutions that optimize energy consumption. Education and awareness in the field of saving and not wasting water, as well as improving air quality.
Regional level:			
Technology and infrastructure	Lower Silesian Railways	**moderate** - mainly for the implementation of emission reductions	It is taking actions that will contribute to achieving the goal of increasing the comfort and accessibility of low-emission long-distance transport.
Governance and policy	Marshal's Office of the Lower Silesian Voivodeship	**moderate** – introduces regulations and has in its disposal funds directed to climate tasks	It affects the possibility of implementing pro-climate projects and investments in Wroclaw and reducing it in all emission sectors.

	Institute of Territorial Development	**high** – has funds directed towards climate tasks	It affects the possibility of implementing pro-climate projects and investments in Wroclaw and reducing it in all emission sectors.
Finance	Regional Fund for Environmental Protection and Water Management	**very high**	It participates in dialogues with local governments on supporting them in the implementation of tasks related to achieving climate neutrality, which may give the potential to adapt financial tools and support programmes to the real needs of local governments.
City Level:			
Technology and infrastructure	KOGENERACJA[26]	**high** - emissions from heat and electricity production, emissions from buildings	It deals with the production of electricity and heat generation in a combined system - meeting the requirements of economical and environmentally friendly energy generation. It cooperates with the city of Wroclaw to reduce emissions and conducts activities such as the Heating of Wroclaw tenement houses programme using the KAWKA programme.
	Fortum[27]	**high** - for emissions from heat production	It deals with the implementation and financing of a project aimed at improving energy efficiency. It conducts activities in the field of modernisation and replacement of thermal insulation of heating pipelines, furnaces and technological lines in facilities.
	PGNiG/ Orlen[28]	**very high** - emissions from heat and electricity production, emissions from buildings	A state-owned energy group that produces heat and electricity based on fossil fuels. PGNiG strives to minimise the harmful impact of its operations on the climate and the environment.
	Municipal Water and Sewage Company	**high** - to reduce emissions	The Municipal Water and Sewage Company S.A. in Wroclaw conducts activities to search for alternative water sources, respond to climate

[26] Wroclaw Combined Heat and Power Plants Group
[27] Operator of district heating in Wroclaw
[28] Polish Oil and Gas Company

			change, implement innovative solutions and modern technologies, improve energy efficiency and use renewable energy sources. A manifestation of the implementation of the educational mission of Municipal Water and Sewage Company is the Hydropolis Environmental Education Center, opened in 2015.
	Municipal Transport Company	**moderate** - mainly for the implementation of emission reductions	It is taking steps to modernize the entire rolling stock to make it more energy efficient.
	PSZOK[29] Ecosystem	**moderate**	It deals with the construction and operation of installations necessary for the proper functioning of the waste management system. It runs a consistent waste segregation system.
	Western Chamber of Commerce	**moderate**	They bring together small and medium-sized entrepreneurs. Reduction of emissions from the business sector.
	AmCham - American Chamber of Commerce in Poland	**moderate**	A non-profit organisation and spokesperson for international investors in Poland. It mainly affects the reduction of emissions from the business sector.
	SPCC - Scandinavian-Polish Chamber of Commerce	**moderate**	A non-profit organisation supporting the development of economic relations between Poland and Scandinavia. Reduction of emissions from the business sector.
Governance and policy	Roads and City Maintenance Authority in Wroclaw	**moderate** - mainly for the implementation of emission reductions	It carries out investments adapting the communication space to climate change.

[29] Selective municipal waste collection point

	Strategy and Sustainable Development Department	**very high**	A green department that carries out work in the field of environmental protection and ecology. It affects the possibility of implementing pro-climate projects and investments in Wroclaw and reducing it in all emission sectors.
	Climate and Energy Division	**very high**	It carries out tasks related to the coordination of activities related to the development of a path to achieve climate neutrality by the City of Wroclaw. Coordination of activities for the adaptation of the City to climate change in the areas of energy efficiency, green and blue infrastructure network and water management, green and blue infrastructure network and energy efficiency, as well as implementation of activities related to sustainable development.
	Municipal Greenery Management Company	**very high**	It joins the efforts to achieve climate neutrality and undertakes a number of activities to support the city of Wroclaw. It runs projects promoting the improvement of the quality of the environment, such as the "GROWinWROclaw" Project, which consists in planting trees, the patrons of which are children born in Wroclaw recently. The main objective of the project is to increase the area of greenery in Wroclaw.
	Wroclaw Strategy Office	**very high**	Impact on provisions in strategic documents, strategy, socio-economic assumptions.
	Department of Real Estate and Operation of the Municipal Office	**high**	Impact on projects related to the modernisation of buildings and the shaping and design of inter-block interiors.
	Communal Resources Management	**high**	It deals with the activities of thermal modernisation of buildings and the possibility of shaping the interiors between blocks. It conducts activities dealing with the modernisation of buildings and connection to the heating network or replacement of furnaces in the municipal stock.

	Municipal Company Wroclaw Housing	**low**	She conducts activities related to the organisation of green areas during the preparation of the concept of courtyard interiors. It is revitalizing the courtyards between the blocks, where green recreation zones are being created.
Science	Wroclaw University of Environmental and Life Sciences	**moderate** – one of the 11 largest universities in Wroclaw	The University of Life Sciences conducts activities related to the promotion of projects related to biodiversity and the popularization of activities and issues related to ecology and climate neutrality. Projects such as a) Promotion of "green roofs" – through the organisation of a scientific conference "Greening the roofs of Polish cities" are undertaken.
	Wroclaw University of Science and Technology	**moderate** - one of the 11 largest universities in Wroclaw	Wroclaw University of Science and Technology undertakes activities related to the promotion and popularization of activities and issues related to ecology and climate neutrality.
	University of Wroclaw	**moderate** - one of the 11 largest universities in Wroclaw	The University of Wroclaw undertakes activities related to neutralizing the negative impact of humans on the climate and conducts classes where discussions on ecology and climate neutrality are undertaken. It undertakes activities such as the organisation of educational activities.
Social	Wroclaw Climate Protection Coalition	**low** – tries to influence raising public awareness	Through their activities, they support residents and other climate activists in their initiatives.
	Polish Ecological Club branch in Wroclaw	**moderate**	The Lower Silesian Ecological Club deals with the protection of the environment and natural heritage, the promotion of ecology, environmental education and the promotion of the idea of sustainable development. It conducts activities such as educational projects, organizing lectures, seminars, conferences, trainings and workshops, and conducting local actions and campaigns for climate neutrality.

	Lower Silesian Smog Alert	**moderate** - mainly for the implementation of emission reductions	The Lower Silesian Smog Alert measures air pollution in towns in the region.
	Local Activity Centres	**low**	They are used to strengthen and integrate local communities.
	ARAW[30]	**low**	It organizes projects promoting activities for climate neutrality and ecology. Organisation of events such as "Saturday with Green Wroclaw" - a family picnic in the ecological spirit under the slogan #RazemDoCelu.

Table 18. Main Barriers.

Sector	A barrier to climate neutrality	Barrier Type	Barrier Description	Sectors and stakeholders involved	Actions to be taken/Description of the proposed barrier solution
Transport (public transport)	High costs of changes	Financial	Modern buses and trams are expensive. The high costs of construction investments, such as the construction of modern communication routes, may also be a problem.	**Transport and public transport sector** Municipal authorities, Municipal Transport Company Wroclaw	• Conducting appropriate market analyses • Assumption of a longer project implementation time • Obtaining financing with a fixed interest rate. Financing investments from own funds.
	The term of office of the authorities	Political	With a change of managers, the priority of urban transport may be abandoned – or its concept may change so much that it causes delays.	**Transport and public transport sector** Municipal authorities, Municipal Transport Company	• Creating a fixed legal framework and prioritizing the continuation of investments and projects related to urban transport and the transformation of transport towards a greener one • Prioritising the classification of climate change projects

[30] Wroclaw Agglomeration Development Agency

	Lack of audience interest	Social/Organisational	Despite the improvement in the quality of public transport, people may not be interested in it (too high ticket prices, development of alternative ways of traveling such as Uber, Blablacar or bicycle transport).	**Transport and public transport sector** Municipal Transport Company	• Changes should be introduced at the level of organisation and synchronization of bus and tram traffic. Efficient transfers between means of transport will optimize the travel time between work and home, which will translate into greater attractiveness of public transport and a lower share of passenger cars in transport in the city • Applying various types of incentives in the form of discounts or passes
	Residents' resistance to change	Social	Due to the nature of the city's transport network, the development of public transport sometimes has to take place at the expense of other types of transport, especially car transport (e.g. the issue of converting lanes into bus lanes), which may cause resistance or even a boycott.	**Transport and public transport sector** Municipal Transport Company	• Organizing open public debates to raise public awareness of GHG emissions reduction and trying to resolve the conflict for the benefit of both parties • Promoting the benefits of a wider range of urban infrastructure (fewer road accidents, more child- and age-friendly urban environment)
	Strong attachment to the use of the car	Social/Sociological	Most people are used to moving around by car and to the so-called door-to-door movement, which can cause outrage and resistance among residents to the proposed changes and regulations introduced by the city.	**Transport and public transport sector** Municipal Transport Company , Municipal authorities	• Promoting the use of electric vehicles, encouraging residents to switch from an internal combustion car to an electric one in order to reduce CO_2 emissions • Promoting the benefits of changing cars and highlighting their value for the quality of life of residents

	Technological limitations – alternative fuels	Technology/Financial	The problem may be insufficient funding for the implementation of all projects, but also insufficient understanding and mastery of the use of some alternative fuels.	**Transport and public transport sector** Municipal authorities, local carriers	• Operating and operating costs should be estimated conservatively on the basis of current data • Signing longer contracts for the purchase of electricity, hydrogen fuel
	Urban sprawl and the process of suburbanization	Financial	The excessive growth of suburban areas puts pressure on the municipality to plan and implement transport solutions convenient for residents. However, this is often associated with high investment costs or a complicated process of rebuilding road infrastructure.	**Transport and public transport sector** Commune authorities	• Creating free parking zones in front of the city center in order to make the city unsealed and encourage people to use public transport • Introduction of changes at the organisational and logistical level to improve the already existing communication • Plan new investments well, gather a group of qualified specialists who will help in the efficient implementation of new projects in accord-ance with all regulations and legal requirements
	Lack of coordination at inter-municipal level and weak multi-level governance	Structural/Financial	The lack of consistent climate policy goals and the implementation of infrastructure projects, there is often a discrepancy in the amount of funding that municipalities can provide for a given project.	Public administration - commune authorities	• Increasing the importance of consultation processescarried out at inter-municipal level • Extension of cooperation based on agreements in the form of territorial contracts: • Identify the objectives and priorities for regional development supported by the contract through a careful assessment of needs and opportunities in municipalities

					• Encourage regional partnerships with municipal associations to support investments on a supra-municipal scale. This could be particularly helpful for peripheral municipalities that do not have the capacity to conclude such agreements themselves.
Buildings and building infrastructure	Shortages in materials and workmanship	Economic	Limited number of specialists and business entities. This can lead to monopolies on the market, which can keep the cost of services and materials rising.	**Construction sector** Local businesses	• Analysis of the current market situation • Comparison of prices in Poland and abroad - sometimes greater profitability of importing material from abroad due to lower costs
	Limited interest in building renovation by private and municipal actors	Legal/Financial	The low interest in building renovation may result from unclear thermo-modernisation policies, unclear conditions that must be met by entities applying for them, and concerns related to the uncertainty of access to financing. Complicated processes of submitting applications and applying for funding can also be discouraging.	**Construction sector** Local businesses, private entities	• Application of incentives and tax reliefs for entities carrying out thermal modernisation of buildings • Use of mixed tools such as budget incentives and a set of town planning rules
	Renovation options at a rate significantly lower than would be required to achieve climate neutrality	Financial	High costs of project implementation, e.g. expensive building materials or professional services	**Construction sector** Local businesses	• Employment of qualified staff to prepare specific investments, who will take care of the calculation of project costs and optimization of the work carried out

					• Conducting market analyses in order to minimize difficulties related to project financing
	Limited or no appropriate support policies/programmes – fiscal, financial, excessive criteria for allocating funds, complicated application process	Financial	A big problem is the lack of ability of the municipality to raise capital. Another problem is complicated application documentation, often inadequate to a given type of project, and difficult and expensive "environmental" criteria to meet, which call into question the possibility of applying for funds for projects that generally have a positive impact on the environment.	**Construction sector** Local businesses, Municipal authorities	• Conducting diagnoses of problems, on the basis of which it will be possible to create an appropriate model of action • Regulating changes related to climate and environmental aspects • Regulation and universalization of "environmental" criteria that call into question the possibility of applying for funds for projects that generally have a positive impact on the environment
	Fragmentation of ownership – individual, combined, a multitude of entities and organisational structures (communities, cooperatives, municipal mix)	Structural/Organisational	Problems with the implementation of projects are related to obtaining the appropriate licenses and permits.	**Construction sector** Local businesses, municipalities, companies and private entities	• Organisation of meetings and conferences with communities, urban cooperatives in order to develop common goals for the sake of climate neutrality • Promotion of ecological projects and solutions and the use of budget and urban planning incentives
	High costs and unknown scale of needs related to increasing the energy efficiency of buildings.	Financial/Legal	The biggest challenge to the climate transition are buildings with an unregulated ownership status, buildings in poor technical condition, buildings entered into the register of monuments or under conservation protection. The problem arises in the issue of acquiring the appropriate	**Construction sector** Local businesses, municipalities, companies and private entities	• Launching (at the national and EU level) systemic financial support programmes for deep thermal modernisation of buildings and a consulting system facilitating the use of programmes and increasing their availability

			licenses and permits. This may translate into additional investment costs and often not all the required conditions for obtaining subsidies may be met, without which it is difficult to find potential investors to carry out a given project. Another problem is the low interest of potential investors in introducing changes to projects and already finished buildings in terms of their energy efficiency due to additional costs.		• Introduce blending tools such as budgetary incentives and a set of urban planning rules that will increase the success rate of the actions
Energy system	High investment costs	Financial	Price fluctuations due to inflation can have an impact on the investment budget	**Energy sector** Municipal authorities, local companies	• Providing adequate budget resources • Using hybrid methods and solutions consisting in combining several types of installations generating energy from renewable energy sources in order to achieve maximum efficiency and reduce the risk of investment failure
	Lack of stable legal regulations and a long-term strategy for the development of renewable energy sources in the city	Systemic/Legal	The problem arises in the issue of legal regulations regarding investment uncertainty, the so-called "distance criterion" in the Act on investments in wind farms, which prevents the construction of wind turbines in more densely built-up areas and the lack of legal possibilities to establish energy	**Energy sector** Municipal authorities, private investors, local companies	• Creation, at the national level, of stable legal regulations and a long-term strategy for the development of renewable energy sources • Legislative changes at the national level that will allow for the reduction of the so-called "distance criterion" in the Act on investments in wind farms

			cooperatives in urban municipalities.		
	Restrictions for prosumers related to the possibility of access to connection capacity	Infrastructure	Due to the lack of appropriate infrastructure, especially in the field of transmission networks, investments in RES may be discouraged or even unprofitable.	**Energy sector** Municipal authorities, private entities, local companies	• Introduction of more advantageous energy settlement systems for prosumers
Blue and green infrastructure	Urbanization pressure of private investors to develop new areas, increasingly difficult habitat conditions for plants in the city	Infrastructure/Finance	The main problem is high temperatures and the decreasing cyclical nature of rainfall. More and more often, the city is affected by drought and water shortage. This may translate into increased costs of maintaining greenery and may slow down the implementation of new projects and the implementation of more greenery in the city.	**Green infrastructure sector** Municipal authorities, private entities, local companies	• Introduction of uniform standards for the development and care of greenery for all entities responsible for the maintenance of urban green areas • Selection of plant species with increased resistance to high temperatures, droughts and other threats
	Social support – conflicting groups	Social	The problem of adapting to the changes, restrictions and regulations introduced for climate neutrality. Complicated application documentation, often inadequate to a given type of project, is also a problem, which can discourage people and exacerbate conflicts.	**Green infrastructure sector** Municipal authorities, private entities, local companies	• Employing qualified staff to mediate in environmental conflicts in order to reach mutually beneficial agreements • Introduction of legal regulations and generalizations when complementing application documentation in order to minimize the occurrence of problems with accepting applications, which has a more positive impact on the relations between individual parties
	Lack of calculation of environmental costs	Financial	Lack of allocated substantive resources in the financial	**Green infrastructure sector**	• A special section in the municipal budget for the

	and ecosystem services		sections to assess the nature of the investment; regulatory restrictions. No designated climate budget for blue-green infrastructure activities and projects.	Municipal authorities, private entities, local companies	climate budget to implement all pro-climate projects • Keeping appropriate documentation and statistics in order to select the appropriate nature of current and future investments
	Complicated ownership structure of the land	Structural	Open areas, valuable in terms of nature, are often outside the property of the city and are not protected from development.	**Green infrastructure sector** Municipal authorities, private entities	• Legislative changes at the national level, which will allow local governments to more effectively protect valuable areas against urbanization pressure and will introduce quality standards for investors regarding the development of the investment environment
Waste management and circular economy	Infrastructure and logistics – no municipal waste management company	Infrastructure	Companies with private capital account for almost 2/3 of companies operating in the waste management industry. Some of them are domestic companies dealing primarily with the collection and transport of waste. The problem is the high fragmentation of responsibility for waste collection due to the large number of private companies. The problem may be insufficient funds of the municipality to cover the costs of waste disposal, which may result in interruptions in waste collection and, consequently, its accumulation on the streets.	**Waste management sector** Municipal authorities, private entities	• Signing longer contracts for a fixed period of time by the city with companies dealing with waste collection and transport, this will allow for setting fixed prices for waste disposal and the risk of price increases will be lower • Engaging more than one company to collect waste in the city, thanks to which it will be possible to prevent the creation of a monopoly and a drastic increase in the prices of services. It can also contribute to covering a larger urban area and making it easier to transport waste -

	National regulations on recycling – difficult to achieve in the current conditions	Legal	No or low consequences drawn from not using waste selection, so the society does not feel the need to segregate waste. Lack of appropriate legal regulations.	**Waste management sector** Municipal authorities, private entities, local companies	• Introduce step-by-step regulation at national level to improve policy delivery and reduce public loopholes abuse • Introduction of higher penal-ties for failure to segregate waste

3 Part B – Pathways towards Climate Neutrality by 2030

3.1 Module B-1 Climate Neutrality Scenarios and Impact Pathways

B-1.1: Impact Pathways

The choice of impact pathways is a direct result of the emission structure in Wroclaw. According to the GHG inventory, but also to the analyses within the economic model, it can be concluded that in Wroclaw the key actions are in 3 areas:

- Production of electricity and heat
- Renovation of the city's building stock
- And in transport

Other emission sectors such as industry or waste management have a much smaller impact on emissions and in total account for less than 15%. For the industrial sector, emission reductions concern both the use of energy and heat for buildings, but above all the decarbonisation of the production processes themselves. Additional areas are the decarbonisation of waste management and water and sewage management as well as adaptation to climate change through the development of blue-green infrastructure and the protection of existing greenery and the unsealing of paved surfaces.

Built environment

The priority of these measures is to reduce the residents demand for heat and electricity. Replacing fossil sources with renewable sources in the same quantity may be difficult but also unjustifiable in terms of energy efficiency. Therefore, it is important to reduce energy consumption. Moreover, the energy transition will result in costs that may be reflected in energy prices in Poland, so thermo-modernisation is necessary to reduce energy poverty. Most of the building stock in Wroclaw consists of buildings with low energy classes and often not even fulfilling the energy efficiency standards. This results in significant consumption of heat in particular and the need to scale up the energy system.

For this reason, increasing the energy efficiency of buildings will be a priority in the area of building construction. It assumes, first of all, the thermo-modernisation of private, cooperative buildings and those belonging to enterprise and institutions not related to the municipality, as well, as the municipal stock of residential and commercial buildings. Most of the buildings that require modernisation are privately owned. Only 10% of the city's buildings are in municipal possession. Therefore, the conclusions of the NEEST pilot project carried out within the framework of the Cities Mission may be particularly valuable for speeding up the process of renovating buildings, which will identify the most beneficial ways of effectively, economically efficient and socially acceptable modernisation of the building stock regarding different types of residential and non-residential buildings. These recommendation can be used by the residents themselves but also by regional and national authorities in the context of planning financial and technical support programmes.

Over the next few years, the city will continue the thermal modernisation of public buildings and residential buildings in the municipal stock, with the aim of increasing their energy efficiency, and will focus on creating a system of incentives and support systems for private buildings owners to undertake such measures. The city has an identified pool of investment projects related to improving the energy efficiency of residential buildings in the municipal housing stock and public buildings. The city also runs programmes to support residents in thermal modernisation measures, but these need to be strengthened. Such support is also provided under national programmes.

It is therefore an important element in speeding up the renovation trend to provide expert advice to residents on the technical aspects of the investments to be made, as well as on the possibilities of using municipal, regional and national funding for thermo-modernisation measures. At the moment, these programmes are highly dispersed and based on different accessibility criteria.

Renovation and thermo-modernisation of non-residential buildings generally concern private buildings- services or production facilities, therefore the city has established cooperation with some of these entities and the city hopes that they will undertake measures to reduce energy demand and strive for neutrality. In the case of municipal/public utility buildings, the necessary work will also be carried out, e.g. in schools and kindergartens (thermo-modernisation, energy management, energy production from renewable energy sources e.g. Small RES Programme).

In the case of new buildings, it is necessary to strengthen cooperation with the development community as a major player in the city's property market and to implement public investments in the zero- or near-zero-carbon facilities, using heat recovery, mechanical ventilation or energy production form RES. The city also has a social housing company (TBS Wroclaw), so it is important that new residential and non-residential buildings have a positive energy balance or are zero-emission.

The process of upgrading the city's lightning with LED luminaries, which will significantly reduce energy consumption, will also continue, as will further action on the issue of recovering and using waste heat form production processes, cooling systems, server rooms, sewage and other sources within the city.

The main stakeholders in this sector are:

- Government of the Republic of Poland, the National Fund for Environmental Protection and Water Management and other operators of funding programmes- the deep thermo-modernisation of buildings involves enormous costs (for the municipality's own investments or financial support for residents), so it is a crucial here to secure adequate funding for local authorities from external sources.
- Science sector- reducing the demand for primary energy requires a continuous search for and implementation of innovative solutions in the form of: ways to reduce consumption, energy recovery methods, ways to use waste energy, efficient storage of surplus energy.
- Municipal companies and manufacturing, commercial, service companies- these are energy-intensive and have a high potential for reducing consumption and using waste or renewable energy.
- Public facility administrators (e.g. schools, public authority buildings, cultural buildings)- have been covered by a common purchasing group for electricity and gas for several years, which allow them to save financial resources; it is important to carry out thermo-modernisation and energy reduction measures in these buildings, e.g. by monitoring consumption, energy management, reduction of reactive power.
- Construction and renovation companies, as well as cooperatives and housing associations- the entities operating in the building sector and those administering the buildings- have a huge influence on the development and implementation of new energy standards in new and renovated buildings. Without their involvement, it will be difficult to carry out effective measures in this area.
- Residents, especially in the area of preserving the principles of a fair energy transition and protection vulnerable groups.

<u>Electricity and heat generation</u>

Decarbonisation of energy production (in the case of Wroclaw, this is produced in a cogeneration system as electricity and heat). This means, as a first step, switching to fuel gas from the currently used hard coal. This process has already partly started (one heat and power plant has switched to gas and the main one is the investment planning process). In the next step, it is possible to switch to decarbonised gases or large-scale renewable sources.

The decarbonisation of individual heat sources is also underway. The replacement of furnaces, which is mainly related to improving air quality but also indirectly contributes to reducing greenhouse gas emissions, is slowly coming to an end. Unfortunately, much of the replacement has involved the

installation of gas-fired furnaces, which will requires further measures in the feature (e.g. installation of heat pumps). This problem is all the more important as there is a relatively high proportion of individual heat sources in Wroclaw (the municipal district heating network covers 53% of demand).

In Wroclaw, the production of electricity from renewable sources is developing dynamically, both by residents, entrepreneurs for production processes, municipal companies (for their own needs and, following changes to regulations, also for the needs of other public or other entities within the framework of civic energy), within cooperatives/ communities/ energy clusters. At the moment, there are no longer-scale photovoltaic farms in the city due to spatial conditions and high demand for land for development. In the case of wind energy, due to high urbanisation of the area and spatial and social conflicts, it is not the preferred direction unless new technologies less intrusive to the environment emerge. Water energy is partially exploited but there is no prospect of increasing this potential.

A source of energy that has not been fully recognised in the city area is waste energy (sewage, servers, production halls, shopping centres). Investment in obtaining waste heat from the sewage network is developing in this case (one investment has already been made in this area covering about 5% of the heat demand). Further analyses of possibilities in this direction are being carried out.

In this area, it is crucial to replace fossil energy sources in the production of electricity and heat with renewable or low-carbon sources. A key action in this area is to change the energy mix the National Energy System (NES) therefore, at the local level, it is important to cooperate strongly with State-owned energy companies in the process of moving away from fossil fuels to low-carbon fuels (e.g. natural gas a transition fuel), and further based on renewable sources (e.g. biogas, green hydrogen, nuclear energy, large-scale heat pumps, geothermal energy).

An important element of system efficiency is also the modernisation of transmission and distribution networks so that they are adapted to the dynamic development of the producer market and distributed prosumer installations.

An innovative approach will also be use waste energy sources on a wider scale, e.g. from the water-sewage system or industry. A very important part of transformation is also the development of an efficient and effective energy storage system for both electricity and heat.

At the local level, it is important to further develop renewable energy installations both on municipal buildings, public utilities (continuation of the Small RES Programme for public facilities indicated in 2022). And on the facilities and sites of municipal companies and units. RES generation will be an important element in the pursuit of climate neutrality of municipal companies, i.e. Municipal Transport Company, Municipal Water and Sewerage Company, Ecosystem Sp. z o.o. These co-partnership's can use their proprieties to invest in RES (photovoltaic's, biogas, plants).

The programme of tax exemptions for residents and businesses for installing renewable energy installations will be continued, as will the modified Kawka+ programme, which allows for subsidies to be granted for replacement of high-emission heat sources with low-emission installations, but also for the installation of renewable energy sources: photovoltaic storage facilities. In addition, a team of energy advisers is in place for local residents on the occasion of the Kawka+ programme.

The Wroclaw heating system operates in a cogeneration system so the decarbonisation of electricity production will also result in charge to this system. This means that, also in this case, the production of heat is on the side of companies belonging to the State Treasury, while the distribution of heat is in the hands of private company (Fortum). Cooperation activities in the context of the decarbonisation of heat and power production in cogeneration have already been undertaken. A Decarbonisation Team has been established, which includes representatives of the key entities involved in this process. The necessary discussions to carry out this action are taking place within the team.

The key stakeholders in this sector are:

- State-owned energy companies- producers of energy and heat. The rate of decarbonisation of the heat and power plants supplying the city depends, to a large extent, on the rate of decarbonisation of the entire city.

- Energy distribution- Wroclaw's power grid needs to be modernised and adapted to new functions related to the development of prosumer energy and the need for energy storage, which means introduction modern energy transmission management systems on which depends, among other things, the profitability of investing in renewable energy sources in the city
- Government of the Republic of Poland and relevant ministries- decarbonisation plans of energy companies depend largely on the policy at the national level, with State Treasury being the main shareholder in these companies. Also important are legal regulations on renewable and the prosumer market in terms of, i.e., favourable accounting of the costs of energy production from renewable or regulation providing opportunities for the development of civic energy in cities.

Transport and mobility

The most significant action in this sector is the reduction in the scale of individual car transport combined with the development of public and other non-car transport and the electrification of both individual and commercial transport as well as public transport.

Transport is the second largest source of greenhouse gas emissions in the Wroclaw area, after construction industry and stationary energy, accounting for almost 31% of all emissions and a source of air pollution. These emissions are mainly generated by road transport, with individual car transport accounting for the largest share. Therefore, key actions should concern the development of low-emission public transport and other alternative ways of moving around the city that are attractive, affordable, and safe for people using individual car transport.

Wroclaw is systematically and consistently developing public transport based on tram, bus and rail transport. This includes both improving travel conditions on the existing network by modernising it and building new transport corridors. It is also replacing the rolling stock with more energy-efficient an low- or zero-emission vehicles. Hydrogen-powered buses are also being tested. Alongside the development of public transport, a system of cycle routes is also being developed including green cycle routes as alternative transport corridors away from min roads. Transport workload is also being increased in cooperation with the agglomeration railway operator (Lower Silesian Railways, a company managed by the provincial government). The use of public transport on a wider scale is also to be encouraged by new P+R car parks in created transfer hubs, an increase in the number of safe and accessible stops, and the development of environmentally friendly (green track and green stops) transport infrastructure.

A measure affecting the reduction of emissions from individual car transport will be the development of electromobility. This means building, together with private partners, an appropriate charging infrastructure for electric vehicles. Shared transport will also be promoted.

The main stakeholders, in this sector, are:

- Government of the Republic of Poland, the National Fund for Environmental Protection and Water Management and other operators of funding programmes- investments in public transport are costly, so the key role here is to ensure adequate funding for local authorities from external sources. Electromobility development, on the other hand, requires support through, for instance, appropriate tax relief or subsidies for the purchase of electric vehicles.
- The provincial government at regional level- as the agglomeration rail transport operator and owner of the Lower Silesian Railways- is a key player in the development of rail transport and tariff integration at city and functional area level.
- Enterprises- operators of vehicle charging stations through which appropriate infrastructure can be developed and maintained to encourage the purchase and use of electric vehicles.
- Municipal corporations- responsible for the development of pedestrian infrastructure, cycling and the public transport network
- Residents- the issues of reducing car traffic and changing transport habits are socially sensitive topics, and therefore the residents of the areas affected by the changes will be involved in each consultation process on specific solutions.

Green infrastructure

Blue-green infrastructure and climate change adaptation measures have less impact on direct emission reductions but are important in terms of reducing energy consumption, quality of life, climate change adaptation and can influence transport behaviour variables.

Green areas in the city need to be protected from excessive urbanisation pressure, renaturalised, increased in terms of providing ecosystem services, as well as increasing the area of biologically active surface where this is possible and most needed. As part of protection of the blue-green infrastructure, the city, incl., through local plans, will influence the densification of urban development in such way as to protect areas of natural value and ensure the sustainability of development (this is particularly important in highly urbanised areas as well as newly created development areas). The compact cities being developed must take climate action adaption issues into account as the greatest challenge to civilisation in the coming years. Action in this area are already being carried out e.g. by deconstructing sealed surfaces, introducing courtyards and schoolyards using blue-green considerations.

The maintenance and development of blue-green infrastructure is very important both in terms of sequestering surplus carbon, as well as in terms of adaptation actions, increasing the city's resilience to the effects of climate change and increasing access for residents to recreational areas.

Planned actions include: securing natural areas from further urbanisation pressures (which will help to ensure the protection and restoration of areas of natural value, e.g. the creation of a reserve on irrigation fields), planting trees and shrubs, increasing biologically active areas and unsealing impervious surfaces, expending small retention facilities.

These activities will be implemented both through direct investments by the city, such as the continuation of the programme of modernisation and greening of streets, the planning of trees as part of existing GROWinWROclaw programme, the expansion of green tracks and other activities. There will also be continuation and expansion of the activities of deconstructing courtyards and squares. Supporting actions are the implementation and enforcement of greenery management standards (greenery protection standards in investments processes, greenery maintenance standards). It is planned to prepare an ambitious plan for greening the city. The Strategy for Managing Stormwater and Meltwater in Wroclaw (2023), which also includes blue-green projects, will also be implemented.

The city also encourages residents, cooperatives, housing communities and entrepreneurs to deconstruct pavements plant greenery and set up small retention facilities on land owned by them, through education (e.g. Good Practice Guides for rainwater management in urbanised and road areas) and support programmes- expert advice from municipal entities and grant programmes for small retention facilities, as well as a civic budget.

Table 19. Impact pathways

Impact sector	System levers	Actions	Early changes (1-2 years)	Late outcomes (3-7 years)	Emission reduction [kt CO2]	Indirect impacts (co-benefits)
Energy and district heating system	Technology/ Infrastructure Governance and Policy Science/ Finance Social behaviour/ Education	**E.1** – Changing the generation of electricity and district heating using low- and zero-carbon technologies	Continuing and accelerating the connection of buildings to the district heating network as a part of the Clean Energy for Wroclaw programme	Modernisation of a combined heat and power plant in Wroclaw using heat pumps, cogeneration and gas boilers, heat storage and Power to Heat (P2H) Modernisation of the Zawidawie heat and power plant with heat pumps, cogeneration and gas boilers, heat storage and P2H Supplying the Wroclaw district heating system from renewable energy sources using P2H technology Utilisation of waste heat from sewage at the Wroclaw Sewage Treatment Plant Janowek Use of waste heat from other diffuse sources for their own use or for the district heating system Improving the efficiency of the existing network (modernisation of the network, district heat substation) Development of a district heating system in the city to cover the demand of new development	750,000	Reduction of CO_2e emissions Improving air quality Strengthening the city's energy security Reducing energy poverty Increased pro-climate awareness among residents

				District heating prosumer: - development of low-carbon sources cooperating with the city's district heating system. Supporting district heating with heat pumps on buildings powered by photovoltaic panels- in municipal as well as private and cooperative properties		
		E.2 – Local electricity generation from renewable sources	Continuation of the Small-scale RES programme for public facilities Continuation of the tax exemption programme for renewable energy installations Creation of an energy cluster (Universities- Municipality of Wroclaw)	Renewable energy installations on public buildings, especially educational facilities Using the potential of RES development on private property Construction of a photovoltaic farm for Municipal Transport Company of at least 20 ha	460,000	
		E.3 – Modernisation of public lighting to more energy-efficient lighting	Implementing requirements in public procurement	Successive replacement of lighting in public assets Successive replacement of lighting in third-party assets Use of hybrid luminaries with LED technology, use of intelligent lighting	7,153	

		E.4 – Active educational, organisational promotion and planning activities for decarbonisation of electricity and heat production	Conducting information and promotional activities for residents and investors Cooperation with the Institute for Territorial Development on the implementation of the energy strategy for Lower Silesia Cooperation with Provincial Funds for Environmental Protection and Water Management on the entity's strategy and educational programmes Cooperation with universities on innovative energy and district heating solutions and energy education	Support of RES development and cooperation Project in the Wroclaw Functional Area Spatial planning and strategic friendly climate neutrality Establish an agency dedicated to working with existing and attracting new investors in the green energy industry, and under certain conditions being an investor or acting as an energy company.	n/a	
Total					**1,217,153**	
Built environment	Technology/ Infrastructure Governance and Policy Science/ Finance Social behaviour/ Education	**B.1** – Energy efficient buildings	Use by residents of municipal support programmes for thermomodernisation- subsides under the Kawka + programme Continued replacement of heat sources until 2028 (as required by the Anti-Smog Act for the Lower Silesian Province) Use of national funds under grants from programmes: Clean Air, Warmer Housing, Stop Smog	Implementation of the Tenement returns programme- preparation of documentation and modernisation of tenement houses in the municipal stock of 22 tenement houses (target for 100) Comprehensive energy modernisation of residential buildings in the municipal housing stock of Wroclaw Municipality in the period 2025-2030. Energy efficient existing commercial buildings (office, retail, industrial) Modernisation of educational buildings (schools, kindergartens)	451,000	Development and creation of new jobs in services related to the thermomodernisation process (construction, installation, sale of materials, consultancy) Reducing energy consumption and operating costs of buildings Increase in property value

	Spatial planning		Use of funds under loans form Bank Gospodarstwa Krajowego (TERMO programme) Development of a transformation model for quarters of different types of development as part of the NEEST pilot programme Monitoring of energy consumption in facilities Reactive Power compensation in public facilities Cooperation with the development sector National implementation of the Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings	and cultural, social and administrative facilities High energy efficiency standards in municipal investments (schools, kindergartens, public buildings) Developing energy standards for buildings New buildings complying with EPBD parameters close to NZEB Construction and development of energy autonomous in the city-PEDs based on prosumer activities on the basis of the organisational, technical and financial models developed in the NEEST pilot project		Improving air quality Reducing energy poverty Improving the quality of life and health of residents

		B.2 – Energy ad vice, education, information and promotion activities for residents and businesses	Cooperation with private building administrators within homeowner associations Cooperation with housing cooperatives Conducting action and information campaigns to promote energy efficiency in households as well as passive and plus-energy housing Public participation (consultation, social action|)	Promoting prefabricated Technologies for building insulation including mechanical ventilation with heat recovery Promoting comprehensive One Stop Shop (OSS) building modernisation services to speed up and facilities the modernisation process		
Total					**451,000**	
Transportation and mobility	Technology/ Infrastructure Governance and Policy Science/ Finance Social behaviour/ education	**T.1** – Development of the public transport network with accompanying infrastructure and reduction of car traffic in the city	Continued development of Park&Ride system at transport hubs Successive increase of the paid parking zone Continued zoning of residential areas. Tariff integration- common agglomeration ticket for public transport in Wroclaw Carpooling and other forms of shared mobility	Realisation of investment within the Wroclaw Tram and Bus Programme for the years 2024-2032 (including tram lines to Swojczyce district, Jagodno district, Borowska Szpital, Maślice, Klecina, Nowe Żerniki, Ołtaszyn – Wysoka Street, Gądów Południowy, Muchobór Wielki, Księże Wielkie, Gajowice, Borowska Centrum, Psie Pole district, Sucha Street) Construction of New railway stations Increase in transport traffic- start of new agglomeration connections	324,800	Saving times in traffic jams Increase in value of property with access to public transport Improved air quality as a result of less car traffic Noise reduction Improving road safety Improving quality of health through the use

	Spatial planning			Construction of a tram depot in connection with the development of the network Construction of a bus depot Aiming for the designation of clean transport zone		of healthy forms of exercise Improving social equality- reducing transport exclusion Renovation of public space- different use of road lanes and squares due to less car traffic Competency development in local government and among cooperating stakeholders Support for private sector involvement
		T.2 Implementation Plan for Cycling Actions until 2030 for Wroclaw	5,000 new bicycle parking space including Bike&Ride and the possibility to park the bicycle at all institutions, educational facilities and all companies (requesting a rack) Continuation and development of Wroclaw City Bicycle	Implementation Or modernisation of 4 main or alternative routes 16 new connections of the settlements to the cycle route network Modernisation of 25 km of existing cycle router, construction of 6 new connections to neighbouring municipalities : Miękinia, Kąty Wroclawskie, Kobierzyce, Siechnice, Długołęka	18,100	
		T.3 – Implementation of a pedestrian programme (in accordance with the Wroclaw Standards for the Design of Pedestrian Friendly Urban Spaces)	Improving safety at pedestrian crossing Pavement renovations Construction of new accesses and walkways		1,000	

		T.4 - Actions for the dissemination of electric car in individual, collective and commercial transport	Realisation of charging infrastructure (charging stations-electric, hydrogen) Subsidies for the purchase of electric cars under national programme Facilities for electric car users Creation of a micro-hub for deliveries within the city centre	Purchase of new trams (at least 86 vehicles) Successive replacement of the bus fleet with low-emission and progressively zero-emission vehicles (electric buses, hydrogen buses) (at least 96 electric buses and 200 low-emission buses complying with Euro 6 and higher standards) Infrastructure development-charging stations (public and commercial)	192,200	
		T.5 – Education, promotion and information activities in transport	Cycling promotion activities for various user groups (schools, students, entrepreneurs) Walking in Wroclaw – educational and promotional activities Electromobility education		n/a	
Total					**531,1020**	

Waste and water and sewage management	Technology/ Infrastructure Governance and policy Science/ Finance	**W.1** – Climate neutrality and energy security of waste and water and sewage management	Research and development to optimize water treatment and sewage treatment processes Application of intelligent solutions in terms of equipment, software and management of the city's water and sewage management Improving the efficiency of separate collection of all waste fractions Purchase of zero- Or low emission vehicles R&D Project for the construction of installations for the mechanical and/or biological treatment of municipal waste with energy recovery Educational activities in the field of circular economy (Wroclaw Doesn't Waste)	Optimisation of aeration system for activated sludge at Wroclaw Sewage Treatment Plant Programme for Energy Efficiency Improvvement in the city's water and sewage management Increasing the share of renewable energy in the water company's balance by building PV plants and heat pumps Construction of installations for receiving organic waste, e.g. from catering facilities and preparing it for the co-fermentation process Implementation of an intelligent waste collection and transport management system Use of innovative Technologies for recycling and recovery of individual material fractions of waste	26,690	Reduction in consumption- based emissions Strengthening the city's energy security Improving water quality
Total					**29,690**	
Green infrastructure and nature-based solutions	Technology/ Infrastructure Governance and Policy	**G.1** – Implementing the Green Revolution programme	Programme implementation: Green lungs of Wroclaw A park in every neighbourhood 3-30-300	Elimination of rain and drought hot spots Improving the functioning of water reservoirs (Pilczycki Pond) Establishment of ecological sites and natural landscape complexes by the Municipal Council	2,100	Creating high quality greenery Increasing property values through parks and urban gardens close to housing Improving air quality

	Science/ Finance Social behaviour/ education Spatial planning		The Strategy for Managing Stormwater and Meltwater in Wroclaw Afforestation of the city Green roofs and facades Revitalisation of courtyard interiors Protection of nature and areas of biodiversity value Rehabilitation and enhancement of existing parks and other green spaces Creation of New parks and other green spaces Implementation of pocket parks Greening the streets Greening of block interiors Unsealing of concreted surfaces Rainwater retention and prevention of flooding Urban farms Adoption of an ambitious greening plan	Creation of nature reserve in the Irrigation Fields Protection of the ecosystem of the River Sleza LifeCoolCity Project from the LIFE programme		Better physical conditions and mental health of residents Improving water quality Ecosystem services provided by nature-based solutions Improving the microclimate Reducing temperature and increasing humidity Saving on water consumption Supporting the growth of biodiveristy Integration of Climate Change Adaptation Mission activities into the CCC

		G.2 – Education, information, organisational climate action	Continuation of activities within I Like Rain, Catch Rain, Wroclaw Doesn't Waste, Bookcrossing			
Total					**2,100**	
Industry		**I.1** – Decarbonisation of industry	Improving the energy efficiency of industrial and manufacturing processes Self-sufficiency/ autonomy/ energy security (captive production of electricity and heat) Reduction of thermal energy demand and heat production from renewable energy sources	Improving the energy efficiency of process electricity consumption Management of waste heat from heating buildings and process heat needs Using natural gas-fired cogeneration systems Installation of photovoltaic systems on/near industrial buildings Thermo-modernisation of industrial buildings Installation of renewable energy sources for the production of heat for heating industrial buildings	295,545	Creation of new workplaces Improving air quality Reduction of CO_2e emissions
Total					295,545	

Emission gap after implementation of activities form the action plan

The table complements the previous one (Table 14) and shows the amount of emission reductions as a result of carrying out the actions planned in this action plan. Combined with the actions planned under the SECAP, this results in emission reductions approaching 80%.

Table 20. The amount of emission reductions as a result of carrying out the actions planned in the Action Plan

	(1) Baseline emissions	(2) Emissions Reduction Target 2030		(3) Emission reduction through other Action Plans		(4) Emissions Gap		(5) Emissions reduction through the CCC Action Plan to address the Gap		(6) Residual emissions	
	Baseline emissions (ideally not older than 2018) - referring to the inventory used for target setting	The emissions reduction target for 2030 ideally achieves a minimum 80% reduction from the baseline, as reported in Section 2 of the Commitments document of the CCC. The overall target should be absolute or net-zero (i.e. including the compensation of any residual emissions).		These are the emissions reductions that would be achieved through existing policies, and plans, outlined in Section A-2.1. Those actions are by definition not part of the action portfolio in section B. If they are fully or partially incorporated in module B-2, their associated reduction potential should be referenced in column (5) and not be included here. WARNING if the baseline is a BAU scenario: If the BAU modelling includes any of these existing measures, please also do not include the associated emissions reduction in this column as otherwise it would be double counted.		(4) = (2) – (3)		This column is used to present the already quantified emission reduction associated with the action portfolios outlined in module B-2. Ideally, this equals the gap. If the there is a difference between the reduction potential of the actions specified in module B-2 (for instance because their reduction potential has not been fully estimated or because additional measures will be identified in future iterations), the CCC AP should be explicit about this difference and explain how the difference will be closed. In principle, as long as the difference has not been addressed, it would be considered as part of the residual emissions.		(6) = (1) – (2)	
	(absolute) (t CO2e)	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**	**(t CO2e)**	**(%)**
Buildings/Heating/Electricity	2,478,830	1,983,064	80	728,715	29	1,254,349	51	1,668,000	132.9	495,766	20
Transport	1,483,345	1,186,676	80	137,438	9	1,049,238	71	531,102	50.6	296,669	20
Waste / water and sewage management	24,595	19,676	80	-	0	19,676	80	29,690	150.9	4,919	20
Industrial Process and Product Use (IPPU)	591,091	472,873	80	80,559	14	392,314	66	295,545	75.3	118,218	20

Agricultural, Forestry and Land Use (AFOLU)	3,277	2,622	80	2,156	66	466	34	2,100	450.6	655	20
Total	**4,581,138**	**3,664,911**	**80**	**948,868**	**21**	**2,716,043**	**79**	**2,526,437**	**93**	**916,227**	**20**

3.2 Module B-2 Climate Neutrality Portfolio Design

Energy and heating system

B-2.2: Individual action outlines		
Action outline	Action name	Action E-1 Generation of electricity and district heating using low-emission and zero-emission technologies
	Action type	Infrastructure activities, analysis, support, financing
	Action description	Examples of activities will include: 1. Modernisation of the combined heat and power plant in Wroclaw using heat pumps, cogeneration and gas boilers, heat storage and P2H and using them in a cogeneration system to produce electricity and heat 2. Construction of an installation for the use of waste heat from sewage at the Wroclaw Janowek Sewage Treatment Plant 3. Analyses of the possibilities of using waste heat from other distributed sources for own needs or the heating system 4. Investments in improving the efficiency of the existing heating network (modernisation of the network, heat substations) 5. Expansion of the heating system in the city to cover the demand of new development and existing development (where justified and economically possible) 6. Implementation by stakeholders of projects in the field of supporting district heating with heat pumps on buildings powered by photovoltaic panels (e.g. in municipal and private resources or cooperative) It is also important to continue and accelerate the connection of buildings to the municipal heating network under the “Clean Energy for Wroclaw” programme.
Reference to impact pathway	Field of action	Energy and heating system, built environment
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behaviour/Education

	Outcome	Taking decarbonisation actions in cooperation with energy and heating companies will enable a move away from or significant reduction of fossil fuels currently used in the city's energy and heating system, and consequently a significant reduction of emissions within the city boundaries.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, energy and heating companies
	Action scale & addressed entities	Covers the entire city area. Activities carried out by energy and heating companies in agreement with municipal units.
	Involved stakeholders	Wroclaw Municipality, energy and heating companies, housing cooperatives
	Comments on implementation – consider mentioning resources, timelines, milestones	Investments in activities aimed at decarbonising the energy industry, which is currently largely based on fossil fuels such as coal, natural gas and heating oil, are activities with a very large impact on the city's final reduction goal. The use of renewable sources to the widest possible extent by switching to RES at the source or building low-temperature heating systems located in the city will significantly reduce emissions and improve air quality. The activity of developing a heating network requires large financial outlays. The development of a heating network in new investment areas is often unprofitable or impossible to implement due to the dispersion of recipients or the reimbursement of its implementation costs. However, the development of this network in highly urbanised areas is also difficult due to the technical complexity of the solutions and the necessary interference with the existing infrastructure. In addition, the development of small heating networks based on local boiler plants fired with heat pumps is an alternative for all those places in the city where there is no heating network or where there are boiler plants fired with fossil fuels.
Impact & cost	Generated renewable energy (if applicable)	No data
	Removed/substituted energy, volume, or fuel type	Fossil fuels

	GHG emissions reduction estimate (total) per emission source sector	750,000 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO2e unit	839.37 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action E –2 Local RES generation of electricity
	Action type	Infrastructure activities, analysis, support, financing, education
	Action description	Examples of activities will include: • Continuation of the Small RES Programme for public facilities - renewable energy installations on public buildings, in particular educational facilities • Maintaining the tax exemption programme for renewable energy installations • Establishing an energy cluster (universities - the city of Wroclaw) • Using the potential for renewable energy development on private facilities • Construction of a photovoltaic farm for MPK with an area of at least 20 ha
Reference to impact pathway	Field of action	Energy system, butli environment
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behaviour/Education
	Outcome	Generating RES energy is important for reducing local emissions from energy and heat production, which has a direct impact on reducing CO_2 emissions.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal units and companies, residents, private and public entities

	Action scale & addressed entities	Covers the entire project area. Activities carried out by municipal units, municipal companies, large industrial plants, private entrepreneurs. This activity will be carried out at the citywide level and outside the contract area, but will have a direct impact on it.
	Involved stakeholders	Wroclaw Municipality, municipal companies and entities, private entrepreneurs, residents, universities
	Comments on implementation – consider mentioning resources, timelines, milestones	In Wroclaw, the tax incentive system has effectively influenced the rapid increase in renewable energy sources among private users. This effect was additionally supported by favourable settlement regulations at the national level. Maintaining this trend is necessary, therefore appropriate legislation is important, as well as modernisation of electric grids at the national and regional level so that they are ready to accept new users. From the point of view of the growing use of RES, power grids must be constantly developed so that they do not fail and are better managed. Implementation of intelligent power grid management systems consists primarily in using systems for: optimizing energy transmission in the networks of energy operators, supervision of energy flow in intelligent networks, management of local energy storage facilities. In the case of public facilities, especially educational ones, obtaining energy from RES allows to reduce operating costs. Creating energy clusters is a new form of the so-called civic energy. In the near future, such a cluster will be created in agreement with universities in Wroclaw. Also in this case, the development of this type of prosumer energy depends on national regulations. In Wroclaw, there is a certain potential of this type, both with the use of public and private buildings. The activity of civic energy has a positive impact on the increase in the use of RES, provides the opportunity for cooperation in the field of energy production, activation of society and reduction of energy costs, and also improves the quality of the environment and the state of the climate. Another element of obtaining energy from RES are large-scale photovoltaic farms. In this case, the availability of land for this type of installation is limited due to the high urbanization of the area and environmental restrictions (soils, valley areas, greenery, birds). However, there is a possibility of locating this type of installation. In this context, cooperation at the regional level is also important, especially within the Wroclaw Functional Area, because Wroclaw is surrounded by large areas of agricultural, open areas, which can potentially be a reservoir for the production of energy from renewable sources for the needs of the city. There are also plans to implement a photovoltaic farm for the needs of the city's transport company, which would fulfill the postulates

		from the citizens' panel for public transport to be powered from renewable sources.
Impact & cost	Generated renewable energy (if applicable)	Power RES – 58 MW in 2023
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	460,000 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	1,259.71 t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action E- 3 Modernisation of public lighting to more energy efficient
	Action type	Infrastructure activities, financing
	Action description	The action consists of modernizing outdoor urban lighting (in streets, green areas, including parks) by using energy-saving LED luminaires and implementing intelligent energy control systems that contribute to the optimization of energy consumption, sustainable development and environmental protection (progressive dimming or motion activation, which allow for controlling the light intensity depending on the needs). The actions taken will include, among others, introducing requirements in public procurement, successive replacement of lighting in public resources and other entities or the use of hybrid lighting luminaires in LED technology, the use of intelligent lighting.
Reference to impact pathway	Field of action	Energy and heating system
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behaviour/Education

	Outcome	Lower energy consumption in the city's lighting infrastructure
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal units, private enterprises
	Action scale & addressed entities	The entire city area: traffic routes, parks, squares, public areas
	Involved stakeholders	Municipal units, private entrepreneurs
	Comments on implementation – consider mentioning resources, timelines, milestones	Wroclaw is gradually replacing its lighting with LEDs. It also purchases energy for lighting purposes as part of the purchasing group. In 2022, there were a total of 55,135 street lighting fixtures in the Wroclaw area. The Roads and City Maintenance Authority owned 8,429 lighting fixtures, which constituted 15.3% of all outdoor lighting fixtures installed in the city of Wroclaw, while Tauron New Technologies (a State Treasury company) owned 39,624 lighting fixtures, which constituted 71.9% of all outdoor lighting fixtures. Some of the lighting fixtures are also used by the Municipal Greenery Authority.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	7,153 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	1,014.03 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action E-4 Active educational, organisational, promotional and planning activities in the field of Decarbonisation of electricity and heat production

	Action type	Educational, support and financing activities
	Action description	The action will consist of: 1. Continuation of cooperation with heating energy companies 2. Conducting information and promotional activities for residents and investors in the field of RES and Decarbonisation of energy and heat production 3. Cooperation at the local and regional level with the Institute of Territorial Development in the implementation of the Energy strategy for Lower Silesia 4. Cooperation with the Voivodeship Fund for Environmental Protection and Water Management in the scope of the unit's operating strategy and educational programmes and the possibility of obtaining financial resources 5. Cooperation with universities in the scope of innovative energy and heating solutions and energy education and within the energy cluster 6. Supporting projects for the development of RES and cooperation in this area in the Wroclaw Functional Area 7. Active spatial and strategic planning friendly to climate neutrality In the long term, the establishment of an agency dealing with cooperation with existing and acquiring new investors in the green energy industry, and in certain conditions being an investor or acting as an energy company, will be analysed.
Reference to impact pathway	Field of action	Energy and heating system
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behaviour/Education
	Outcome	Education, cooperation and consulting will facilitate investment decisions made by both large private enterprises and State Treasury companies, but also by smaller public and private investors, including residents.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality

	Action scale & addressed entities	The area of the city and the Wroclaw Urban Functional Area. Educational or informational activities may have a broader scale than just the urban one.
	Involved stakeholders	Municipal units, energy and heating companies, private enterprises, residents, universities, local governments
	Comments on implementation – consider mentioning resources, timelines, milestones	In order to implement the transformation of the energy and heating system, broad cooperation is necessary at various levels of administration, but also in agreement with local and national energy and heating companies. Therefore, the city can act as a mediator and intermediary in this process. In addition, the city can effectively create and stimulate the development of civic energy using renewable energy sources. Municipal units and companies, as well as universities and enterprises, can become prosumers in the production of electricity for their own needs and within energy clusters.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Not applicable
	GHG emissions reduction estimate (total) per emission source sector	Not applicable
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	Not applicable

Built environment

B-2.2: Individual action outlines		
Action outline	Action name	Action B - 1 Energy efficient buildings
	Action type	Buildings, direct reduction of emission

	Action description	The action involves increasing energy efficiency in existing residential and commercial buildings owned by the city and other public and private entities, through deep thermal modernisation and optimisation of energy consumption by installing intelligent energy management systems and installing RES (electricity and heat). The action includes, among others: • Utilisation of municipal support programmes for thermal modernisation by residents - subsidies under the Kawka + programme • Continuation of the replacement of heat sources until 2028 (in accordance with the requirements of the Anti-smog Act for the Lower Silesian Voivodeship) • Utilisation of national funds by residents as part of subsidies from the programmes: Clean Air, Warm Apartment, Stop Smog • Utilisation of funds as part of loans from the National Economy Bank (TERMO Programme) • Development of a transformation model for quarters of various types of buildings under the NEEST pilot programme • Monitoring of energy consumption in facilities • Reactive power compensation in public facilities • Implementation of the PoWROty programme - preparation of documentation and modernisation of tenement houses in the municipal housing stock of 22 tenement houses (ultimately for 100) • Comprehensive energy modernisation of residential buildings in the municipal housing stock of the Wroclaw Commune in the years 2025-2030 • Improvement of the energy efficiency of existing commercial buildings (office, retail, industrial) • Modernisation of educational facilities (schools, kindergartens) and cultural, social welfare and administrative facilities • Construction and development of energetically autonomous areas in the city - PED based on prosumer activities based on

		organisational, technical and financial models developed in the NEEST pilot project In the case of new buildings, it is necessary to: • Cooperation with the developer sector • Implementation of the EPBD building directive at the national level (New public and private buildings) meeting the parameters of the EPBD building directive similar to NZEB • High energy efficiency standards in urban investments (schools, kindergartens, public buildings) • Development of energy standards for buildings
Reference to impact pathway	Field of action	Buil environment
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behavior/Education, Spatial Planning
	Outcome	Lower energy consumption in existing buildings and lower energy consumption in newly constructed private and public buildings.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, private companies, residents, development companies.
	Action scale & addressed entities	Deep thermal modernisation of all buildings: commercial (office, commercial, service), residential (multi- and single-family), while the installation of intelligent energy management systems mainly applies to commercial buildings.
	Involved stakeholders	Municipal budget units, entrepreneurs cooperating within PPP (public-private partnership), ESCO formulas and other forms of financing public investments, private entrepreneurs, development companies, residents, housing communities, housing cooperatives, universities, construction and technology companies
	Comments on implementation – consider mentioning resources, timelines, milestones	The measure assumes direct investments in the urban stock of residential and utility buildings (municipal buildings, schools, hospitals, offices, social buildings, warehouses). The implementation of this measure on a large scale

		is dependent on financial support systems at the national, EU and regional levels and the availability of a sufficient number of qualified service providers on the market. In addition, the measure assumes stimulating investments in the modernisation of private, residential and utility buildings (industrial, commercial, service, warehouse), belonging to housing cooperatives, enterprises and institutions not related to local government, private individuals, by creating a system of incentives and financial and substantive support for building owners. The implementation of this measure on a large scale is also dependent on financial support systems at the national, EU and regional levels, in particular subsidy and credit programmes on preferential terms and support instruments for people affected by energy poverty, as well as the introduction of national and legal regulations motivating building owners to undertake modernisation activities, e.g. the implementation of the European "buildings directive" (Energy Performance of Buildings Directive, EPBD). The essence of the action is to reduce energy demand and use emission-free energy sources by designing and constructing new buildings, in accordance with high energy efficiency standards. The city has a direct influence only on the energy standard of its own buildings. The condition for effective implementation of high efficiency standards for buildings is legislative changes at the national level, e.g. implementation of the EU "building directive" (Energy Performance of Buildings Directive, EPBD). Actions consisting in replacing non-ecological heat sources through subsidy programmes addressed to residents and small entrepreneurs directly affect the reduction of the city's CO2 emissions and improve air quality. Low emission is a direct cause of smog in the city and its effects. Subsidy programmes mobilize entities to act and are an effective form of combating low city emissions and can be implemented for many years. They require large financial outlays and the introduction of a system of incentives and educational campaigns for all interested in replacing the heat source. The actions taken should also include those related to spatial policy, bearing in mind that space is a limited resource and the way it is used, in particular the dispersion of development and dysfunctional spatial structure,

		significantly contribute to the increase in energy consumption.
Impact & cost	Generated renewable energy (if applicable)	No data
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	451,000 t CO_2
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	17,013.85 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action B - 2 Energy consulting, educational, informational and promotional activities for residents and entrepreneurs
	Action type	Education, information, consulting, participation
	Action description	The action aims to cooperate with private building managers within housing communities and with housing cooperatives in the context of the renovation wave and implementation of the building directive. It is also very important to conduct information campaigns and actions aimed at promoting efficient energy management in households as well as passive and energy-plus construction. Experience from the “Change the stove” campaign (replacement of heat sources) will be used, including social participation (consultations, social campaigns). Information activities will include comprehensive support in the field of building modernisation in the One Stop Shop (OSS) formula aimed at accelerating and facilitating the modernisation process (coordination of activities between local and national programmes, energy and financial consulting, among others, using models developed from the pilot project).

Reference to impact pathway	Field of action	Built enviromnet
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social Behaviour/Education
	Outcome	Accelerate the wave of building renovations in the city and increase awareness of the need to undertake these actions. Support for people in energy poverty and excluded groups.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality (coordination)
	Action scale & addressed entities	The area of the entire city
	Involved stakeholders	Residents, non-governmental organisations, universities and research institutes, local, regional and national administration units
	Comments on implementation – consider mentioning resources, timelines, milestones	The basis for achieving climate neutrality and implementing energy transformation is raising the level of social awareness and stakeholder involvement. Actively involving all social groups in development processes is beneficial for finding lasting and acceptable solutions that guarantee socio-economic development. Improving the creation and dissemination of knowledge bases and best practices is also of particular importance in this process. Increasing the level of knowledge about climate and the environment requires the support of society and interested entities, as well as the promotion of knowledge about sustainable development and new models of sustainable consumption. Full knowledge and awareness of the problems resulting from energy transformation (e.g. periodic increase in energy prices) will allow for gaining social acceptance, which is an essential element of achieving climate neutrality. Enabling citizens and consumers to become active participants in the transformation is also intended to provide energy-poor households with easier access to energy-efficient buildings and cheaper energy sources based on renewable energy sources. Available data indicate that the energy poverty rate in households living in single-family houses in the Lower Silesian Voivodeship in 2016 was 12.4% (35,113 households – no dedicated data for Wroclaw). Targeting information and support activities for this group of residents of the voivodeship is one of the significant challenges.

Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Not applicable
	GHG emissions reduction estimate (total) per emission source sector	Not applicable
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	Not applicable

Transportation and mobility

B-2.2: Individual action outlines		
Action outline	Action name	Action T-1 Expansion of the public transportation network with accompanying infrastructure and reduction of car traffic in the city
	Action type	Infrastructural, informational and educational, organisational, financial activities
	Action description	Examples of activities to be implemented: a) increasing accessibility to public mass transportation and counteracting transportation exclusion, especially for the elderly, children and people with disabilities, b) b) expansion of the public transport network (zero-emission buses, streetcars, including, among others, implementation of investments from the Wroclaw Tram and Bus Programme for 2024 - 2032 (including streetcar lines to Swojczyce district, Jagodno district, Borowska Hospital, Maślice, Klecina, Nowe Żerniki, Oltaszyn – Wysoka Street, Gądów Południowy, Muchobór Wielki, Księże Wielkie, Gajowice, Borowska Centrum, Psie Pole district, Sucha Street). c) purchase of modern, energy-efficient low-floor streetcars, replacement of bus fleets with electric/hydrogen ones,

		d) construction of a streetcar and bus depot in connection with the development of the network and electrification of the rolling stock e) support the use of public transportation, improving passenger comfort, f) Continued development of Park&Ride system at transportation hubs, g) Successive expansion of the paid parking zone h) Continuation of the designation of residential zones i) Tariff integration - common agglomeration ticket for public transport in Wroclaw j) Popularization of carpooling/carsharing and other forms of semi-shared transportation, k) Construction of new train stops and increase of traffic - launch of new agglomeration connections l) Moving toward the designation of a clean transportation zone.
Reference to impact pathway	Field of action	Transportation and mobility
	Systemic lever	Technology/Infrastructure, Management and Policy, Science/Finance, Social behaviour/education, Urban planning.
	Outcome	Reduced demand for motorized passenger transportation and shift to public and non-motorized transportation. Decarbonisation of public and private transportation.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, transport companies (local and national government).
	Action scale & addressed entities	Actions carried out by city units, transport companies (local and national government), the entire city area and within the Wroclaw Functional Area
	Involved stakeholders	Wroclaw Municipality, transport companies of the city and provincial government, residents, national and regional authorities
	Comments on implementation – consider mentioning	The most important measure is to reduce the scale of individual car transport combined with the development of public transport. Transportation is the

	resources, timelines, milestones	second largest source of greenhouse gas emissions in the Wroclaw area, after construction and stationary energy - it accounts for almost 31% of all emissions and a source of air pollution. These emissions are mainly generated by road transport, with individual car transport accounting for the largest share. Therefore, the key actions should concern the development of low-emission public transportation and other alternative ways of getting around the city that will be attractive, comfortable, physically accessible and affordable, safe for people moving around the city by individual car transport. Wroclaw is systematically and consistently developing public transportation based on tramway, bus and rail transportation. This includes both improving travel conditions on the existing network through its modernization and building new transport corridors. Transportation work is also being increased in cooperation with the agglomeration rail operator, which is a company under the management of the province's local government). The use of public transport on a wider scale is also to be encouraged by new P+R parking lots in created interchanges, an increase in the number of safe and accessible stops, and the development of environmentally friendly (green tracks and green stops) transport infrastructure. The measure assumes the continuation of these activities in accordance with the adopted sector documents at the urban level.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	324,800 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	2,090.28 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action T-2

		Implementation of the Bicycle Action Programme until 2030 for Wroclaw
	Action type	Infrastructural, educational, support activities
	Action description	Examples of actions to be implemented: a) construction of new bicycle routes or modernisation of existing ones, together with accompanying infrastructure and connecting them into coherent networks (e.g. realization or modernisation of 4 main or alternative (greenaway) routes, 16 new connections of settlements with the network of bicycle routes, modernisation of 25 km of existing bicycle routes, construction of6 new connections with neighboring municipalities: Miękinia, Kąty Wroclawskie, Kobierzyce, Siechnice, Długołęka) b) 5,000 new bicycle parking spaces including Bike&Ride and the possibility to park a bicycle at all institutions, educational institutions and at all companies applying for a rack) c) Continuation and development of the Wroclaw City Bicycle d) Development of programmes for reducing car traffic and enabling safe zero-emission traffic and pedestrian traffic in the vicinity of schools, e) Promoting the use of bicycles on the way to work and school and as freight transportation - educational and information campaign on city media.
Reference to impact pathway	Field of action	Transportation and mobility
	Systemic lever	Technology/Infrastructure, Management and Policy, Science/Finance, Social behaviour/education, Urban planning
	Outcome	Increased accessibility to bicycle transportation and bicycle coverage in the city.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal entities, private sector
	Action scale & addressed entities	City-wide and systemic actions

	Involved stakeholders	Wroclaw Municipality, city companies, residents, national and regional authorities, private sector, residents
	Comments on implementation – consider mentioning resources, timelines, milestones	Expand and improve the safety of infrastructure designed for cyclists. Creation of high-speed bicycle thoroughfares with limited traffic lights and stops for covering longer distances in the city. Bicycle May action for children and young people combined with gamification action for adults from the business sector and the Wroclaw City Council and city units. Expansion of the urban bicycle network and inclusion of the remaining towns and cities of the Wroclaw Functional Area in the system.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	18,100 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	1,675.87 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action T-3 Implementation of a pedestrian programme (in accordance with Wroclaw standards for shaping pedestrian-friendly urban spaces)
	Action type	Infrastructural, educational, supportive actions
	Action description	Examples of actions to be implemented: a) Improving safety at pedestrian crossings b) Repairs to sidewalks

		c) Construction of new safe accesses and crossings
Reference to impact pathway	Field of action	Transportation and mobility
	Systemic lever	Technology/Infrastructure, Management and Policy, Science/Finance, Social behaviour/education, Urban planning
	Outcome	Increased accessibility and safety and opportunities for convenient walking.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal units
	Action scale & addressed entities	City-wide and systemic actions
	Involved stakeholders	Wroclaw Municipality, city companies, residents, private sector
	Comments on implementation – consider mentioning resources, timelines, milestones	Expand and improve the safety of pedestrian infrastructure.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	1000 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	2,693.34 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action T-4

		Measures for the dissemination of electric cars in individual, collective and freight transportation
	Action type	Infrastructural, educational, supportive, financial activities
	Action description	Examples of actions to be implemented: a) Successive replacement of the bus fleet with low-emission and gradually zero-emission vehicles (electric buses, hydrogen buses) (at least 96 electric buses) b) Subsidies for the purchase of electric cars under national programmes c) Implementation of charging infrastructure (charging stations - electric, hydrogen) d) Facilities for users of electric cars e) Establishment of a micro-hub for delivery within the city center f) Purchase of new streetcars (at least 86 vehicles) g) Development of charging infrastructure. Incentives to install chargers on private land for businesses and individuals (possibly with energy storage).
Reference to impact pathway	Field of action	Transportation and mobility
	Systemic lever	Technology/Infrastructure, Governance and Policy, Science/Finance, Social behaviour/education, Urban planning
	Outcome	Electrification and improved efficiency of public transportation. Increasing the number of private electric cars. Improving charging and energy storage infrastructure for private and public transportation.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal units, private sector, residents
	Action scale & addressed entities	Activities carried out by city units
	Involved stakeholders	Wroclaw Municipality of Wroclaw, city companies, residents, national and regional authorities, thermal and electric power generation companies, charging

		station operators and alternative fuel development organisations, neighbourhood fleet companies.
	Comments on implementation – consider mentioning resources, timelines, milestones	Wroclaw is systematically and consistently replacing its rolling stock with more energy-efficient and low- or zero-emission vehicles. Hydrogen-powered buses are also being tested. A measure affecting the reduction of emissions from individual car transport will be the development of electromobility. This means building, together with private partners, appropriate infrastructure for charging electric vehicle.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	192,200 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	3,355.17 EUR / t CO_2e

B-2.2: Individual action outlines		
Action outline	Action name	Action T-5 Education, promotion and information activities in transportation
	Action type	Educational, support activities
	Action description	Examples of activities to be implemented: a) Cycling promotion activities for different user groups (for schools, students, entrepreneurs) b) b) Pedestrian Wroclaw - educational and promotional activities c) Education on electromobility

Reference to impact pathway	Field of action	Transportation and mobility
	Systemic lever	Technology/Infrastructure, Management and Policy, Science/Finance, Social behaviour/education, Urban planning
	Outcome	Increased awareness of the need to develop public transportation, bicycling, improved safety of writers and electromobility. Popularization of the use of non-self-driving modes of transportation for daily trips to work, school, university. Changing the awareness of residents and entrepreneurs towards multimodlancy and mobility in moving around the city.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, city units and companies, private sector, NGOs
	Action scale & addressed entities	Activities carried out by city units throughout the city
	Involved stakeholders	Wroclaw Municipality of Wroclaw, city companies and units, residents, charging station operators and alternative fuel development organisations, neighbourhood fleet companies, NGOs
	Comments on implementation – consider mentioning resources, timelines, milestones	Actions taken are aimed at promoting public transport, energy-efficient vehicles, changing individual transportation modes (car) in favor of walking, cycling and the use of personal transport equipment (UTO), and changes in land use (e.g., appropriate shaping of the settlement network and organisation of the functional and spatial structure of development, including prevention of dispersion of development) reducing the demand for transportation.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Not applicable
	GHG emissions reduction estimate (total) per emission source sector	Not applicable
	GHG emissions compensated (natural or technological sinks)	Not applicable

	Total costs and costs by CO_2e unit	Not applicable

Green infrastructure & nature-based solutions

B-2.2: Individual action outlines		
Action outline	Action name	Action G-1 Implementation of the Green Revolution programme
	Action type	Infrastructural, supportive, strategic actions
	Action description	Adoption of an ambitious greening plan, and within it: implementation of programmes - Green Lungs of Wroclaw, Park on every estate, striving for the 3-30-300 rule; Afforestation of the city, creation of green roofs and facades on public buildings and support for private buildings (continuation of tax exemptions), revitalization of courtyard interiors, rehabilitation and expansion of existing parks and other green areas, creation of new parks and other green areas, implementation of pocket parks in highly urbanized areas, greening of streets, greening of block interiors, continuation and development of urban farms, family allotment gardens as biodiversity areas. Protection of valuable green areas and other valuable natural areas from urbanization pressures by enacting appropriate forms of protection by the City Council, appropriate provisions in strategic documents and local plans. These actions may include, among others, the establishment of ecological uses and natural and landscape complexes by the City Council, the creation of a nature reserve on the Irrigation Fields, the protection of the Sleza River ecosystem, the protection of allotment gardens in local plans, the amendment of local plans for wooded areas previously earmarked for development, and the introduction of provisions in local plans to protect and develop BZI. In this context, it is also important to provide funds in the city budget for the purchase of land with natural values so as to protect it from urban pressure. A Stormwater Management Strategy involving, among other things, the unsealing of concreted surfaces, retention of rainwater and prevention of flooding, elimination of rain and drought hot spots, improvement of the functioning of water reservoirs (e.g. Pilczycki Pond).

		Development of a spatial database on the city, in particular smart solutions for the inventory of greenery in the city and assessment of ecosystem services, biodiversity (inventory of naturally valuable areas and their condition) in conjunction with the ongoing LifeCoolCity project from the LIFE programme, which will provide a management system for blue-green infrastructure in the city area.
Reference to impact pathway	Field of action	Blue-green infrastructure and nature-based solutions
	Systemic lever	Technology/Infrastructure, Management and Policy, Science/Finance, Social Behaviour/Education, Urban Planning
	Outcome	Provide close access to green spaces for city residents. Preservation of biodiversity. Adaptation to climate change including reduction of urban heat island and increase of rainwater retention.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, city units and companies
	Action scale & addressed entities	Activities throughout the city
	Involved stakeholders	Wroclaw Municipality, city units and companies, residents, NGOs, private sector
	Comments on implementation – consider mentioning resources, timelines, milestones	Green areas account for nearly 41% of the area of Wroclaw, which gives great potential for maintaining and developing a coherent system of blue-green infrastructure in the city. They perform important environmental functions and provide residents with a range of sustaining, regulatory, cultural and provisioning services, determining the quality of life in the city and its adaptation to climate change. There are deficiencies in the city's greenery continuity, which should be remedied through the various measures taken, just as the quality of the greenery should be systematically improved. These measures will be implemented both through direct investments by the city, such as the continuation of the street modernisation and greening programme, the planting of trees as part of the existing Wro programme, the expansion of green tracks and other activities. There will also be a continuation and expansion of activities in the de-paving of backyards and squares. Supporting activities are the implementation and enforcement of greenery management standards (standards for protection of greenery in investment processes,

		standards for maintenance of green areas). It is planned to prepare an ambitious plan for greening the city. The Stormwater Management Strategy (2023), which also includes blue-green projects, will also be implemented.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Not applicable
	GHG emissions reduction estimate (total) per emission source sector	2,100 t CO_2e
	GHG emissions compensated (natural or technological sinks)	No data available
	Total costs and costs by CO_2e unit	No data available

B-2.2: Individual action outlines		
Action outline	Action name	Action G-2 Educational, informational, organisational climate action
	Action type	Infornmation, education, subsidy, support activities
	Action description	Continuation and strengthening of activities under the programmes I like rain (education facilities), Catch the rain (residents, communities, housing cooperatives, grants), Wroclaw does not waste, bookcrossing. Expand educational activities on blue-green infrastructure and ecosystem services, sustainable development goals, food policy, climate change challenges.
Reference to impact pathway	Field of action	Blue-green infrastructure and nature-based solutions
	Systemic lever	Governance and policy, science, finance and financing, education and communication

	Outcome	Development of blue-green infrastructure in the city. Protection of biodiversity. Increasing the living comfort of residents, health levels and tourist attractiveness of Wroclaw and the surrounding area, through the expansion and diversification of the urban ecosystem and the creation of friendly places for recreation and relaxation.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal units
	Action scale & addressed entities	City-wide activities
	Involved stakeholders	Wroclaw Municipality of Wroclaw, city units and companies, residents, private sector, NGOs, universities, education units
	Comments on implementation – consider mentioning resources, timelines, milestones	Activities in the field of blue-green infrastructure and climate change adaptation have less impact on direct emission reduction but are important from the point of view of reducing energy consumption, quality of life, climate change adaptation, and can influence transport behaviour variables. As part of education and outreach activities, the city encourages residents, cooperatives, housing communities, and businesses to deconstruct pavement, plant greenery, and establish small retention facilities on land owned by them, through education (e.g., Good Practice Guides for Stormwater Management in Urbanized and Road Areas) and support programmes - expert advice from city entities and grant programmes for small retention facilities, as well as civic budgeting.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Not applicable
	GHG emissions reduction estimate (total) per emission source sector	Not applicable
	GHG emissions compensated (natural or technological sinks)	Not applicable

	Total costs and costs by CO_2e unit	Not applicable

Waste and water and sewage management

B-2.2: Individual action outlines		
Action outline	Action name	Action W-1 Climate neutrality and energy security of water, wastewater and waste management
	Action type	Infrastructure actions
	Action description	Examples of activities to be implemented: a. construction of Selective Collection Points for municipal waste, b. information and education campaigns for residents about the operation of Selective Collection Points for Municipal Waste, c. support for entrepreneurs in the field of selective waste collection, e.g. development of information materials on the principles of municipal waste management for entrepreneurs; d. Implementation of a smart waste collection and transportation management system e. Use of innovative technologies for recycling and recovery of individual material fractions of waste f. Educational activities in the area of closed-loop economy Wroclaw does not waste g. Improving the efficiency of selective collection of all waste fractions h. R&D projects for construction of installations for mechanical and/or biological transformation of municipal waste with energy recovery i. R&D work to optimize water treatment and wastewater treatment processes

		j. Application of intelligent solutions in hardware, software and management of urban water and wastewater management k. Optimization of the operation of the aeration system for activated sludge at the Wroclaw Wastewater Treatment Plant. l. Programme to improve energy efficiency in the city's water and wastewater management m. Increasing the share of renewable energy in the balance of the water company through the construction of PV systems and heat pumps, n. Construction of a plant for receiving organic waste, e.g. from collective catering facilities, and preparing it for the co-digestion process.
Reference to impact pathway	Field of action	Waste, water and wastewater management
	Systemic lever	Technology/Infrastructure, Management and Policy, Science, Finance
	Outcome	Waste and water and wastewater management do not generate significant emissions, however, improving their efficiency will have an impact on improving the quality of the environment, including in particular water, soil condition, air quality. Improving the efficiency of these processes will significantly improve the quality of the city's environment and living conditions.
Implementation	Responsible bodies/person for implementation	Wroclaw Municipality, municipal companies
	Action scale & addressed entities	Covers the area of the entire city. Activities carried out in parallel by stakeholders - city companies, private companies responsible for waste disposal.
	Involved stakeholders	Wroclaw Municipality, city companies, local companies, residents, private companies, NGOs
	Comments on implementation – consider mentioning resources, timelines, milestones	Adaptation of infrastructure in the field of waste management and water and wastewater management to current and future legislation. Further development of the selective waste

		collection process requires measures to improve the existing waste collection process, including additional education of residents or implementation of new waste sorting technologies. Some of the necessary measures are conditioned by national regulations. Improving energy efficiency and wastewater treatment and the use of bio-waste.
Impact & cost	Generated renewable energy (if applicable)	Not applicable
	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	26,690 t CO_2e
	GHG emissions compensated (natural or technological sinks)	Not applicable
	Total costs and costs by CO_2e unit	4,131.58 EUR / t CO_2e

Industry

B-2.2: Individual action outlines		
Action outline	Action name	ActionI-1 Decarbonisation of industry
	Action type	Infrastructure, information activities
	Action description	Examples of actions to be taken: a) Increase energy efficiency of industrial and production processes b) Self-sufficiency / autonomy / energy security (captive power and heat production) c) Reduction of thermal energy demand and production of heat from RES d) Improvement of energy efficiency of electricity consumption of technological processes

		e) Utilisation of waste heat for heating buildings and process heat needs f) Application of cogeneration systems based on natural gas g) Installation of photovoltaic systems on/near industrial buildings h) Thermal modernisation of industrial buildings i) Installation of renewable energy sources for heat production for heating industrial buildings
Reference to impact pathway	Field of action	Construction, energy and heating systems, industry
	Systemic lever	Technology/Infrastructure, Management and policy, Science, Finance
	Outcome	Activities undertaken in the field of corporate social and environmental responsibility (ESG). Reduction of industrial nuisance to local residents. Impact on local energy and heat production emission factor.
Implementation	Responsible bodies/person for implementation	Private companies, Wroclaw Municipality (supportively).
	Action scale & addressed entities	City-wide action
	Involved stakeholders	Municipality of Wroclaw, municipal companies, local companies, residents, businesses, private companies, NGOs
	Comments on implementation – consider mentioning resources, timelines, milestones	The scale of activities has not yet been precisely defined. There are large enterprises in the city area that have in their strategies the implementation of measures leading to the improvement of energy efficiency of industrial processes as well as power supply to buildings, and those that have not yet started this process. Meetings in the course of the work on the Climate Contract indicated strong business interests in joining the quest for climate neutrality. This cooperation will continue.
Impact & cost	Generated renewable energy (if applicable)	No data available

	Removed/substituted energy, volume, or fuel type	Fossil fuels
	GHG emissions reduction estimate (total) per emission source sector	491,950 t CO_2e
	GHG emissions compensated (natural or technological sinks)	No data available
	Total costs and costs by CO_2e unit	No data available

B-2.3: Summary strategy for residual emissions

To close the gap from reducing emissions to 80% of net climate neutrality, primarily actions as a result of independent sequestration of CO_2 (through the selection of vegetation and the scope of blue-green infrastructure areas) within the city. Much of this activity has been demonstrated within the Green Infrastructure and Nature-based activities sector. A specific action plan will be presented in one of the next iterations of the document, including: preparing an ambitious plan for greening the city.

However, at this stage of work on the climate contract for Wroclaw, no other activities related to the reduction of residual emissions are planned. We assume that the organisational and financial effort that we must undertake to implement the planned activities will not allow us to effectively implement additional projects with a high degree of technical and financial uncertainty (e.g. related to geological sequestration, the use of which will only be possible after the emergence of new, more effective and cheaper technologies). The situation is similar with the purchase of carbon credits - green certificates confirming the reduction of greenhouse gases by investing in an environmental project. The issues of purchasing carbon credits must be thoroughly analysed by legal and accounting services in terms of their compliance with the regulations governing the functioning of local governments.

<u>The impact of the national level on local emission reductions</u>

The effects of emission reduction resulting from the action plan presented in the action plan depend largely on the electricity emission index. in turn, this indicator depends on the amount of energy used in the city from the national system, including its emissivity and renewable electricity produced in the city and for the city's needs and its purchase

The National Centre for Emissions Management (KOBiZE) publishes the CO_2, SO_2, NOx, CO and total dust emission indicators for electricity every year.

Product emission indicators are information used to assess changes in the ecological condition of individual economic sectors. The above-mentioned indicators are also used when calculating the ecological effect in the case of modernisation or implementation of new projects resulting in emission reduction. The total emission volume in KOBiZE materials includes emissions reported to the National Database on emissions of greenhouse gases and other substances. The National Database collects, among others: information on emissions from fuel burning installations that produced only electricity or electricity and heat in a given year (installations producing only heat were not taken into account). All fuels were taken into account, including renewable ones, which were reported to the National Database as used in combustion processes and responsible for the emissions of the pollutants in question. KOBiZE additionally determines the emission indicators of electricity for end users, i.e. after

taking into account all electricity produced in the country (fuel combustion installations and energy from renewable energy sources - the so-called RES) and losses on the transmission and distribution of electricity.

This indicator for 2022 was 685 kg CO_2/MWh and was lower than in 2018 when it was 708 kg CO_2/MWh.

The gradual electrification of final energy consumption in construction, infrastructure and transport means that this indicator and the volume of electricity in the city are of key importance for the volume of emissions and for the process of achieving climate neutrality.

In the study Polska Net-Zero 2050 Road Map for Achieving Community Climate Policy Goals for Poland Until 2050 by KOBiZE and of Environmental Protection - National Research Institute (IOŚ-PIB from June 2021, a change in this indicator is forecast in the system of adopted scenarios for the needs of the national road map.

Based on the above the study assumes a reduction of the national indicator from the current level of approximately 700 kg CO_2/MWh to 200-450 kg in 2030 and below 100 kg in 2050.

It follows that the achievable emission reduction effect in Wroclaw, especially in the 2030 perspective, depends significantly on changes in the power supply system of the national power system, which will determine the scale of EF reduction in the national system. Therefore, the final residual emission may be lower than expected.

3.3. Module B-3 Indicators for Monitoring, Evaluation and Learning

B-3.1: Impact pathways

The city has many strategic documents for which it collects indicators. In the case of broadly understood climate policy, these include: Wroclaw City Strategy by 2030, Climate Change Adaptation Plan (MPA), Environmental Protection Programme (EPP), Sustainable Urban Mobility Plan (SUMP), Wroclaw Mobility Policy, State of the city report, Sustainable Energy and Climate Plan (SECAP), Economy Plan Low-emission (PGN). We also report to the Statistics Poland in the field of greenery, waste, mobility and water and sewage management. In addition, we strive to present reports on the platform provided by the Covenant of Mayors and, to a limited extent, on the CDP/ICLEI platform.

Completing all this data by units at the office level or municipal units and companies is time-consuming and requires additional resources. Unfortunately, we do not have a separate unit dealing with the analysis of urban data, so the proposed indicators must be, to some extent, complementary to those already collected for the city.

In the case of emission reduction activities, the annual inventory of greenhouse gas emissions performed for the purposes of PGN and SECAP is crucial, and will become an important element of CCC monitoring. In addition, a good tool for evaluating activities in CCC and its future iterations may be the use of an economic model in which assumptions can be modified depending on the progress of tasks and the changing legal and economic environment.

The idea behind the indicators:

1. Possible to obtain by those implementing activities, including municipal units

2. Tailored to CCC's areas of operation

3. Relating to emission inventories (result indicators), but also to individual activities (output indicators)

4. As activities within the CCC include tasks in the field of, among others: transport, which is an important emission sector, it is proposed to use indicators for mobility policy and SUMP (annual monitoring since 2013)

5. Similarly, indicators for the 2030 Strategy and the new 2050 (under development) - they may partly refer to co-benefits and general improvement of the quality of life in the city

6. Typical mitigation indicators would be related to a decrease in CO_2 emissions from individual sectors and an increase in the share of energy production from renewable energy sources

7. As part of CCC monitoring, tracking of the emission factor from energy and heat production may be taken into account - in the national and local system (based on the actual energy production sources used by the local energy and heat producer (KOGENERACJA) - the national mix will improve but locally it may be different - the emission factor from energy production is crucial for the correct calculation of emissions in the inventory and, consequently, emission reduction - examples of how this affects emission reduction are above in the chapter about residual emission).

Table 21. Economic Indicators by Sector

Action category - impact pathway	Activity/ project	Indicator code	Indicator name	Data source	Indicator Unit	Baseline	Target
						2022	2030
Global	All actions	1	Amount of carbon dioxide emissions from the area of the municipality in a given year / reduction level in relation to the base year	Emission inventory	kg CO_2/MWh/ %	4,581,138	Reduction of 80%
	All actions	2	GHG emissions per capita	Emission inventory	kg CO_2/per capita	7.04	TBD
Energy and district heating system	E.1, E.2	3	Emission factors for electricity in the National Energy System (NES)	National Centre for Emissions Management (KOBiZE)	kg CO_2/MWh	685[31]	400 – 600[32]
	B.1, E.1, E.2, E.3, T.4	4	Electricity consumption in the city	Emission inventory/ update of assumptions for the plan of supply with heat, electrical energy and gas fuel for the area of the Municipality of Wroclaw	MWh	2,481,576	TBD (3,201,000 in 2037[33])
	E.2, E.1,	5	Local electricity emissions factor in the city area	Emission inventory	kg CO_2/MWh	TBD	TBD

[31] the 2021 index was used in the 2022 inventory because the 2022 index was published at the end of 2023

[32] the value of the indicator depends on the actions taken within the national energy system, the values given are predictions according to the action scenarios presented in the analyses of KOBIZE and (the Centre for Climate and Energy Analyse (CAKE)

[33] The given value results from the supply plan and is related to the city's economic and spatial planning development projections, it is recommended to reduce consumption through energy demand reduction measures, e.g. within the CCC

	E.2	6	Power of photovoltaic installations installed in the city	Data from the Municipality of Wroclaw in consultation with the NES operator	MWh	58.3	increase
	E.2	7	Share of renewable energy sources in energy production	Update of assumptions for the plan of supply with heat, electrical energy and gas fuel for the area of the Municipality of Wroclaw	%	5	increase
Built environment	B.1, E.1, E.2,	8	GHG emissions from residential buildings	GHG inventory	kg CO_2/MWh	1,384,934	decrease
	B.1, E.1, E.2,	9	GHG emissions from service buildings	GHG inventory	kg CO_2/MWh	1,071,493	decrease
	E.1	10	Share of district heating in the building heating supply	Update of assumptions for the plan of supply with heat, electrical energy and gas fuel for the area of the Municipality of Wroclaw	%	53	TBD
	E.1	11	Emission factor for district heating	Emission inventory	kg CO_2/GJ	99.6	decrease
	B.1	12	Number of buildings thermally modernised in the municipal stock	Data of the Municipality of Wroclaw	pcs/year	8	increase
	B.1	13	Heat energy consumption	Update of assumptions for the plan of supply with heat, electrical energy and gas fuels for	TJ	15,619	decrease

				the area of the Municipality of Wroclaw/Emissio n inventory			
Transportation and mobility	T.1 – T.4, E.1, E.2	14	Transport emissions	Emission inventory	kg CO_2/MWh	1,483,345	
	T.1	15	Share of non-automotive transport	Monitoring – Sustainable Urban mobility Plan (SUMP)	%	59	70
	T.4	16	Share/number of electric vehicles in the total number of registered vehicles in the municipality	Wroclaw Strategy for the Development of Electromobility	%/pcs	0.32 / 2,227	TBD
	T.4	17	Share/number of electric buses in public transport	Wroclaw Strategy for the Development of Electromobility	pcs/%	13	increase
	T.1	18	Number of vehicle kilometres of inter-municipal transport ordered by the organiser (Local Government Unit)	Monitoring SUMP	carriage km/y	Communication inter-municipal - 4,535,382 / Public transport - 29,507,442	increase
	T.1, T.2, T.3	19	Number of passengers on public transport	Data of Municipal Transport Company	pcs/y	Municipal Transport Company – 194,490,000 9xx lines - 1,193,000	increase
	T.1, T.2, T.3	20	Total number of kilometres travelled in the city by vehicles	Environmental Insights Explorer – Google tool	km/y	4,780,000,000	decrease
	T.1	21	Number of parking spaces in the park & ride system		pcs	2,751	increase

	T.1	22	Share of the population of the Wroclaw Functional Area residing within 800 m of railway stations and stops or 500 m of a public transport stop (regarding the number of people registered for permanent residence)	SUMP for Wroclaw Functional Area (37 municipalities)	%	90.3 (2020)	increase
Green infrastructure and nature-based solutions	G.1	23	Surface and share of paved land in the city (planned)	Monitoring of the MPA	%/ha	TBD	TBD
	G.1	24	Surface and share of urban heat island and share and number of residents within its extent (planned)	Monitoring of the MPA	ha /%/ pcs	3477.8 /11.9 / 22.4 / 130464 (2021)[34]	decrease
	G.1	25	Area of green areas subject to ongoing maintenance by the Urban Greenery Management	Monitoring of the MPA	ha	2,870.53	increase
	G.1	26	Percentage of the population living within 300 m of green areas of any area	Monitoring of the MPA and Wroclaw city Strategy by 2030	% downtown / entire city	95.64/ 83.96	increase
	G.1	27	Area of the basic green system with adaptive functions / Share per capita	Monitoring of the MPA	ha/m^2 per capita	10,783.97 / 159.98	increase
	G.1	28	Share of high greenery (tree canopy cover)	Monitoring of the MPA	%	25	30
	G.1	29	Green areas in local plans adopted in a given year	Monitoring of the MPA	ha	136.06	increase
	G.1	30	Surface and share of protected areas in the city area	Monitoring of the MPA	ha/%	2,504.43 / 8.6	increase
	G.1	31	AFOLU Emission	Emission inventory	kg CO_2/MWh	3,277	decrease
Waste and water	W.1	32	Emissions from waste management and water and sewage management	Emission inventory	kg CO_2/MWh	24,595	decrease

[34] Based on a study entitled (Study on the occurrence of a surface urban heat island for the area of the city of Wroclaw from 2021)

and sewage management	W.1	33	Amount of garbage per capita	Data from the Statistics Poland /Report on the state of the municipality	kg/per capita	486	decrease
	W.1	34	Share of non-segregated (mixed) municipal waste in the total municipal waste stream	Monitoring of the Environmental Protection Programme/Report on the state of the municipality	%	58.77	decrease
	W.1	35	Water consumption per capita	Monitoring of the Environmental Protection Programme / Statistics Poland	m^3 per capita	76.9	decrease
	W.1	36	Amount of municipal wastewater treated	Statistics Poland data	m^3	38,295	TBD
Industry	I.1	37	Emissions from industry	Emission inventory	kg CO_2/MWh	591,091	decrease
	I.1	38	Number of companies taking ESG action (planned)	Data of the Municipality of Wroclaw[35]	pcs	TBD	TBD
Co-benefits	All actions	39	Number of days per year for which the PM_{10} standard is exceeded	Monitoring of the Wroclaw city Strategy by 2030 / Reports of the Provincial Inspectorate of Environmental Protection	Number of days	9	no

[35] Data received from Mission Cities partners as part of Transition Team activities or other initiatives

	All actions	40	Average annual concentration of $PM_{2.5}$	Monitoring of the Wroclaw city Strategy by 2030 / Reports of the Provincial Inspectorate of Environmental Protection	$\mu g/m^3$	17	decrease

4 Part C – Enabling Climate Neutrality by 2030

4.1 Module C-1 Governance Innovation Interventions

C-1.1: Description or visualisation of the participatory governance model for climate neutrality

In 2017, the **Sustainable Development Department** was established, called “Green Department”. One of the goals of the department was work on the topic of climate neutrality. The results were the Low Emission Plan (**PGN)** and Sustainable Energy and Climate Action Plan (**SECAP)**.

However, works of the new department and its tasks did not immediately and directly contribute to the shift in municipal actions and investment decisions. It was the fight against air pollution and the obligation to implement “anti-smog resolutions” in 2018[36], followed by the City Council Position[37] on climate emergency, that mobilized the city to take a serious approach to the topic of replacing heat sources, which, in addition to high dust emissions, are a source of greenhouse gas emissions, because they are based on burning the most emitting fossil fuels.

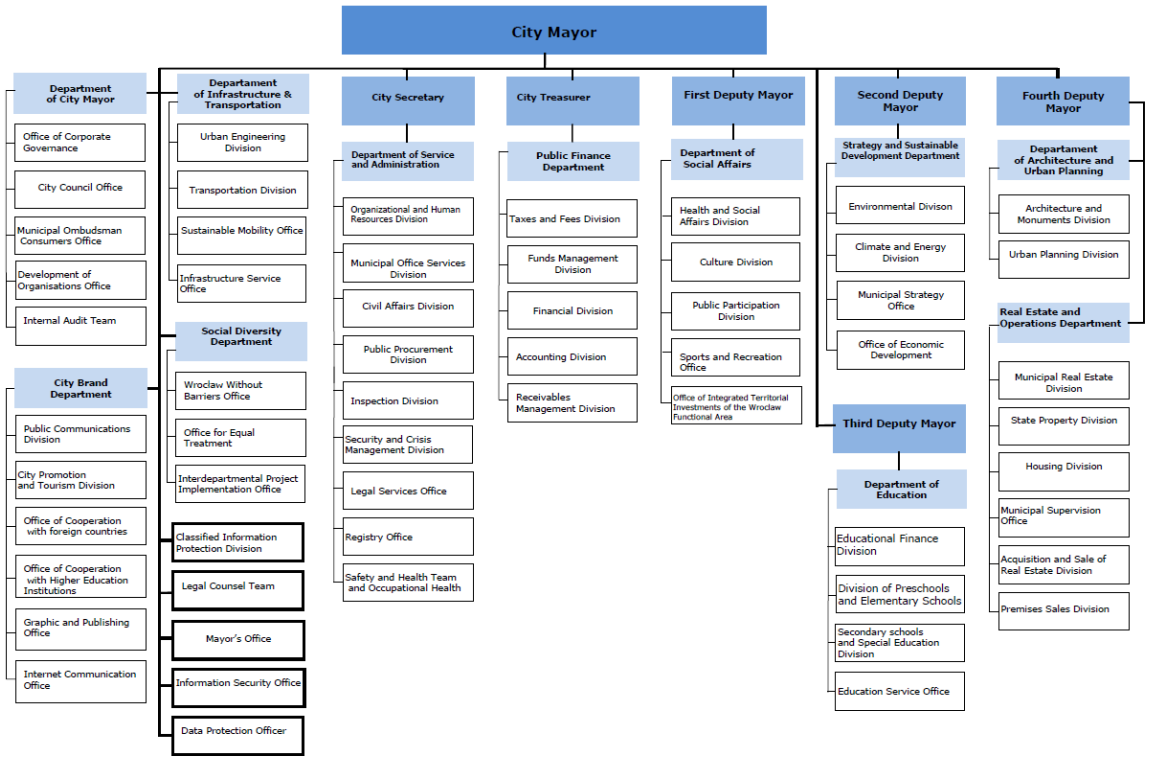

Figure 11. The structure of the Municipality of Wroclaw.

[36] Resolution of the Lower Silesian Regional Assembly of November 30, 2017 on the introduction on the territory of the municipality of Wroclaw of restrictions and prohibitions on the operation of installations in which fuel is burned
[37] Position No.XIV of thr Wroclaw City Council datek October 17, 2019, regarding the climate emergency

In 2018 r. there was established in municipality **Smart City Office** promoting **Smart City Wroclaw[38]. The idea of Smart City Wroclaw** is based on six pillars: smart economy, smart people, smart mobility, smart environment, smart management, smart way of life. The unit focuses on supporting activities that improve the quality of life of residents, pro-environment and pro-innovation, as well as investments related to supporting mobility and public transportation.

CityLab is part of Smart City Wroclaw. Its goal is to create areas in the city space where entrepreneurs, start-ups, researchers will be able to test innovative solutions in the public space. Currently, the Lab's priority is to study technologies that affect the environment and the health of residents, namely those related to transportation and the reduction of low emissions.

There is no smart city without open data. Wroclaw, like other cities in Poland and around the world, wants to make available as much of the data produced and processed by the city as possible, thus simplifying access to public information. **Open Data Wroclaw** is a Wroclaw-based Internet service that allows all interested parties to quickly and easily access public information collected by the Wroclaw Municipality and other city units. It is also a way to meet the expectations of Wroclaw residents who want to learn about the way the city functions. Open data is information or datasets that everyone can freely use. They can be distributed and used basically without any restrictions, including for commercial purposes.

In Wroclaw, decarbonisation of the construction and transportation sectors will be key to the energy transition. In the case of transportation, efforts to promote public transportation and other environmentally friendly transportation solutions have already been underway for many years. A **Bicycle Officer** was appointed in 2007. The main tasks of the bicycle officer in Wroclaw have been coordinating all matters related to bicycles, including: creation and implementation of bicycle policy, investment in bicycle infrastructure, coordination of the bicycle rental system, creating a network of bicycle routes, cooperation with non-governmental organisations for cyclists. Bicycle rental system called **Wroclaw City Bicycle** is an alternative means of transportation, allowing residents to get around the city quickly. It complements public transportation.

In 2015, the Bicycle Officer was joined by a **Pedestrian Officer**. Pedestrian Offcer's tasks are to ensure that pedestrians are treated as equal participants in traffic, that the infrastructure provided for them meets current standards, so that pedestrians feel safe, move quickly and efficiently through the city.

In the case of public transportation and efforts to increase its use, **free tickets** for certain groups using public transportation were introduced in 2018. Elementary, secondary, high school students have free tickets until they turn 21, as for senior citizens, it was 69, since 2022 the age was reduced to 65 years. It comes along with increasing paid parking zone and parking fees in the city centre, expanding "Park and Ride" lots and designating special parking spaces for zero-emission vehicles. In 2023 city started discussion and consultation process on the introduction of a low-emission zone for the city centre and parts of the downtown area.

In terms of housing and involving residents in the climate transition, a more organized process began with the establishment of "Wroclaw without smog" information and support campaign. With the implementation of the "anti-smog resolutions" came support systems consisting of municipal **Energy Advisors**, dedicated funds and cooperation of many groups of stakeholders. As these actions started to grow and developed, since year 2020 they were all gathered under the umbrella "Change the stove" action.

Energy Advisors, in addition to the consultation desk at the municipality's headquarters, they also worked "in the field", reaching municipal districts, in cooperation with **municipal district councils**. Contacting individual building managers, participating in community meetings, they helped residents go through the process of eliminating stoves, presenting them with offers, funding programmes, solutions and dispelling doubts. A set of programmes (financial, informational, organisational) aimed at encouraging city residents to replace their heat sources: full subsidisation of the cost of replacing stoves - KAWKA Plus, exemptions and rent reductions, subsidies for the replacement of wooden, leaky windows - Thermo KAWKA, subsidies for heating bills for people who have eliminated solid fuel stoves - Local Shield Programme[39]. It was all followed by information,

[38] Smart City Office was transformed into **Smart City Unit**

[39] Resolution No. LIX/1375/18 of the Municipal Council of Wroclaw dated July 5, 2018 on the local social assistance programme called Local Shield Programme for persons who incur increased heating costs of the premises related to permanent change of the heating system based on solid fuel to one of the low-emission systems

cooperation, billboards, website, competitions. The process of replacing stoves related to improving air quality is slowly coming to an end. However, much of the replacement has involved the installation of gas furnaces, which will require further measures in the future, such as the installation of heat pumps. But procedures have been established, proven methods for engaging and educating residents and other stakeholders. More procedures and mechanisms involving citizens towards a shared understanding and buy-in of the climate agenda are described in next chapter "Social innovations".

In order to encourage building owners to install renewable energy sources, a resolution was passed in 2019[40]. Those who incur the cost of purchasing or connecting a photovoltaic system (or other above-mentioned energy sources) to a building or part of a building can apply for a **property tax exemption**, after meeting certain conditions.

The Municipality[41] has initiated in 2012 **Purchasing Group**. A purchasing group combines the needs of multiple units for a given medium by appointing a single unit to carry out the procedure for the purchase (in the case of Wroclaw) of gas and electricity. Currently, there are two purchasing groups: gas - a comprehensive contract, i.e. purchase and distribution of gas; and electricity group: energy purchase (without distribution) for facilities and public lighting. In 2025, the electricity group will expand to include the supply of facilities for which RES have been implemented. The purchasing group brings together municipal companies, cultural entities, schools and kindergartens. The city is responsible for organising the procedure, selecting the contractor and changing the seller. After signing the contracts, the units themselves implement their contracts, are responsible for payments and for the fulfilment of obligations by the contractor/vendor.

Complementing the activities of the energy purchasing group is the **Energy Saving Register**. This is an electronic application for the recording of planned and incurred costs and consumption of utilities, the handling of processes in purchasing groups as well as the implementation of purchasing groups, as well as implemented laws, decrees and regulations in the area of utility cost control and statistics. It obliges municipal building managers to periodically report on the costs incurred for utility consumption and the savings measures carried out.

From 2022, the city[42] coordinates the **implementation of RES** projects on selected buildings of city units - e.g. educational facilities. On the basis of the projects, the units appoint installation contractors, while the city additionally appoints a supervision inspector.

As for involving stakeholders in the process of changes, different groups of stakeholders can have a real impact on city policy through community councils. **Community Council** is a body, composed of representatives of various professional and creative circles, non-governmental organisations, city institutions, private business, but also the public sector and universities, who decide to socially interact as a consultative and advisory body to the mayor of the city. There are 23 Community Councils, each of them represents a specific group of Wroclaw residents, including: seniors, children and youth, people with disabilities, cyclists or entrepreneurs, there is Mobility Policy Council, Council for Bicycle Policy and Council for Ecology, among others.

Joining the "100 Climate Neutral and Smart Cities Mission" provided the Municipality opportunity to accelerate activities towards climate transition and better organize them. After becoming the Mission city, the Sustainable Development Department, in order to set up a cooperation through departments, units and companies, started working on building Transition Team, consisting of **Interdepartmental Team**, **Decarbonisation Team and there was Air Quality and Energy Efficiency Team** working till June 2024.

Interdepartmental Team was established in year 2022, by Mayoral Ordinance[43]. Team consists of representatives of divisions, units and municipal companies, engaged in transformation processes in the city.

[40] Resolution No. XIII/316/19 of the Wroclaw City Council dated September 5, 2019, regarding exemptions from property tax for buildings or their parts connected to photovoltaic installations, solar collectors, heat pumps, heat recovery systems, or ground heat exchangers as amended
[41] Strategy and Sustainable Development Department
[42] Strategy and Sustainable Development Department
[43] Ordinance No. 8741/22 of the Mayor of Wroclaw of 13 October 2022 on the establishment of a team for the implementation of the EU Mission: Climate Neutral and Smart Cities followed by amendments extending the composition of the team for the implementation of the Cities Mission

Each person acts as a liaison and works towards building close cooperation and better coordination of work between departments. The team meets at least 4 times a year to discuss the progress of the implementation of the objectives of the City Mission in their organisational units. The division of authority and responsibility between the various organisational units and individuals allows for efficient management and implementation of activities in accordance with the planned objectives. The team representatives in their units have separate "implementation teams" to make management decisions and monitor the progress of the work of implemented initiatives, including climate neutrality activities. For example:

- in the Department of Infrastructure and Transport, there is a cross-cutting team that carries out ongoing monitoring of ongoing investments, meeting a minimum of once every three weeks with the implementing units and quarterly reporting on the solutions implemented, possible remediation plan for the next period).

- in the Public Finance Department there is a team of people who look for funding from regional, national, European sources and private investors.

The activities of the **Interdepartmental Team** at the current stage focus in particular on strengthening climate issues in urban planning documents and cooperation in this regard at regional level. At city level, the Wroclaw 2050 Strategy (with a strongly embedded climate component) is being developed. These goals are also being reinforced in updates to sectoral policies and programmes such as the Wroclaw Sustainable Urban Mobility Plan (SUMP), the Sustainable Mobility Plan for the Wroclaw Urban Functional Area (37 municipalities), the Electromobility Development Strategy or the Wroclaw Mobility Policy, as well as spatial policy documents.

In year 2023, due to another Mayoral Ordinance[44], there was appointed **Air Quality and Energy Efficiency Team,** which played an opinion and advisory role for the city Mayor in the implementation of the anti-smog resolution**.**

In the same year there was established **Decarbonisation Team**[45] as well. The team is working on implementing activities to meet the requirements of the Polish Energy Policy until 2040. The major role of the team is decarbonisation of the heating system of Wroclaw. It consists of representatives of the organisational departments of Wroclaw Municipality, municipal organisational units and municipal companies, as well as energy companies and other institutions. It plays an advisory and coordinating role in the cooperation of the city with energy companies, institutions and external entities on the directions of development and activities in pursuit of decarbonisation of the heating system in Wroclaw.

There is also external cooperation between municipality and external stakeholders, called **External Sector Leaders**, as a part of cooperation to achieve climate neutrality. Sectors are represented by, among others: academia, NGO-s and private sector - SME entrepreneurs, broken down by sub-sectors: energy/heat, development, cooperatives, architects and designers. Some of the sectors had already created coalitions, for example - **Coalition of Wroclaw and Lower Silesian Universities for Sustainable Development and Climate Protection** and included actions towards climate neutrality into their agenda. Some of the universities has already signed a declaration on cooperation within the Climate Neutral and Smart Cities Mission.

In parallel, a series of meetings and workshops are being held with various stakeholders in the city who are or can be co-responsible for the implementation process of the measures and financing in their own right. In particular, a great deal of interest can be seen on the business side in terms of energy-related companies, but also developers and the design community responsible for shaping space in the city.

Cooperation, that has been carefully built, is coalition with business. In May 2024, a conference "1.5 Degree Mission – Business for Climate" was organised by the city, dedicated for business. During the conference, representatives of the business community discussed ESG reporting, shared their experiences of implementing pro-climate projects, and presented the benefits of climate neutrality measures. During the event, there was an opportunity to sign a declaration on cooperation within the Climate Neutral and Smart Cities Mission. There was also meeting with development and cooperatives representatives and it resulted in next meeting and potential cooperation. Similar situation is with NGO's.

[44] Ordinance No. 10421/23 of the Mayor of Wroclaw of 26 May 2023 setting up a team on air quality and energy efficiency in Wroclaw
[45] Ordinance No. 10546/23 of the Mayor of Wroclaw of 12 June 2023 setting up a team for the decarbonisation of the Wroclaw district heating system

For many years, Wroclaw has worked closely with the municipalities of Lower Silesia in order to coordinate development processes in the region more effectively. Representatives of Wroclaw Municipality continued to meet with local government officials from the Wroclaw Metropolitan Area **(WrOM)[46].** Formalised inter-municipal cooperation was reflected in the activities of: Agency for the Development of Wroclaw Agglomeration S.A. (ARAW), the Wroclaw Agglomeration Association (StAW) and the Integrated Territorial Investment of the Wroclaw Functional Area (ZIT WrOF). Meetings of municipal governments concerned, among other things, agreements on bus transport in the agglomeration and solutions to strengthen the idea of the Wroclaw Metropolitan Railway and the implementation of the Sustainable Mobility Plan for the Urban Functional Area of Wroclaw. The result of the cooperation is a common agglomeration ticket, which enables passengers to use public transport in Wroclaw and the neighbouring municipalities.

At the same time, the Wroclaw Municipality is expanding its network of Park&Ride car parks, including on the outskirts of the city, to encourage residents of other towns to switch to public transport when entering the city. In general, expanding Park&Ride car parks and designating more parking spaces for zero-emission vehicles provide additional benefits such as developing habits of using public transport, reducing car journeys in the city centre (reducing congestion) and increasing the share of electric vehicles, improving air quality, resulting in lower hospitalisation costs for residents due to pollution and noise in the city.

On regional level there is close cooperation with Marshal's Office. The city has reached an agreement with the Marshal's Office and signed an agreement with the railway authorities, thanks to which a rail agglomeration ticket is in operation, meaning that the public transport ticket also gives the opportunity to travel by train within the municipality.

This year, a cooperation agreement was signed with the Institute for Territorial Development, regarding projects and initiatives that bring European cities and regions closer to achieving climate neutrality. The memorandum creates a platform for the exchange of knowledge, experience and best practices useful for the city, the entire region and other interested European and national partners. The cooperation is expected to help accelerate decarbonisation and increase the involvement of residents and key stakeholders in efforts to achieve climate neutrality.

The Lower Silesian Hydrogen Valley was established in 2022. The aim of the Association is to support the development of the hydrogen economy, with particular emphasis on the Lower Silesian Voivodship and neighbouring voivodships. Lower Silesian Hydrogen Valley utilises the research and scientific potential of the region to undertake, among other things, innovative scientific, technological and industrial ventures and investment projects aimed at building common hydrogen economy value chains. Furthermore, through its activities, the Lower Silesian Hydrogen Valley promotes pro-environmental attitudes, especially among entrepreneurs and local communities.

On national level, it was crucial establishing **Coalition of Polish Mission Cities** – which is a Cooperation Agreement between Krakow, Lodz, Rzeszow, Warsaw and Wroclaw. One of the results of this cooperation is Horizon2020 project – **NEEST** „NetZero Emission and Environmentally Sustainable Territories", in partnership of five cities. NEEST is a pilot project that will develop necessary and universal models to demonstrate how to carry out comprehensive and locally acceptable modernisation of buildings and neighbourhoods to improve their energy efficiency and reduce greenhouse gas emissions from electricity and heat consumption.

Building the dialogue platform for the climate transition with stakeholders on national level is supported by **CapaCITIES** project[47]. CapaCITIES is bringing together key players in the transition process, namely national, regional authorities and cities, including Ministry of Economic Development and Technology, Ministry of Climate and Environment, Ministry of Development Funds and Regional Policy. We all are aware that achieving the goal of climate neutrality requires cooperative coordination and innovation at multiple levels of governance.

On December 6-7, 2023, the CapaCITIES National Event was held as part of the National Urban Forum, with the Ministry of Development Funds and Regional Policy. During the event, the Polish Mission Cities presented the experiences developed in implementing the Mission and identified barriers to climate transformation in

[46] **WrOM** - an area encompassing 44 municipalities and 8 districts of the former Wroclaw Voivodeship
[47] funded by the EU's Horizon Europe programme

cities (legislative, financial, other). During the event, the need to include representatives of ministries and government institutions in the implementation of the Mission was emphasized.

Wroclaw is also active on international level – cooperating with several organisations such as Metrex, ICLEI, Eurocities. In 2022 the city has been recognized internationally for its commitment to climate adaptation and refugee assistance. The United Nations Office for Disaster Risk Reduction (UNDRR) and its partners in the Making Cities Resilient 2030 (MDG2030) global collaboration welcomed Wroclaw as one of the world's Resilience Hubs.

Table 22. Relations between governance innovations, systems, and impact pathways

Relations between governance innovations, systems, and impact pathways					
Intervention name	Description	Systemic barriers / opportunities addressed	Leadership and stakeholders involved	Enabling impact	Co-benefits
Strategy and Sustainable Development Department (former Sustainable Development Department)	Department coordinates the work of the Municipality in the field of environmental protection and ecology. In the department, ecological approach meets with the existing Municipal activity, so as to further change the actions of officials in matters of sustainable development. A special part of the activity is to educate and involve residents in the process of building a resilient city. One of the tasks is the city's neutrality activities. Also adaptation measures, new greenery standards and water management.	Siloed nature of work in the office, dispersion and poor coordination of activities and communication. Weak monitoring and evaluation of local strategies – lack of adequate communication at all levels of cooperating departments disorganization between departments Building awareness among residents about the importance of reducing emissions and how they can get involved will be crucial to the success of the effort.	Leaders: Divisions within the Green Department. Stakeholders: all groups of internal and external stakeholders.	Department is responsible for coordination the 100 Climate Neutral and Smart Cities Mission, including management of Transition Team works.	Institutional impact: 1. establishing regulations and laws at the local level; 2. setting standards or guidelines for areas of operation; 3. developing strategies and action plans, e.g. strategies and action plans to achieve zero-emission status; 4. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 5. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals.
Smart City Wroclaw	Implementation of Smart City objectives	Engaging partners: Collaboration with external partners,	Smart City Wroclaw is	Supporting activities that improve the	Institutional impact:

		such as NGOs, academic institutions or businesses, can contribute to the exchange of knowledge and experience and the joint implementation of projects.	led by Smart City Unit Stakeholders: all groups, according to 6 pillars	quality of life of residents, pro-environment and pro-innovation, as well as investments related to supporting mobility and public transportation.	1. setting standards or guidelines for areas of operation; 2. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 3. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 5. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
CityLab Wroclaw	It allows entrepreneurs, start-ups, researchers to test unique and unprecedented solutions in the public space.	Engaging partners: Collaboration with external partners, such as NGOs, academic institutions or businesses, can contribute to the exchange of knowledge and experience and the joint implementation of projects; Incentives for entrepreneurs: Introducing incentives for companies that invest in environmentally friendly technologies can accelerate the transformation of the industrial sector.	CityLab is led by Smart City Unit in cooperation with various divisions, Users: academic institutions, enterprises, start ups	Supporting activities that improve the quality of life of residents, pro-environment and pro-innovation, as well as investments related to supporting mobility and public transportation.	Institutional impact: 1. setting standards or guidelines for areas of operation; 2. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 3. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals

Open Data Wroclaw	It is Internet service that allows all interested parties, including residents of Wroclaw, to quickly and easily access public information collected by the Wroclaw Municipality and other city units.	Monitoring and updating: Taking regular inventories and monitoring progress against targets will allow actions to be adjusted in response to changing circumstances	Leader: IT service centre, one of the municipal units Users: academic institutions, enterprises, start ups, residents	Data could be used in research or for startups	Institutional impact: monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
Bicycle Officer	Coordinating all matters related to bicycles	Attachment to car use - a sociological factor difficult to change Lack of interest from the public	Leader: the Bicycle Officer Users: mainly bicyclists (current and future)	Increase in use of bicycle; reduction of use of cars	Promotion of “clean” transportation: Given the significant contribution of transportation to emissions, it is recommended to invest in the expansion of clean transportation and to promote its use and reduce individual car transportation.
Wroclaw City Bicycle	Bicycle rental system	Attachment to car use - a sociological factor difficult to change Lack of interest from the public Residents' resistance to change	Leader: the Bicycle Officer/ Department of Infrastructure and Transporta-tion Users: mainly bicyclists (current and future), including tourists	Increase in use of bicycle; reduction of use of cars	Promotion of “clean” transportation: Given the significant contribution of transportation to emissions, it is recommended to invest in the expansion of clean transportation and to promote its use and reduce individual car transportation.

Pedestrian Officer	Coordinating all matters related to pedestrians	Attachment to car use - a sociological factor difficult to change Residents' resistance to change	Leader: the Pedestrian Officer/ Department of Infrastructure and Transporta-tion Stakeholders: all groups of stakeholders	Encouraging walking instead of using the car, especially for short distances	Reducing car traffic over short distances, e.g. walking children to school instead of dropping them off by car
Free tickets for public transport	Resolution No. LIII/1271/18 of the Wroclaw City Council dated April 5, 2018 on the establishment of prices for transport services provided by means of public transport	Attachment to car use - a sociological factor difficult to change Lack of interest from the public	Free public transport tickets for selected groups of residents including students till 21 years old and seniors	Increase the use of public transport, decrease the use of cars	Promotion of “clean” transportation: Given the significant contribution of transportation to emissions, it is recommended to invest in the expansion of clean transportation and to promote its use and reduce individual car transportation.
Change the stove	Support system connected with the implementation of the “anti-smog resolutions”, it consists of municipal Energy Advisors, dedicated funds and cooperation of many groups of stakeholders.	Lack of ability to build programmes with complex organisational structure - financial weakness of local governments, dependence on grants, lack of business experience Increasing energy efficiency: Investing in projects to improve the energy efficiency of public and private buildings can yield significant benefits in terms of both emissions reductions and cost savings.	Leader: Strategy and Sustainable Development Department in cooperation with various divisions; Recipients: residents of the city	This programme had big impact on improving air quality due to replacing stoves	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).

		Shortages in materials and workmanship - limited number of specialists and business entities.			
KAWKA Plus	Target subsidy from the municipal budget granted for the implementa-tion of investment tasks in the field of environmental protection in dwellings and properties used for residential purposes, involving the permanent liquidation of the fixed heating system based on coal fuel and its change to environmen-tally friendly heating	Lack of ability to build programmes with complex organisational structure - financial weakness of local governments, dependence on grants, lack of business experience Shortages in materials and workmanship - limited number of specialists and business entities.	Leader: Strategy and Sustainable Development Department in cooperation with various divisions; Recipients: residents of the city	This programme had big impact on improving air quality due to replacing stoves	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).
Local Shield Programme	It is a system of subsidies for heating bills for those who replaced a coal stove with an environmen-tally friendly heat source: electric, gas, oil or district heating. It targeted the poorest social groups, as these were the groups hit the most by the obligation to replace stoves.	Increasing energy efficiency: Investing in projects to improve the energy efficiency of public and private buildings can yield significant benefits in terms of both emissions reductions and cost savings. Lack of ability to build programmes with complex organisational structure - financial weakness of local governments, dependence on grants, lack of business experience Limited or no appropriate support policies/programmes – fiscal, financial, excessive criteria for	Leader: Strategy and Sustainable Development Department in cooperation with various divisions; Recipients: residents of the city, the most vulnerable group	This programme had big impact on improving air quality due to replacing stoves	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).

		allocating funds, complicated application process			
reTURN of the tenements	New municipal programme, renovation of city-owned tenements together with their surroundings - greenery and courtyards. This programme complements the 'Change the Stove' programme, the next step after replacing the cookers will be to thermo-modernise them, combined with other necessary works, such as replacing woodwork and electrical installations	Limited or no appropriate support policies/programmes - fiscal, financial, exorbitant award criteria, complicated application process	Leader: municipal real estate management companies Stakeholders: residents, entrepreneurs	This programme reinforces the effects of the 'Change the Stove' programme, by thermally upgrading buildings and landscaping courtyards with greenery	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).
Property tax exemption	Resolution No. XIII/316/19 of the Wroclaw City Council dated September 5, 2019, regarding exemptions from property tax for buildings or their parts connected to photovoltaic installations, solar collectors, heat pumps, heat recovery systems, or ground heat exchangers as amended	Limited or no appropriate support policies/programmes - fiscal, financial, exorbitant award criteria, complicated application process	Building owners – residents and companies	Support for renewable energy sources: Encouraging businesses and residents to invest in renewable energy sources, such as solar panels and wind turbines, will help reduce emissions associated with energy production.	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).

Purchasing Groups	the joint purchase of electricity and gas for municipal entities, i.e. schools, kindergartens and cultural institutions, municipal companies	Organisational weakness - lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	Leader: Municipality, Stakeholders: municipal companies, schools and kindergartens	Energy and gas savings, monitoring of use the energy;	Institutional impact: 1. setting standards or guidelines for areas of operation; 2. promoting partnerships and cooperation, 3. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
Energy Saving Register	This is an electronic application for the recording of planned and incurred costs and consumption of utilities	Organisational weakness - lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	Leader: Municipality, Stakeholders: municipal companies, municipal entities, including schools and kindergartens		Institutional impact: 1. establishing regulations and laws at the local level; 2. setting standards or guidelines for areas of operation 3. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
RES installations	Implementation of RES on selected buildings of city units – e.g. educational facilities.	High investment costs - price fluctuations Restrictions for prosumers related to the possibility of access to connection capacity Lack of stable legal regulations and a long-term strategy for the development	Leader: Municipality Stakeholders: schools, kindergartens and other municipal facilities users	In 2022, 8 RES installations were completed along with the necessary renovations, with a total capacity of 140.745 kWp. In 2023, 8 project documentations were prepared.	Institutional impact: 1. setting standards or guidelines for areas of operation; 2. promoting partnerships and cooperation, e.g. public-

		of renewable energy sources in the city Support for renewable energy sources.		6 RES installations were completed (the remaining 2 were carried forward to 2024) together with the necessary roof renovations. The total capacity of the installations is 205.49 kWp. In 2024, 6 design dossiers have been prepared for RES installations on public facilities owned by the city, which will be implemented (planned capacity of 204.36 kWp).	private, cross-sector partnerships; 3. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
Community Council	It is a body, composed of representatives of various professional and creative circles, non-governmental organisations, city institutions, private business, but also the public sector and universities, who decide to socially interact as a consultative and advisory body to the mayor of the city.	Engaging partners: collaboration with external partners, such as NGOs, academic institutions or businesses, can contribute to the exchange of knowledge and experience; Social support - conflicted groups;	Leader: municipal units, depending on the council, Strategy and Sustainable Development Department is responsible for works of Council for ecology and greenery	Influencing/ supporting ecological solutions	Institutional impact: 1. setting standards or guidelines for areas of operation; 2. developing strategies and action plans, e.g. strategies and action plans to achieve zero-emission status; 3. promoting partnerships and cooperation;
Transition Team	Interdepartmental Team, Decarbonisation Team and there was Air Quality and Energy Efficiency Team	Siloed nature of work in the office, dispersion and poor coordination of activities and communication	Leader: Sustainable Development Department	Better allocation of resources and coordination of activities, communication, ability to use different	Institutional impact: 1. setting standards, rules, guidelines for areas of

	Team is established to facilitate cooperation between departments, units, companies and institutions	Building awareness among residents about the importance of reducing emissions and how they can get involved will be crucial to the success of the effort		sources of expertise. Cooperation on the development of system solutions.	operation; 2. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 3. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships;
Coalition of Wroclaw and Lower Silesian Universities for Sustainable Development and Climate Protection	The coalition is the result of the activity of the academic community aimed at cooperation, initiation and synchronization of actions in the area of synchronization of climate protection activities in the city of Wroclaw and Lower Silesia	Engaging partners: Collaboration with external partners, such as NGOs, academic institutions or businesses, can contribute to the exchange of knowledge and experience and the joint implementation of projects.	Wroclaw and Lower Silesian Universities	Cooperation on the development of system solutions. Co-financing or funding of activities. Searching for new sources of funding. Searching for technology and organisational solutions.	Institutional impact: 1. establishing regulations and laws at the local level; 2. setting standards or guidelines for areas of operation; 3. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 4. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 5. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals

1.5 Degree Mission – Business for Climate	Conference organised in May 2023 for business	Engaging partners: Collaboration with external partners, such as NGOs, academic institutions or businesses, can contribute to the exchange of knowledge and experience and the joint implementation of projects; Incentives for businesses: Introducing incentive programmes for companies that invest in environmentally friendly technologies can accelerate the transformation of the industrial sector.		Cooperation on the development of system solutions. Searching for new sources of funding. Searching for technology and organisational solutions.	Institutional impact: 1. establishing regulations and laws at the local level; 2. setting standards or guidelines for areas of operation; 3. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 4. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 5. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
Cooperation with Marshal's Office	Cooperation Agreement was signed with the Institute for Territorial Development	Insufficient cooperation between the government and local governments - underestimating the role of urban centers, limiting decision-making authority and financial self-reliance.	Stakeholders: Wroclaw Municipality, Marshal's Office	Cooperation on the development of system solutions. Co-financing or funding of activities. Searching for new sources of funding. Searching for technology and organisational solutions.	Institutional impact: 1. setting standards, rules, guidelines for areas of operation; 2. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 3. promoting

					partnerships and cooperation, e.g. public-private, cross-sector partnerships;
Coalition of Polish Mission Cities	Cooperation Agreement between Krakow, Lodz, Rzeszow, Warsaw and Wroclaw – “mission cities”	Insufficient cooperation between the government and local governments - underestimating the role of urban centres, limiting decision-making authority and financial self-reliance, Poorly defined support programmes and lack of appropriate legislation - unambitious strategies, rapidly changing laws, lack of consistency in actions, insufficient number of innovative projects Poland	Leader: “mission cities”	Cooperation on the development of system solutions. Co-financing or funding of activities. Searching for new sources of funding. Searching for technology and organisational solutions.	Institutional impact: 1. setting standards, rules, guidelines for areas of operation; 2. developing strategies and action plans, e.g., strategies and action plans to achieve zero-emission status; 3. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 4. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
CapaCITIES	It is a project bringing together key players in the transition process, namely national, regional authorities and cities	Insufficient cooperation between the government and local governments - underestimating the role of urban centers, limiting decision-making authority and financial self-reliance, Poorly defined support programmes	Leader: Strategy and Sustainable Development Department in cooperation with various divisions; Beneficiaries: different groups of stakeholders represented	This cooperation should result in changing legislation and accelerating the climate transition	Institutional impact: 1. setting standards, rules, guidelines for areas of operation; 2. developing strategies and action plans, e.g., strategies and action plans

		and lack of appropriate legislation - unambitious strategies, rapidly changing laws, lack of consistency in actions, insufficient number of innovative projects Poland	by External Sector Leaders		to achieve zero-emission status; 3. promoting partnerships and cooperation, e.g. public-private, cross-sector partnerships; 4. monitoring and evaluating progress, e.g., collecting data and assessing achievement of goals
MCR2030 Hub	MCR2030 is a multi-partner initiative led by the United Nations Office for Disaster Risk Reduction (UNDRR)	Insufficient cooperation between the government and local governments - undervaluing the role of urban centres, limiting decision-making authority and financial self-reliance, Lack of coordination with other levels of government and weak multi-level management Poorly defined support programmes and lack of appropriate legislation - unambitious strategies, rapidly changing laws, lack of consistency in actions, insufficient number of innovative projects Poland	Leader: Strategy and Sustainable Development Department in cooperation with various divisions; Recipients: all residents	Cooperation on the development of system solutions. Searching for new sources of funding.	Institutional impact: setting standards, rules, guidelines for areas of operation;

4.2 Module C-2 Social Innovation Interventions

Table 23. Relations between social innovations, systems, and impact pathways

Relations between social innovations, systems, and impact pathways					
Intervention name	Description	Systemic barriers / opportunities addressed	Leadership and stakeholders involved	Enabling impact	Co-benefits
Public Participatory Division (former Public Participatory Office)	Interventions: conducts public consultations; coordinates activities related to the civic budget; cooperates with NGOs; CALs; Coordination of the website dedicated to participatory processes "Wroclaw talks"	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools.	Public Participation Division works with all types of stakeholders – internal (municipal workers) and external (including residents, NGOs, academia), depending on the topic that is consulted	The Division informs and engages residents in municipal actions in many ways, through consulting municipal policy documents, investments. This helps to: increase stakeholders motivation and commitment to climate transformation; understand mutual expectations and interdependencies among stakeholder groups; build trust;	Educating, capacity building, Engaging residents in co-creation process
Local Activity Center (CAL)	CALs are places co-financed by Municipality, operated by local NGOs, working with the residents. CALs are places and activities co-created together with Wroclaw residents, open to diversity and in solidarity with those who need help or support. at the local level.	Insufficient cooperation between the government and local governments - undervaluing the role of urban centres, limiting decision-making authority and financial self-reliance, organisational weakness - lack of male and female leaders of change, lack of specialised staff, poor prioritisation, ineffective management of horizontal	Leader : Third sector CALs are led by local NGOs, they cooperate with local stakeholders: residents, schools, kindergartens, local leaders, local businesses, District Councils and Municipality	Canters are a strong link between municipality and residents, supporting the process of positive social change on the district level; Centres educate and initiate changes. These actions results in: Increasing stakeholders motivation and commitment to climate transformation; understand	Educating, capacity building

		processes, insufficient budget.		mutual expectations and interdependencies among stakeholder groups; build trust and sectoral and trans-sectoral partnerships;	
District Council	It represents its residents to the bodies and organisational units of the Municipality. It carries out its tasks, cooperating with the bodies of the local government and institutions and organisations operating in the district. There are 48 District Councils in the city	Insufficient cooperation between the government and local governments - undervaluing the role of urban centres, limiting decision-making authority and financial self-reliance, Organisational weakness - lack of male and female leaders of change, lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	Leaders – local activists and politicians create District Councils, they are selected during elections and represent the district before the municipality, close cooperation with City Council, CALs and local residents, local businesses	Through close cooperation between municipality and residents Councils have a huge influence on local residents, business and they are the ones who often initiate changes - for example, by passing an extension of the paid parking zone, supporting environmental projects, initiatives. These actions results in: Increasing stakeholders motivation and commitment to climate transformation; understand mutual expectations and interdependencies among stakeholder groups; build trust and sectoral and trans-sectoral partnerships.	Educating, capacity building, supporting environmental projects, initiatives
The Youth City Council	The Council has a consultative, advisory and initiative character. The purpose of the Council is: 1) disseminate	Organisational weakness - lack of young male and female leaders of change, lack of specialised staff.	Leader: council members who were selected during the elections; Recipients: young people.	Education and community involvement: Building awareness among residents about the importance of reducing emissions and	Initiating/ supporting ecological solutions Educating, capacity building, supporting environmental

	the idea of self-government; 2) to create civic attitudes among young people; 3) to develop student self-government; 4) organizing a youth forum for expression on public issues; 5) representing youth and student self-governments of Wroclaw schools before the authorities of Wroclaw and other institutions and organisations.			how they can get involved will be crucial to the success of the effort.	projects, initiatives.
Wroclaw Participatory Budget	It is a part of the city's budget, the allocation of which is decided by residents themselves through direct voting. It is one of three participatory budgets implemented by Wroclaw.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools.	Leader : Public sector Led by Public Participatory Division in cooperation with various divisions responsible for reviewing projects and the municipal companies responsible for implementing projects; the real hero of each project is a leader responsible for submission the idea/proposal and residents voting for the proposal.	The civic budget includes many green investments - not only parks, squares but also bicycle and pedestrian paths, promoting NBS; This results in: building trust and sectoral and trans-sectoral partnerships; deepening knowledge and awareness of the climate transition; building shared ownership of the climate transition and the responsibilities and commitments of individual stakeholders.	capacity building, supporting environmental projects, initiatives – especially in terms of NBS, clean transportation, educating, counteracting light pollution.
Microgrants	Part of the city's budget supporting grassroots local initiatives, within the framework of	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/	Leader : public sector - municipality The call is open to: individuals, informal groups, young people, NGO's;	Through supporting grassroots initiatives, it helps building more	Education, capacity building ; supporting environmental

	which residents can implement their own ideas for creative ventures aimed at spreading culture in the city.	neighbours, lack of a platform for continuous cooperation and effective engagement tools.	coordinated by municipality.	aware and open society.	projects, initiatives.
District Fund	These are separate funds allocated for the implementation of district investments submitted by the District Councils according to the rules and procedures set forth herein.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools.	Leader : public sector - municipality District Councils get the funds and decide together with residents how to use them; projects are implemented under supervision of municipal companies.	The district fund are used for many green investments - not only parks, squares but also bicycle and pedestrian paths and streets with NBS. This results in: building trust and sectoral and trans-sectoral partnerships; deepening knowledge and awareness of the climate transition; building shared ownership of the climate transition and the responsibilities and commitments of individual stakeholders.	capacity building, supporting environmental projects, initiatives – especially in terms of NBS, clean transportation, educating, counteracting light pollution.
Small steps, big changes	Education campaign which inspired residents to change their small daily habits regarding choices that affect air quality or the protection of biodiversity in the immediate area.	Lack of a template for climate transformation of cities - a strategic concept demonstrating that transformation is possible, profitable, and even a condition for successful city operations in the future.	Leader : public sector - municipality Campaign was coordinated by Sustainable Development Department, it was directed to all residents of the city and Lower Silesia region.	Campaign helped to inspire residents to change their small daily habits regarding choices that affect air quality or the protection of biodiversity; Results: increasing stakeholders motivation and commitment to climate transformation; understanding mutual expectations and interdependencies	Education, capacity building Initiating/ supporting ecological solutions.

				among stakeholder groups.	
C-Change	Urbact funds financed project in which arts and culture inspired climate action in cities.	Lack of a template for climate transformation of cities - a strategic concept demonstrating that transformation is possible, profitable, and even a condition for successful city operations in the future. Organisational weakness - lack of male and female leaders of change, lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	Leader : public sector - municipality Project was led by Sustainable Development Department, it was dedicated to Cultural and art institutions working with citizens and NGOs.	Changing the behaviour of residents, their daily habits regarding choices that affect air quality; Results: increasing stakeholders motivation and commitment to climate transformation; understanding mutual expectations and interdependencies among stakeholder groups.	Education through art and culture, capacity building.
Change the stove	Support system consisting of municipal Energy Advisors, dedicated funds and cooperation of many groups of stakeholders.	Fragmentation of ownership - individual, combined, multiplicity of entities and organisational structures (communities, cooperatives, municipal mix) Limited interest in renovation of buildings by private and municipal entities due to other conditions Limited number or lack of adequate support policies/programmes - fiscal, financial, exorbitant criteria for awarding funds, complicated application process Need for tailor-made solutions - non-	Leader : public sector - municipality Coordinated by Sustainable Development Department in cooperation with various entities; beneficiaries - residents of the city, especially from poorer neighborhoods, who needed the most support.	This programme had big impact on improving air quality due to replacing stoves.	Reducing the carbon footprint of individual heat sources - replacing stoves related to improving air quality; unfortunately, much of the replacement consisted of installing gas stoves, which will require further measures in the future (such as installing heat pumps).

		standard, comprehensive Insufficient cooperation between the government and local governments - underestimating the role of urban centers, limiting decision-making authority and financial self-reliance, Poorly defined support programmes and lack of appropriate legislation - unambitious strategies, rapidly changing laws, lack of consistency in actions, insufficient number of innovative projects Poland Lack of ability to build programmes with complex organisational structure - financial weakness of local governments, dependence on grants, lack of business experience. Shortages in materials and workmanship - limited number of specialists and business entities			
Civic panel	Represented demographic structure of the city, it was chosen to analyze the topic “How to improve the movement of people around Wroclaw, with a view to	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and	Leader : Public sector at the city level Coordinated by Public Participatory Office in cooperation with Department of Infrastructure and Transportation and various divisions;	Promoting solutions that have positive impact on air quality and increasing biodiversity. This results in: building trust and sectoral and trans-sectoral	Capacity building, education Initiating/ supporting ecological solutions

	improving the quality of life and protecting the climate?"	effective engagement tools. Organisational weakness - lack of male and female leaders of change, lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	dedicated to vast group of stakeholders, represented by participants selected by lottery.	partnerships; deepening knowledge and awareness of the climate transition; building shared ownership of the climate transition and the responsibilities and commitments of individual stakeholders.	
Civic meeting	Each group of stakeholders has its representative, in order to achieve balance between different groups of stakeholders. The topic was the future development of Ruska Street.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools. Organisational weakness - lack of male and female leaders of change, lack of specialised staff, poor prioritisation, ineffective management of horizontal processes, insufficient budget.	Public sector at the city level Coordinated by Public Participatory Office in cooperation with Sustainable Mobility Office and municipal company; dedicated to vast group of stakeholders, represented by participants selected by lottery.	Promoting solutions that have positive impact on air quality and increasing biodiversity; This results in: building trust and sectoral and trans-sectoral partnerships; deepening knowledge and awareness of the climate transition; building shared ownership of the climate transition and the responsibilities and commitments of individual stakeholders.	Capacity building, education Initiating/ supporting ecological solutions
NEEST (on-going)	Project focuses on solutions that will enable comprehensive retrofitting of buildings and neighbourhoods to improve their energy efficiency.	Fragmentation of ownership - individual, combined, multiplicity of entities and organisational structures (communities, cooperatives, municipal mix); Limited interest in renovation of buildings by private and municipal	Leader : public sector at city level Led by Sustainable Development Department in cooperation with Transition Team (described in Governance Innovations); dedicated to all groups related to improving building energy efficiency - building managers,	Results of this project will have big impact on improving air quality due to indicating the most beneficial ways of effective, and socially acceptable modernisation of the housing stock for different types of residential and	The project is expected to indicate the most beneficial ways of effective, economically efficient and socially acceptable modernisation of the housing stock for different types of residential and non-residential buildings, these

		entities due to other conditions ; Limited number or lack of adequate support policies/programmes - fiscal, financial, exorbitant criteria for awarding funds, complicated application process ; Need for tailor-made solutions - non-standard, comprehensive ; Insufficient cooperation between the government and local governments - underestimating the role of urban centers, limiting decision-making authority and financial self-reliance.	housing communities, residents, energy suppliers, researchers.	non-residential buildings. It is also deepening knowledge and awareness of the climate transition (particularly about systemic dependencies).	recommendations will be able to be used by the residents themselves but also by regional and central authorities in the context of planning financial and technical support programmes.
Green patronage	Green patronage encourages residents and businesses to sponsor green solutions in the city.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools. Competition for space with other infrastructure, economic and transportation needs; Social support - conflicted groups; Costs - no calculation of environmental and ecosystem service costs;	Leader : public sector at city level Recipient : Private sector – developers, business organisations (trade unions and associations) Led by Municipal Greenery Management Company, directly involves residents and businesses in the responsibility of co-creating green spaces in the city.	Increasing the area of green spaces. Results: increasing stakeholders motivation and commitment to climate transformation; understanding mutual expectations and interdependencies among stakeholder groups.	capacity building, supporting green projects, initiatives – especially with the use of NBS.

		Fragmentation of responsibility - road managers, municipal, private, cooperatives, business.			
GROWin WROclaw	It involves planting trees with newborns and young children as patrons of the trees.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools ; Social support - conflicted groups.	Leader : public sector at city level Led by Municipal Greenery Management Company in cooperation with various Divisions; dedicated to parents and their children	Increasing the area of green spaces Results: increasing stakeholders motivation and commitment to climate transformation; understanding mutual expectations and interdependencies among stakeholder groups.	Increasing area of green space; capacity building – including children.
WroCHEF	It is a competition aimed at elementary school children, promoting a plant-based diet, based on local and seasonal products.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools. Lack of a template for climate transformation of cities - a strategic concept demonstrating that transformation is possible, profitable, and even a condition for successful city operations in the future.	Leader : public sector at city level Led by Sustainable Development Department in cooperation with various Divisions and restaurants; dedicated to school children and their parents.	Plant-based food production uses less water, uses less land, results in less air pollution and fewer greenhouse gas emissions.	Capacity building, supporting green projects.
Wroclaw Magnolia	It is competition is aimed at graduates of Wroclaw universities	Lack of a template for climate transformation of cities - a strategic concept	Leader : Public sector at municipal level in cooperation with Academia	Promoting innovating projects/solutions that have positive impact on air	Promoting young scientists, looking for new/ smart solutions.

	who, have defended a master's thesis addressing issues in the field of environmental protection.	demonstrating that transformation is possible, profitable, and even a condition for successful city operations in the future.	Stakholders involved : Academia/Students; due to the interdisciplinary nature of topics related to the zero-carbon city, specialists/ future specialists are sought from various fields - those involved in the development of new technologies, energy, construction, but also specialists in natural sciences (biologists, hydrologists) and social sciences (social and environmental psychologists, sociologists, educators).	quality and increasing biodiversity.	
Saturday with Green Wroclaw	A family picnic; picnic is an opportunity to introduce residents to the activities of the city in the sustainability field.	Too little involvement of residents/ neighbours and stakeholders/schools - limited powers of the authorities/ neighbours, lack of a platform for continuous cooperation and effective engagement tools; Lack of a template for climate transformation of cities - a strategic concept demonstrating that transformation is possible, profitable, and even a condition for successful city operations in the future.	Leader : public sector at municipal level Led by Sustainable Development Department, in cooperation with Municipal Greenery Management Company and various divisions, dedicated to all groups stakeholders, but mainly families	Promoting solutions that have positive impact on air quality and increasing biodiversity.	Capacity building, education.
Cycling May	It is Poland's largest campaign	Attachment to car use - a sociological	Leader – Cycling Officer together with Sustainable Mobility	The campaign has an impact: shaping positive	Promote use of bicycle, scooters, rollerblades as

	promoting cycling, scootering, rollerblading or skateboarding among elementary school students and preschoolers.	factor difficult to change; Efficiency of public transport - limitations of the network.	Office Workers, but there are involved workers of other divisions, including Public Participation Office; stakeholders affected – school and kindergarten children together with their parents and children, but also municipal police.	transportation habits, promoting healthy lifestyles, in supporting children's independence, improving traffic safety, on the environment, engaging local environments - social and business.	source of clean transportation.
Low-emission Zone (participatory process on-going)	An introduction of a clean transportation zone for the city centre and parts of the downtown area.	Attachment to car use - a sociological factor difficult to change; Residents' resistance to change Technological limitations – alternative fuels (insufficient understanding and mastery of the use of some alternative fuels) Lack of unambiguous policies and legislation.	Leader : public sector at city level Leader: Department of Infrastructure and Transportation Stakeholders: residents of the city, privatre sector, academia, third sector	Results: deepening knowledge and awareness of the climate transition (particularly about systemic dependencies).	Encourage and induce the choice of public transportation in getting around the city - appropriate transportation policy, clean transportation zone,

C-2.2: Description of social innovation interventions

In order to better communicate with residents and involve them in participatory processes, in year 2015 municipality has established **Public Participatory Office** (changed into **Public Participatory Division)**. Wroclaw has a website dedicated exclusively to public participation “Wroclaw talks”. It is created in an attractive and accessible form that encourages residents to get involved in the participatory process in their city. During participatory processes, Municipality informs residents about: how their activity will be used, how they can influence their surroundings, how they can monitor the progress of the processes in which they participate, and what the next steps in the process are. During the public consultation, strategic documents are analysed in order to obtain feedback from residents-comments on local development policies.

All citizens and residents of Wroclaw are encouraged to take part in participatory processes. One of the conditions for conducting public consultations in Wroclaw is to ensure their wide availability. When

using digital tools, city prepares instructions for their use. Municipality uses the support of sign language interpreters, city also takes care of digital accessibility of documents. In recent years, Wroclaw has tried to increase the number of actions involving children and young people in participatory processes, who are also residents of the city and users of its infrastructure.

The Public Participatory Division cooperates with Local Activity Centres **(CALs).** There are 21 CALs, these are places run by local NGO's, with initiatives co-created together with residents. At the local level, the Centres are a strong glue supporting the process of social change. There are also **District Councils**, which cooperate with Wroclaw City Council. There are 48 such institutions in the city.

District councils together with CALs build a network of places, actively supporting residents, and are a link between residents and the city. A system that works this way helps build trust, especially among the most marginalized groups in society. Since the Canters are run by local NGOs, they are recognized by residents as their own, operating in the area, which translates into building close relationships and involvement of residents in various actions taken by Centers. Hence, the majority of the city initiatives are carried out either by or in cooperation with CALs and District Councils.

At this point, it is also worth mentioning **The Youth City Council**. It is a group of young and ambitious people who also want to have an impact on the future of the city. It began its activities more than 25 years ago, in 1994. It was then that the first session of the Youth Parliament of Wroclaw was held, which in 2017 became the Youth Council of the City of Wroclaw. The objectives of the council's activities are primarily to popularize the idea of self-government, create civic attitudes among young people, develop student self-government and represent the youth and student governments of Wroclaw schools to the authorities of Wroclaw and other institutions or organisations. The Youth Council initiates ecological projects. In cooperation with the Department of Sustainable Development, it has announced a competition addressed to students of Wroclaw secondary schools. The purpose of the competition was to adapt schoolyards to climate change, take care of the development of biodiversity in urban space and educate young people about greenery. The competition consisted in creating a concept for developing a school green area in a bio-diverse way, adapted to the needs of students. The best ideas received Department funding and were implemented. There is also **Wroclaw Council of Senio**rs**,** that was established in 2014 to represent the needs and interests of seniors over 60 years of age who reside in the Wroclaw municipality.

An excellent example of a tool activating the resident in the development of the city, including the subject of counteracting climate change, is the municipal participatory budget called the **Wroclaw Participatory Budget**, where applications can be submitted with a proposal, for example, greening urban areas. It can be observed how the needs and preferences of residents have been changing over the years with regard to the projects submitted and implemented. At first, they concerned sidewalks, playgrounds, bicycle paths, lighting. Over time, projects for greening the city appeared. In 2016, a special edition dedicated exclusively to green projects was announced. Today, green realisations make up the majority of winning projects, often in combination with a network of bicycle, pedestrian and recreational paths, and smart lighting.

Microgrants is another city-wide programme supporting grassroots local initiatives, within the framework of which residents of Wroclaw (mainly, although this is not a formal requirement) can implement their own ideas for creative ventures aimed at spreading culture in the city, thanks to the financial support received under the programme. The activities undertaken may concern animation, social activation, education, recreation and may be related to any area of art and other fields with a cultural function. The goal of the programme is to help creative people acquire or develop the skills necessary to effectively influence their city, to lead grassroots local initiatives, and to encourage both the community and the originators of the initiatives to creatively exchange ideas and discussions. The

programme also aims to use the functional and spatial potential of Wroclaw's neighbourhoods to implement activation and bonding initiatives, with an emphasis on activating areas outside the Old Town. The programme was created in 2018. As more than 200 thousand foreigners already live in Wroclaw. Therefore, **Microgrants** support activities for integration. Applicants for whom Polish is not their first language are welcome as well. Information and consultation meetings are also held in Ukrainian, Belarusian, Russian and English.

District Funds are separate funds allocated for the implementation of district investments submitted by the District Councils according to the rules and procedures set forth herein. This, along with Wroclaw Participatory Budget and Microgrants, is one of the forms of residents' participation in the allocation of the municipal budget for investments that are important for their neighbourhood. Thanks to the rules of the District Funds, the subjective role of the District Councils in shaping spatial order in the settlements and creating strong local communities is increasing. Very often these are investments in restoring green areas or recreation on the area of neighbourhood.

The city uses external funding to prepare educational and informational campaigns. **"Small steps, big changes"**[48] campaign started in 2018 and lasted till 2019. The project was aimed at the citizens of Wroclaw and residents of ten municipalities in Lower Silesia. It educated and inspired residents for over a year, drawing their attention to changing their small daily habits regarding choices that affect air quality or the protection of biodiversity in the immediate area. The substantive content of the campaign was prepared based on the National Environmental Monitoring. Since November 2018, 85 meetings have also been organized for nearly 1,600 people, including the Innovation Center, senior citizen clubs, or in schools and kindergartens. About 500 people took part in special workshops at the Zoo and Botanical Garden. And there were nineteen "small steps" presented.

Innovating approach towards climate education and integration gave project **C-Change**[49] - Arts and culture leading climate action in cities. The project began in 2018 and ended in Wroclaw with the Green Culture Festival. The main objective of the C-Change project was to implement the good practices developed by Manchester in Wroclaw in creating a network of cooperation between cultural and art institutions. The project envisaged conducting educational activities that contributed to increasing the environmental awareness of residents for the improvement and adaptation to climate change. Cultural and art institutions were finally working together on the collective purpose, building recognition of the unique role the arts and culture could play on climate action and engagement. This resulted in municipal programme "Green Culture".

Actively inviting residents to use urban initiatives such as "Change the stove", "Wroclaw does not waste" increases the resident's awareness of the need to care for the common good and has a direct impact on reducing GHG emissions or mitigating climate change. As for involving residents in the climate transition, a more organized process began with the establishment of "Wroclaw without smog" information and support campaign. With the implementation of the "anti-smog resolutions" came support systems consisting of municipal Energy Advisors, dedicated funds and cooperation of many groups of stakeholders. As these actions started to grow and developed, since year 2020 they were all gathered under the umbrella "Change the stove" action. One of the initiatives involving residents was a competition dedicated creating a "Change the stove" local hero. Residents who replaced their stove were able to enter a competition, sharing their story and experience (presented on billboard or in short movie) and encouraging other residents to do the same. This activity was aimed at breaking

[48] Campaign was co-financed by European Funds under the ROP 2014-2020 for the Lower Silesian Voivodeship co-financed by the European Regional Development Fund (ERDF)
[49] The project was implemented in the framework of the URBACT III Operational Programme and financed by the European Regional Development Fund

down barriers, showing that replacement is not so complicated, and thanks to this, the “Change the stove” action became more familiar, as it received a neighbour's face.

Wroclaw is open to the participation of residents in the development of the city's policies and actions, including climate issues. In order to engage citizens in more active way, including co-creation process, the city has tested new form of public engagement “civic panel” or “civic meeting”.
The **“Civic panel”** was unique for a number of reasons, from the way participants were selected to the impact of the panel's findings on urban policies. Seventy-five people were selected to participate in the civic panel, taking into account demographic criteria, such as gender and age, the idea being to map the demographic structure of the “city in a nutshell.” The role of the civic panel was to analyze the topic “How to improve the movement of people around Wroclaw, with a view to improving the quality of life and protecting the climate?” , discussing various solutions, listening to arguments for and against, and then making informed and thoughtful decisions. According to the declaration of the Mayor of Wroclaw, recommendations that receive the support of at least 80 percent of the panel will be treated by him as binding, that is, they will be indicated for implementation. The panel was substantively supported by experts from the country and abroad. The process involved 21 parties representing NGOs, urban movements and District Councils and Wroclaw Municipality. The panellists made a total of 63 recommendations - 50 binding and 13 for consideration. The recommendations are reflected in such documents as the Masterplan for the City Centre, the Wroclaw Tram Programme for the years 2024-2032, Plan for Cycling Actions until 2030.

“Civic meeting” was tested in year 2023, the idea was that each group of stakeholders has its representative, in order to achieve balance between different groups of stakeholders. The topic was redevelopment of Ruska Street, one of the streets in the city centre. Participants discussed solutions such as closing street to cars, introducing more greenery, how to enhance security of residents living there. The civic meeting on the future of Ruska Street showed that it is possible to meet different points of view, discuss the topic, and come to common conclusions.

City also has an experience in introducing new methods of engaging citizens such as systems thinking and systems innovation. These methods take into account a multi-sectoral approach using co-creation with selected stakeholders, like during workshops within **NEEST** „NetZero Emission and Environmentally Sustainable Territories” project. NEEST is a pilot project that will develop necessary and universal models that will show how to carry out comprehensive and locally acceptable modernisation of buildings and neighbourhoods to improve their energy efficiency and reduce greenhouse gas emissions from electricity and heat consumption. The highlight of the workshop was a session on participatory systems mapping – an approach that combines systems thinking, multi-sector approach, co-design and design thinking. The method is directed at developing (co-design) by participants representing organisations from multiple sectors systemic innovations - that is, innovations that go beyond narrowly defined organisational improvements or technological innovations. System innovations take into account dependencies between elements of a larger system and find hidden synergies between them.

There is a whole package of actions dedicated to increasing green space in the city with the involvement of residents and businesses. Thanks to the **Green Patronage**, residents can contribute to the planting of trees, shrubs or perennial beds in the city, but also enhance the space with small architecture and even a pocket park. The city offers various packages to choose from, depending on the willingness to get involved. The programme is aimed at residents but also businesses. **GROWin WROclaw** programme involves planting trees with newborns and young children as patrons of the trees. The tree planting campaign is accompanied by a picnic. The trees are planted together with the parents of the children. Each tree has its own number, is often given the child's name and parents

receive a certificate. The goal of the project is to expand the city's green spaces while involving residents. The programme started in 2017 and since then 3431 children have become tree patrons.

WROchef is a competition aimed at elementary school children. Elementary school children are a difficult target when it comes to involving them in pro-environmental actions. The purpose of the competition is to promote a plant-based diet, based on local and seasonal products. It aims to educate students about healthy lifestyles and prevent food waste. But there is innovative way of approaching students – through social media and well-known faces – restaurant chefs and finalists of famous cooking TV shows are being used to promote the competition. The competition entry also looks more like a video from TikTok containing a description and execution of a dish made from plant products than a "good-old" poster. Prizes include cooking with the finalists of TV shows (TopChef and MasterChef). The authors of the best recipes have the opportunity to improve their recipes with the chefs of the restaurants that sponsor the competition.

The **"Wroclaw Magnolia"** competition is aimed at graduates of Wroclaw universities who, in a given academic year, have defended a master's thesis addressing issues in the field of improving the quality of life of the citizens of Wroclaw, particularly the broadly understood protection of the environment and nature of the City of Wroclaw, as well as the protection of health and human life.

Since 2021, the city has been organizing a family picnic called **"Saturday with Green Wroclaw**". The picnic is an opportunity to introduce residents to the activities of the Department of Sustainable Development, but also other departments, city companies and organisations cooperating with the city, all in the form of games and activities. The 2023 picnic was combined with the celebration of Sustainability Week and European Mobility Week. The motto was "Together to the Goal," as the information and education campaign on the Sustainable Development Goals was launched with this event.

Changing transportation attitudes, reducing car traffic, promoting public transportation and other forms of clean transportation is crucial to the city's climate transformation. In terms of social innovations two actions stand out. One is Cycling May, the other consultations on introducing clean transportation zone. **Cycling May** is Poland's largest campaign promoting cycling, scootering, rollerblading or skateboarding among elementary school students and preschoolers. It was born in 2014 in Gdansk, and since 2016 Wroclaw has joined the campaign.

The campaign has an impact:

- shaping positive transportation habits,
- promoting healthy lifestyles,
- in supporting children's independence,
- improving traffic safety,
- on the environment,
- engaging local environments - social and business.

Cycling May, through fun combined with elements of competition, popularizes the bicycle as a means of transportation to school, teaches good and healthy habits that continue even after the campaign ends. Cycling May effectively changes the neighborhoods around schools and kindergartens to be safer and more bike-friendly, reducing the number of cars transporting children and motivating local governments to make pro-bike investments.

In 2023 a consultation started on the introduction of a low-emission zone for the city centre and parts of the downtown area. Consultation process is divided into three stages. In the first stage of consultations, Municipality presented different variants of the zone, both in terms of the area and the

pace at which the most toxic vehicles would be eliminated from the zone. After this stage, officials prepared a draft zone for further consultation. The next stage will be “civic meeting”. This is the second of three stages of public consultation on the zone. During the third stage, everyone will be able to give their opinion on the draft resolution on the low-emission zone

The selected examples of social innovations present a cross-section of different activities related to climate transformation. Building social capacity is an important aspect, and it is also important to use diverse forms of participation, adapted to different social groups, including marginalized groups. There are programmes and projects focusing on cooperation with different stakeholders.

Long-term impact and scale up of innovation activities will be provided through:
● Increasing stakeholders motivation and commitment to climate transformation
● Understand mutual expectations and interdependencies among stakeholder groups
● Build trust and sectoral and trans-sectoral partnerships
● Deepening knowledge and awareness of the climate transition (particularly about systemic dependencies)
● Building shared ownership of the climate transition and the responsibilities and commitments of individual stakeholders.

5 Outlook and next steps

Plans for next CCC and CCC Action Plan iteration

The presented first version of the action plan is part of an analysis of the sectors responsible for greenhouse gas emissions from the city area, and thus key in the process of reducing these emissions. In part, the proposed actions are a continuation of the city's ongoing programmes or activities identified in the SECAP, among others. However, achieving climate neutrality by 2030, understood as an 80% reduction in greenhouse gas emissions compared to the base year (2022), requires acceleration and expansion of efforts in key sectors. That's why it's important to work with key stakeholders, including, in particular, electricity and heat production companies. It is also important to parameterize goals and an action plan at the national and regional levels. According to the NZC Neutrality Map, this is the first iteration of the action plan and the process involves continuous refinement, supplementation and revision during the implementation period therefore in this version, due to the lack of sufficient data, scale and scope of activities, the plan is general in nature and includes approximate emission reduction values and cost estimates. These data will be successively detailed.

The following activities will be undertaken as part of the work on the next iteration of the plan:

- Updating the emission inventory - we plan to perform two more emission inventories for 2023 and 2024 so as to more precisely determine the scale of greenhouse gas emissions from the city area. To this end, we will use suggestions for corrections and improvements indicated in the 2022 inventory we currently have, but also conclusions from training on the use of the CIRIS programme. They include, among other things, suggestions to verify the possibility of obtaining emission factors specific to energy trading companies, to check the source of data on average fuel consumption and distance traveled within the municipality, to plan how to cooperate with the industrial sector. Accurate determination of emissions will allow better selection of scale and scope of activities.
- SECAP update - we are planning to update the existing Sustainable Energy and Climate Action Plan for the City of Wroclaw (SECAP) in order to more precisely define and parametrize the municipality's activities in the pursuit of neutrality.

- We want to start reporting using the CDP / ICLEI portal so as to more effectively monitor the progress achieved.
- Financial indicators and identification of the climate budget - further activities require cooperation with the city's financial divisions so as to more effectively raise funds for financing pro-climate actions, especially since increasingly often obtaining these funds from external sources requires determining their impact on emissions reductions or impact on climate change adaptation.
- We plan to prepare an update of the Climate Change Adaptation Plan and build to a similar approach to that presented in the City Mission. Along with the Climate Change Adaptation Plan, we will proceed with the development of an ambitious Urban Greening Plan, which, in addition to the main goals of climate change adaptation and improving the quality of life in the city, will also be part of a plan to reduce residual emissions.
- We will begin analysis and activities to identify ways to reduce residual emissions other than the use of greenery.
- We will take steps toward working with private industry with the goal of working toward individual climate contracts or at least declarations of action related to reducing energy consumption, sourcing energy from renewable sources or reducing emissions in Scope 3.
- We will continue to work with power and heating companies toward Decarbonisation of these sectors as key to the effectiveness of the Action Plan.
- We will continue to cooperate at the local level in the work on the implementation plan of the Energy Strategy for Lower Silesia and at the national level in cooperation with the Ministry of Climate and Environment and the Ministry of Funds and Regional Development as key to the work on the National Plan for Energy and Climate by 2030, among others.
- We will also, in cooperation at the national level and other Mission cities from Poland, build a platform for sharing knowledge and experience for other cities using the knowledge acquired during the work on the Climate Contract.

Other activities include:

- identification of thermo-modernisation needs in municipal and private assets using, among other things, national data of the Integrated Low Emission Reduction System (ZONE), of which the Central Emission Inventory of Buildings (CEEB) is a part;
- analysis of the potential for RES development, particularly in terms of photovoltaics (examining the potential of building roofs (especially large-scale buildings), parking lot canopies and shelters, and sites suitable for ground-mounted installations).
- Analysis of the potential of municipal companies in terms of RES development ;
- mapping and analyzing the potential of waste heat sources. Future iterations must include a map of waste heat sources created jointly with stakeholders and an analysis of the potential for their use. Currently implemented one such project using heat from the municipal sewage system. To be studied and mapped, together with the city's stakeholders, are other sources of waste heat recovery, such as industrial processes, server rooms, cooling processes, transportation ;
- to take into account the phenomenon of energy poverty. This is necessary because it is the poorest or excluded people who will need the most systemic support and assistance in the energy transition process, both from the local government and at the national level ;
- analysis of the potential for electromobility development. To be studied is the potential for electromobility development: the possibility of developing a network of electric vehicle charging stations and hubs, and the possibility of increasing the number of bus lines served by electric buses.
- plans for cooperation with stakeholders. Subsequent iterations of the document will include increasingly specific plans for actions and ways to support the implementation of the Municipal Climate City Contract obtained from key stakeholders. These will be developed

during the External Transition Team collaboration and individual agreements. This includes city stakeholders (city companies), private entities, NGOs, businesses, institutions.

Further work on solutions to systemic barriers is important. Representatives of the cities participating in the EC Mission and representatives of the Government of Poland (the most important ministries for the implementation of the CCC) are cooperating within the framework of the National Cooperation Platform, the purpose of which is to discuss ways of needed support (legislative, financial, technical, etc.) and necessary interventions at the national level, enabling the implementation of the CCC and elimination of systemic barriers. Meetings have already been held on funding sources for Decarbonisation activities and barriers to their use, and on the needs of local governments for support from the Government of the Republic. Another meeting is planned to discuss the draft National Energy and Climate Plan 2021-2030, and the solutions developed will be taken into account in subsequent iterations of the Action Plan.

Given the extensive thematic scope of the Climate Contract and the large number of activities to be performed but also the not too distant time for the implementation of these tasks (2030), it is proposed to review the progress of activities and possible iteration of the Contact in two-year cycles. This will allow monitoring of individual tasks and making necessary adjustments as new knowledge is gained and new skills are built especially in areas that need improvement.

In addition, the approved Action Plan, along with the other elements of the Climate Contract, will also be presented to city councilors as representatives of the citizens of Wroclaw.

6 Annexes

Appendix: Estates of Wroclaw