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Scenario-Based Assessment of Climate Neutrality Pathways in Rīga Municipality, Latvia

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This document presents an assessment of future energy demand and CO_2 emissions in Rīga municipality up to 2050, using a scenario-based modelling approach. The analysis covers major sectors, including buildings, transport, public infrastructure and waste management, and evaluates the impacts of selected policy measures on energy consumption, fuel structure, and emissions.

The analysed scenario assumes a modest economic development and a slight population increase (0.5 % per year), which leads to relatively stable or slowly increasing demand in several sectors. In this scenario, decarbonisation is primarily achieved through energy efficiency improvements, demand reduction, behavioural measures, and integrated sectoral policies. The document highlights the trade-offs between energy demand reduction and technology-led decarbonisation, and provides insights into how different policy choices can shape Rīga's long-term energy system and climate outcomes.

NB! The simulations were conducted solely for exploratory and analytical purposes. They do not represent official projections, nor have they been adopted or endorsed by Rīga municipality. Rather, these exercises serve as a basis for discussion and reflection among municipal stakeholders and may support future decision-making processes.

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Contents

1. MUNICIPALITY BUILDINGS

Energy consumption in municipal buildings refers to the amount of energy used by public facilities owned or managed by local governments, including city halls, schools, libraries, police and fire stations, public works facilities, and recreational centers. These buildings often have diverse functions and require energy for lighting, heating, cooling, water heating, and running various equipment and systems.

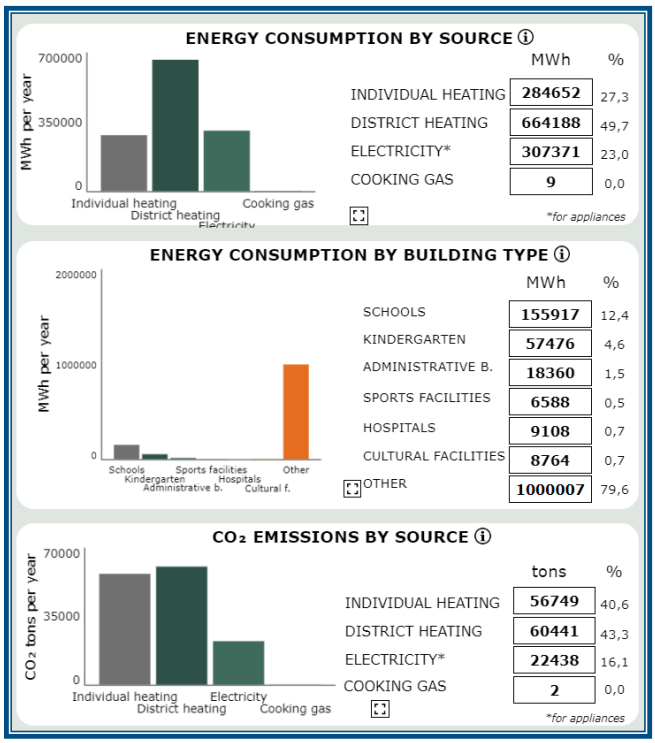
1.1. Current situation

In Rīga municipality, the total area of municipal buildings in the baseline year is 5 423 397 m². The largest share by area is made up of school, kindergarten and other building groups. The total energy consumption in municipal buildings in 2021 was 1 337 179 MWh, which accounted for 11,7 % of energy consumption in Rīga municipality.

In energy consumption, the largest share is the district heating supply with 49,7 % of the total energy consumption, followed by individual heating systems (27,3 %) and electricity consumption for appliances (23 %). It should be noted that electricity for appliances does not include electricity used for heating, rather it is included in individual heating.

The average specific heat energy consumption in municipal buildings is 175 kWh/m²/year and electricity consumption is 57 kWh/m²/year (weighted average across the entire building stock).

Total CO_2 emissions in municipal buildings related to energy use in the Baseline year were 139 630 tons of CO_2. The largest source of CO_2 emissions is district heating (43,3 %), followed by individual heating (40,6 %) and electricity for appliances (16,1 %). Overall, CO_2 emissions in municipal buildings make up 7,3 % of the total CO_2 emissions in the municipality. As no building construction or demolition is planned, energy demand and CO_2 emission values remain unchanged through the whole baseline scenario.



1.2. Policies

In this sector, no policy measures were proposed or tested, as the municipality has currently no plans to implement additional interventions. Therefore, the baseline scenario remains unchanged, and no simulated energy or emission reductions are projected for this sector.

This decision may reflect limited municipal influence, lack of cost-effective measures, or prioritization of other sectors with higher reduction potential.

2. RESIDENTIAL BUILDINGS

Energy consumption in residential buildings refers to the total amount of energy used for various activities, including heating, cooling, lighting, cooking, and powering appliances. All residential building stock is grouped according to four types – single family detached, single-family attached, large multi-family, and other.

2.1. Current situation

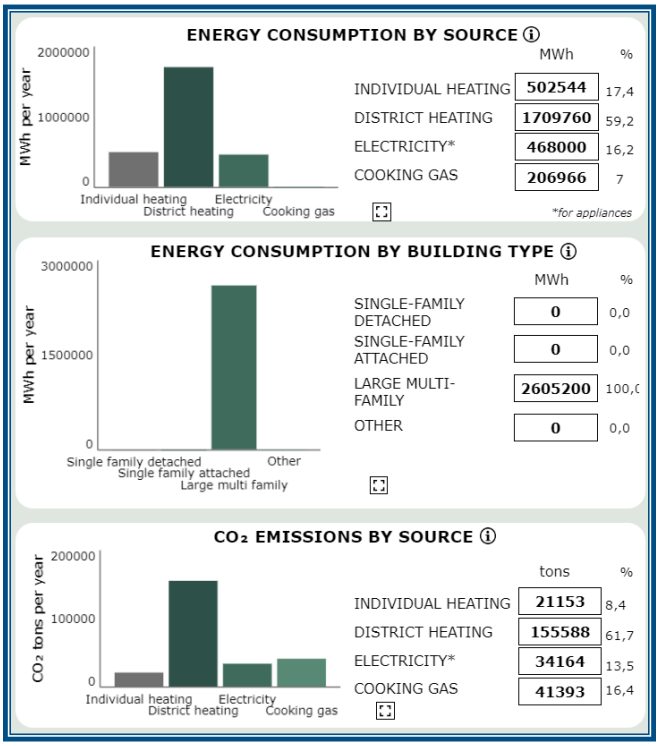
In Rīga municipality, the total area of residential buildings accounted in calculation is 15 600 000 m². This area is made up of multi-family houses. In 2021, the total energy consumption in residential buildings was 2 887 270 MWh, accounting for 25,4 % of total energy consumption in Rīga municipality.

Of the total energy consumption, district heating systems make up 59,2 % or 1 709 760 MWh and energy for individual heating – 17,4 % of total energy demand. Electricity consumption for appliances makes up 16,2 % or 468 000 MWh. It should be noted that electricity for appliances does not include electricity used for heating, rather it is included in individual heating.

Since the baseline scenario does not predict the construction of new residential buildings or the demolition of existing ones, the energy consumption of the baseline scenario is unchanged with the existing assumptions.

The average specific energy consumption for space heating and hot water preparation in the residential sector is 137 kWh/m²/year per year, and electricity consumption is 30 kWh/m²/year (weighted average across the entire building stock).

The amount of CO_2 generated in the household sector in the Baseline year were 252 298 tons/year, which is 13,2 % of the municipality's CO_2 emissions. The largest source of CO_2 emissions in residential buildings is the district heat supply, which is responsible for 61,7 % of total CO_2 emissions.



2.2. Policies

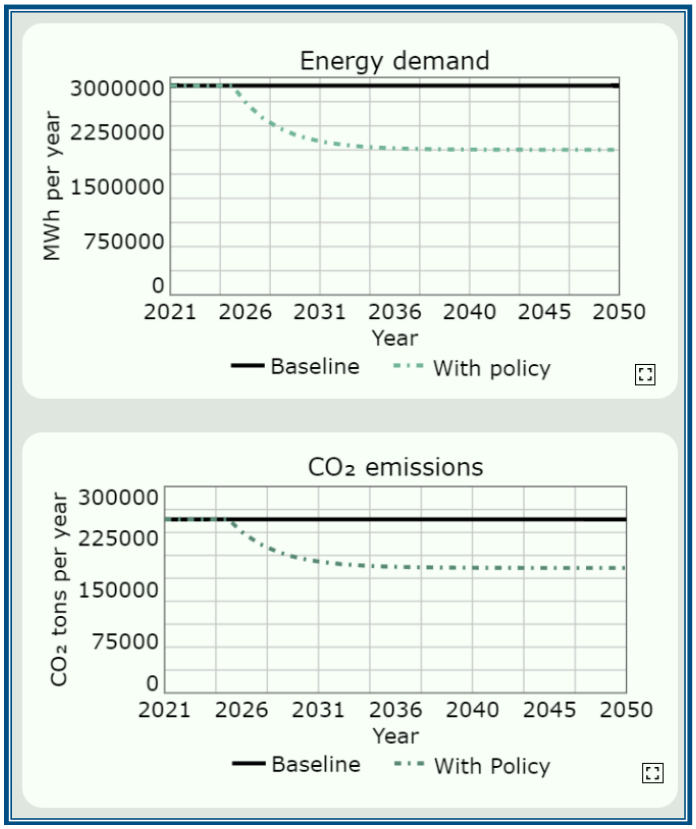
To reduce energy consumption and emissions, a comprehensive multi-family home renovation strategy was tested, starting in 2025.

- **Renovation of multi-family houses** (*IS* 30 %/year, *ES* 40 %)

The policy implementation start year was 2025, while implementation end year was 2050.

In total, the selected policies achieved 884 802 MWh in energy savings and 70 687 tCO_2 in emission savings in 2050 compared to the baseline scenario (30,6 % and 28 % reductions respectively).

After the policy implementation start year in 2025, both energy consumption and emissions decrease relatively fast until around 2034, after which they slow down, as ~90 % of the building stock has been renovated.


Energy demand
MWh per year
3000000
2250000
1500000
750000
0
2021
2026
2031
2036
2040
2045
2050
Year
Baseline
With policy
CO₂ emissions
CO₂ tons per year
300000
225000
150000
75000
0
2021
2026
2031
2036
2040
2045
2050
Year
Baseline
With Policy

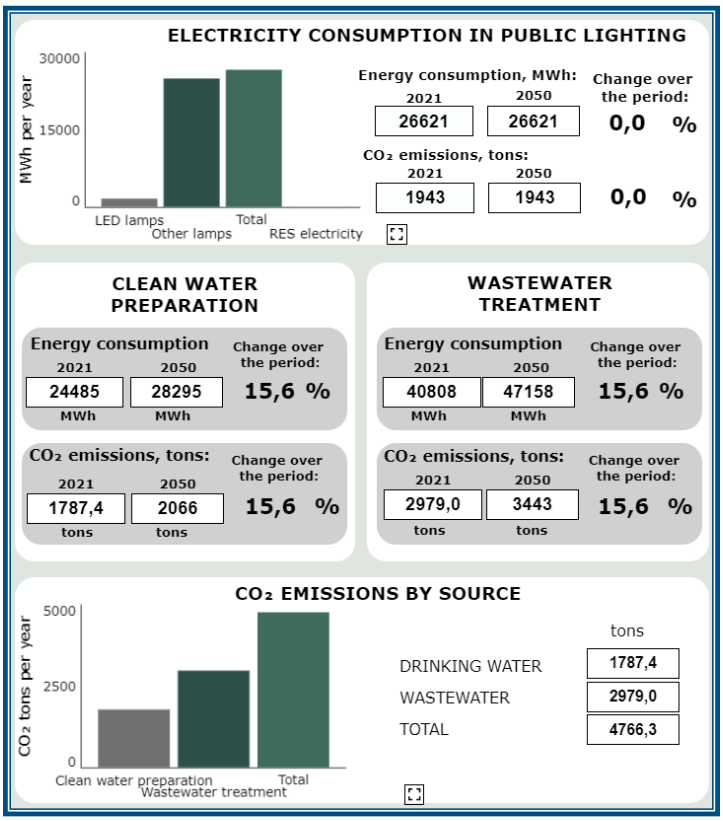
3. PUBLIC INFRASTRUCTURE

The Public Infrastructure sector encompasses essential services and systems that support communities and contribute to their quality of life. This sector includes electricity consumption related to public lighting, clean water preparation, and wastewater treatment, all of which are critical to maintaining public health, safety, and urban functionality.

3.1. Current situation

In Rīga municipality, the expected total electricity consumption in the Public infrastructure sector in the baseline year is 98 264 MWh/year, which is 0,9 % of the municipality's total energy consumption. Due to constant population growth, the amount energy used for clean water preparation and wastewater treatment is expected to increase by 15,6 %, bringing the total energy consumption of the sector to 102 074 MWh per year in 2050; with wastewater treatment accounting for 46,2 %, drinking water preparation – 27,7 % – and public lighting – 26,1 % of the total energy consumption.

The amount of CO_2 generated in the Public Infrastructure sector in the baseline year is 6703,4 tons/year and it is expected to increase to 7452 tons/year (15,6 %) in 2050 due to population growth.



3.2. Policies

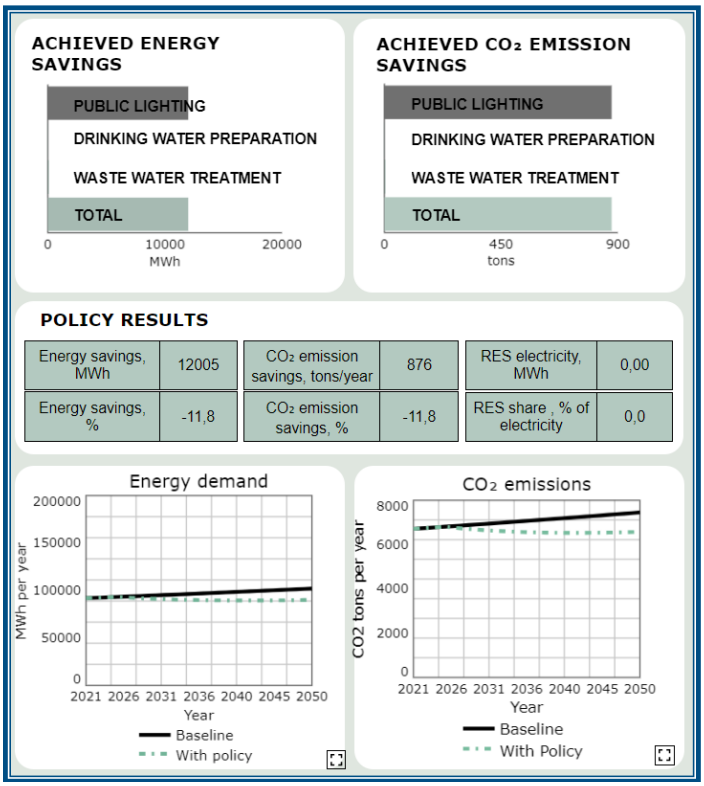
The following policy measure was implemented in the public infrastructure sector:

- **Replacement of inefficient light bulbs in public lighting** (*IS* 5 %/year)

The policy implementation start year was 2025, while implementation end year was 2050.

In total, the selected policy achieved 12 005 MWh in energy savings (11,8 % reduction) and 876 tCO_2 in emission savings (11,8 % reduction) in 2050 compared to the baseline scenario.

In the policy scenario both energy demand and CO_2 emissions remain at a relatively constant rate compared to the baseline scenario, where energy demand and emissions continue to rise due to the constant population increase.



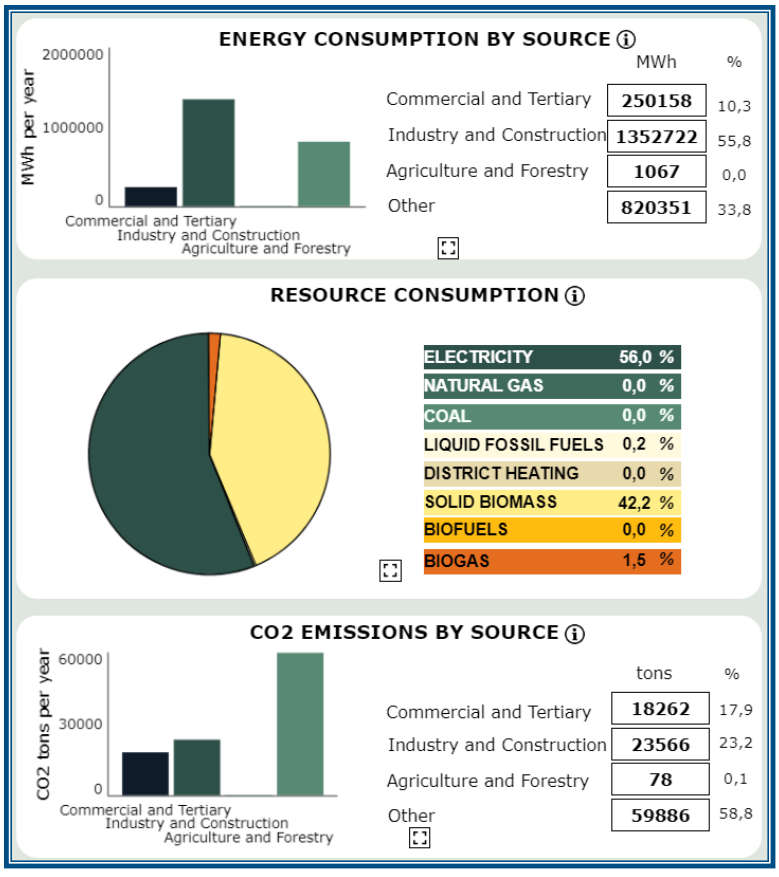
4. OTHER SECTORS

In Other sectors, energy consumption from four sub-sectors is considered: Commercial and Tertiary, Industry and Construction, Agriculture and Forestry, and Other. Only emissions related to energy consumption are considered in this sector. The calculations are based on aggregated statistical data on energy consumption in sectors and assumptions about future development trends.

4.1. Current situation

In Rīga municipality, Other sectors' Baseline energy consumption is 2 424 298 MWh. Of this, the largest share is made up of energy consumption in the Industry and Construction sector (55,8 %), followed by Other sectors with 33,8 % and the Commercial and Tertiary sector (10,3 %). Electricity and solid biomass dominate the energy mix with 56 % and 42,2 % of the total energy demand, respectively.

Energy consumption in Other sectors accounts for 21,3 % of the municipality's total energy consumption. Total CO_2 emissions in Other sectors are 101 791 tons/year or 5,3 % of the Municipality's total CO_2 emissions in 2023. As no growth in any of the sectors was projected, energy demand and emissions remain unchanged all throughout the baseline scenario.



4.2. Policies

In this sector, no policy measures were proposed or tested, as the municipality has currently no plans to implement additional interventions. Therefore, the baseline scenario remains unchanged, and no simulated energy or emission reductions are projected for this sector.

This decision may reflect limited municipal influence, lack of cost-effective measures, or prioritization of other sectors with higher reduction potential.

5. TRANSPORT

The transport sector in municipalities is a significant contributor to greenhouse gas (GHG) emissions, primarily due to reliance on fossil fuels. Sectors covered include: municipal vehicle fleet, public and private transportation. Only land transport and CO_2 emissions related to fuel combustion are considered. It should be noted that the results for the transport sector are obtained through calculations, not based on actual fuel invoices. Therefore, there may be data discrepancies.

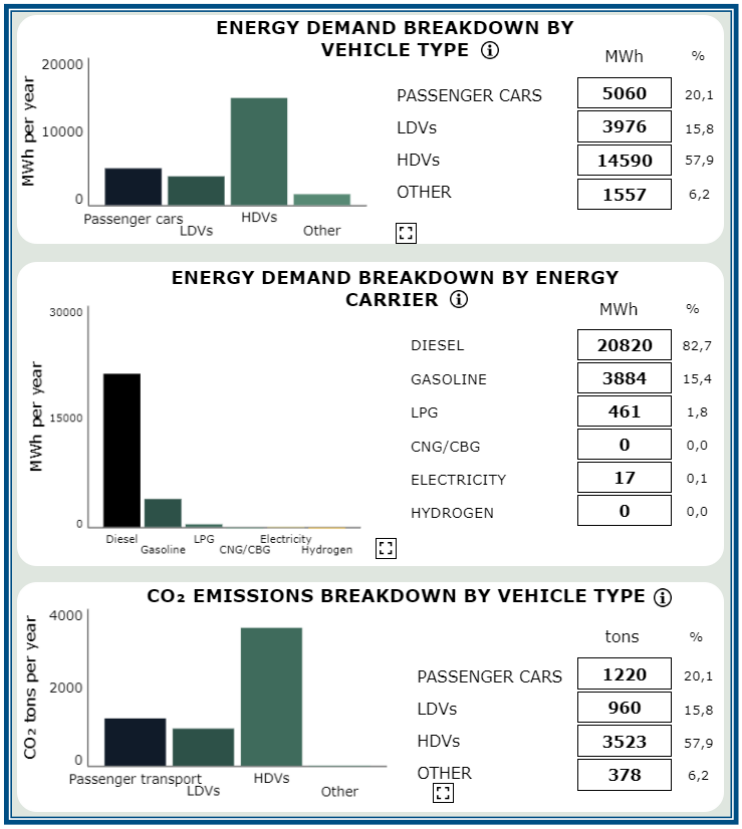
5.1. Current situation

Municipal vehicle fleet

The municipal vehicle fleet consists of 697 passenger cars, 277 LDVs, 162 HDVs un 308 other vehicles. Assuming the average annual vehicle mileage, specific fuel consumption by fuel type and fuel type distribution, it was calculated that the energy consumption of the municipal vehicle fleet is 25 182 MWh per year, which is equivalent to 0,2 % of the municipality's total energy consumption.

In terms of fuel consumption, diesel fuel accounts for the largest share (82,7 %), followed by gasoline (15,4 %). By vehicle type, the most significant energy consumer is HDVs (57,9 %), followed by passenger cars (20,1 %) and LDVs (15,8 %). Total CO_2 emissions related to the municipality's vehicle fleet amount to 6082 tons of CO_2 per year, or approximately 1,2 % of the municipality's total CO_2 emissions.

The baseline scenario does not assume any changes in the municipal vehicle fleet, thus energy consumption and emissions are assumed to remained unchanged from the base year.



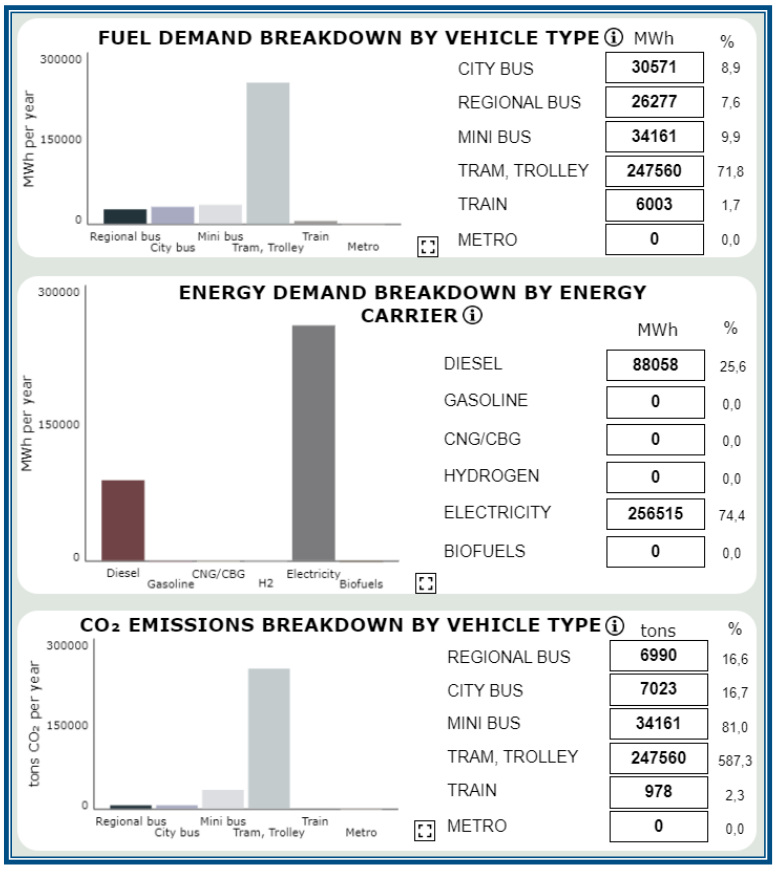
Public transport

According to existing data, 940,6 million passenger kilometres per year are performed by public transport. The largest share of this demand is made up of city public transport (80 %), followed by regional public transport (20 %).

Based on the assumptions made regarding the use of various public transport modes, average occupancy rates, average fuel consumption and type of fuel used, it has been calculated that the energy consumption of public transport is approximately 298 171 MWh per year in 2021 or 3 % of the municipality's energy consumption. Of this, the largest share is made up of tram and trolley (71,8 %), followed by mini bus (9,9 %) and city bus (8,9 %). Electricity dominates in terms of fuel consumption with 74,4 %, followed by diesel with 25,6 %. Total CO_2 emissions related to energy consumption in public transport amounted to 36 473 tons of CO_2 in 2021 or approximately 2,2 % of the municipality's total CO_2 emissions.

The baseline scenario assumes no changes in the public transport vehicle fleet or usage patterns, and no policy measures are applied. Changes in energy consumption are driven solely by exogenous assumptions, including a gradual increase in population. As a result, public transport energy demand increases over time.

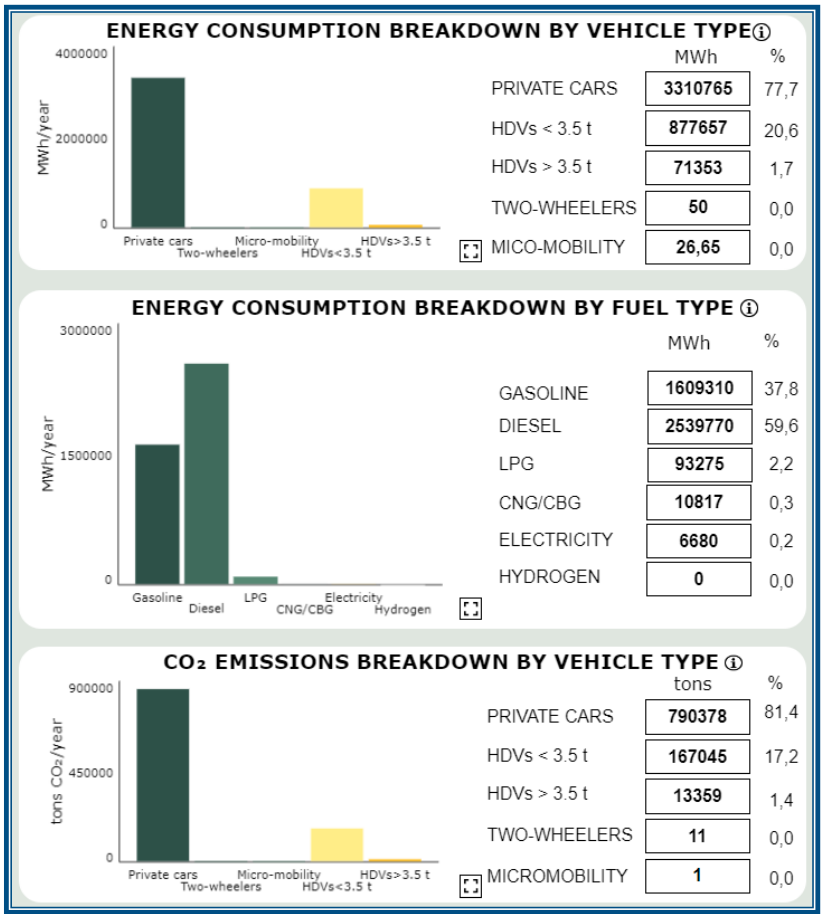
The projected energy consumption in 2050 is 344 573 MWh, with associated CO_2 emissions of 42 149 tons, corresponding to an increase of 15,6 % compared to the base year.



Private transport

According to existing input data, private transport demand in the municipality is approximately 6897,6 million passenger kilometres per year. Based on the assumptions made regarding the use of private vehicles, average fuel consumption and type of fuel used, it has been calculated that the energy consumption in the private transport sector will reach 4 259 852 MWh per year by 2050 and reach 37,4 % of the municipality's total energy consumption. Of this, the largest share is made by up private cars (77,7 %), followed by HDVs below 3,5 tons (20,6 %) and HDVs above 3,5 tons (1,7 %). Energy demand of other transportation modes, namely two-wheelers and micro-mobility tools, is negligible. Looking at the type of fuel, the two main types of fuel are diesel (59,6 %) and gasoline (37,8 %). Electricity accounts for a small proportion – 6680 MWh per year or 0,2 % of total energy demand. Total CO_2 emissions in the private transport sector in 2050 amount to 8 643 566 tons of CO_2 per year, or approximately 50,9 % of the municipality's total CO_2 emissions.

The baseline scenario assumes no changes in private transport usage patterns and no policy interventions. Changes in energy consumption and emissions are driven solely by exogenous assumptions, including a gradual increase in population. As a result, energy consumption increases by approximately 11,7 % and emissions by 12,3 % in 2050 compared to the base year.



5.2. Policies

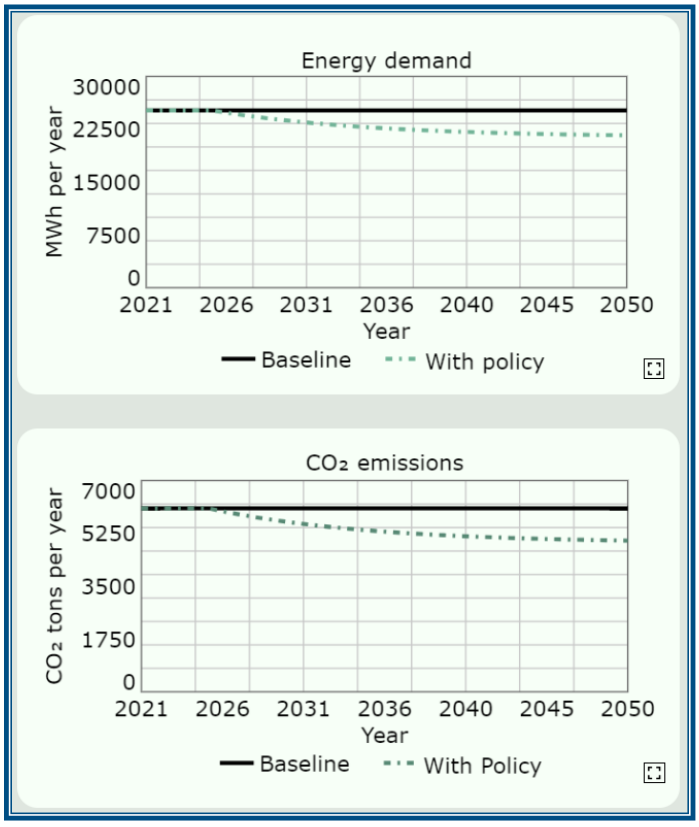
Municipal vehicle fleet

In this sector, a single policy measure was proposed:

- **Passenger vehicle fleet decarbonization** (*Target technology choice Electric vehicles* - 100 %)

The policy start year was 2025 and the implementation end year was 2050.

In total, the selected policies achieved 3540 MWh in energy savings and 1073 tCO_2 in emission savings in 2050 compared to the baseline scenario (14,1 % and 17,6 % reductions respectively).



Public transport

No policy measures were proposed or tested for public transport in this simulation. As a result, the baseline scenario remains unchanged and no additional reductions in energy consumption or CO_2 emissions are projected due to policy intervention.

This may reflect either limited municipal influence over public transport operations, prioritization of other sectors, or ongoing improvements already integrated into baseline assumptions.

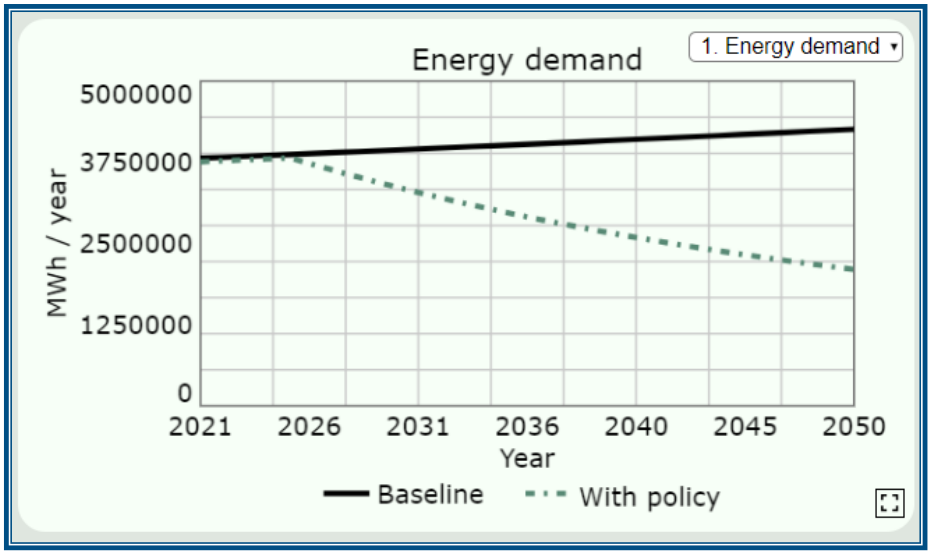
Private transport

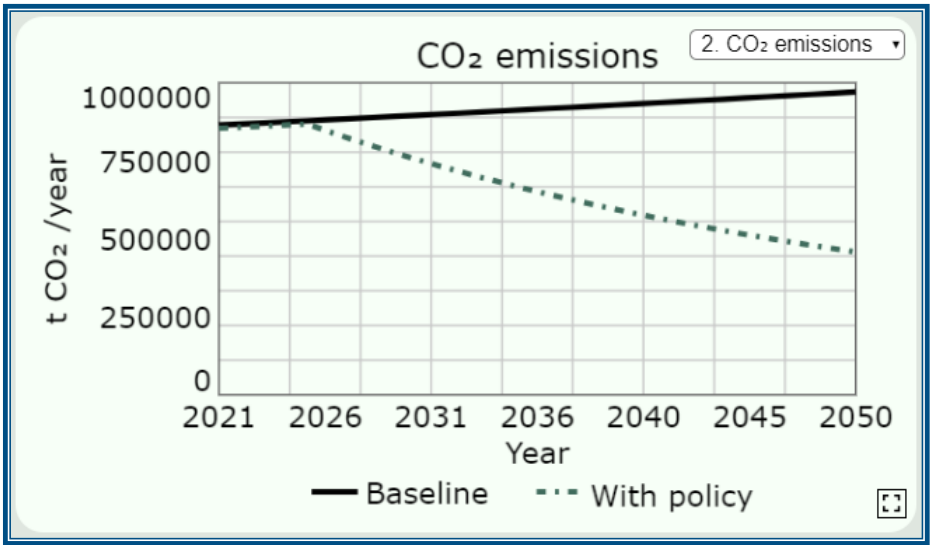
The following policy was implemented in the private transport sector:

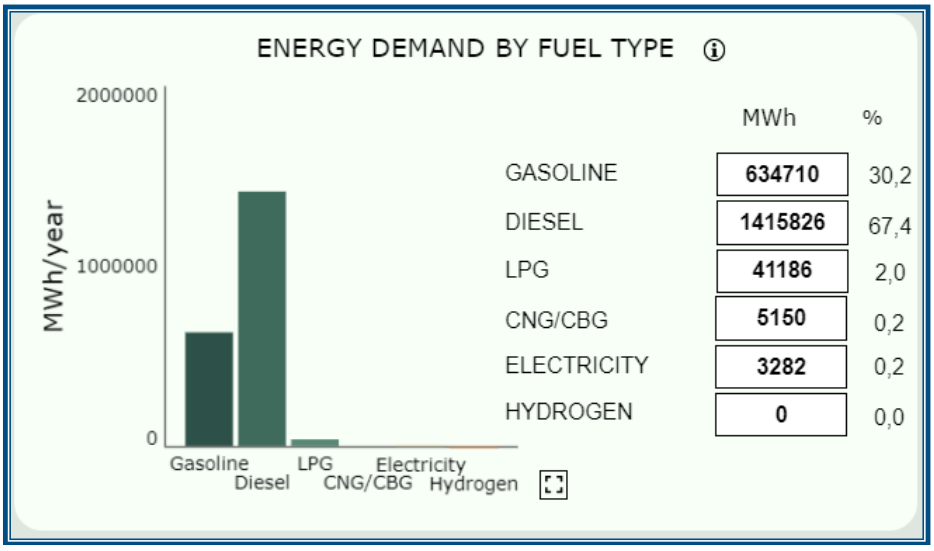
- **Reduction in passenger transport demand** (*Daily distance reduction IS* 2 %/year, *Travel frequency reduction IS* 2 %/year)

The policy implementation start year was 2025 and the implementation end year was 2050.

In total, the selected policies result in a reduction of approximately 2 159 698 MWh in energy demand and 512 769 tons of CO_2 emissions by 2050 compared to the baseline scenario, corresponding to reductions by 50,7 % and 52,8 %, respectively.






ENERGY DEMAND BY FUEL TYPE
2000000
1000000
0
MWh/year
Gasoline
Diesel
LPG
CNG/CBG
Electricity
Hydrogen
MWh
%
GASOLINE
634710
30,2
DIESEL
1415826
67,4
LPG
41186
2,0
CNG/CBG
5150
0,2
ELECTRICITY
3282
0,2
HYDROGEN
0
0,0

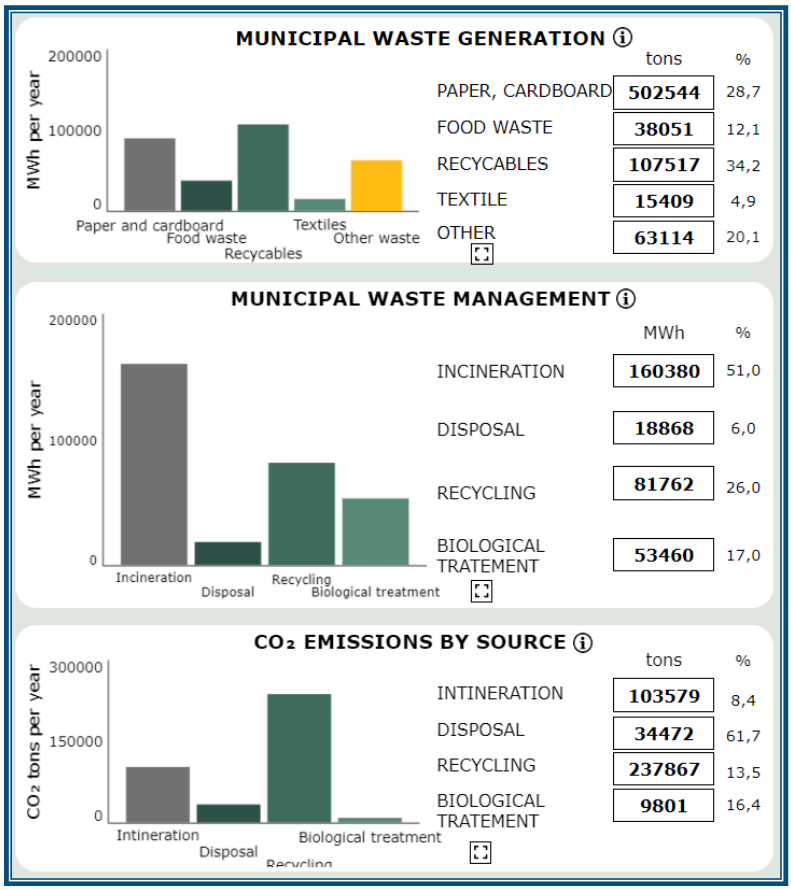
6. WASTE MANAGEMENT

In the waste management sector, GHG emissions related to waste management are considered. Effective waste management strategies, such as recycling, composting, and energy recovery, help reduce emissions by minimizing landfill waste and promoting circular economy practices. Municipalities can lower their carbon footprint by implementing sustainable waste policies, investing in waste-to-energy technologies, and encouraging community participation in waste reduction efforts.

6.1. Current situation

The calculations of the baseline scenario are based on assumptions about the number of inhabitants, the amount of waste generated per inhabitant (478 kg/capita/year) and the structure of municipal waste. Based on these assumptions, the amount of municipal waste generated in Rīga municipality in the base year is 296 895 tons and the GHG emissions related to waste management constitute 345 424 tons CO_2eq. The waste management sector accounts for approximately 20,2 % of the municipality's emissions

The baseline scenario assumes an annual 0,5 % increase in the municipality's population, however an annual 0,3 % decrease in waste generated per habitant is assumed. Consequently, by 2050, the total amount of waste generated is expected to increase by approximately 5,9 % and GHG emissions are expected to increase by approximately 11,7 % compared to the baseline year reaching 314 470 tons of generated waste and 385 719 tons CO_2eq, respectively.



6.2. Policies

No policy measures were proposed or tested for waste management in this simulation. As a result, the baseline scenario remains unchanged and no additional reductions in energy consumption or CO_2 emissions are projected due to policy intervention.

This may reflect either limited municipal influence over waste management operations, prioritization of other sectors, or ongoing improvements already integrated into baseline assumptions.

7. LOCAL ENERGY PRODUCTION

The Local Energy Production Sector encompasses energy production technologies and their associated environmental impact. This sector includes local electricity and heat generation parameters. The municipality can reduce CO_2 emissions in this sector by reducing heat losses in the system, recovering lost heat and decarbonizing various energy systems.

NB! The local energy production sector differs from other sectors in that it represents energy supply rather than energy demand. The 2050 scenario without energy-production-specific policies therefore reflects the energy demand generated by all other sectors after their respective policies are applied, but before any policies targeting local energy production are introduced.

7.1. Current situation

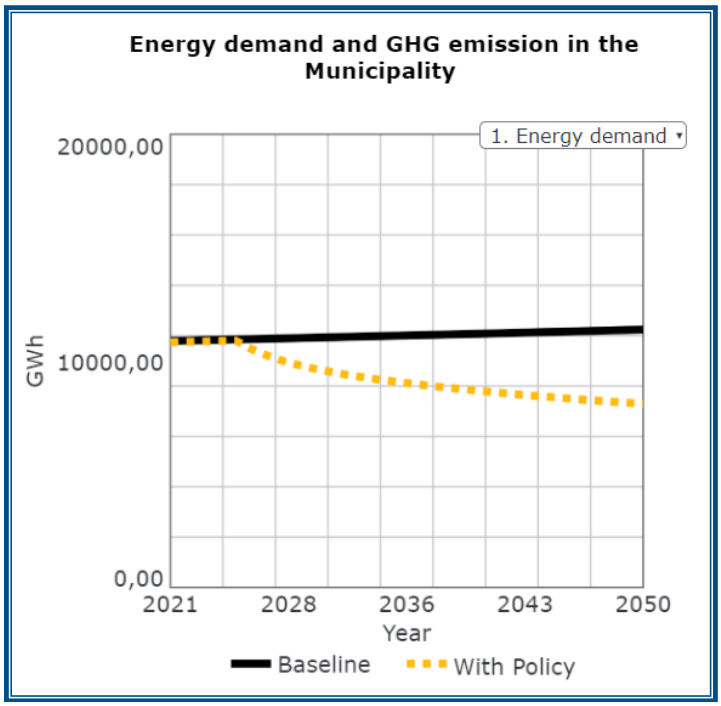
In Rīga municipality, Local energy production energy demand and GHG emissions are not included in the baseline inventory and projection.

7.2. Policies

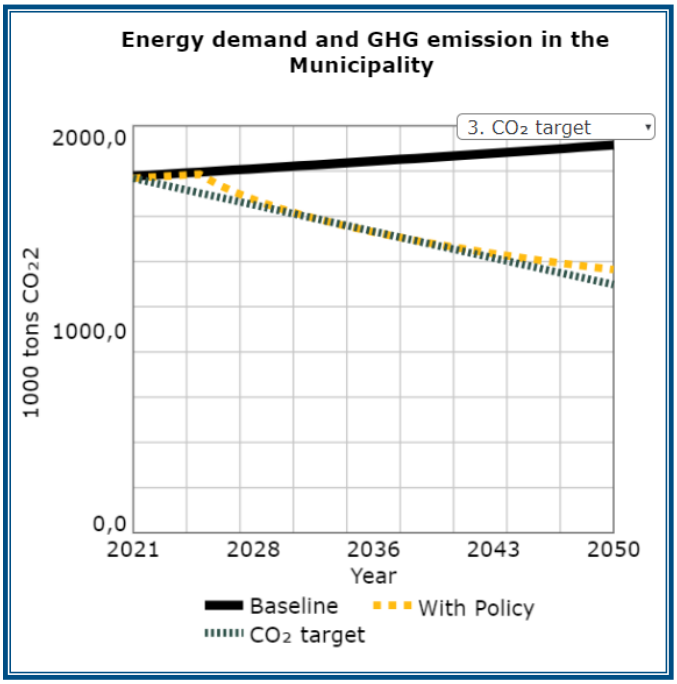
In Rīga municipality, Local energy production energy demand and GHG emissions were not included in the baseline inventory and projection; thus, no policy analysis was conducted.

8. RESULT OVERVIEW

The results of the simulation show that in the baseline scenario energy demand in the municipality increases by approximately 0,15 %/year over time due to population increase and economic and activity growth assumptions. As illustrated in the figure below, total energy demand rises over time, reaching 11 380,43 GWh in the baseline scenario by 2050. The implementation of the selected policy package causes a gradual energy demand decrease, resulting in an energy demand of 8101,29 GWh by 2050. This corresponds to energy savings of 3 279 135,4 MWh, or 28,8 % compared to the baseline projection.



The selected policy package leads to significant emission reductions – CO_2 emissions decrease from 1905,9 thousand tons in the baseline scenario to approximately 1293,7 thousand tons in the policy scenario by 2050, resulting in annual emission savings of 612 204,9 tons (32,1 %). As shown in the figure below, while the policy scenario lowers emissions below the long-term CO_2 target (30 % reduction by 2050) in the time period between 2033 and 2037, the increasing energy demand due to population growth eventually places it above the target trendline indicating that additional mitigation measures would be required to fully achieve the municipality's climate objectives.


Energy demand and GHG emission in the Municipality
3. CO_2 target
2000,0
1000,0
0,0
1000 tons CO_22
2021
2028
2036
2043
2050
Year
Baseline
With Policy
CO_2 target

9. CONCLUSIONS

The results of the scenario analysis for Rīga municipality demonstrate that the implementation of the selected policy package leads to substantial reductions in both energy demand and greenhouse gas emissions by 2050, despite continued population growth and increasing activity levels.

Overall, total energy demand is reduced by approximately 28,8 % (3 279 135 MWh) compared to the baseline scenario, indicating that the implemented measures are highly effective in counteracting demand growth. At the same time, CO_2 emissions decrease by 32,1 % (612 205 tCO_2), demonstrating a significant decarbonisation effect at the municipal level.

The results clearly show that **the transport sector** is the dominant driver of emission reductions, particularly due to strong demand-side measures. In private transport alone, policies achieve reductions of 2 159 698 MWh in energy demand (−50,7 %) and 512 769 tCO_2 (−52,8 %), making it the most impactful sector in terms of both energy and emissions. This highlights the critical importance of reducing travel demand and improving transport efficiency in large urban areas.

The residential building sector also contributes significantly to overall reductions. A large-scale renovation strategy results in 884 802 MWh energy savings (30,6 %) and 70 687 tCO_2 emission reductions (28 %), demonstrating that deep renovation of multi-family buildings is a key lever for decarbonisation in densely populated cities.

In **the public infrastructure sector**, more moderate but consistent reductions are achieved, with 12 005 MWh energy savings (11,8 %) and 876 tCO_2 emission reductions, mainly driven by improvements in public lighting systems.

The municipal vehicle fleet contributes relatively small but measurable reductions, achieving 14,1 % energy savings and 17,6 % emission reductions through electrification.

However, the results also reveal several important limitations. No policy measures were implemented in **municipal buildings**, **public transport**, **other sectors**, **waste management**, or **local energy production**, meaning that a large share of the municipality's energy demand and emissions remains unaffected by the policy package. This significantly limits the overall decarbonisation potential.

Despite achieving significant reductions, the results indicate that emissions do not consistently remain below the long-term climate target, as increasing energy demand driven by population growth eventually offsets part of the achieved gains. This suggests that additional measures—particularly in currently unaddressed sectors and energy supply systems—would be required to ensure long-term alignment with climate neutrality goals.

Overall, the analysis demonstrates that large-scale demand reduction in transport and deep renovation of residential buildings are the most effective strategies for reducing emissions in urban environments, while a broader and more integrated policy approach would be necessary to fully decarbonise the energy system of Rīga municipality.

Table 1. Summary Table of Key Quantitative Results (2050)

Sector	Indicator	Results
Municipal buildings	Energy savings	–
	Emission reduction	–
	Renewable generation	–
Residential buildings	Energy savings	884 802 MWh (30,6 %)
	Emission reduction	70 687 tCO_2 (28 %)
	Renewable generation	–
Public infrastructure	Energy savings	12 005 MWh (11,8 %)
	Emission reduction	876 tCO_2 (11,8 %)
	Renewable generation	–
Other sectors	Energy savings	–
	Emission reduction	–
Municipal fleet	Energy savings	3540 MWh (14,1 %)
	Emission reduction	1073 tCO_2 (17,6 %)
Public transport	Energy savings	–
	Emission reduction	–
Private transport	Energy savings	2 159 698 MWh (50,7 %)
	Emission reduction	512 769 tCO_2 (52,8 %)
Waste management	Waste generation reduction	–
	Emission reduction	–
Local energy production	Energy savings	–
	Emission reduction	–
	Renewable generation	–
Peak emissions from imported electricity	tCO_2	–