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

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This document presents an assessment of future energy demand and CO_2 emissions in Cēsis municipality, Latvia, 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 Cēsis'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 Cēsis 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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1. PLANNING CONTEXT

Cēsis Municipality has an existing municipal climate and energy planning document: *Cēsu novada Integrētais Ilgtspējīgas Enerģētikas un Klimata Rīcības plāns līdz 2030. gadam* / Integrated Sustainable Energy and Climate Action Plan of Cēsis Municipality until 2030 (IEKRP2030).

The first Sustainable Energy Action Plan for Cēsis was developed and approved in 2016. In 2022, the plan was reviewed, updated and expanded to include short-, medium- and long-term objectives. Following the administrative territorial reform, the current IEKRP2030 covers the entire Cēsis Municipality, including the former Amata, Jaunpiebalga, Vecpiebalga, Pārgauja, Līgatne and Priekuļi municipalities.

The IEKRP2030 covers five main planning areas: municipal infrastructure, housing, transport and mobility, energy production, and climate change adaptation. It also defines the need for regular monitoring and review of the plan, including assessment of implementation progress, achieved results and the need for additional measures.

The CommitClimate simulation report does not replace or formally amend the Cēsis IEKRP2030. Instead, it provides an additional scenario-based analytical layer that can support the implementation, monitoring and future review of the existing municipal climate and energy planning framework.

2. SCOPE OF THE COMMITCLIMATE SIMULATION REPORT

The CommitClimate simulation report for Cēsis Municipality assesses future energy demand and CO_2 emissions up to 2050 using a scenario-based modelling approach. The report covers the main emission- and energy-related sectors, including municipal buildings, residential buildings, public infrastructure, transport, waste management and local energy production.

The modelling compares a baseline development pathway with selected policy measures and shows how different interventions may influence long-term energy demand, fuel structure and CO_2 emissions. The analysed policy package focuses primarily on energy efficiency improvements, demand reduction, behavioural and operational measures, renewable energy use and selected transport-related measures.

The simulations were carried out for exploratory and analytical purposes. They should be understood as a basis for discussion and reflection among municipal stakeholders and as a tool that may support future decision-making, rather than as official municipal projections.

3. MODELLING RESULTS

3.1. 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.

Current situation

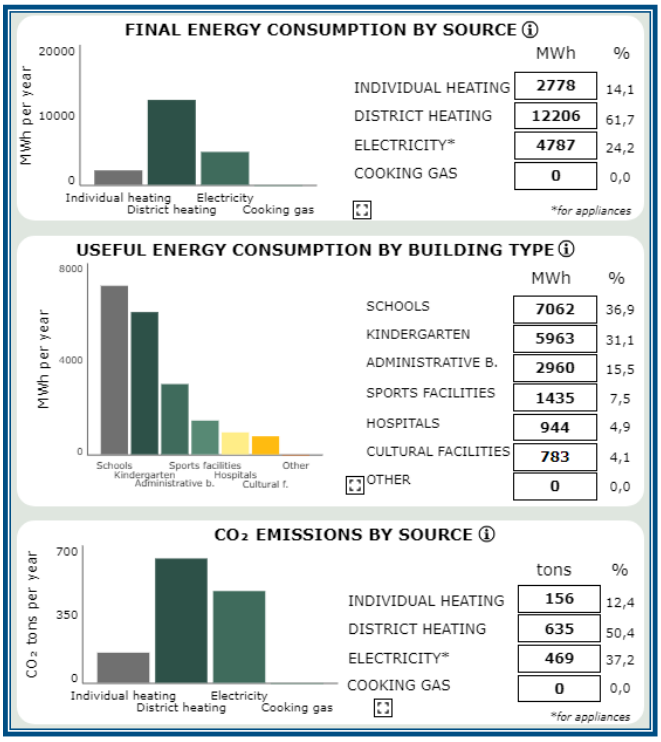
In the baseline year 2021, the total floor area of municipal buildings in Cēsis Municipality was 184,101 m². The largest building categories were schools (67,900 m²) and kindergartens (57,332 m²), followed by administrative buildings, sports facilities, hospitals and cultural facilities.

The total final energy demand of municipal buildings amounted to 19,771 MWh/year. District heating was the dominant energy source, accounting for 12,206 MWh/year (61.7% of total energy demand), followed by electricity consumption for appliances and equipment at 4,787 MWh/year (24.2%) and individual heating systems at 2,778 MWh/year (14.1%).

The weighted average specific heat consumption of the municipal building stock was 78 kWh/m²/year, while the average specific electricity consumption reached 26 kWh/m²/year.

Total CO_2 emissions associated with municipal building energy use amounted to 1,260 tCO_2/year. District heating represented the largest emission source (635 tCO_2/year or 50.4%), followed by electricity consumption (469 tCO_2/year or 37.2%) and individual heating (156 tCO_2/year or 12.4%).

Municipal buildings accounted for approximately 10% of the emissions associated with electricity and district heating consumption within the modelled municipal energy system.



Policies

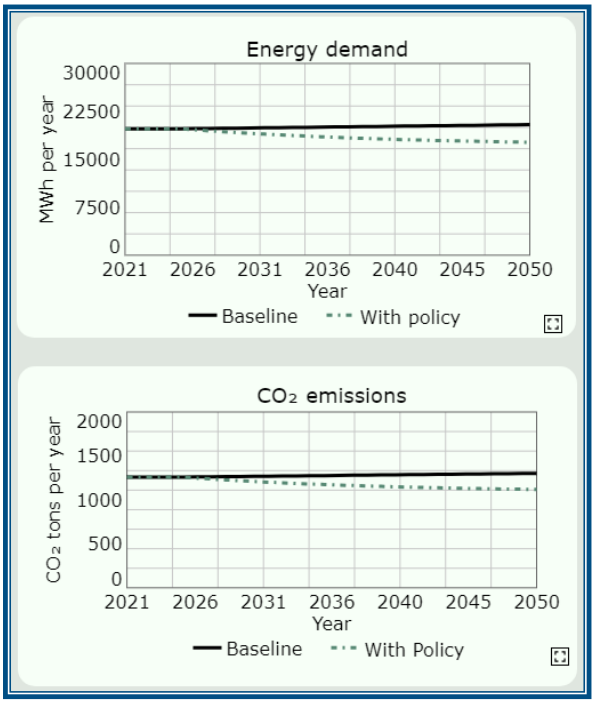
In the municipality buildings sector, several policy measures were proposed:

- **Replacement of windows** (*Implementation speed (IS)* 10 %/year, *Expected savings (ES)* 15 %)
- **Wall insulation** (*IS* 10 %/year, *ES* 40 %)
- **Replacement of light bulbs** (*IS* 10 %/year, *ES* 80 %)
- **Increased use of natural light** (*IS* 10 %/year, *ES* 5 %)
- **Ventilation optimization** (*IS* 10 %/year, *ES* 10 %)
- **Optimal use of appliances** (*IS* 10 %/year, *ES* 10 %)
- **RES-E generation** (*Solar photovoltaics installed capacity* 10 kW, *Heat pump air installed capacity* 10 kW, *Heat pump ground installed capacity* 10 kW)

All measures are assumed to be implemented gradually between 2025 and 2050.

The selected measures reduce final energy demand in municipal buildings by 3,210 MWh/year by 2050 compared with the baseline scenario, corresponding to a 15.7% reduction. Annual CO_2 emissions decrease by 208 tCO_2/year, equivalent to a 16.0% reduction.

The largest contribution to these reductions comes from improvements to the building envelope and operational energy efficiency, including window replacement, wall insulation, ventilation optimisation, improved use of natural light and optimisation of appliance use. In addition, the deployment of renewable energy technologies contributes 288.5 MWh/year of locally generated renewable energy. As a result, annual energy demand in municipal buildings decreases to 17,219 MWh/year by 2050, while annual CO_2 emissions decrease to 1,094 tCO_2/year.



3.2. 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.

Current situation

In Cēsis Municipality, the total residential building area included in the calculations is 976,572 m², comprising single-family detached houses, single-family attached houses and large multi-family buildings. The largest share of the building stock is represented by single-family detached houses (510,670 m²), followed by large multi-family buildings (417,302 m²) and single-family attached houses (48,600 m²).

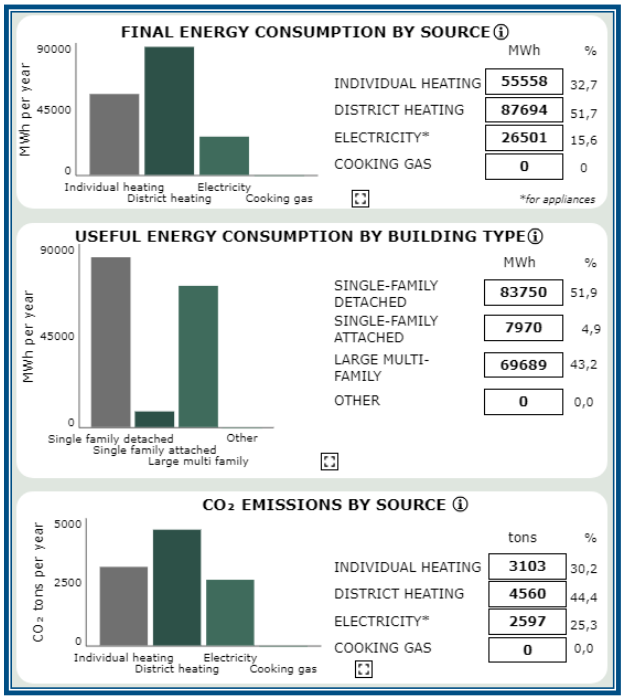
In 2021, the total final energy consumption in residential buildings amounted to 182,709 MWh/year, making residential buildings the largest energy-consuming sector within the modelled framework and accounting for approximately 47.6% of total municipal energy demand.

District heating represented the largest share of final energy consumption, accounting for 87,694 MWh/year (48.0%), followed by individual heating systems with 55,558 MWh/year (30.4%), electricity consumption for appliances and equipment with 26,501 MWh/year (14.5%), and cooking gas with 12,956 MWh/year (7.0%). It should be noted that electricity consumption refers only to appliances and equipment, while electricity used for heating is included under the respective heating technologies

As no changes in residential building floor area are assumed in the baseline scenario, energy consumption and emissions remain constant between 2021 and 2050.

The average specific heat consumption of the residential building stock is 138 kWh/m²/year, while the average specific electricity consumption is 27 kWh/m²/year.

Total CO_2 emissions from residential buildings amounted to 12,851 tCO_2/year in the baseline year. District heating was the largest source of emissions, generating 4,560 tCO_2/year (35.5%), followed by individual heating systems with 3,103 tCO_2/year (24.1%), electricity consumption with 2,597 tCO_2/year (20.2%) and cooking gas with 2,591 tCO_2/year (20.2%). Residential buildings account for approximately 17.2% of total municipal CO_2 emissions in the baseline year.



Policies

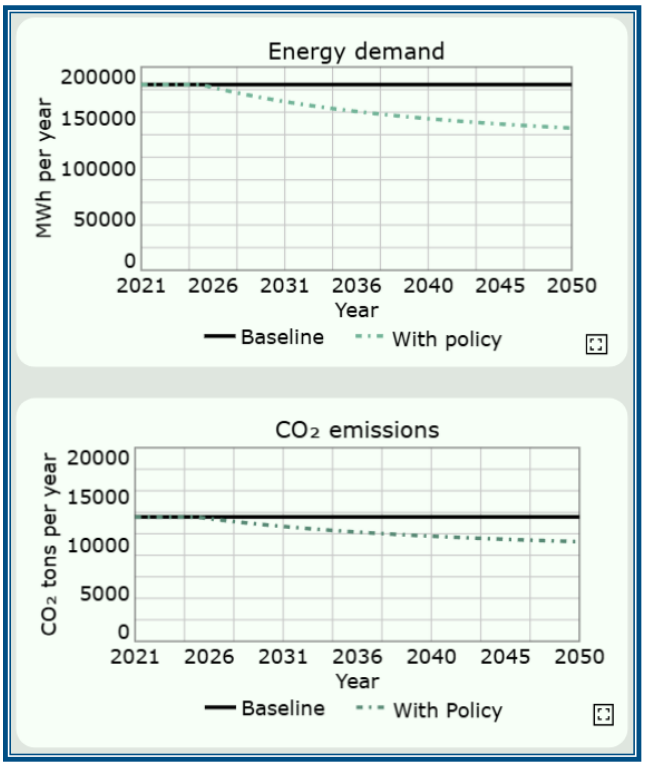
To reduce energy consumption and emissions, a comprehensive renovation and electrification strategy was tested, starting in 2025:

- **Renovation of single-family houses** (*IS* 5 %/year, *ES* 40 %)
- **Renovation of multi-family houses** (*IS* 10 %/year, *ES* 40 %)
- **Renovation of other houses** (*IS* 10 %/year, *ES* 40 %)
- **Electricity saving measures** (*IS* 5 %/year, *ES* 30 %/year)
- **Renewable and low carbon technologies** (*Solar photovoltaics installed capacity* 20 kW, *Heat pump air installed capacity* 20 kW, *Heat pump ground installed capacity* 20 kW)

For all policies, the implementation start year was 2025, while the implementation end year was 2050.

The implementation of the selected policy measures significantly improves the energy performance of the residential building sector. By 2050, annual energy demand decreases from 182,709 MWh/year to 139,850 MWh/year, representing a reduction of 42,860 MWh/year (23.5%). At the same time, annual CO_2 emissions decline from 12,851 tCO_2/year to 10,294 tCO_2/year, corresponding to a reduction of 2,557 tCO_2/year (19.9%).

The largest contribution to these reductions comes from the renovation of residential buildings, which lowers heat demand and overall energy consumption. Additional savings are achieved through electricity-saving measures, while the deployment of renewable and low-carbon technologies contributes 577 MWh/year of renewable energy generation. Overall, the policy package substantially improves the energy efficiency of the residential sector and supports the municipality's long-term climate neutrality objectives.



3.3. 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.

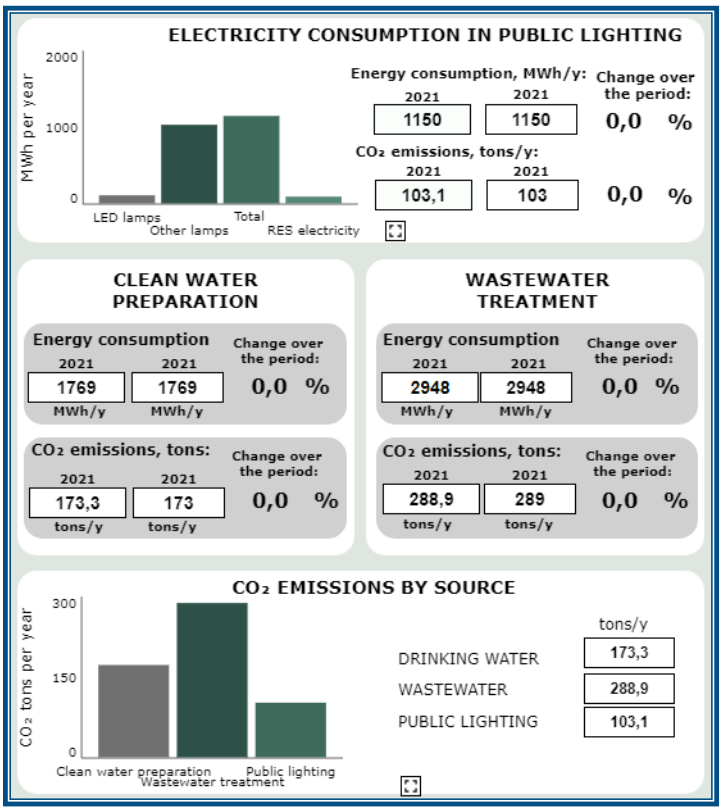
Current situation

In Cēsis Municipality, the total electricity consumption in the public infrastructure sector in the baseline year is 5,866 MWh/year, representing approximately 1.6% of the municipality's total energy consumption.

The sector comprises public lighting, drinking water preparation and wastewater treatment. Wastewater treatment is the largest energy consumer, accounting for 2,948 MWh/year (50.2%), followed by drinking water preparation with 1,769 MWh/year (30.1%) and public lighting with 1,150 MWh/year (19.6%).

As population growth is assumed in the baseline scenario, energy consumption in drinking water preparation and wastewater treatment gradually increases over time. Consequently, total sectoral energy demand increases from 5,866 MWh/year in 2021 to 6,600 MWh/year in 2050, while annual CO_2 emissions increase from 565 tCO_2/year to 637 tCO_2/year.

In the baseline year, wastewater treatment is the largest source of emissions (288.9 tCO_2/year), followed by drinking water preparation (173.3 tCO_2/year) and public lighting (103.1 tCO_2/year).



Policies

The following policy measures were implemented in the public infrastructure sector:

- **Replacement of inefficient light bulbs in public lighting** (*IS* 5 %/year)
- **RES usage in public lighting** (*IS* 5 %/year)
- **Wastewater treatment energy efficiency improvement** (*IS* 0.5 %/year)
- **Wastewater generation decrease** (*IS* 5 %/year)

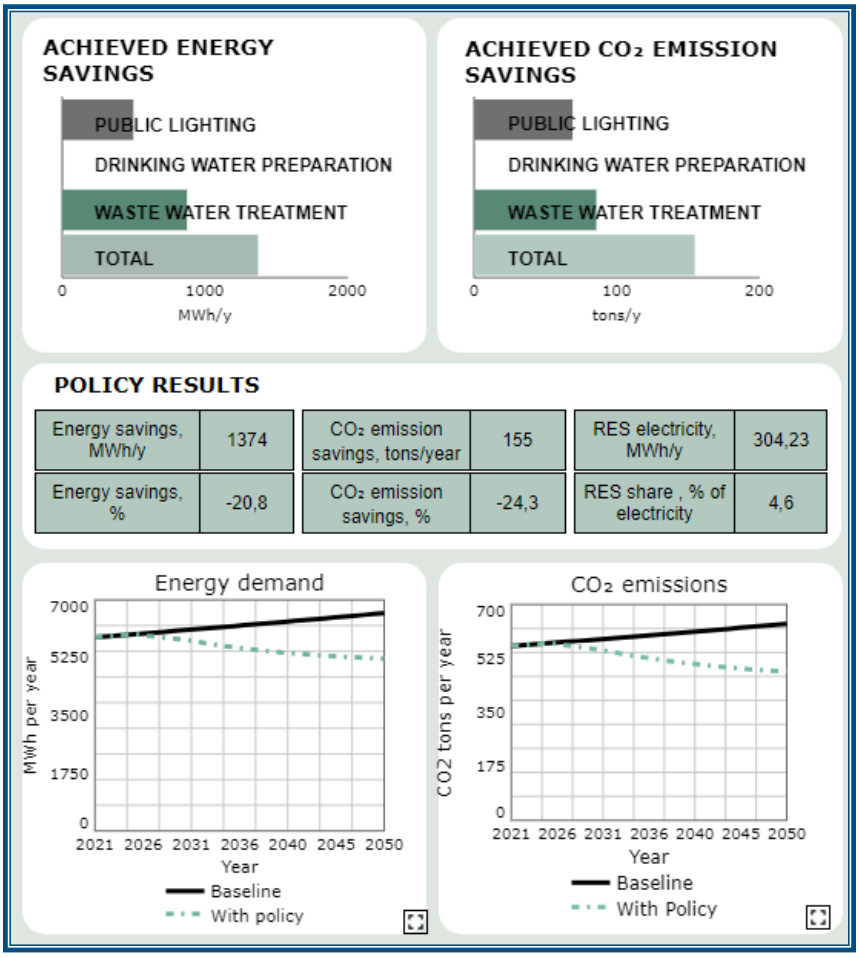
For all policies, the implementation start year was 2025, while the implementation end year was 2050.

The combined policy package reduces annual energy demand in the sector from 6,600 MWh/year in the baseline scenario to 5,227 MWh/year by 2050, corresponding to energy savings of 1,374 MWh/year or 20.8%.

Similarly, annual CO_2 emissions decrease from 637 tCO_2/year in the baseline scenario to 482 tCO_2/year in the policy scenario, resulting in emission savings of 155 tCO_2/year or 24.3%.

The largest energy savings are achieved through wastewater treatment energy efficiency improvements and wastewater generation reduction measures, while replacement of inefficient public lighting contributes additional electricity savings. The RES usage policy in public lighting primarily affects the electricity supply mix rather than total energy consumption, introducing 304.2 MWh/year of renewable electricity and increasing the renewable electricity share to 4.6%.

Although energy demand and emissions initially remain close to the baseline trajectory, the cumulative effect of the implemented measures becomes increasingly visible over time, resulting in a substantial reduction in both energy consumption and CO_2 emissions by 2050.



3.4. 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.

Current situation

In Cēsis municipality, Other sectors energy consumption and GHG emissions are not included in the baseline inventory and projection.

Policies

In Cēsis municipality, Other sectors energy consumption and GHG emissions were not included in the baseline inventory and projection; thus, no policy analysis was conducted.

3.5. 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.

Current situation

Municipal vehicle fleet

The municipal vehicle fleet in Cēsis Municipality consists of 156 vehicles, including 28 passenger cars, 61 light-duty vehicles (LDVs), 41 heavy-duty vehicles (HDVs), and 26 vehicles classified as other.

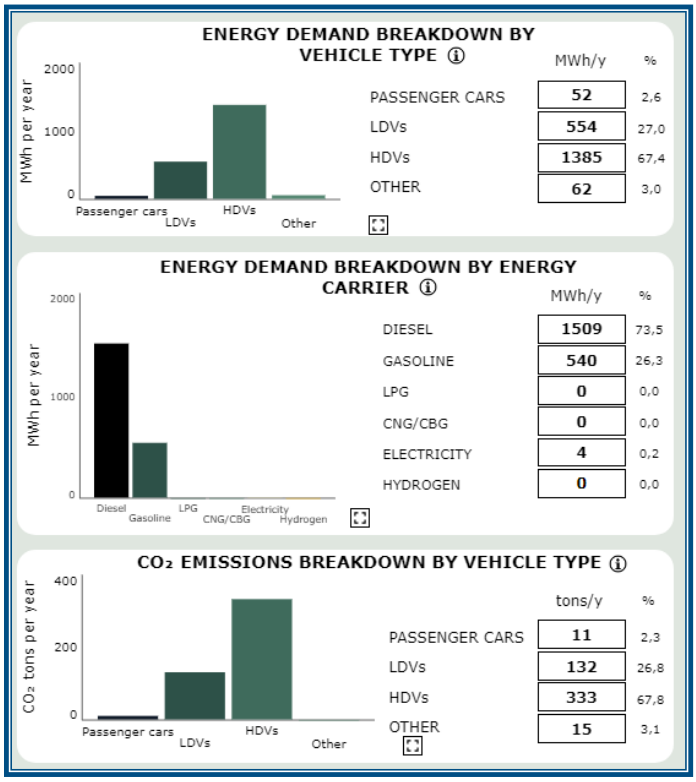
Based on the assumed annual mileage, vehicle composition, fuel-consumption characteristics and emission factors, the total energy demand of the municipal vehicle fleet is estimated at 2,818 MWh/year. This corresponds to approximately 0.7% of the municipality's total modelled energy consumption.

Diesel is the dominant energy carrier, accounting for 1,509 MWh/year (53.5% of total energy demand), followed by LPG with 765 MWh/year (27.1%) and gasoline with 540 MWh/year (19.2%). Electricity consumption amounts to 4 MWh/year (0.1%), while no consumption of CNG/CBG or hydrogen is assumed in the baseline scenario.

Heavy-duty vehicles are the largest energy consumers within the municipal fleet, accounting for 1,888 MWh/year (67.0% of total energy demand). Light-duty vehicles consume 626 MWh/year (22.2%), while passenger cars and other vehicles account for 222 MWh/year (7.9%) and 82 MWh/year (2.9%), respectively.

Total CO_2 emissions associated with the municipal vehicle fleet amount to 665 tCO_2/year, representing approximately 0.8% of total modelled municipal CO_2 emissions. Heavy-duty vehicles are responsible for the majority of emissions, generating 447 tCO_2/year (67.2%), followed by light-duty vehicles with 148 tCO_2/year (22.3%). Passenger cars and other vehicles contribute 50 tCO_2/year (7.5%) and 20 tCO_2/year (3.0%), respectively.

The baseline scenario assumes no changes in the size, composition, annual mileage or fuel mix of the municipal vehicle fleet. Therefore, energy consumption and CO_2 emissions remain constant throughout the simulation period, at 2,818 MWh/year and 665 tCO_2/year, respectively.



Public transport

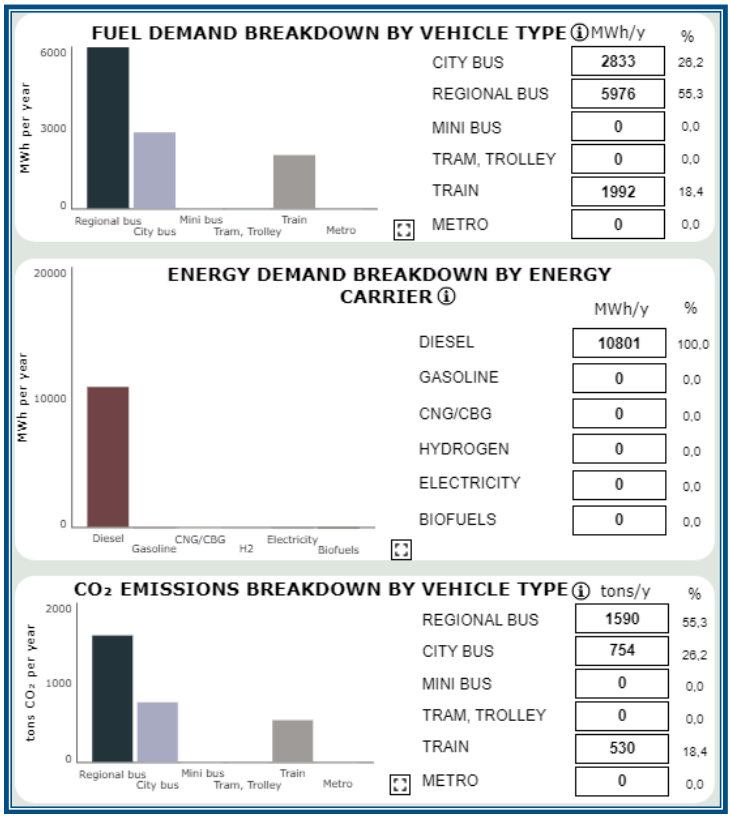
According to the model assumptions, public transport demand amounts to 78.4 million passenger kilometres per year in the baseline year and is projected to increase to 90.6 million passenger kilometres by 2050. The increase is driven by population growth and higher mobility demand. In 2050, regional public transport accounts for 54.4 million passenger kilometres, while city public transport accounts for 36.2 million passenger kilometres.

Based on assumptions regarding public transport demand, vehicle occupancy rates, fuel consumption and fuel type, the energy consumption of public transport in 2021 is estimated at 10,801 MWh/year, corresponding to approximately 2.8% of the municipality's total energy consumption.

Regional buses represent the largest share of energy demand, accounting for 5,976 MWh/year (55.3%), followed by city buses with 2,833 MWh/year (26.2%) and trains with 1,992 MWh/year (18.4%). Diesel fuel is the only energy carrier used in the baseline scenario, accounting for 100% of total public transport energy consumption.

Total CO_2 emissions associated with public transport amount to 2,873 tCO_2/year in the baseline year, representing approximately 3.8% of total municipal CO_2 emissions. Regional buses are the largest contributor to emissions, generating 1,590 tCO_2/year (55.3%), followed by city buses with 754 tCO_2/year (26.2%) and trains with 530 tCO_2/year (18.4%).

The baseline scenario assumes no changes in vehicle technologies, fuel mix or public transport operating characteristics. Consequently, energy consumption and emissions increase only as a result of growing transport demand. By 2050, energy demand increases to 12,482 MWh/year and associated CO_2 emissions rise to 3,320 tCO_2/year, representing an increase of 15.6% compared to the baseline year.



Private transport

According to the model assumptions, private transport demand in Cēsis Municipality amounts to approximately 574.9 million passenger kilometres per year in the baseline year and is projected to increase to 664.3 million passenger kilometres by 2050.

Based on assumptions regarding passenger travel demand, vehicle fleet composition, fuel consumption and fuel types, the energy consumption of the private transport sector is estimated at 162,280 MWh/year in 2021. This corresponds to approximately 42.4% of the municipality's total energy consumption, making private transport the largest individual energy-consuming transport category.

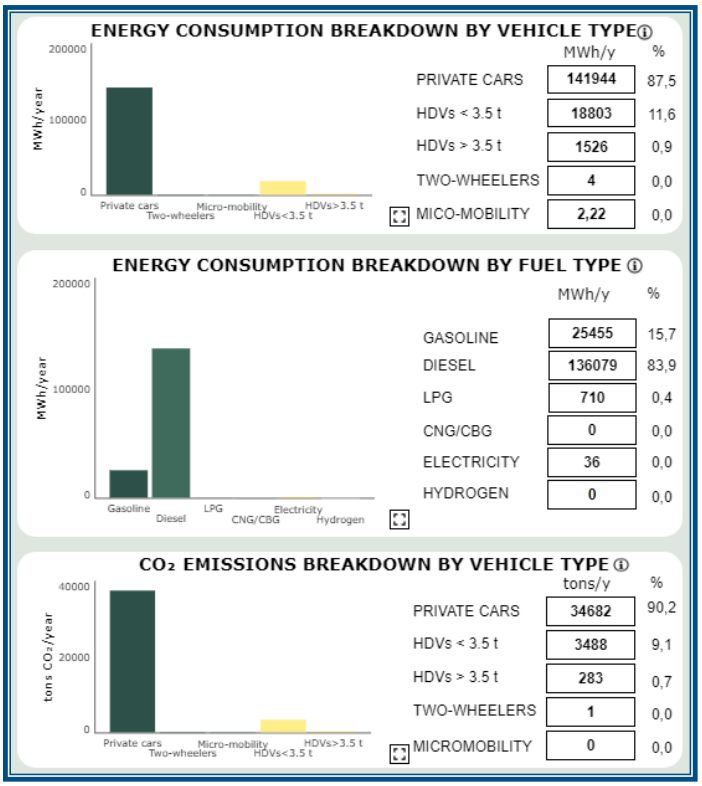
Private cars account for the largest share of energy consumption, amounting to 141,944 MWh/year (87.5%), followed by light-duty vehicles below 3.5 tonnes with 18,803 MWh/year (11.6%) and heavy-duty vehicles above 3.5 tonnes with 1,526 MWh/year (0.9%). Energy consumption associated with two-wheelers and micro-mobility is negligible.

Diesel fuel dominates the sector's energy demand, accounting for 136,079 MWh/year (83.9%), followed by gasoline with 25,455 MWh/year (15.7%). LPG contributes 710 MWh/year (0.4%), while electricity consumption remains very limited at 36 MWh/year.

Total CO_2 emissions associated with private transport amount to 38,454 tCO_2/year in the baseline year, representing approximately 51% of total municipal CO_2 emissions. Private cars are responsible for the vast majority of emissions, generating 34,682 tCO_2/year (90.2%), followed by light-duty vehicles below 3.5 tonnes with 3,488 tCO_2/year (9.1%) and heavy-duty vehicles above 3.5 tonnes with 283 tCO_2/year (0.7%).

The baseline scenario assumes no policy interventions and no major changes in vehicle technologies or travel behaviour. Consequently, future changes in energy demand and emissions are driven primarily by population growth and increasing mobility demand.

By 2050, private transport energy demand is projected to increase to 184,370 MWh/year, while annual CO_2 emissions rise to 43,851 tCO_2/year. This corresponds to increases of 13.6% and 14.0%, respectively, compared to the baseline year.



Policies

Municipal vehicle fleet

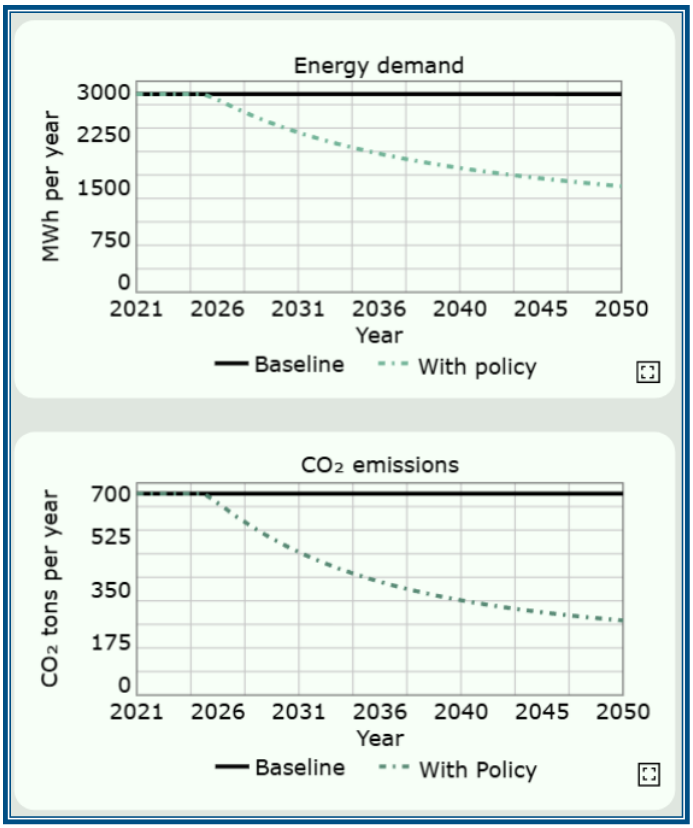
In this sector, several policy measures were proposed:

- **Other vehicle fleet decarbonization** (*Target technology choice Electric vehicles* - 100 %)
- **Fleet modernization and driver awareness training** (*IS* 0,5 %/year)
- **Fleet management improvement** (*IS* 0,5 %/year)

The fleet decarbonisation policy is assumed to start in 2030, while fleet modernisation, driver training and awareness-raising, and fleet-management measures begin in 2025. All measures continue until 2050.

By 2050, the selected policy package reduces annual energy demand in the municipal vehicle fleet by 1,312 MWh/year compared with the baseline scenario, corresponding to a reduction of 46.6%. Annual CO_2 emissions decrease by 419 tCO_2/year, equivalent to a reduction of 63.0%.

The largest contribution comes from the gradual decarbonisation of non-passenger municipal vehicles. Additional savings are achieved through fleet modernisation, driver training and awareness raising, and improved fleet-management practices. Passenger-car fleet decarbonisation and additional renewable-energy use were not included in this scenario.



Public transport

In this sector, the following policy was tested:

- **Operational efficiency and route optimization** (*IS* 2 %/year)

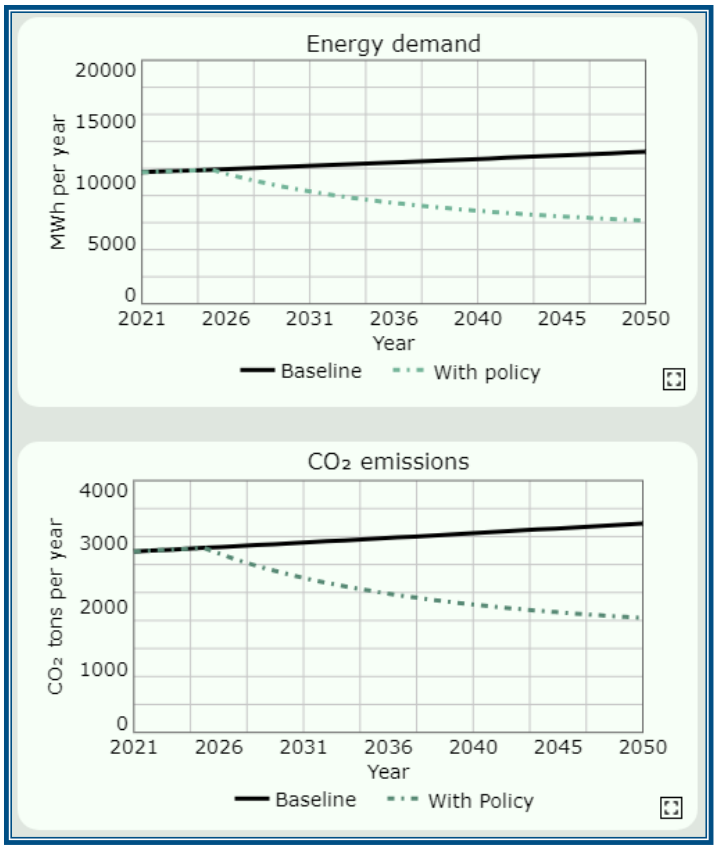
The policy implementation starts in 2025 and continues until 2050.

The selected measure achieves annual energy savings of 5,644 MWh/year by 2050 compared to the baseline scenario. This corresponds to a reduction of 45.2% in final energy demand.

The policy also reduces annual CO_2 emissions by 1,501 tCO_2/year, corresponding to a 45.2% reduction compared to the baseline scenario.

The achieved reductions result from improvements in operational performance, including more efficient route planning, better vehicle utilization and lower fuel consumption per passenger-kilometre. As public transport demand continues to increase over time, the policy helps decouple mobility growth from energy consumption and emissions.

By 2050, energy demand is reduced from 12,482 MWh/year in the baseline scenario to approximately 6,838 MWh/year in the policy scenario. Similarly, annual CO_2 emissions decrease from 3,320 tCO_2/year to approximately 1,819 tCO_2/year.



Private transport

In this sector, two key policies were implemented:

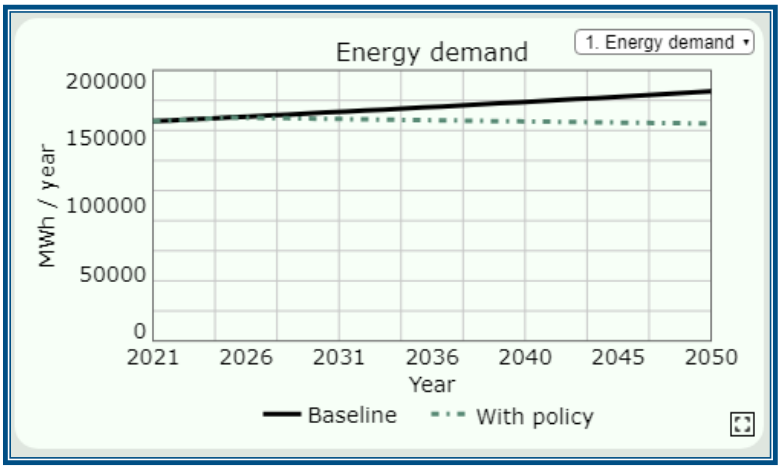
- **Car sharing** (*IS* 0,5 %/year)
- **Freight transport demand reduction** (*Daily distance reduction IS* 0,5 %/year, *Travel frequency reduction IS* 0,5 %/year)

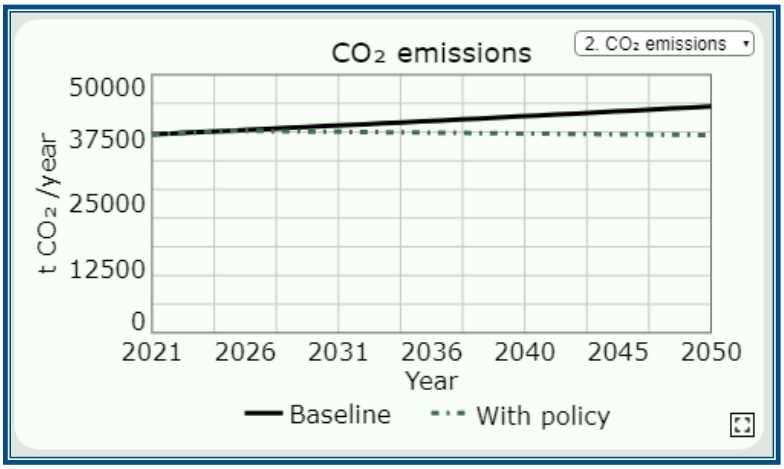
The car-sharing and freight-transport-demand-reduction measures are assumed to start in 2025 and continue until 2050.

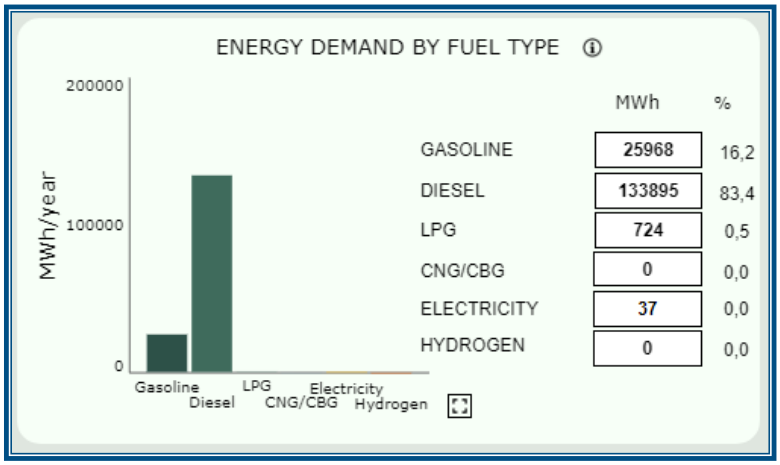
By 2050, the selected policy package reduces annual energy demand in private transport by 23,746 MWh/year compared with the baseline scenario, corresponding to a reduction of 12.9%. Annual CO_2 emissions decrease by 5,536 tCO_2/year, equivalent to a reduction of 12.6%.

These reductions result from lower private-car use through car sharing and from reductions in the daily travel distance and travel frequency of freight transport. The measures moderate the growth in transport activity but do not fundamentally change the vehicle fleet composition or fuel mix.

By 2050, annual private-transport energy demand decreases from 184,370 MWh/year in the baseline scenario to approximately 160,624 MWh/year in the policy scenario. Annual CO_2 emissions decrease from 43,851 tCO_2/year to approximately 38,315 tCO_2/year.







3.6. 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.

Current situation

The calculations of the baseline scenario are based on assumptions regarding population, waste generation per capita (400 kg/capita/year) and the composition of municipal waste. Based on these assumptions, the amount of municipal waste generated in Cēsis Municipality in the baseline year is 17,947 tons, resulting in greenhouse gas emissions of 18,116 tCO_2eq.

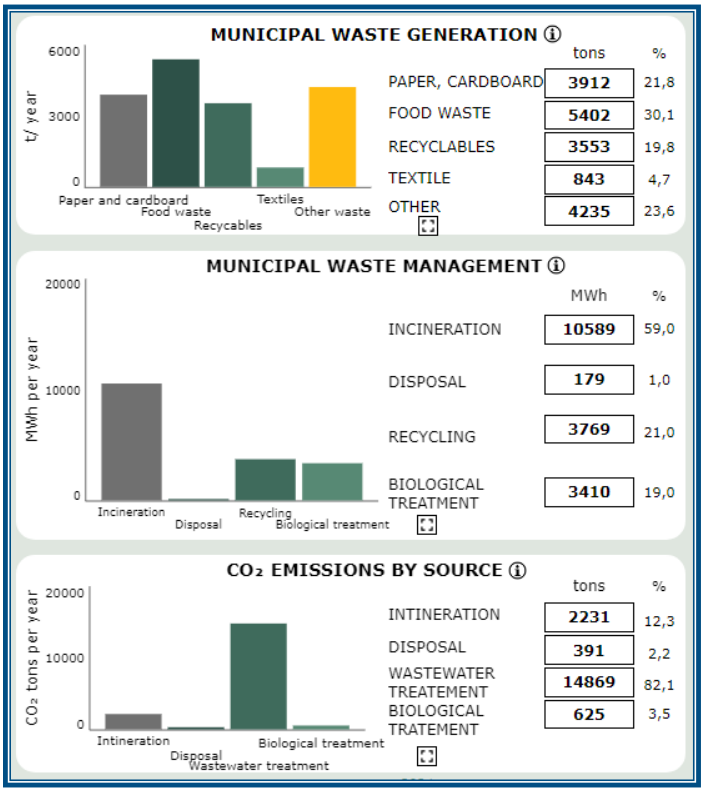
The waste management sector is one of the major emission sources within the municipality and accounts for approximately 25.2% of total municipal CO_2-equivalent emissions.

Food waste represents the largest waste fraction (5,402 tons/year or 30.1%), followed by other waste (4,235 tons/year or 23.6%), paper and cardboard (3,912 tons/year or 21.8%), recyclables (3,553 tons/year or 19.8%) and textiles (843 tons/year or 4.7%).

Most waste is treated through incineration (10,589 MWh equivalent or 59.0%), while recycling accounts for 3,769 MWh (21.0%), biological treatment for 3,410 MWh (19.0%) and disposal for 179 MWh (1.0%).

Wastewater treatment is the dominant source of greenhouse gas emissions within the waste sector, generating 14,869 tCO_2eq/year (82.1% of sector emissions), followed by incineration with 2,231 tCO_2eq/year (12.3%), biological treatment with 625 tCO_2eq/year (3.5%) and disposal with 391 tCO_2eq/year (2.2%).

The baseline scenario assumes an annual population growth of 0.5% and a gradual reduction in waste generation per capita of 0.3% per year. Consequently, municipal waste generation is projected to increase to approximately 19,009 tons by 2050, while greenhouse gas emissions increase to approximately 20,438 tCO_2eq, representing an increase of around 12.8% compared to the baseline year.



Policies

In this sector, the following policy was tested:

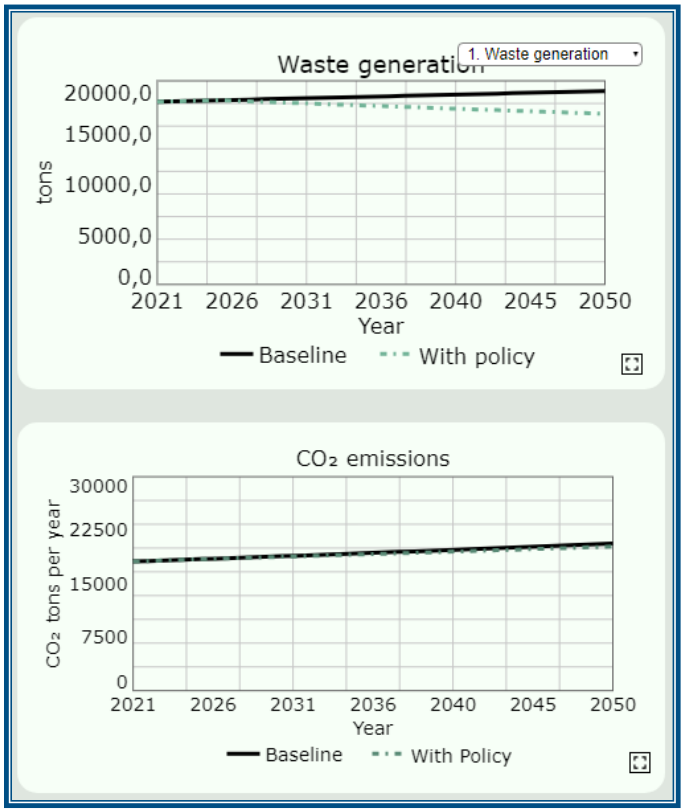
- **Reducing amount of waste generated** (*IS* 0,5 %/year)

The policy implementation starts in 2025 and continues until 2050.

The selected measure reduces the amount of municipal waste generated from 19,009 tons/year in the baseline scenario to 16,764 tons/year by 2050. This corresponds to a reduction of approximately 11.8%, equivalent to 2,245 tons of waste annually.

As a result, greenhouse gas emissions from the waste management sector decrease from 20,438 tCO_2eq/year in the baseline scenario to 20,216 tCO_2eq/year in the policy scenario by 2050. This corresponds to an emission reduction of approximately 2.0%.

The policy primarily affects the quantity of waste generated rather than the treatment technologies employed. Consequently, the reduction in greenhouse gas emissions is smaller than the reduction in waste generation, as the overall emissions profile remains largely influenced by wastewater treatment and other waste-treatment processes. Nevertheless, reducing waste generation lowers the amount of material requiring collection, treatment and disposal, contributing to resource efficiency, waste prevention and circular economy objectives within the municipality.


Waste generation
1. Waste generation
20000,0
15000,0
10000,0
5000,0
0,0
tons
2021
2026
2031
2036
2040
2045
2050
Year
Baseline
With policy
CO₂ emissions
30000
22500
15000
7500
0
CO₂ tons per year
2021
2026
2031
2036
2040
2045
2050
Year
Baseline
With Policy

3.7. 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.

Current situation

Electricity and district-heating demand and their associated emissions are included in the Cēsis simulation. However, no data on local electricity generation, local heat generation, combined heat and power production, energy imports and exports, or certified green-electricity purchases were entered into the model. Consequently, all local-energy-production technologies were set to zero.

As a result, the local electricity production and local heat production charts remain empty throughout the simulation period. This does not imply that electricity or district heat are not consumed within Cēsis Municipality. Rather, electricity demand is assumed to be supplied by the grid, while district-heating demand is represented as an aggregated heat-supply category without explicitly modelling the underlying generation technologies or fuel mix.

In the baseline year, total electricity demand amounts to 68,659 MWh/year, while district-heating demand reaches 99,900 MWh/year. When distribution losses are included, total electricity demand increases to 71,405 MWh/year and district-heating demand to 114,885 MWh/year. Associated emissions amount to 6,988 tCO_2/year from electricity consumption and 5,974 tCO_2/year from district heating, resulting in total emissions of 12,962 tCO_2/year.

The implementation of energy-efficiency and demand-reduction measures in municipal buildings, residential buildings, public infrastructure and transport reduces both electricity and district-heating demand over time. By 2050, total electricity demand decreases to 63,344 MWh/year and district-heating demand to 72,506 MWh/year. Including distribution losses, total electricity and district-heating demand amount to 65,878 MWh/year and 83,382 MWh/year, respectively.

Consequently, total emissions from electricity and district-heating consumption decrease from 12,962 tCO_2/year in the baseline year to 10,736 tCO_2/year in 2050, corresponding to a reduction of 17.2%. Similarly, combined electricity and district-heating demand decreases from 186,290 MWh/year to 149,260 MWh/year, representing a reduction of 19.9%.

The reductions observed in this sector are not the result of local energy production measures, as no local electricity or heat generation technologies were included in the model. Instead, they result from lower electricity and district-heating demand achieved through energy-efficiency improvements and demand-reduction measures implemented primarily in the residential and municipal building sectors, complemented by measures in public infrastructure and transport.

Policies

No policies targeting local electricity generation, district-heating production, fuel substitution, energy imports or exports, or certified green electricity purchases were tested in the Cēsis simulation.

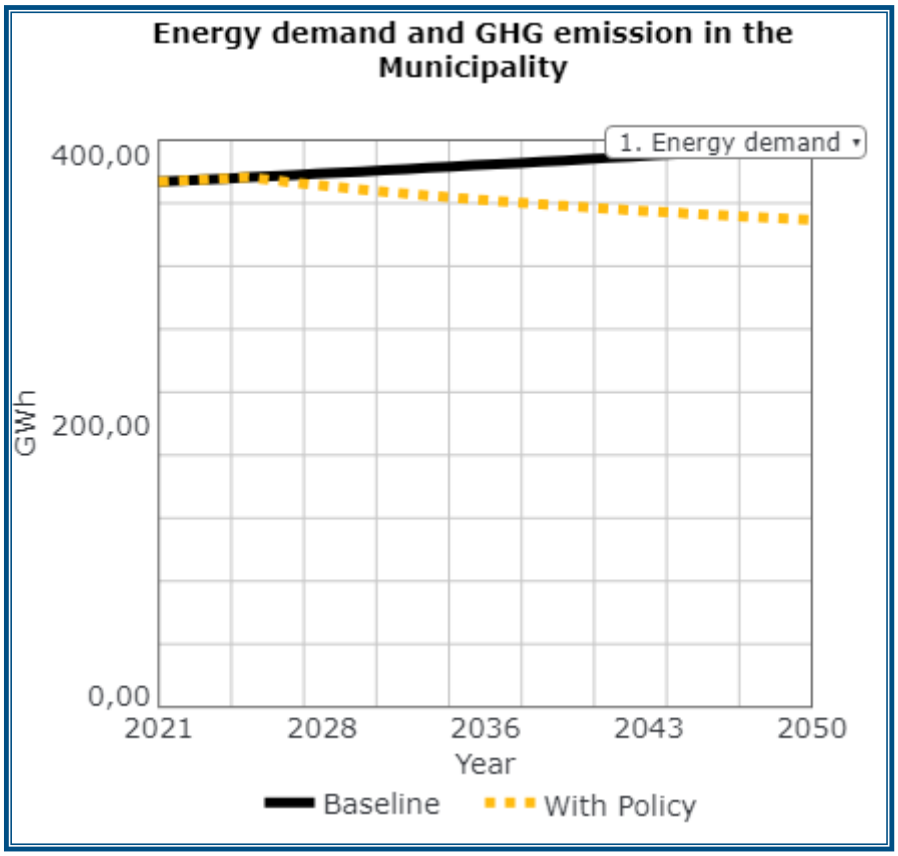
The current results therefore do not assess the potential effects of local renewable-energy development, district-heating decarbonisation, changes in the heat-generation fuel mix, combined heat and power production or other energy-supply measures. Including local generation and fuel-input data would be necessary for a more complete assessment of the municipality's energy-supply system and its decarbonisation potential.

4. RESULT OVERVIEW

The simulation results show that total municipal energy demand gradually increases in the baseline scenario as a result of population growth and increasing activity levels. By 2050, total energy demand reaches 409.4 GWh/year in the baseline scenario.

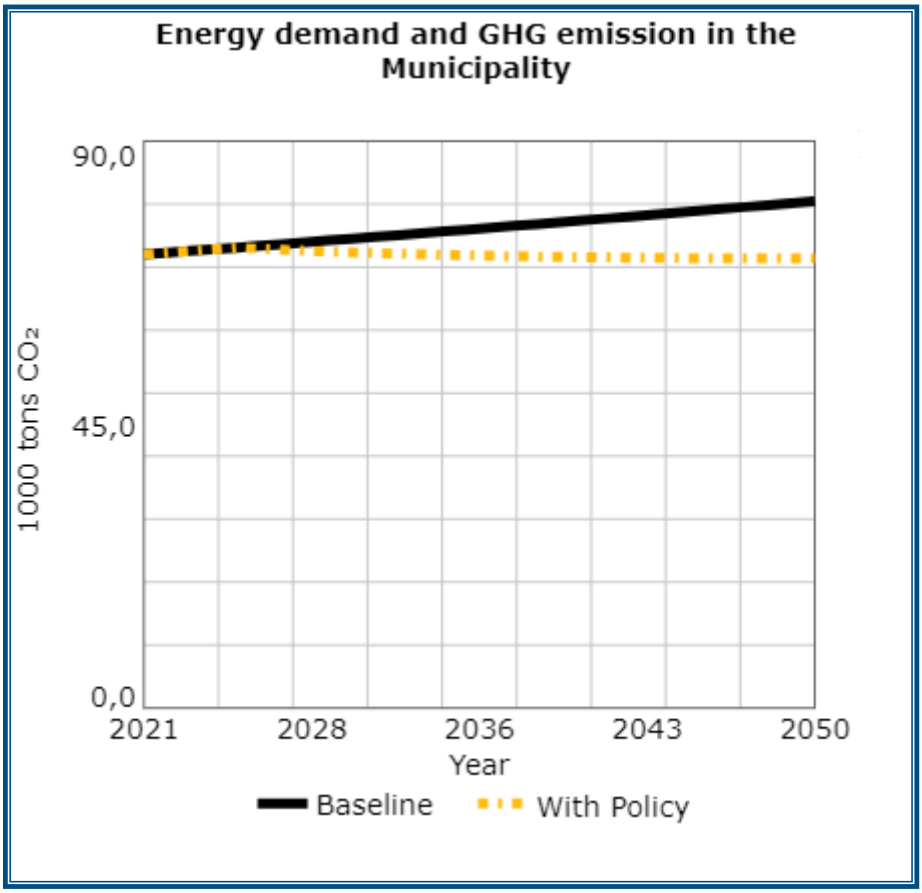
The implementation of the selected policy package reverses this trend and gradually reduces energy demand across the municipality. By 2050, total energy demand decreases to 332.6 GWh/year in the policy scenario. Compared to the baseline projection, this corresponds to annual energy savings of 76 771 MWh/year, or 18.8%.

The achieved reductions are primarily driven by energy-efficiency improvements in municipal and residential buildings, complemented by measures implemented in public infrastructure and transport sectors.



The selected policy package also leads to a reduction in greenhouse-gas emissions. By 2050, emissions decrease from approximately 83.2 thousand tonnes CO_2eq/year in the baseline scenario to 72.6 thousand tonnes CO_2eq/year in the policy scenario. This corresponds to annual emission savings of approximately 10.6 thousand tonnes CO_2eq/year, or 12.8% compared with the baseline projection.

Although the implemented measures significantly reduce both energy demand and emissions, the results indicate that additional mitigation measures would be required to achieve deeper long-term emission reductions. The remaining emissions are largely associated with private transport, waste management and energy consumption that are not fully addressed by the selected policy package.


Energy demand and GHG emission in the Municipality
90,0
45,0
0,0
1000 tons CO₂
2021
2028
2036
2043
2050
Year
Baseline
With Policy

5. LINK WITH CĒSIS MUNICIPAL CLIMATE AND ENERGY PLANNING

5.1. Link between IEKRP2030 sectors and CommitClimate modelling

The table below summarises how the main IEKRP2030 planning areas correspond to the sectors and measures analysed in the CommitClimate simulation report.

IEKRP2030 planning area	CommitClimate modelled sector / measures	Link and added value
Municipal infrastructure and municipal buildings	Municipal buildings: window replacement, wall insulation, replacement of light bulbs, increased use of natural light, ventilation optimisation, optimal use of appliances and RES-E generation.	Strong link. The modelling supports assessment of energy efficiency and renewable energy measures in municipal buildings. It quantifies potential energy and CO_2 savings and can support prioritisation of building-related measures.
Housing / residential buildings	Residential buildings: renovation of single-family houses, multi-family houses and other residential buildings; electricity-saving measures; renewable and low-carbon technologies.	Strong link. The modelling supports analysis of residential energy demand and the potential impact of renovation and energy efficiency measures. This is relevant for IEKRP2030 housing-sector actions, especially building renovation and household energy efficiency.
Public infrastructure	Public lighting, drinking water preparation and wastewater treatment: replacement of inefficient light bulbs, RES use in public lighting, wastewater treatment energy efficiency improvement and wastewater generation decrease.	Good link. The model can support evaluation of electricity-saving and renewable energy measures in public infrastructure and municipal service systems.
Transport and mobility	Municipal fleet, public transport and private transport: vehicle fleet decarbonisation, fleet modernisation, driver awareness, fleet management improvement, public transport route optimisation, car sharing and freight transport demand reduction.	Very strong link. Transport is one of the most important sectors for CO_2 reduction in Cēsis Municipality. The model helps assess how different transport and mobility measures may influence energy demand and emissions over time.
Energy production and renewable energy	Local energy production is included as a sector in the model structure. However, local energy production energy demand and GHG emissions were not included in the Cēsis baseline inventory and projection; therefore, no detailed policy analysis was conducted for this sector.	Partial link. The sector is relevant for IEKRP2030, especially in relation to renewable energy, district heating and local energy supply. However, the current CommitClimate Cēsis simulation does not fully assess energy production or district heating decarbonisation measures.
Waste management and circular economy-related emissions	Waste generation and waste-management-related GHG emissions; reduction of waste generated.	Additional analytical value. Waste management is not one of the core IEKRP2030 energy-sector areas, but the results provide supplementary information on municipal emission sources and reduction potential.
Climate change adaptation	Not directly modelled.	Limited link. The CommitClimate CO_2 simulation focuses on energy demand and emission

		mitigation. Climate risks, adaptation measures, green infrastructure and CO_2 sequestration are outside the main scope of the model.
Monitoring and review of the IEKRP2030	Baseline and policy scenario results up to 2050; comparison of energy demand and CO_2 emission trajectories.	Strong conceptual link. The model can support IEKRP2030 monitoring and review by helping the municipality compare baseline development, policy scenarios and remaining emission-reduction gaps.

5.2. Main modelling results relevant for IEKRP2030 monitoring

The CommitClimate simulation indicates that the selected policy package alters the municipality's long-term energy and emission trajectory, although it does not fully eliminate the modelled emission-reduction gap.

By 2050, total energy demand decreases from 409.4 GWh/year in the baseline scenario to 332.6 GWh/year in the policy scenario. This corresponds to annual energy savings of approximately 76.8 GWh/year, or 18.8%. Similarly, greenhouse gas emissions decrease from approximately 83.2 thousand tonnes CO_2eq/year to 72.6 thousand tonnes CO_2eq/year, corresponding to annual emission savings of approximately 10.6 thousand tonnes CO_2eq/year, or 12.8%.

From an IEKRP2030 monitoring perspective, the results highlight two key areas of importance. Building-related measures provide the largest contribution to energy-demand reduction, particularly through improvements in municipal and residential buildings. At the same time, transport measures contribute significantly to emission reductions, especially those targeting municipal fleets, public transport efficiency and private transport demand. These sectors should therefore remain central to monitoring and implementation efforts, as delays or lower-than-expected uptake could substantially affect the municipality's overall progress.

The results also reveal a difference between energy savings and emission reductions. Energy demand decreases more strongly than greenhouse gas emissions, indicating that demand-side and energy-efficiency measures alone are insufficient to fully decarbonise the municipal energy system. Additional progress would require broader deployment of renewable energy technologies, further transport decarbonisation and measures addressing remaining emission sources, particularly in the transport and waste-management sectors.

While the selected policy package achieves substantial improvements compared to the baseline scenario, significant residual emissions remain in 2050. The model results therefore suggest that additional mitigation measures may be required to achieve deeper long-term emission reductions. The CommitClimate simulation should be viewed primarily as a decision-support tool that helps identify trends, compare alternative policy pathways and highlight sectors where further action could deliver the greatest benefits.

For future IEKRP2030 monitoring and review, the CommitClimate results can therefore support:

- comparison of actual developments with the modelled baseline and policy trajectories;
- identification of sectors in which implementation is progressing more slowly than expected;
- assessment of whether the current combination of measures remains sufficient;
- identification of sectors and energy sources requiring additional or more ambitious action;
- development of updated scenarios when new municipal data become available.

5.3. Link with the Cēsis feasibility study

The Cēsis feasibility study prepared within CommitClimate focuses on improving energy efficiency in historic brick public buildings while preserving cultural heritage.

This feasibility study complements the Cēsis simulation report by providing a more detailed assessment of one locally relevant priority area. It links directly to the IEKRP2030 municipal infrastructure and municipal buildings sector, where building renovation, energy efficiency and responsible management of municipal assets are important priorities.

The feasibility study adds practical value to the broader modelling exercise by showing how general energy efficiency objectives can be translated into a more specific local implementation context. This is particularly relevant for Cēsis Municipality, where historic buildings form an important part of the built environment and require renovation approaches that balance energy performance with heritage preservation.

5.4. Municipality feedback and practical relevance

Feedback from Cēsis Municipality confirms the relevance of the CommitClimate CO_2 simulator and simulation results for local planning.

The municipality noted that the model outputs effectively illustrate both the current energy situation and future goals. The results were considered to align closely with existing municipal planning documents and to support the visualisation and analysis of alternative development scenarios.

Cēsis Municipality also highlighted that the model supports structured, data-driven climate mitigation planning, investment prioritisation, stakeholder communication and alignment with national and EU-level reporting requirements. The flexibility to adjust assumptions and test different scenarios was considered particularly valuable for identifying effective local mitigation strategies.

At the same time, the municipality pointed out that further localisation of assumptions and policy parameters would improve practical use. In particular, more flexible annual implementation rates and more sector-specific policy options would help better reflect local conditions and implementation capacity.

5.5. Scope and limitations

The CommitClimate simulation report should be understood as a supporting analytical document. It does not by itself formally amend, replace or update the Cēsis IEKRP2030. Its results may nevertheless be used as analytical input for the implementation, monitoring and review of the existing plan, as well as for the preparation of future SECAP updates or new municipal climate and energy planning documents.

There are also differences in scope and time horizon. The IEKRP2030 focuses on actions and targets up to 2030, while the CommitClimate simulation report provides a longer-term scenario analysis up to 2050. Therefore, the model results should not be interpreted as a direct assessment of formal IEKRP2030 target achievement, but rather as an additional tool for long-term reflection, monitoring and future planning.

Some IEKRP2030 areas are only partly covered or not covered by the simulation. Climate change adaptation, climate risk management, green infrastructure and CO_2 sequestration are outside the main

scope of the CommitClimate CO_2 model. Local energy production is included in the model structure, but no detailed policy analysis was conducted for Cēsis due to the available baseline data.

The quantitative results of the CommitClimate simulation should not be directly compared with the formal IEKRP2030 target values without harmonising the baseline year, sectoral scope and time horizon.

These limitations should be considered when interpreting the results. However, they do not reduce the value of the model as a planning-support tool. Instead, they show where future data development, sectoral expansion and additional scenario work may be needed.

5.6. Use of CommitClimate results for future SECAP monitoring and review

The Cēsis IEKRP2030 includes a regular monitoring and review approach. The CommitClimate simulation results can support this process by providing an additional scenario-based perspective on energy demand, emission trends and the potential impact of selected measures.

The modelling approach may also support the preparation of new or updated SECAP/SEAP-type documents. It can contribute to the analytical stages of plan development by supporting baseline assessment, testing alternative policy packages, comparing development pathways and identifying sectors in which additional action may be required.

In practical terms, the model can be used to:

- develop and compare baseline and policy scenarios;
- assess the potential effects of proposed climate and energy measures;
- identify sectors with the largest energy- and emission-reduction potential;
- assess whether the selected combination of measures is sufficient to move towards long-term climate objectives;
- support the prioritisation of measures during SECAP preparation or revision;
- compare observed developments with modelled trajectories during monitoring;
- support discussions with municipal stakeholders on additional or more ambitious measures;
- provide visual and quantitative material for stakeholder communication;
- support future updates and reviews of existing municipal climate and energy plans.

Overall, the CommitClimate Cēsis simulation report is closely linked to the mitigation and energy-planning components of the Cēsis IEKRP2030, particularly in the sectors of municipal buildings, residential buildings, public infrastructure and transport. It provides a quantitative and scenario-based analytical layer that can complement the existing planning document and support its implementation, monitoring and future review. The same modelling approach may also provide analytical input for the development of new or updated SECAP/SEAP-type documents. However, the model remains a planning-support tool and does not replace the formal preparation, stakeholder consultation and political adoption of a municipal climate and energy plan.

6. CONCLUSIONS

The scenario analysis for Cēsis Municipality demonstrates that the selected policy package can deliver meaningful reductions in both energy demand and greenhouse gas emissions by 2050, despite the assumed gradual increase in population and activity levels.

Compared with the 2050 baseline scenario, total energy demand decreases from 409.4 GWh/year to 332.6 GWh/year. This corresponds to annual energy savings of approximately 76.8 GWh/year, or 18.8%. Greenhouse gas emissions decrease from approximately 83.2 thousand tonnes CO_2eq/year to 72.6 thousand tonnes CO_2eq/year, corresponding to annual emission savings of approximately 10.6 thousand tonnes CO_2eq/year, or 12.8%. The smaller relative reduction in emissions than in energy demand reflects the fact that the selected measures focus primarily on demand reduction and energy efficiency rather than energy-supply decarbonisation.

Municipal-building measures provide a significant contribution to the overall results. Building-envelope improvements, operational energy-efficiency measures and renewable energy deployment reduce municipal-building energy demand by 3,210 MWh/year (15.7%) and CO_2 emissions by 208 tCO_2/year (16.0%). In addition, renewable energy technologies contribute approximately 289 MWh/year of local renewable energy generation.

Residential-building measures provide the largest contribution to overall energy savings. Renovation, electricity-saving measures and renewable-energy technologies reduce residential-sector energy demand by 42,860 MWh/year (23.5%) and CO_2 emissions by 2,557 tCO_2/year (19.9%). These results highlight the importance of long-term renovation programmes and household energy-efficiency improvements for reducing municipal energy demand.

Private transport remains one of the most important sectors for emission reduction. The tested car-sharing and freight-demand-reduction measures reduce private-transport energy demand by 23,746 MWh/year (12.9%) and CO_2 emissions by 5,536 tCO_2/year (12.6%). As private transport remains one of the largest emission sources in the municipality, additional measures in this sector could deliver substantial further reductions.

Municipal-fleet and **public-transport** measures achieve the highest relative reductions. Municipal-fleet measures reduce energy demand by 46.6% and emissions by 63%, while public-transport operational-efficiency and route-optimisation measures reduce both energy demand and emissions by 45.2%. Although their absolute contributions are smaller than those of residential buildings and private transport, these measures demonstrate the effectiveness of transport-sector efficiency improvements and fleet electrification.

Public-infrastructure measures provide additional measurable benefits. Energy demand is reduced by 1,374 MWh/year (20.8%), while CO_2 emissions decrease by 155 tCO_2/year (24.3%). Renewable electricity deployment in public lighting contributes approximately 304 MWh/year of renewable energy generation.

Waste-prevention measures reduce projected municipal waste generation by approximately 2 245 tons/year (11.8%). However, waste-sector emissions decrease by only 2.0%, indicating that additional measures addressing waste-treatment processes would be required to achieve more substantial emission reductions in this sector.

The analysis also highlights several limitations. Commercial and industrial sectors were not included in the simulation, and no local electricity generation, heat production or district-heating decarbonisation

measures were modelled. Consequently, the results do not capture potential reductions that could be achieved through broader energy-supply transformation. Climate adaptation, climate-risk management, green infrastructure and carbon sequestration were also outside the scope of the analysis.

The results should therefore be interpreted as scenario-based estimates rather than official municipal projections. Nevertheless, the simulation provides a useful decision-support tool for identifying high-impact sectors, comparing policy options and exploring long-term energy and emission trajectories.

Overall, the analysis shows that residential-building renovation, municipal-building efficiency measures and transport-sector interventions provide the largest contributions to the modelled reductions. While the selected policy package achieves substantial improvements compared with the baseline scenario, significant residual emissions remain in 2050. Achieving deeper long-term decarbonisation would likely require additional measures related to renewable energy deployment, energy-supply decarbonisation, transport electrification and further emission reductions in the waste sector.

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

Sector	Indicator	Results
Municipal buildings	Energy savings	3 210 MWh (15.7 %)
	Emission reduction	208 tCO_2 (16 %)
	Renewable generation	289 MWh
Residential buildings	Energy savings	42 860 MWh (23.5 %)
	Emission reduction	2 557 tCO_2 (19.9 %)
	Renewable generation	577 MWh
Public infrastructure	Energy savings	1 374 (20.8%)
	Emission reduction	155 tCO_2 (24.3 %)
	Renewable generation	304.2 MWh
Other sectors	Energy savings	–
	Emission reduction	–
Municipal fleet	Energy savings	1 312 MWh (46.6 %)
	Emission reduction	419 tCO_2 (63.0 %)
Public transport	Energy savings	5 644 MWh (45.2 %)
	Emission reduction	1 501 tCO_2 (45.2 %)
Private transport	Energy savings	23 746 MWh (12.9 %)
	Emission reduction	5 536 tCO_2 (12.6 %)
Waste management	Waste generation reduction	2 245 tonnes/year (11.8 %)
	Emission reduction	406 tCO_2eq (2.0 %)
Local energy production	Energy savings	–
	Emission reduction	–