

Scenario-Based Assessment of Climate Neutrality Pathways in Jokkmokk Municipality, Sweden

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This document presents an assessment of future energy demand and CO₂ emissions in Jokkmokk municipality, Sweden, 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 decrease (-0,6 % per year), which leads to relatively stable or slowly decrease 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 Jokkmokk's long-term energy system and climate outcomes.

NB! The simulations were conducted by Lapplands Kommunalförbund solely for exploratory and analytical purposes. They do not represent official projections, nor have they been adopted or endorsed by Jokkmokk 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. 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.

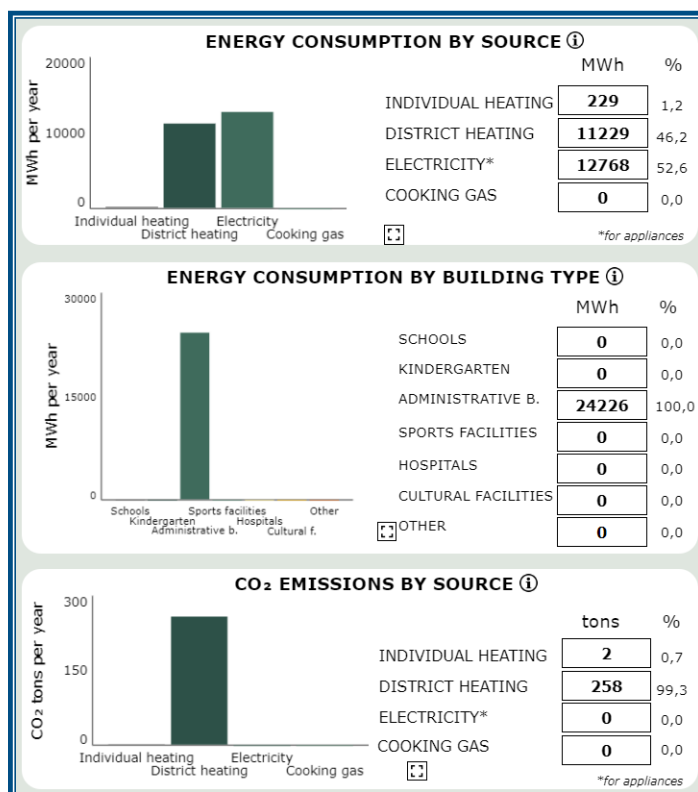
1.1. Current situation

In Jokkmokk municipality, the total area of municipal buildings in the baseline year is 81 843 m². The largest share by area is made up of administrative buildings. The total energy consumption in municipal buildings in 2023 was 24 281 MWh, which accounted for 7,8 % of energy consumption in Jokkmokk municipality.

In energy consumption, the largest share is electricity consumption for appliances with 52,6 % of the total energy consumption, followed by district heating (46,2 %). 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 140 kWh/m²/year and electricity consumption is 156 kWh/m²/year (weighted average across the entire building stock).

Total CO₂ emissions in municipal buildings related to energy use in the Baseline year were 260 tons of CO₂. The largest source of CO₂ emissions is district heating (99,3 %), followed by electricity consumption for appliances (0,7 %). Overall, CO₂ emissions in municipal buildings make up 1,1 % of total CO₂ emissions in the municipality.



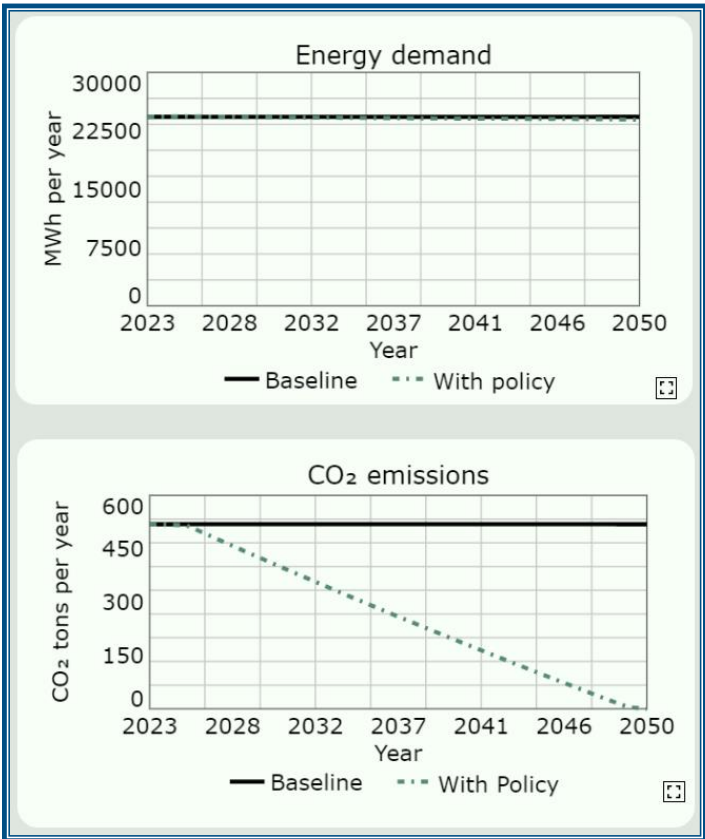
1.2. Policies

In the municipality buildings sector, a comprehensive energy efficiency strategy was proposed:

- **Replacement of windows** (*Implementation speed (IS) 3 %/year, Expected savings (ES) 15 %*)
- **Shading** (*IS 3 %/year, ES 5 %*)
- **Replacement of light bulbs** (*IS 3 %/year, ES 80 %*)
- **Lighting control** (*IS 3 %/year, ES 5 %*)
- **Use of natural light** (*IS 3 %/year, ES 10 %*)
- **Ventilation optimization** (*IS 3 %/year, ES 10 %*)
- **Energy efficient ventilation fans** (*IS 5 %/year, ES 10 %*)
- **Heat recovery** (*IS 3 %/year, ES 10 %*)
- **Heating optimization** (*IS 3 %/year, ES 10 %*)
- **Installation of thermostatic valves** (*IS 3 %/year, ES 10 %*)
- **Installation of new circulation pumps** (*IS 3 %/year, ES 10 %*)
- **Replacement of inefficient appliances** (*IS 3 %/year, ES 20 %*)
- **Optimal use of appliances** (*IS 3 %/year, ES 10 %*)
- **RES-E generation** (*Solar photovoltaics installed capacity 500 kW, Heat pump air installed capacity 200 kW, Energy storage installed capacity 100 kW*)

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

In total, the selected policies achieved 364 MWh in energy savings and 260 tCO₂ in emission savings in 2050 compared to the baseline scenario (1,5 % and 100 % reductions respectively). Additionally, the RES-E policy introduced 2854 MWh/year of renewable energy in the policy scenario.



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.

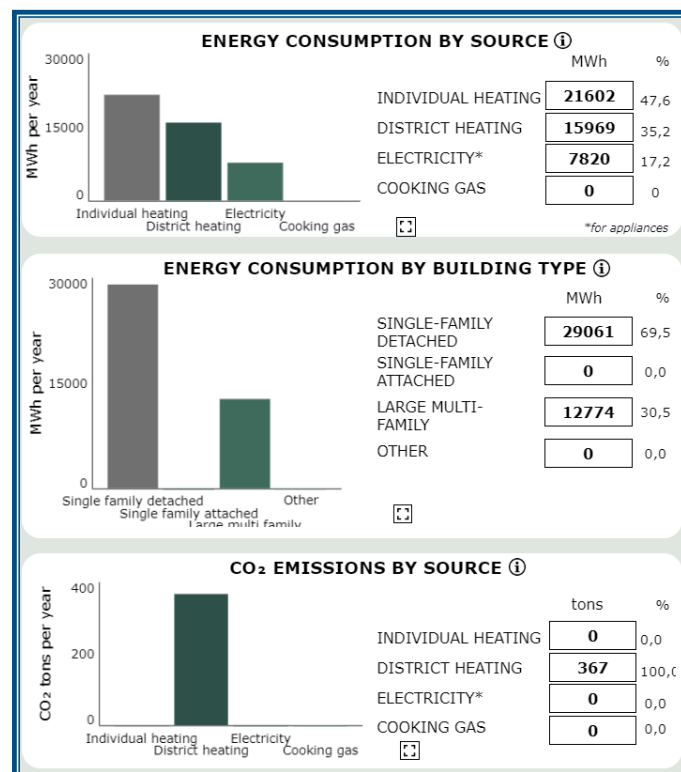
2.1. Current situation

In Jokkmokk municipality, the total area of residential buildings in the baseline year is 251 979 m². This area is made up of single-family detached and large multi-family houses. In 2023, the total energy consumption in residential buildings was 45 391 MWh, accounting for 14,6 % of total energy consumption in Jokkmokk municipality.

Of the total energy consumption, district heating systems make up 35,2 % or 13 361 MWh and energy for individual heating – 47,6 % of total energy demand. Electricity consumption for appliances makes up 17,2 % or 7820 MWh. 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 energy consumption for space heating and hot water preparation in the residential sector is 135 kWh/m²/year per year, and electricity consumption is 31 kWh/m²/year (weighted average across the entire building stock).

The amount of CO₂ generated in the household sector in the Baseline year were 367 tCO₂/year, which is 1,6 % of the municipality's CO₂ emissions. The only source of CO₂ emissions in residential buildings is district heating, which is responsible for 100 % of total CO₂ emissions.



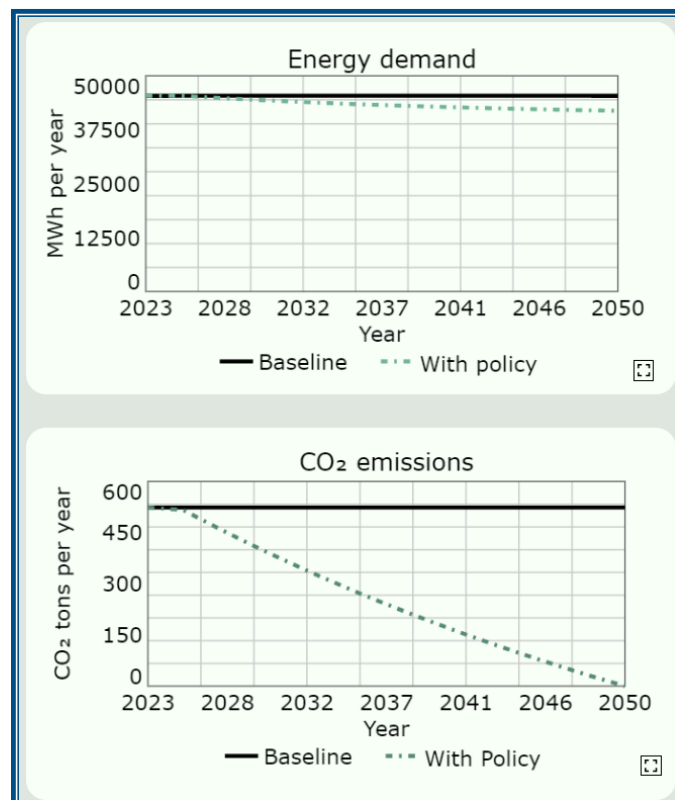
2.2. Policies

To reduce energy consumption and emissions in residential buildings, the following policies were tested:

- **Renovation of single-family houses** (IS 5 %/year, ES 10 %)
- **Renovation of multi-family houses** (IS 5 %/year, ES 10 %)
- **Electricity saving measures** (IS 5 %/year, ES 30 %)
- **Renewable and low-carbon technologies** (Solar photovoltaics installed capacity 1000 kW, Heat pump air installed capacity 700 kW, Heat pump ground installed capacity 700 kW, Energy storage installed capacity 900 kW)

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

In total, the selected policy achieved 3492 MWh in energy savings and 367 tCO₂ in emission savings in 2050 compared to the baseline scenario (7,7 % and 100 % reductions respectively). Additionally, the RES-E policy introduced 20 697 MWh/year of renewable energy in the policy scenario.



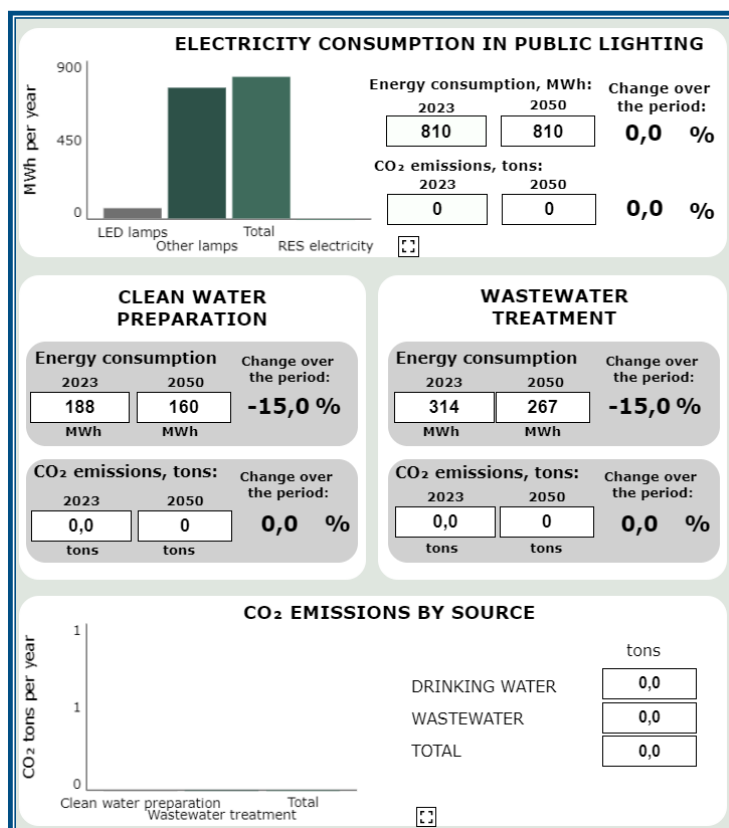
3. PUBLIC INFRASTRUCTURE

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 Jokkmokk municipality, the expected total electricity consumption in the Public infrastructure sector in the baseline year is 1312 MWh/year, which is 0,4 % of the municipality’s total energy consumption. Due to constant population decrease, the amount energy used for clean water preparation and wastewater treatment is expected to decrease by 15 %, bringing the total energy consumption of the sector to 1237 MWh per year in 2050; with public lighting accounting for 65,5 %, wastewater treatment – 21,6 % – and drinking water preparation – 12,9 % of the total energy consumption.

Due to all of the electricity used in public infrastructure being produced by renewable resources, associated emissions are 0 tCO₂/year.



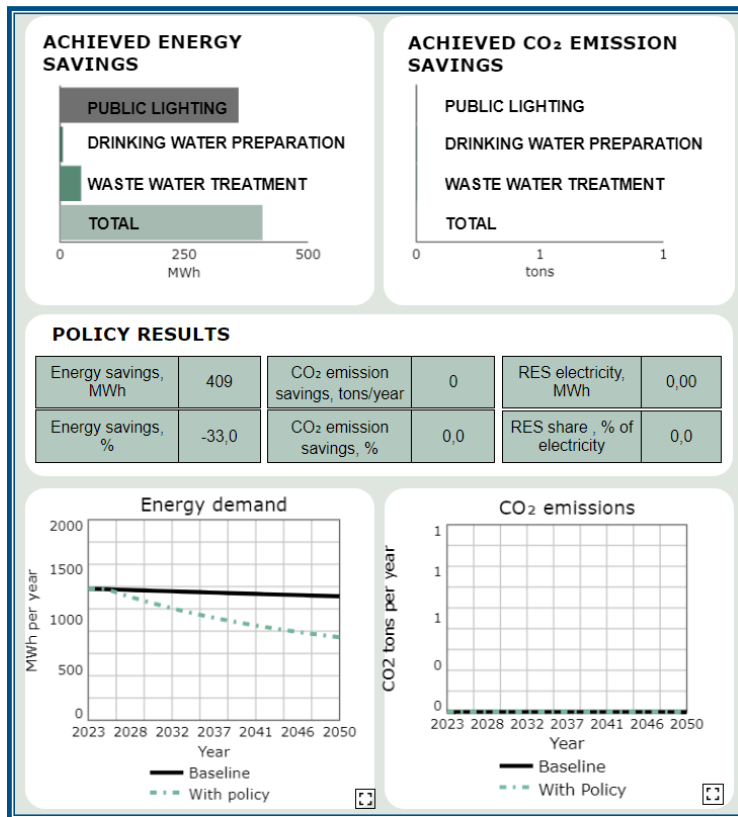
3.2. Policies

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

- **Replacement of inefficient light bulbs in public lighting** (IS 5 %/year)
- **Clean water preparation energy efficiency improvement** (IS 3 %/year)
- **Wastewater treatment energy efficiency improvement** (IS 0,5 %/year)

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

In total, the selected policies achieved 409 MWh in energy savings in 2050 compared to the baseline scenario (33 % reduction). The largest reduction in energy consumption is achieved through the replacement of inefficient light bulbs in the municipality’s public lighting system, resulting in a 29,1 % decrease.



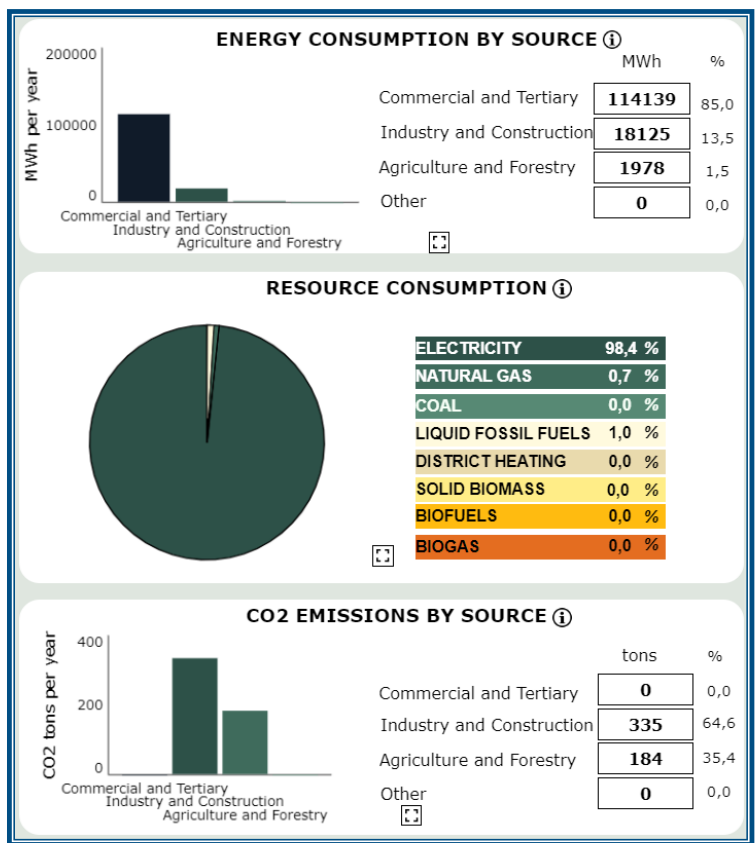
4. OTHER SECTORS

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 Jokkmokk municipality, Other sectors' Baseline energy consumption in 2023 is 130 250 MWh. As energy consumption required by the Industry and Construction sector increases at a rate of 1 %/year, the total energy consumption of other sectors will reach 134 242 MWh in 2050. Of this, the largest share is made up of energy consumption in the Commercial and Tertiary sector (85 %), followed by Industry and Construction with 13,5 % and Agriculture and forestry (1,5 %). Electricity dominates the energy mix with 98,4 %, followed by liquid fossil fuels with 1 %.

Energy consumption in Other sectors accounts for 43,1 % of the municipality's total energy consumption. Total CO₂ emissions in Other sectors are 518 tons/year or 2,2 % of the Municipality's total CO₂ emissions in both 2023 and 2050.



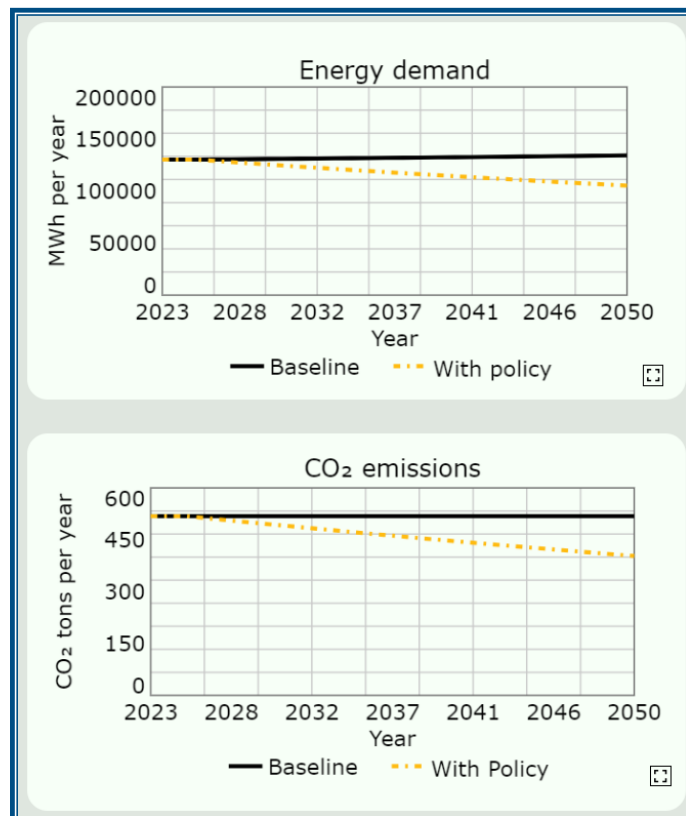
4.2. Policies

The following policies were proposed to reduce energy demand and emissions in other sectors:

- **EE measures in Commercial and Tertiary sector** (IS 1 %/year)
- **EE measures in Industry and Construction** (IS 1 %/year)
- **EE measures in Agriculture and Forestry** (IS 1 %/year)
- **EE measures in Other sectors** (IS 1 %/year)

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

In total, the selected policies achieved 28 939 MWh in energy savings in 2050 compared to the baseline scenario (21,6 % reduction). After implementing policies, CO₂ emissions drop by 115 tCO₂, which is a 22,2 % reduction.



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 CO₂ 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.

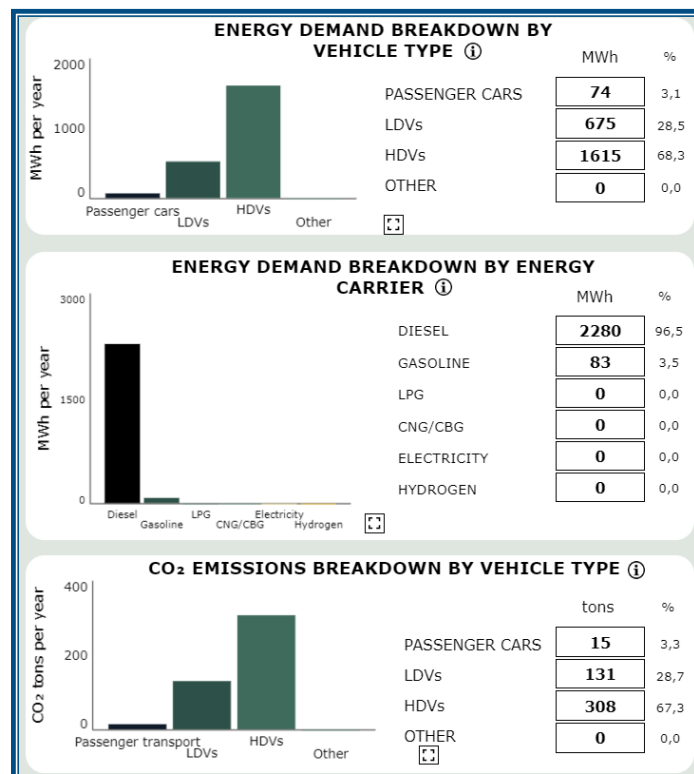
5.1. Current situation

Municipal vehicle fleet

The municipal vehicle fleet consists of 5 passenger cars, 35 LDVs and 10 HDVs. 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 2364 MWh per year, which is equivalent to 0,8 % of the municipality's total energy consumption.

In terms of fuel consumption, diesel accounts for the largest share (96,5 %), followed by gasoline (3,5 %). By vehicle type, the most significant energy consumer is HDVs (68,3 %), followed by LDVs (28,5 %) and passenger cars (3,1 %). Total CO₂ emissions related to the municipality's vehicle fleet amount to 457 tons of CO₂ per year, or approximately 2 % of the municipality's total CO₂ 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.



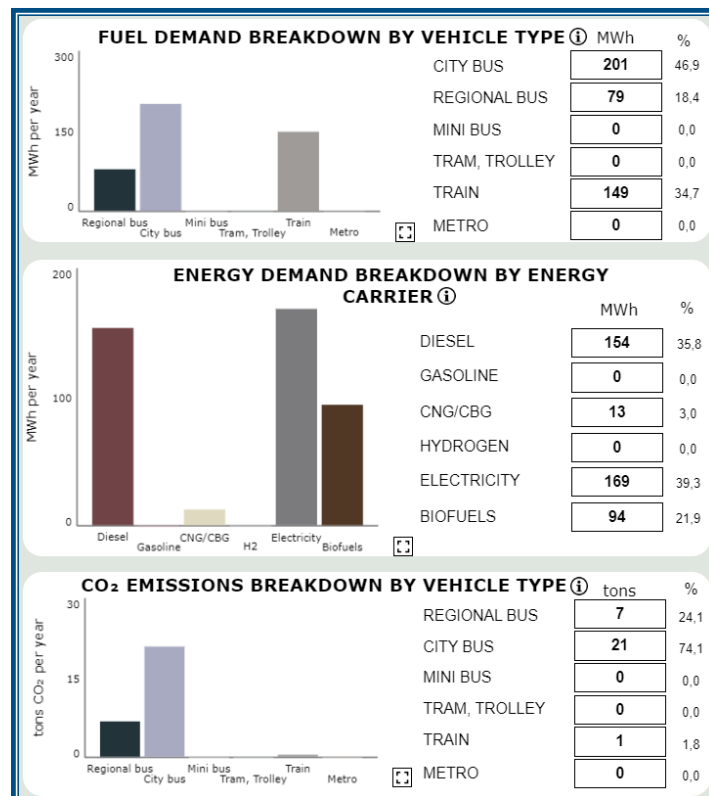
Public transport

According to existing data, 5,7 million passenger kilometres per year are performed by public transport. The largest share of this demand is made up of city public transport (70 %), followed by regional public transport (30 %).

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 498 MWh per year in 2023 or 0,1 % of the municipality's energy consumption. Of this, the largest share is made up of city bus (46,9 %), followed by train (34,7 %) and regional bus (18,4 %). Electricity dominates in terms of fuel consumption with 39,3 %, followed by diesel (35,8 %) and biofuels (21,9 %). Total CO₂ emissions related to energy consumption in public transport amounted to 33 tons of CO₂ in 2023 or approximately 0,1 % of the municipality's total CO₂ 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 decrease in population. As a result, public transport energy demand decreases over time.

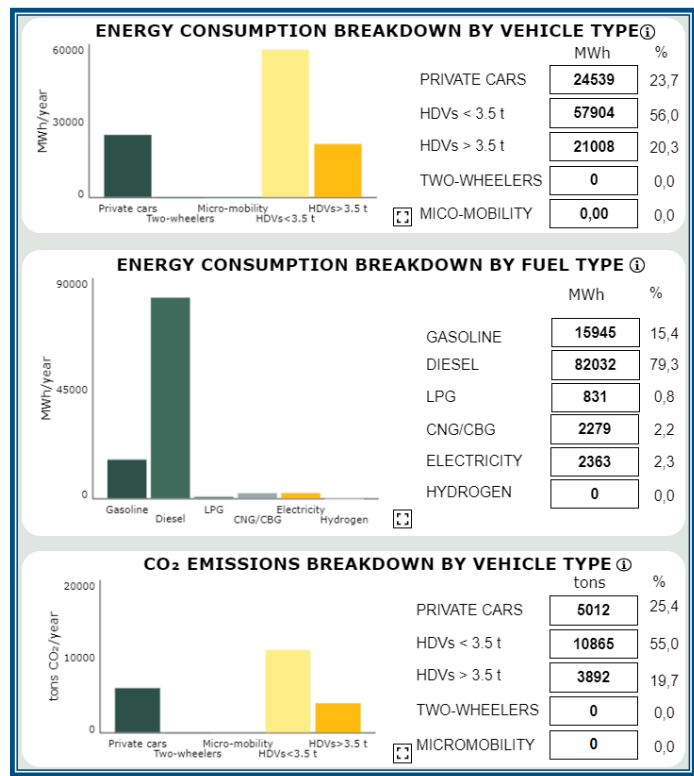
The projected energy consumption in 2050 is 429 MWh, with associated CO₂ emissions of 28 tons, corresponding to a decrease of 13,8 % and 14 %, respectively.



Private transport

According to existing input data, private transport demand in the municipality is approximately 78,4 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 103 450 MWh per year by 2050 and reach 33,2 % of the municipality's total energy consumption. This energy demand is mainly comprised of HDVs under 3,5 tons (56 %), passenger cars (23,7 %) and HDVs over 3,5 tons (20,3 %). Energy consumed by other types of vehicles, namely two-wheelers and micro-mobility, is negligible. Looking at the type of fuel, the two main types of fuel are diesel (79,3 %) and gasoline (15,4 %). Electricity accounts for a small proportion – 2363 MWh per year or 2,2 % of total energy demand. Total CO₂ emissions in the private transport sector amount to 19 769 tons of CO₂ per year, or approximately 84,4 % of the municipality's total CO₂ emissions in baseline year.

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 decrease in population. As a result, energy consumption and emissions decrease by approximately 3,6 % and 3,9 %, respectively, in 2050 compared to the base year.



5.2. Policies

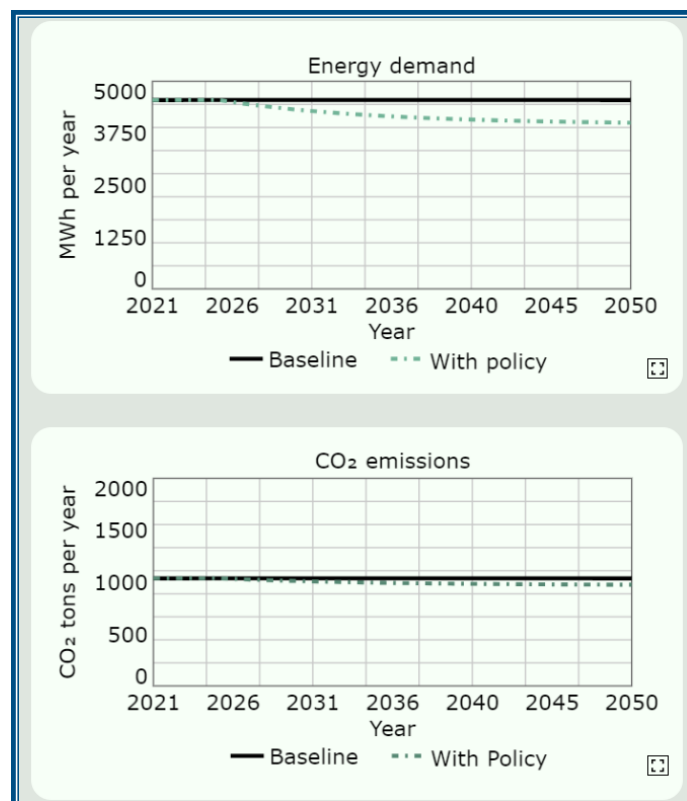
Municipal vehicle fleet

In this sector, the following policy measures were proposed:

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

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

In total, the selected policies achieved 547 MWh in energy savings and 109 tCO₂ in emission savings in 2050 compared to the baseline scenario (23,2 % and 23,9 % reductions respectively).



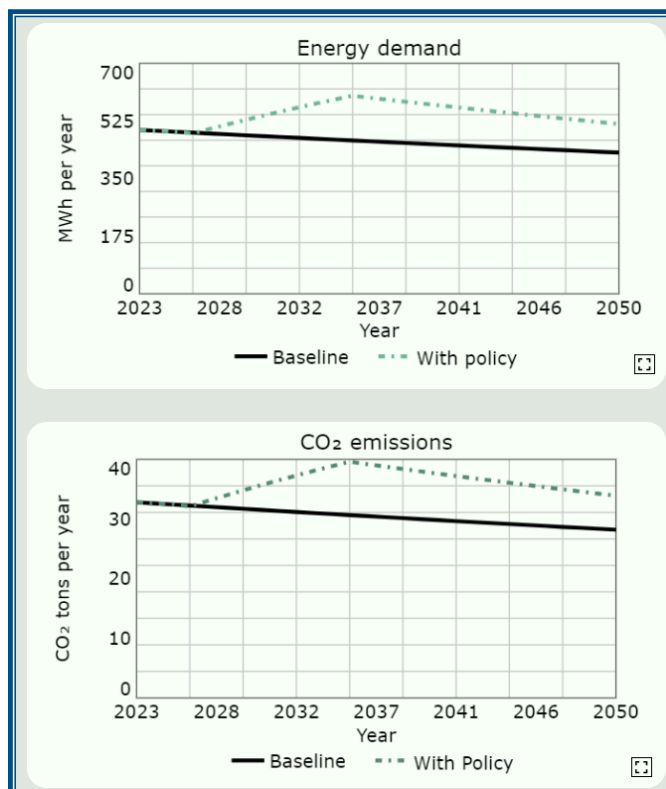
Public transport

In the public transport sector, the following policy was tested:

- **Mode shift to public transport** (Target share – Public transport 10 % (+3 %), Bicycle 3 %, Walking 5 %, Car 82 % (-3 %))

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

In total, the selected policy results in an increase of approximately 87 MWh in energy demand and 6 tons of CO₂ emissions by 2050 compared to the baseline scenario. With policy implementation in 2025, both energy demand and emissions continue rising until 2035, reaching peaks of 602 MWh and 40 tCO₂ respectively. After that, due to population decrease, energy demand and emissions start dropping at a relatively constant rate of ~0,95 % and 1 % respectively, while still remaining above the baseline scenario trendline.



Private transport

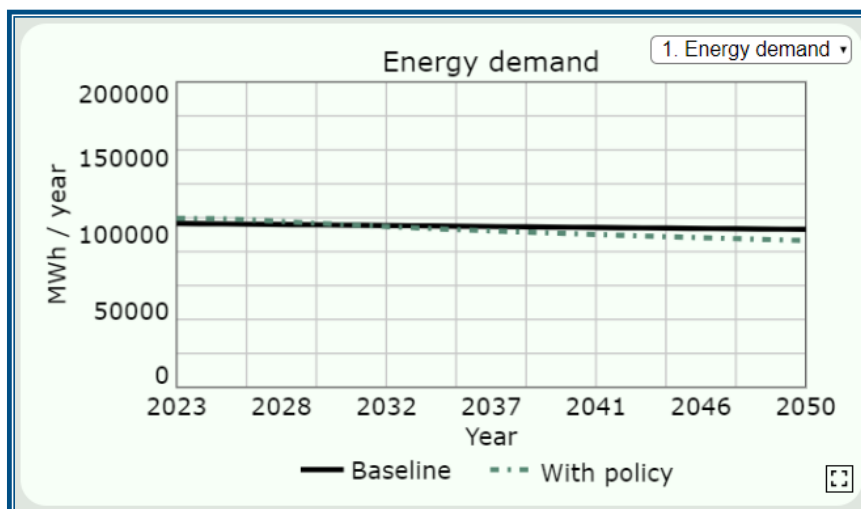
The following policies were implemented in the private transport sector:

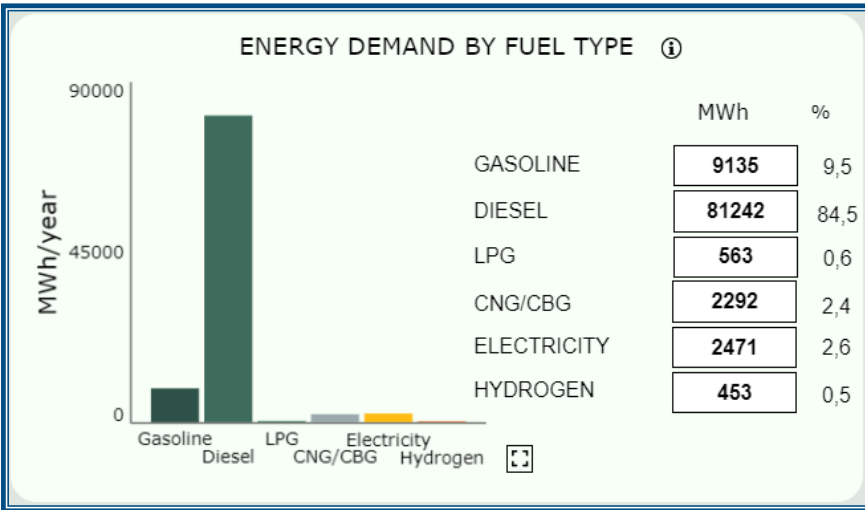
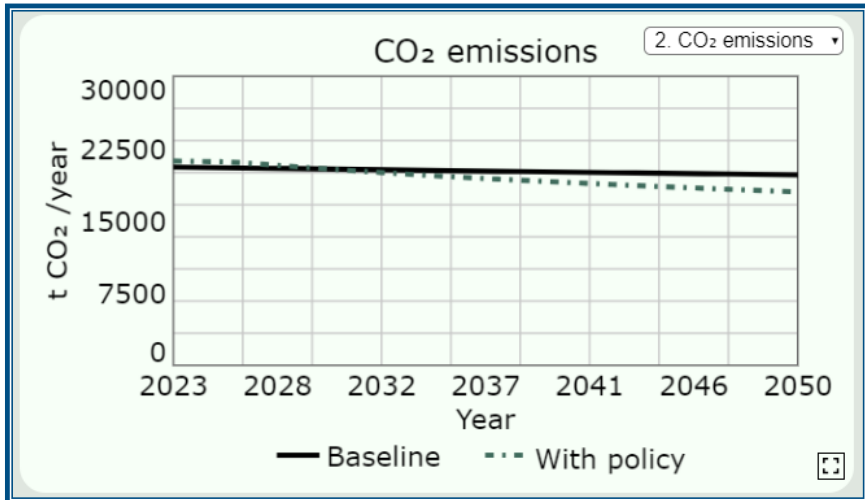
- **Reduction in passenger transport demand** (*Daily distance reduction IS 0,5 %/year, Travel frequency reduction IS 0 %/year*)
- **Car sharing** (IS 1 %/year)
- **Transition to low and zero carbon technologies in passenger cars** (*Passenger cars Target share – Gasoline 30 %, Diesel 24,6 %, Electricity 40 %, Hydrogen 4,6 % HDVs < 3,5t Target share – Gasoline 5 %, Diesel 10 %, Electricity 70 %, Hydrogen 15 % HDVs > 3,5t Target share – Diesel 20 %, Electricity 40 %, Hydrogen 40 %*)
 - **Apply selected passenger car policies to guest travellers**

Additionally, the mode shift policy used in the public transport sector has an effect on the share of passenger cars in the private transport sector:

- **Modal change in passenger transport** (*Target share – Public transport 10 % (+3 %), Bicycle 3 %, Walking 5 %, Car 82 % (-3 %)*)

The policy implementation start year was 2025 and the implementation end year was 2050 for all policies. In total, the selected policies result in a reduction of approximately 7295 MWh in energy demand and 1770 tons of CO₂ emissions by 2050 compared to the baseline scenario, corresponding to reductions by 7,1 % and 9 %, respectively.





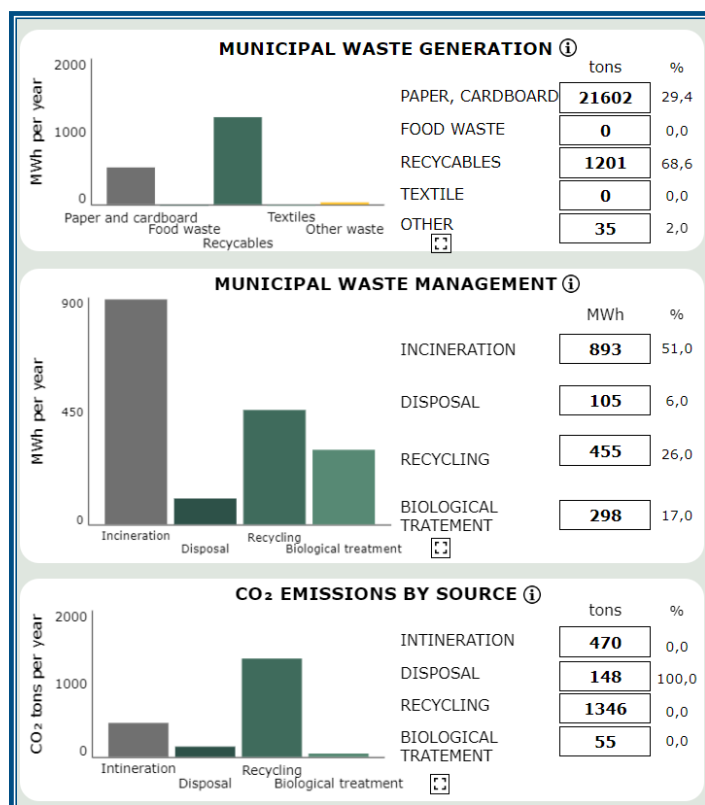
6. WASTE MANAGEMENT

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 (431 kg/capita/year) and the structure of municipal waste. Based on these assumptions, the amount of municipal waste generated in Jokkmokk municipality in the base year is 2060 tons and the GHG emissions related to waste management constitute 2376 tons CO₂eq. The waste management sector accounts for approximately 8,6 % of the municipality's emissions

As the baseline scenario assumes an annual 0,48 % decrease in the municipality's population, by 2050, the total amount of waste generated and GHG emissions are expected to decrease by approximately 15 %, reaching 1751 tons of generated waste and 2020 tons CO₂eq, respectively.



6.2. 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.

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 CO₂ emissions in this sector by reducing heat losses in the system, recovering lost heat and decarbonizing various energy systems.

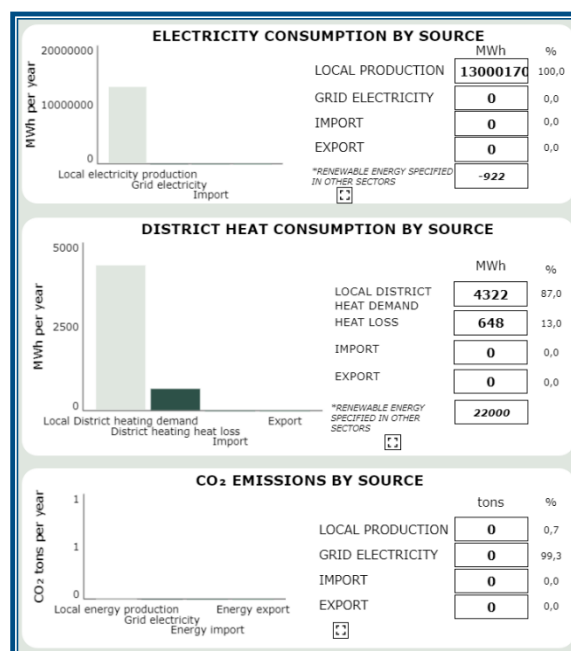
NB! The local energy production sector differs from other sectors in that it represents energy supply rather than energy demand. The 2050 scenario without energy-production-specific policies therefore reflects the energy demand generated by all other sectors after their respective policies are applied,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

7.1. Current situation

In the local energy production sector, district heating demand amounts to 26 322 MWh/year, with the largest share attributed to residential buildings (58,1 %), followed by municipal buildings (41,9 %). When distribution losses are considered, total heating demand increases to 26 970 MWh/year.

Total electricity demand is 136 901 MWh/year, with the largest share coming from other sectors (76,1 %), followed by transport (11,1 %) and municipality buildings (8,3 %). Including distribution losses, total electricity demand rises to 142 414 MWh/year.

Consequently, the total energy demand in the baseline year amounts to 190 441 MWh/year. CO₂ emissions from energy production in the baseline year are 719 tCO₂/year. Due to the diminishing population, energy demand from public infrastructure and transport sectors decreases over time throughout the baseline scenario, along with the associated emissions eventually reaching 169 384 MWh and 114 tCO₂ in 2050 (11,1 % and 84,1 % reductions respectively).



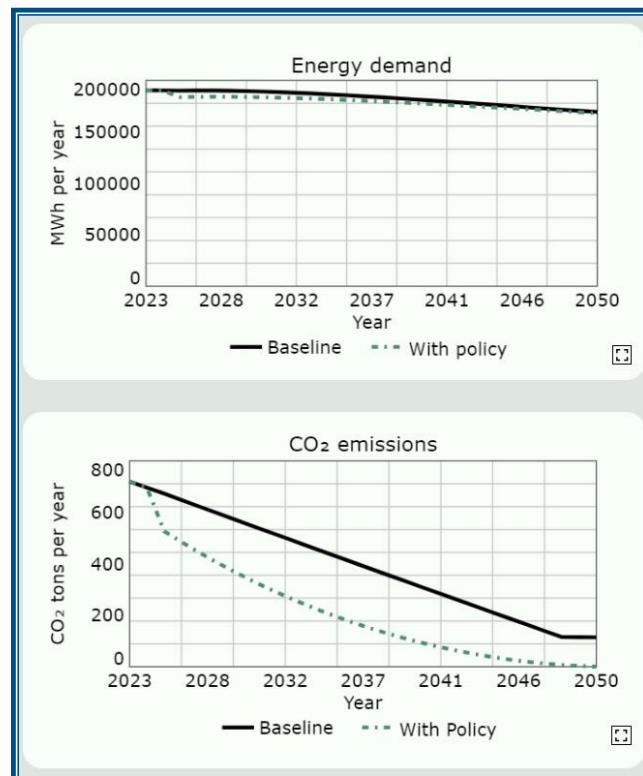
7.2. Policies

To further reduce CO₂ emissions from local energy production, the following policies were implemented:

- **Reduction of heat loss** (*Heat loss reduction limit 7 %, IS 5 %/year*)
- **Waste heat recovery** (*Savings potential 25 %*)
- **District heating decarbonization** (*Target emission factor 0,000 tCO₂/MWh (-0,023 tCO₂/MWh)*)
- **Local electricity production decarbonization** (*Target emission factor 0,000 tCO₂/MWh (-0,000 tCO₂/MWh)*)
- **Grid electricity production decarbonization** (*Target emission factor 0,000 tCO₂/MWh (-0,020 tCO₂/MWh)*)

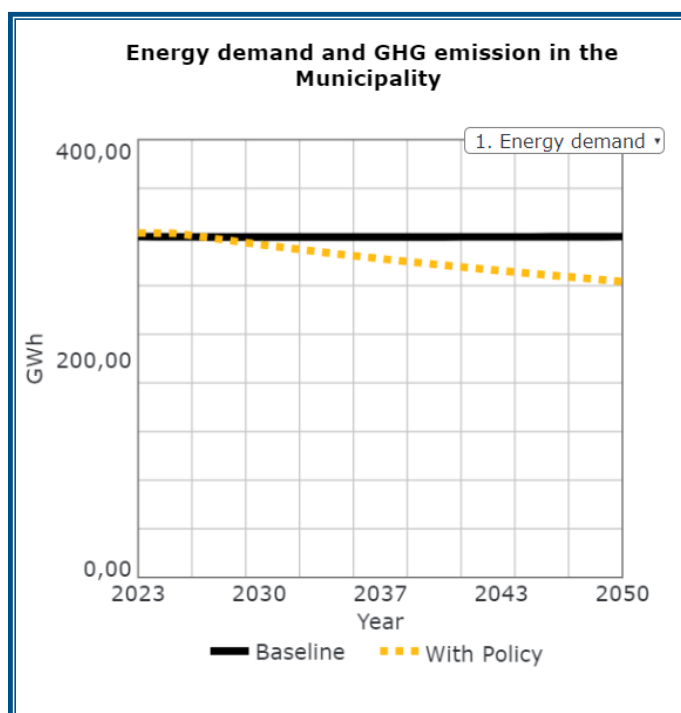
For all selected policies, the start year was 2025 and the end year was 2050.

In total, these policies achieved 1330 MWh (0,8 %) and 114 tCO₂ (100 %) in energy demand and emission reductions respectively.

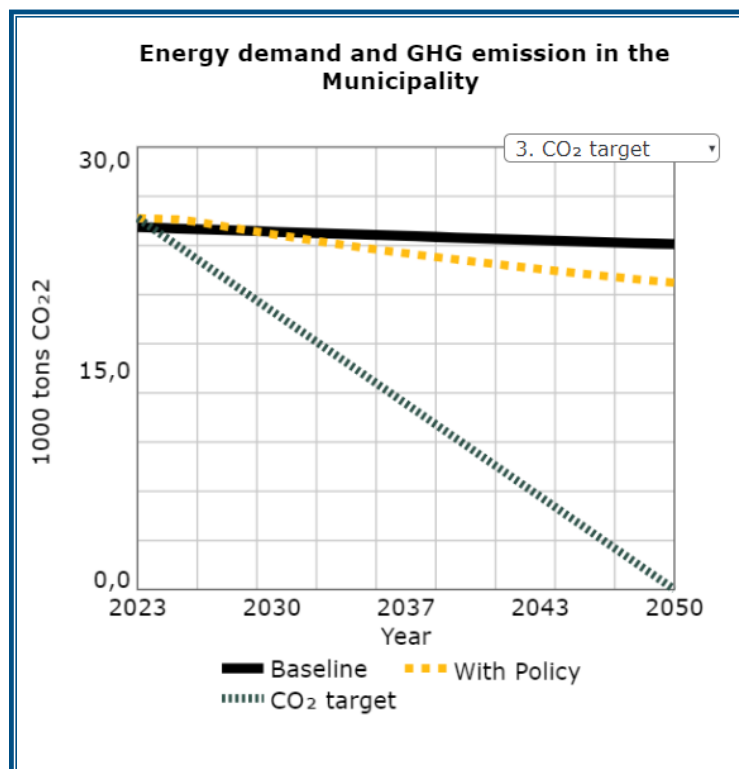


8. RESULT OVERVIEW

The results of the simulation show that in the baseline scenario energy demand in the municipality remains relatively stable, reaching 311,39 GWh by 2050. As illustrated in the figure below, the implementation of the selected policy package causes a gradual energy demand decrease, resulting in an energy demand of 270,43 GWh by 2050. This corresponds to energy savings of approximately 40 959,6 MWh, or 13,2 % compared to the baseline projection.



The selected policy package leads to similarly modest emission reductions – CO₂ emissions decrease from 23,4 thousand tons in the baseline scenario to approximately 20,8 thousand tons in the policy scenario by 2050, resulting in annual emission savings of 2616,3 tons (11,2 %). As shown in the figure below, while the policy scenario slightly lowers emissions compared to the baseline trajectory, emissions remain above the long-term CO₂ target (100 % reduction by 2050), indicating that additional mitigation measures would be required to fully achieve the municipality's climate objectives.



9. CONCLUSIONS

The results of the scenario analysis for Jokkmokk municipality show that the implementation of the selected policy package leads to moderate reductions in both energy demand and greenhouse gas emissions by 2050, in the context of a gradually declining population and relatively stable economic development.

Overall, total energy demand decreases by approximately 13,2 % (40 960 MWh) compared to the baseline scenario, indicating that energy efficiency improvements and demand-side measures are effective in reducing energy consumption even under conditions of already declining demand. At the same time, CO₂ emissions decrease by 11,2 % (2 616 tCO₂), reflecting a more limited but still notable decarbonisation effect.

The results highlight that **the building sector** plays a significant role in emission reduction, particularly due to the complete decarbonisation of heating systems. In both **municipal** and **residential** buildings, emissions are reduced by 100 %, despite relatively modest energy savings (1,5 % and 7,7 % respectively). This indicates that fuel switching and renewable energy integration are the dominant drivers of emission reduction in this sector, rather than large reductions in energy demand.

The other sectors also contribute substantially to overall energy savings, achieving 28 939 MWh reductions (21,6 %) and significant emission reductions. This demonstrates the importance of continuous energy efficiency improvements across commercial and tertiary activities, even in municipalities with relatively low industrial intensity.

In **the transport sector**, the results show more moderate impacts compared to other case studies. Private transport achieves 7,1 % energy savings and 9 % emission reductions, while municipal fleet improvements contribute additional reductions. However, the introduction of modal shift policies in public transport results in a slight increase in energy demand and emissions, reflecting the trade-off between shifting travel behaviour and overall system efficiency in a low-demand context.

The public infrastructure sector achieves notable energy savings of 33 % (409 MWh), mainly through lighting improvements, although emissions remain unchanged due to the already renewable electricity supply. Similarly, in the waste management sector, no additional emission reductions are achieved, as no policy measures were implemented.

The local energy production sector demonstrates a complete elimination of emissions (100 % reduction) through decarbonisation measures, although the impact on total energy demand remains limited (0,8 % reduction).

Despite these improvements, the results indicate that the overall policy package leads to only moderate emission reductions at the municipal level, and emissions remain significantly above the long-term climate neutrality target. This suggests that additional and more ambitious measures—particularly in the transport sector and demand reduction policies—would be required to achieve deeper decarbonisation.

Overall, the analysis shows that in municipalities with declining population and relatively low growth, decarbonisation is driven more by fuel switching and energy system transformation than by large reductions in energy demand. A broader policy mix, including stronger behavioural measures and deeper transport interventions, would be necessary to further increase emission reduction potential in Jokkmokk municipality.

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

Sector	Indicator	Results
Municipal buildings	Energy savings	364 MWh (1,5 %)
	Emission reduction	260 tCO ₂ (100 %)
	Renewable generation	2854 MWh
Residential buildings	Energy savings	3492 MWh (7,7 %)
	Emission reduction	367 tCO ₂ (100 %)
	Renewable generation	20 697 MWh
Public infrastructure	Energy savings	409 MWh (33 %)
	Emission reduction	0 tCO ₂ (0 %)
	Renewable generation	–
Other sectors	Energy savings	28 939 MWh (21,6 %)
	Emission reduction	2676 tCO ₂ (86,9 %)
Municipal fleet	Energy savings	115 MWh (22,2 %)
	Emission reduction	109 tCO ₂ (23,9 %)
Public transport	Energy savings	-87 MWh (-20,3 %)
	Emission reduction	-6 tCO ₂ (-20,3 %)
Private transport	Energy savings	7295 MWh (7,1 %)
	Emission reduction	1770 tCO ₂ (9 %)
Waste management	Waste generation reduction	–
	Emission reduction	–
Local energy production	Energy savings	1330 MWh (0,8 %)
	Emission reduction	114 tCO ₂ (100 %)
	Renewable generation	–
Peak emissions from imported electricity	tCO ₂	–