



Scenario-Based Assessment of Climate Neutrality Pathways in Pałecznica Municipality, Poland

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This document presents an assessment of future energy demand and CO₂ emissions in Pałecznica 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 decrease (-0.48% per year), which leads to relatively stable or slowly decreasing 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 Pałecznica'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 Pałecznica municipality. Rather, these exercises serve as a basis for discussion and reflection among municipal stakeholders and may support future decision-making processes.

Contents

1.	PLANNING CONTEXT.....	3
2.	SCOPE OF THE COMMITCLIMATE SIMULATION REPORT	4
3.	MODELLING RESULTS	5
3.1.	MUNICIPAL BUILDINGS.....	5
	Current situation.....	5
	Policies	6
3.2.	RESIDENTIAL BUILDINGS.....	8
	Current situation.....	8
	Policies	9
3.3.	PUBLIC INFRASTRUCTURE.....	11
	Current situation.....	11
	Policies	12
3.4.	OTHER SECTORS.....	13
	Current situation.....	13
	Policies	13
3.5.	TRANSPORT.....	14
	Current situation.....	14
	Policies	17
3.6.	WASTE MANAGEMENT.....	19
	Current situation.....	19
	Policies	20
3.7.	LOCAL ENERGY PRODUCTION.....	22
	Current situation.....	22
	Policies	23
4.	RESULT OVERVIEW	24
5.	LINK WITH PAŁECZNICA PMECPF.....	27
5.1.	Link between PMECPF and CommitClimate modelling.....	27
5.2.	Main modelling results relevant for PMECPF review and future development.....	28
5.3.	Link with the Pałecznicza feasibility study	29
5.4.	Municipality feedback and practical relevance	30
5.5.	Scope and limitations	30
5.6.	Use of CommitClimate results for future PMECPF review and planning	31
6.	CONCLUSIONS.....	32

1. PLANNING CONTEXT

Pałecznica Municipality has an existing local climate, energy and development planning framework. Within the OwnYourSECAP project, a SECAP development process was undertaken, including the preparation of a baseline emissions inventory and the assessment of local energy and climate challenges. However, no final Sustainable Energy and Climate Action Plan (SECAP) was formally adopted by the municipality.

Following the completion of the baseline work, the municipality identified the need for a broader strategic perspective and initiated the development of a Municipal Energy Transition Strategy. The purpose of this strategy is to explore pathways towards greater energy independence, particularly for municipal facilities and installations, by assessing local energy demand, renewable energy generation potential, and opportunities for balancing local energy production and consumption. As part of this process, an Energy Cooperative has already been established, and the municipality is currently analysing energy surpluses and deficits to support the definition of future actions and investment priorities.

In addition, Pałecznica Municipality has an adopted local development strategy, *Strategia Rozwoju Gminy Pałecznica 2030 (Development Strategy of Pałecznica Municipality 2030)*, adopted by the Municipal Council in November 2022. The strategy provides a broader framework for the municipality's development and includes objectives related to environmental protection, renewable energy development, energy management, deep building renovation, low-energy and passive construction, and increased climate and energy awareness. It also promotes the concept of an energy self-sufficient municipality through improved balance between local energy production and consumption.

The CommitClimate simulation report should therefore be understood within the context of Pałecznica's municipal energy and climate planning framework, including the Development Strategy 2030, the ongoing Municipal Energy Transition Strategy, and potential future SECAP-related planning activities.

The CommitClimate simulation report does not replace, formally amend or update any existing municipal planning document. Instead, it provides an additional scenario-based analytical layer that can support evidence-based decision-making and help inform the implementation and future development of Pałecznica's energy and climate policies.

For the purposes of this report, the term Pałecznica Municipal Energy and Climate Planning Framework (PMECPF) refers to the municipality's overarching policy framework, including the *Development Strategy of Pałecznica Municipality 2030*, the ongoing *Municipal Energy Transition Strategy*, and any potential future SECAP-related planning activities. Unless otherwise specified, references throughout this report to municipal energy and climate plans, targets, priorities or strategic objectives should be understood as referring to this broader framework.

The added value of the CommitClimate modelling lies in its ability to quantitatively assess and compare alternative policy and investment pathways against a baseline development scenario. This enables the municipality to evaluate the potential impacts of selected measures on energy demand and CO₂ emissions, identify gaps between current trajectories and long-term objectives, and support the prioritisation of future actions within the broader municipal energy transition process.

2. SCOPE OF THE COMMITCLIMATE SIMULATION REPORT

The CommitClimate simulation report for Pałecznica Municipality assesses future energy demand and CO₂ 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 CO₂ emissions. The analysed scenario assumes modest economic development and a slight population decrease of -0.48 % per year, which contributes to relatively stable or slowly decreasing demand in several sectors.

The tested policy package focuses mainly on selected measures in municipal buildings, residential buildings, municipal fleet and waste management. These include lighting replacement, ventilation optimisation, small-scale renewable electricity generation, residential building renovation, municipal fleet decarbonisation and waste reduction.

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. MUNICIPAL 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

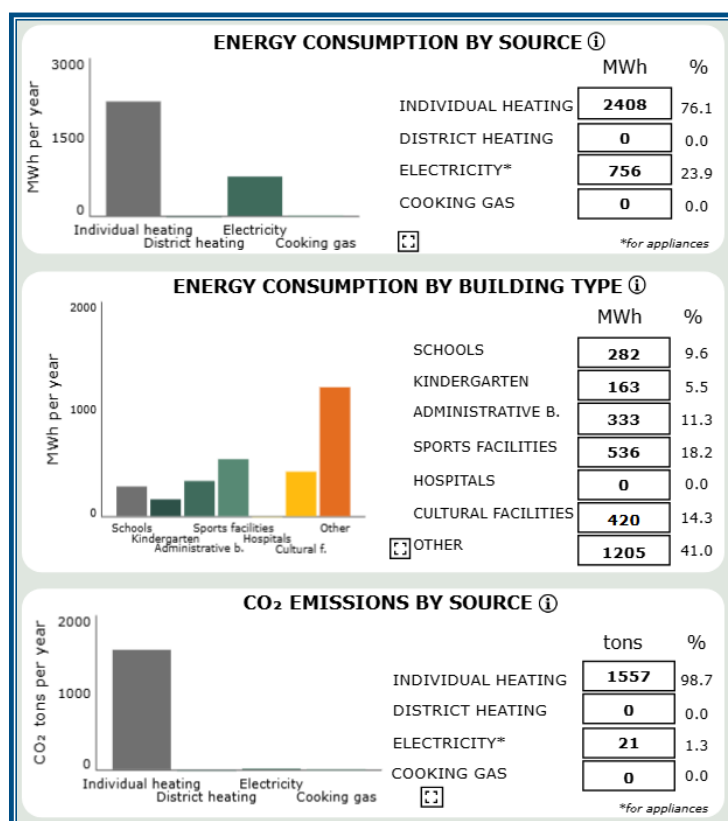
In Pałecznica municipality, the total area of municipal buildings in the baseline year (2021) was 14 388 m². Other buildings accounted for the largest share of the building area (42.5 %), followed by sports facilities (18.9 %), cultural facilities (14.8 %), schools (9.9 %), administrative buildings (8.1 %) and kindergartens (5.7 %). Annual energy demand in municipal buildings amounted to 3054 MWh/year, representing 6.3 % of the municipality's total energy demand.

By 2050, an additional 740 m² of administrative buildings is expected to be constructed, increasing the total municipal building area to 15 128 m². As a result, annual energy demand in the baseline scenario increases by 111 MWh/year (3.6 %), reaching 3165 MWh/year in 2050. The sector's contribution to total municipal energy demand consequently increases to 6.1 %.

In 2021, individual heating accounted for 2335 MWh/year, or 76.4 % of municipal building energy demand, while electricity consumption for appliances accounted for 719 MWh/year, or 23.6 %. By 2050, these values increase to 2408 MWh/year and 756 MWh/year, respectively. Electricity used for heating is included under individual heating rather than electricity consumption for appliances.

In the baseline year, the average specific heat consumption of municipal buildings was 147 kWh/m²/year, while specific electricity consumption amounted to 50 kWh/m²/year. Following the construction of additional administrative buildings, average specific heat consumption decreases to 144 kWh/m²/year by 2050, while specific electricity consumption remains unchanged.

Annual CO₂ emissions from energy use in municipal buildings amounted to 1509 tCO₂/year in 2021, representing 6.2 % of the municipality's total CO₂ emissions. In the baseline year, all modelled emissions in this sector were attributed to individual heating. By 2050, annual emissions increase by 68 tCO₂/year (4.5 %), reaching 1577 tCO₂/year. Individual heating accounts for 98.7 % of these emissions and electricity consumption for appliances for the remaining 1.3 %.



Policies

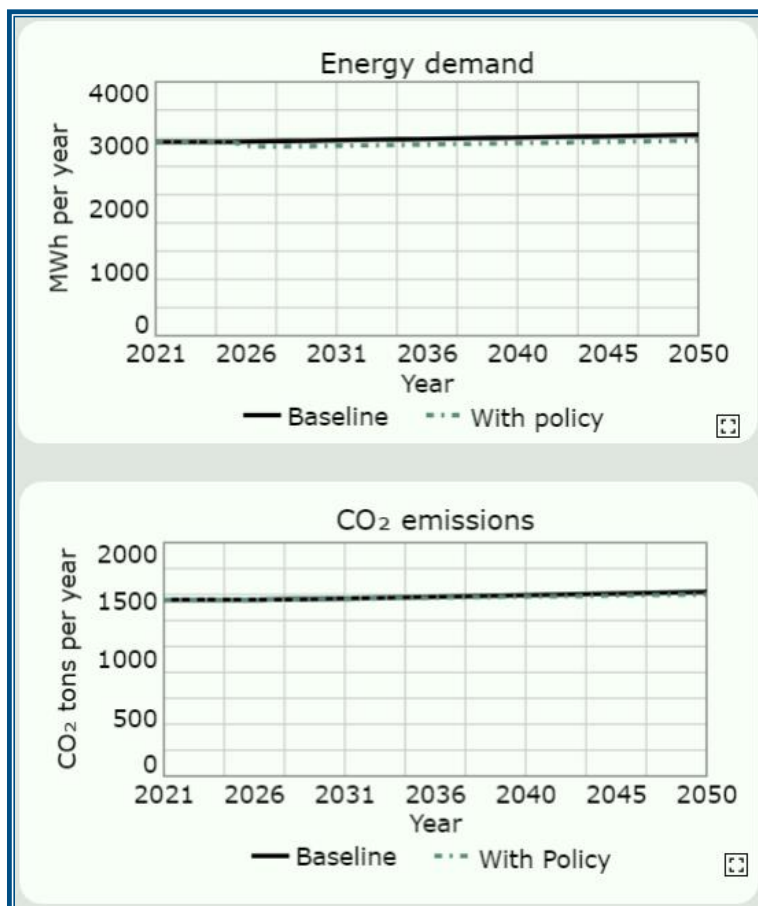
In the municipal buildings sector, several policy measures were proposed:

- **Replacement of light bulbs** (*Implementation speed (IS) 100 %/year , Expected savings (ES) 80 %*)
- **Ventilation optimization** (*IS 5 %/year, ES 10 %*)
- **RES-E generation** (*Solar photovoltaics installed capacity 151 kW*)

The implementation of the selected policy measures results in modest reductions in both energy demand and CO₂ emissions from municipal buildings. In 2050, annual energy demand in the policy scenario reaches 3075 MWh/year, compared with 3165 MWh/year in the baseline scenario. This corresponds to annual energy savings of 90 MWh/year, or 2.8 %. Annual CO₂ emissions decrease from 1577 tCO₂/year in the baseline scenario to 1557 tCO₂/year in the policy scenario. Based on the model's unrounded results, this represents emission savings of approximately 21 tCO₂/year, or 1.3 %.

The municipality has 849 kW of existing solar PV capacity. The tested policy gradually adds 151 kW of capacity by 2050, increasing total installed capacity to 1 MW. The additional capacity generates approximately 0.129 MWh/year of renewable electricity, while total annual PV generation reaches approximately 854 MWh/year. Because existing renewable generation already covers most electricity demand for appliances, the energy-efficiency measures reduce grid-electricity consumption only until it reaches zero. Any resulting renewable electricity surplus is not allocated to heating or credited as an additional emission reduction in this scenario.

Following the introduction of the policies in 2025, energy demand and CO₂ emissions initially decrease. Thereafter, both indicators gradually increase as the total area of municipal buildings expands. Nevertheless, they remain below the baseline scenario throughout the remainder of the modelling period, indicating that the selected energy-efficiency measures partially offset the additional energy demand and emissions associated with the construction of new municipal buildings.



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 Pałecznica Municipality, the total residential building area amounted to 113 200 m² in the baseline year (2021). The entire modelled residential building stock consisted of single-family attached houses. Annual final energy consumption in residential buildings amounted to 34 281 MWh/year, representing 70.2 % of the municipality's total energy demand.

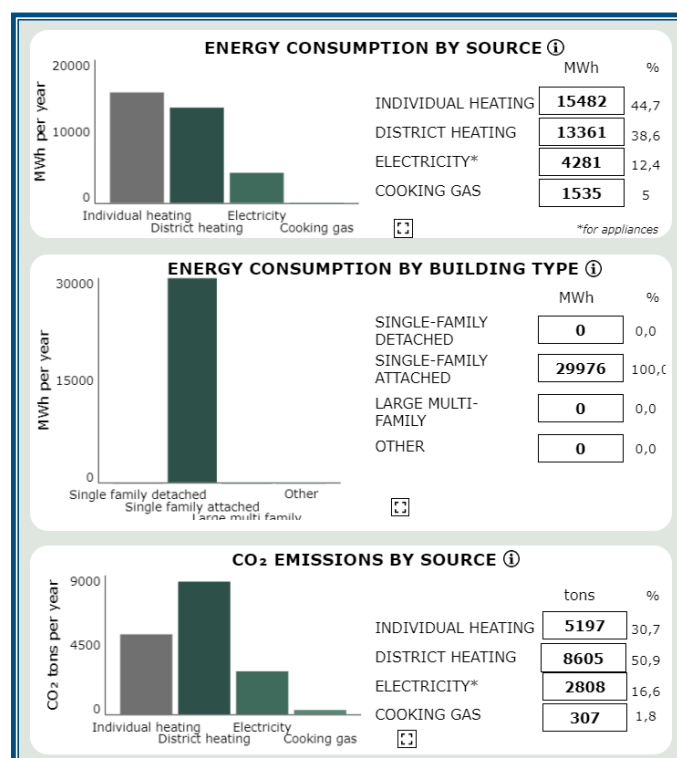
In 2021, individual heating accounted for 15 347 MWh/year, or 44.8 % of residential final energy consumption. District heating accounted for 13 244 MWh/year (38.6 %), electricity consumption for appliances for 4188 MWh/year (12.2 %), and cooking gas for 1502 MWh/year (4.4 %). Electricity used for heating is included under individual heating rather than electricity consumption for appliances.

The average specific heat demand for space heating and hot-water preparation amounted to 225 kWh/m²/year in 2021, while specific electricity consumption for appliances amounted to 37 kWh/m²/year. Based on these assumptions, useful energy demand by building type amounted to approximately 29 658 MWh/year. This value is lower than final energy consumption by source because useful energy demand does not include heating-system conversion losses or cooking-gas consumption.

By 2030, an additional 2500 m² of single-family attached houses is expected to be constructed, increasing the total residential building area to 115 700 m². As a result, annual final energy consumption in the 2050 baseline scenario increases by approximately 379 MWh/year, or 1.1 %, reaching 34 660 MWh/year. Individual heating accounts for approximately 15 482 MWh/year (44.7 %), district heating for 13 361 MWh/year (38.6 %), electricity consumption for appliances for 4281 MWh/year (12.4 %), and cooking gas for 1535 MWh/year (4.4 %). Average specific heat demand decreases to approximately 222 kWh/m²/year, while specific electricity consumption remains unchanged at 37 kWh/m²/year.

Annual CO₂ emissions from residential buildings amounted to approximately 16 729 tCO₂/year in 2021, representing 72.1 % of the municipality's total emissions. District heating was the largest emission source, accounting for 51.0 % of residential building emissions, followed by individual heating at 30.8 %, electricity consumption for appliances at 16.4 %, and cooking gas at 1.8 %.

By 2050, annual emissions in the baseline scenario increase to approximately 16 917 tCO₂/year. This is approximately 188 tCO₂/year, or 1.1 %, higher than in 2021 and is primarily attributable to the construction of additional residential buildings. In 2050, district heating accounts for approximately 50.9 % of residential building emissions, individual heating for 30.7 %, electricity consumption for appliances for 16.6 %, and cooking gas for 1.8 %. The residential sector's contribution to total municipal emissions consequently increases to approximately 71.1 %.



Policies

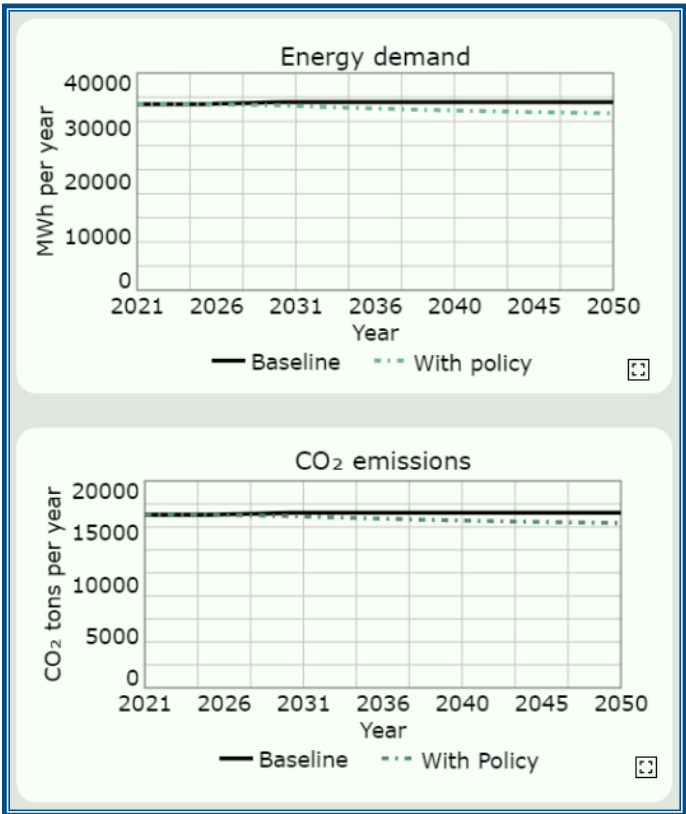
To reduce energy demand and CO₂ emissions in residential buildings, a renovation measure for single-family houses was tested:

- **Renovation of single-family houses** (IS 3 %/year, ES 10 %)

The policy was implemented over the period from 2025 to 2050.

By 2050, the selected policy reduces annual energy demand by approximately 1524 MWh/year, or 4.4 %, compared with the baseline scenario. Annual energy demand reaches approximately 33 136 MWh/year in the policy scenario, compared with 34 660 MWh/year in the baseline scenario. Annual CO₂ emissions decrease from 16 917 tCO₂/year in the baseline scenario to approximately 16 188 tCO₂/year in the policy scenario, corresponding to annual emission savings of approximately 729 tCO₂/year, or 4.3 %.

Following the introduction of the renovation policy in 2025, annual energy demand and CO₂ emissions gradually decrease, while the difference between the baseline and policy scenarios becomes progressively larger throughout the implementation period. The policy more than offsets the additional energy demand and emissions associated with the projected construction of new residential buildings. Nevertheless, the reductions remain moderate, indicating that a higher renovation rate, deeper energy savings or additional heating-system measures would be required to achieve a more substantial impact.



3.3. PUBLIC INFRASTRUCTURE

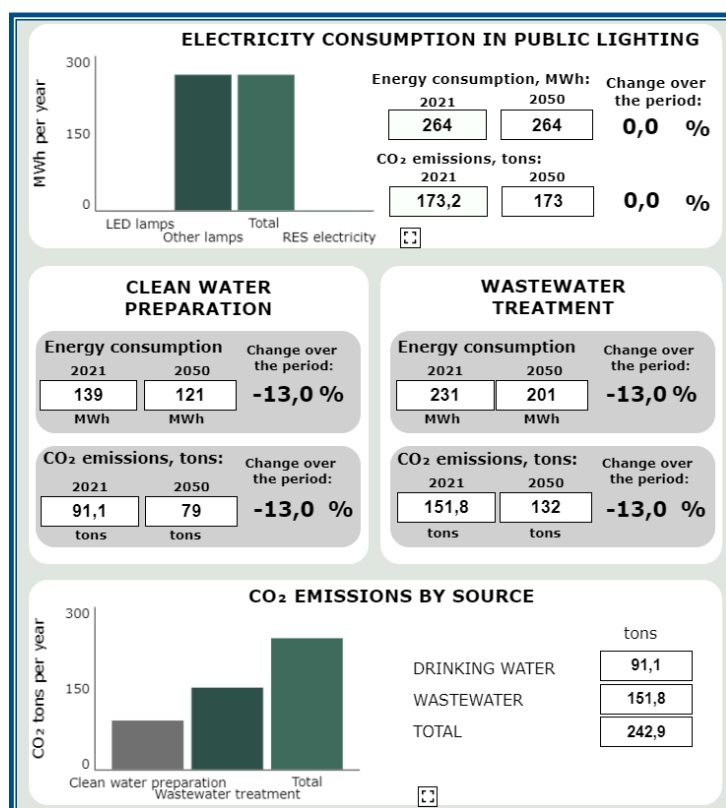
The Public Infrastructure sector encompasses essential services and systems that support communities and contribute to their quality of life. This sector includes electricity consumption related to public lighting, clean water preparation, and wastewater treatment, all of which are critical to maintaining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

Current situation

In 2021, annual electricity demand in the public infrastructure sector amounted to 634 MWh/year, representing approximately 1.3 % of the municipality's total energy demand. Public lighting accounted for 264 MWh/year (41.6 %), clean water preparation for 139 MWh/year (21.9 %), and wastewater treatment for 231 MWh/year (36.5 %).

In the baseline scenario, electricity demand for public lighting remains constant at 264 MWh/year throughout the modelling period. Due to the assumed population decline, electricity demand for clean water preparation and wastewater treatment decreases by approximately 13 % in each sub-sector. By 2050, annual electricity demand reaches 121 MWh/year for clean water preparation and 201 MWh/year for wastewater treatment. Consequently, total annual electricity demand in the public infrastructure sector decreases to 586 MWh/year, corresponding to an overall reduction of 48 MWh/year, or approximately 7.6 %, compared with 2021.

Annual CO₂ emissions from public infrastructure amounted to 416.1 tCO₂/year in 2021, representing approximately 1.7 % of the municipality's total CO₂ emissions. Public lighting accounted for 173.2 tCO₂/year, clean water preparation for 91.1 tCO₂/year, and wastewater treatment for 151.8 tCO₂/year. By 2050, annual emissions are projected to decrease to approximately 384 tCO₂/year, corresponding to a reduction of 32.1 tCO₂/year, or 7.7 %, compared with 2021. The sector's contribution to total municipal CO₂ emissions consequently decreases to approximately 1.6 %.



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.

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

Policies

In Pałecznica 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 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.

Current situation

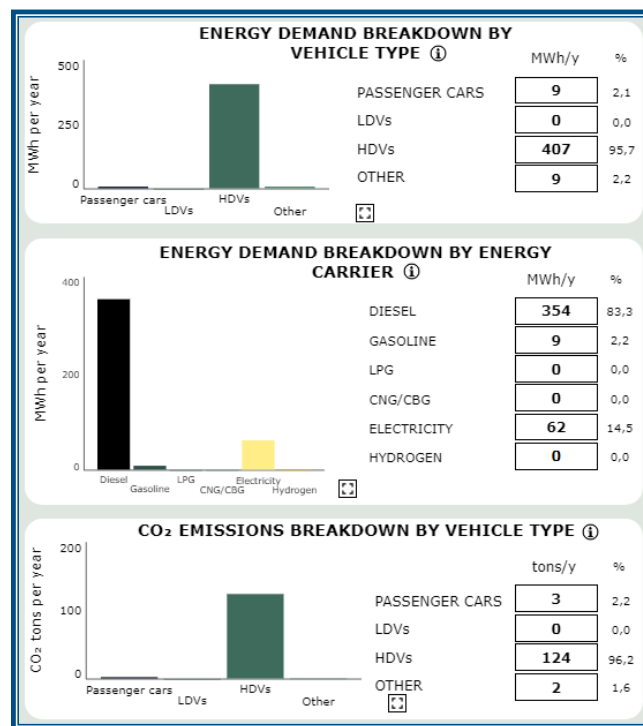
Municipal vehicle fleet

The municipal vehicle fleet consists of 7 vehicles: 2 passenger cars, 4 heavy-duty vehicles (HDVs) and two other vehicles. Based on the assumed annual mileage, vehicle-specific fuel consumption and fuel distribution, annual energy demand from the municipal vehicle fleet amounted to 425 MWh/year in 2021. This represented approximately 0.9 % of the municipality's total energy demand.

HDVs were the largest energy-consuming vehicle group, accounting for 407 MWh/year, or 95.7 % of municipal fleet energy demand. Passenger cars accounted for 9 MWh/year (2.1 %), and other vehicles for 9 MWh/year (2.2 %).

Diesel was the dominant energy carrier, accounting for 354 MWh/year, or 83.3 % of total fleet energy demand, while electricity accounted for 62 MWh/year (14.5 %) and gasoline accounted for 9 MWh/year (2.2 %).

Annual CO₂ emissions from the municipal vehicle fleet amounted to 129 tCO₂/year in 2021, representing approximately 0.6 % of the municipality's total CO₂ emissions. HDVs were responsible for the largest share of emissions, accounting for 124 tCO₂/year followed by other transport (2 tCO₂/year) and passenger cars (3 tCO₂/year). The vehicle-kilometre-weighted average emission factor of the municipal fleet was approximately 719 gCO₂/km.



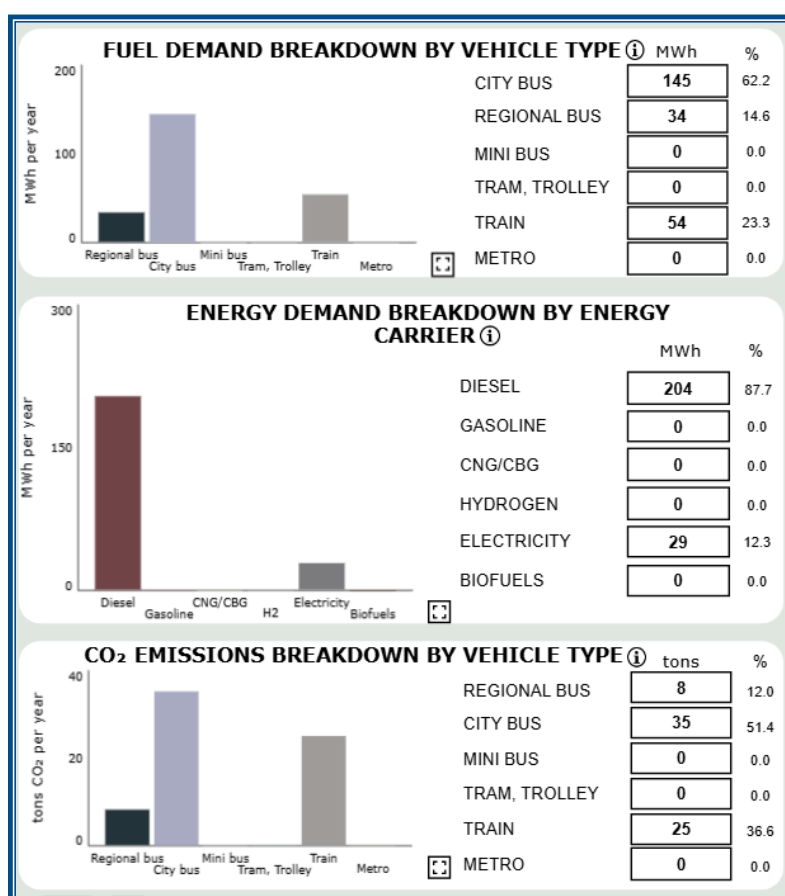
Public transport

According to existing data, 3.3 million passenger kilometres per year are performed by public transport in 2021. This number decreases to 2.9 million passenger kilometers by 2050. The largest share of this demand is made up of city public transport (62.2 %), followed by train (23.3%) and regional public transport (14.6 %).

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 233 MWh per year in 2021 or 0.5 % of the municipality's energy consumption. Of this, the largest share is made up of city bus (51.4 %), followed by train (36.6 %) and regional bus (12 %). Diesel dominates in terms of fuel consumption with 87.7 %, followed by electricity with 12.3 %. Total CO₂ emissions related to energy consumption in public transport amounted to 68 tonnes of CO₂ in 2021 or approximately 0.3 % 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 202 MWh, with associated CO₂ emissions of 60 tonnes, corresponding to a decrease of 13 % compared to the base year.

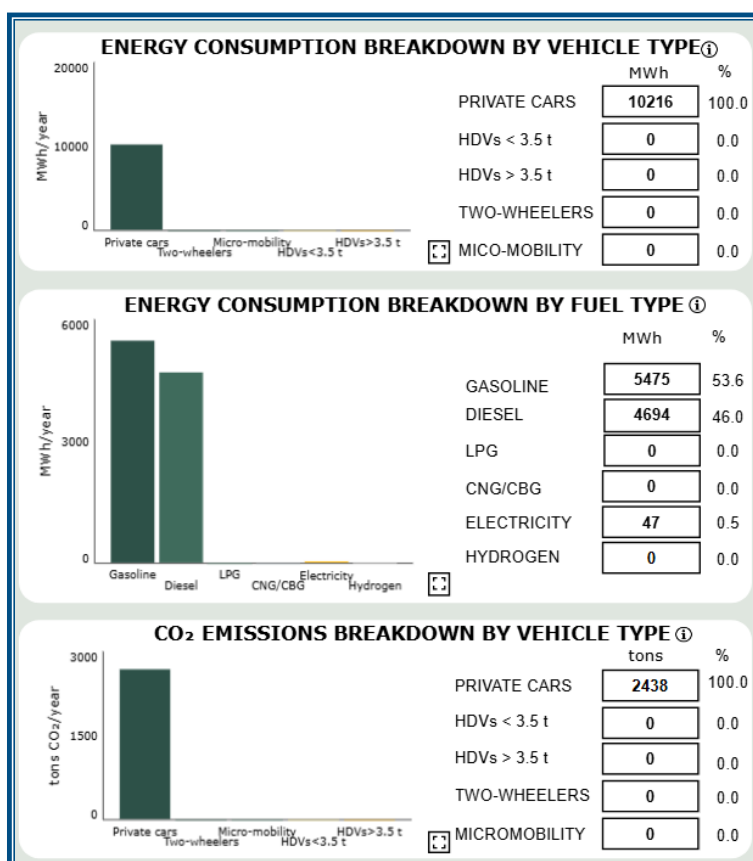


Private transport

In the baseline year (2021), annual private passenger travel demand in Pałecznica municipality amounted to approximately 17.2 million passenger-kilometres. Based on the assumptions regarding private vehicle use, average fuel consumption and fuel distribution, annual energy demand from private transport was estimated at 10 216 MWh/year, representing approximately 20.9 % of the municipality's total energy demand. All modelled private transport energy demand was attributed to private cars.

Gasoline was the dominant fuel, accounting for 5475 MWh/year, or 53.6 % of private transport energy demand. Diesel accounted for 4694 MWh/year (46.0 %), while electricity represented only 47 MWh/year (0.5 %). Annual CO₂ emissions from private transport amounted to 2438 tCO₂/year in 2021, corresponding to approximately 10.5 % of the municipality's total CO₂ emissions.

The baseline scenario assumes no policy interventions and no changes in per-capita private transport usage patterns, vehicle composition or fuel shares. Changes in total passenger travel demand, energy demand and CO₂ emissions are driven by the assumed gradual population decline. Consequently, all three indicators decrease by approximately 13 % between 2021 and 2050.



Policies

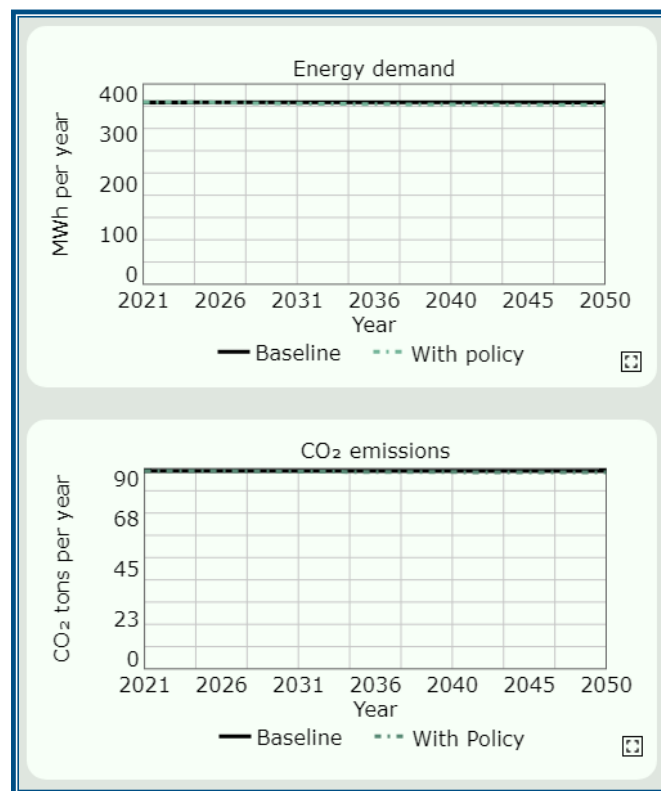
Municipal vehicle fleet

In this sector, the following policy measure was proposed:

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

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

In total, the selected policies achieved 5 MWh in energy savings and 1 tCO₂ in emission savings in 2050 compared to the baseline scenario (1.4 % and 0.7 % reductions respectively).



Public transport

No policy measures were introduced for public transport in the simulation. Therefore, the baseline scenario remains unchanged, with only assumed effect of a decreasing population leading to a projected 13 % reduction in energy use by 2050. No additional policy-driven reductions in emissions or energy consumption were calculated.

This approach may reflect limited municipal control over public transport systems or a strategic focus on other, more impactful sectors.

Private transport

Similarly, no specific policy actions were applied in the private transport sector. As a result, projected energy consumption and CO₂ emissions follow the baseline trajectory, which includes a 13 % decrease in energy use by 2050, driven by assumed demographic trends. No further reductions were modelled from new policy interventions.

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.

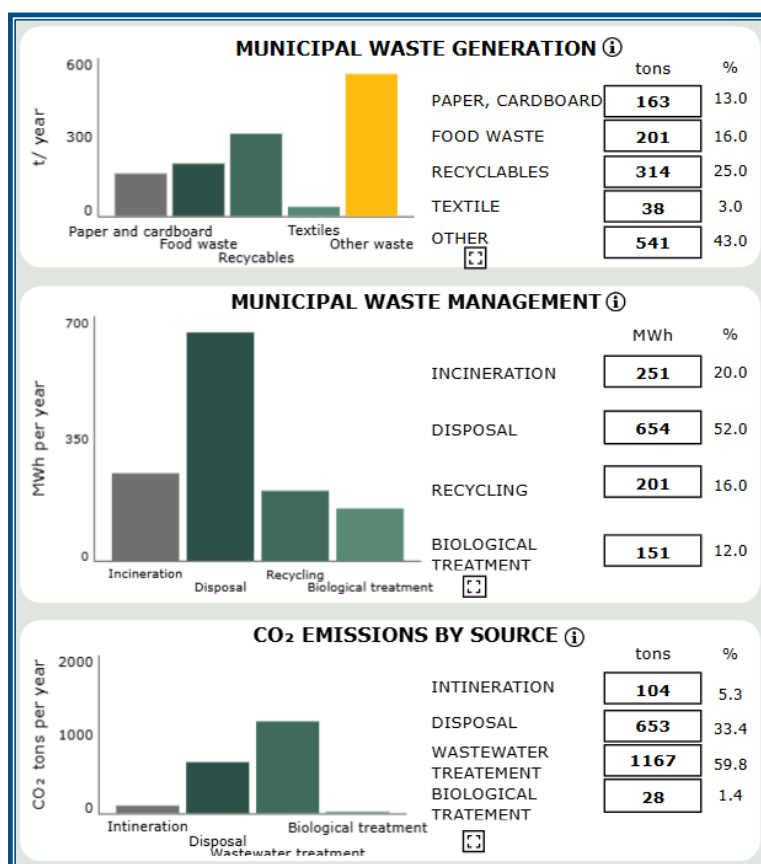
Current situation

The baseline scenario calculations are based on the municipality's population, annual municipal waste generation of 357 kg/capita/year, and the assumed composition and treatment structure of municipal waste.

In 2021, approximately 1257 tonnes of municipal waste were generated, corresponding to 357 kg per capita per year. Other waste accounted for the largest share of the total (43 %), followed by recyclable materials (25 %), food waste (16 %), paper and cardboard (13 %), and textile waste (3 %). Of the total municipal waste generated, 52 % was disposed of, 20 % was incinerated, 16 % was recycled and 12 % underwent biological treatment.

Annual GHG emissions associated with waste management amounted to approximately 1952 tCO₂eq/year in 2021, representing 8.4 % of the municipality's total GHG emissions.

The baseline scenario assumes that per-capita waste generation, waste composition and treatment shares remain unchanged, while the municipality's population decreases by approximately 0.48 % per year. Consequently, annual municipal waste generation and associated GHG emissions decrease by approximately 13 % between 2021 and 2050. By 2050, annual waste generation falls to approximately 1094 tonnes/year, while annual GHG emissions decrease to approximately 1697 tCO₂eq/year. The waste management sector's contribution to total municipal GHG emissions consequently decreases to approximately 7.4 %.



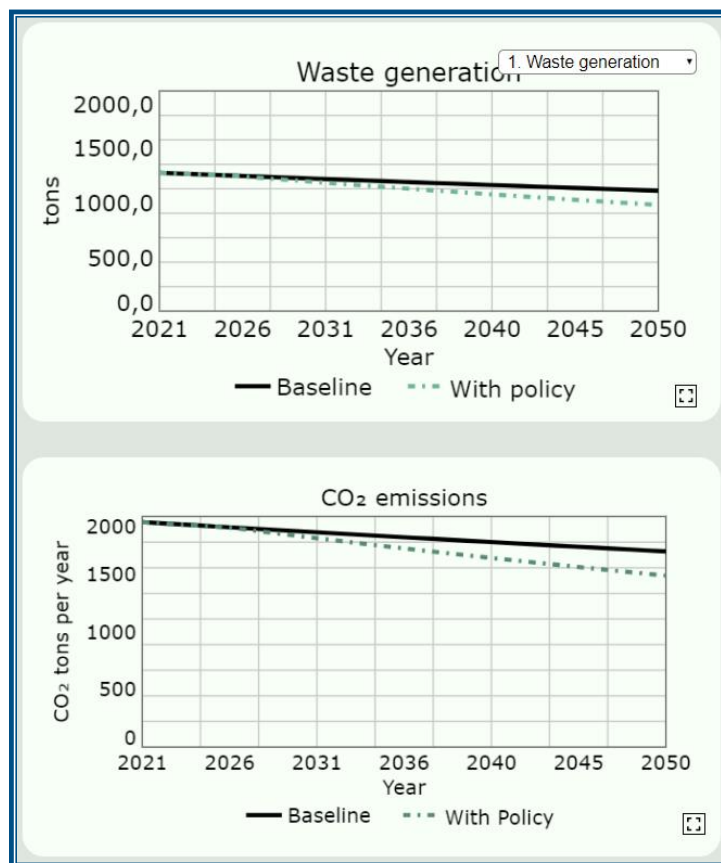
Policies

To assess the potential for further reduction of emissions, two waste-related policies were tested:

- **Reducing amount of waste generated** (IS 0,5 %/year)
- **Reducing the amount of waste landfilled** (Target share – Disposal 38 % (-14 %), Incineration 20 %, Recycling 30 % (+14 %), Biological treatment 12 %)

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

In total, the selected policies reduced the amount of waste generated by 292 tonnes and achieved 464 tCO₂ in emission savings in 2050 compared to the baseline scenario (11.8 % and 12.4 % reductions respectively).



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 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.

This sector does not provide a detailed representation of specific electricity- or heat-generation technologies in Pałecznica. Instead, the associated CO₂ emissions are calculated using aggregate emission factors for grid electricity and district heat.

The 2050 scenario without energy-production-specific policies reflects changes in energy demand resulting from policies implemented in the other sectors. Renewable electricity generated within those sectors is accounted for as an alternative supply source and reduces the amount of electricity required from the grid. It does not reduce the total end-use electricity demand.

Current situation

In 2021, the combined demand for electricity and district heat, including distribution losses, amounted to approximately 26 306 MWh/year. The associated emissions amounted to approximately 16 598 tCO₂/year.

Renewable electricity generation specified in other sectors provides approximately 725 MWh/year, or 6.5% of the required electricity supply. The remaining 10 350 MWh/year, corresponding to 93.5 %, is supplied by grid electricity.

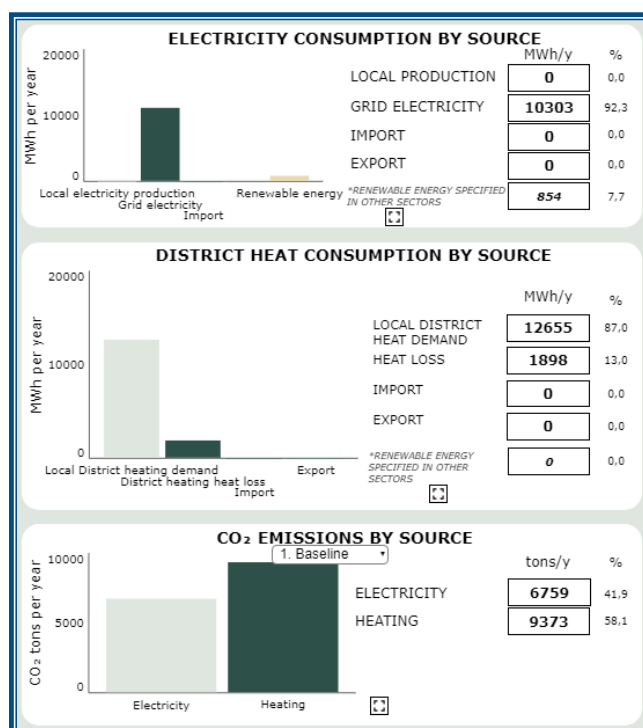
By 2050, end-use electricity demand decreases to approximately 10 728 MWh/year. When distribution losses are included, the required electricity supply reaches 11 157 MWh/year.

End-use district heat demand amounts to approximately 12 655 MWh/year in 2050. When district heat distribution losses of 1898 MWh/year are included, the required district heat supply reaches 14 554 MWh/year. No additional local heat-production technologies, energy imports or energy exports are included in the modelled scenario.

Electricity-related emissions are calculated by applying a fixed grid-electricity emission factor of 0.656 tCO₂/MWh to the remaining grid electricity after renewable electricity generation has been deducted. District-heat-related emissions are calculated using an aggregate emission factor of approximately 0.644 tCO₂/MWh, applied to the required district heat supply, including distribution losses.

Consequently, annual emissions associated with grid electricity amount to approximately 6759 tCO₂/year in 2050, while emissions associated with district heat amount to approximately 9373 tCO₂/year. Electricity accounts for approximately 41.9 % and district heat for 58.1 % of the combined emissions.

Overall, the combined demand for electricity and district heat, including distribution losses, decreases from approximately 26 306 MWh/year in 2021 to 25 711 MWh/year in 2050, corresponding to a reduction of approximately 2.3 %. Associated annual CO₂ emissions decrease from approximately 16 598 to 16 131 tCO₂/year, representing a reduction of approximately 2.8 % over the modelling period.



Policies

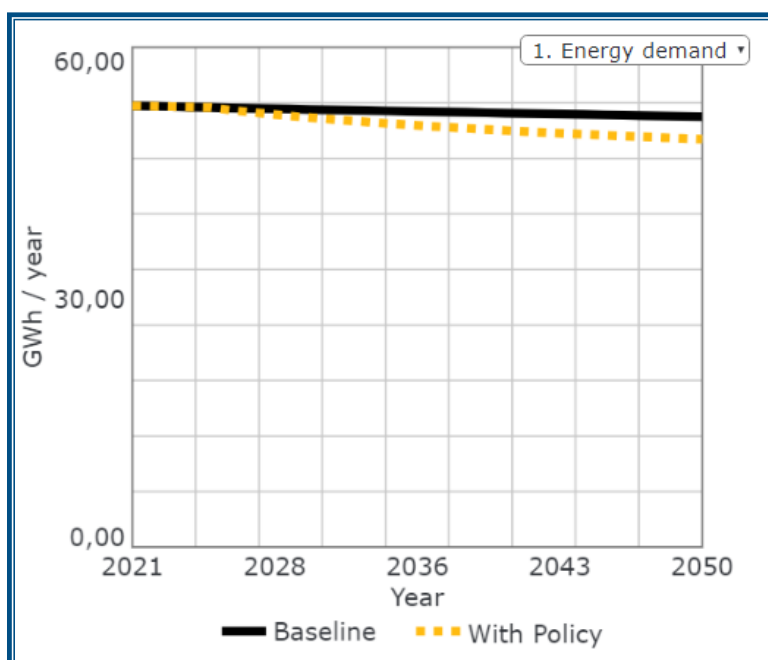
No additional policies targeting local energy production were tested for Pałecznicza Municipality. Therefore, all policy measures available in this sector were left inactive.

The baseline results presented in this sector already reflect the electricity and district heat demand resulting from policies applied in the other end-use sectors. As no additional local energy production policies were implemented, the policy scenario is identical to the baseline scenario, with no further changes in energy demand or CO₂ emissions.

4. RESULT OVERVIEW

The simulation results show that, under the baseline scenario, total annual energy demand in Pałecznica Municipality decreases from approximately 48.84 GWh in 2021 to 47.92 GWh in 2050. This corresponds to a reduction of approximately 0.92 GWh. The decrease is primarily driven by the assumed gradual population decline, although it is partly offset by the projected construction of additional municipal and residential buildings.

With the selected policy package, total annual energy demand decreases to approximately 46.3 GWh by 2050. Compared with the 2050 baseline scenario, the policies achieve annual energy savings of approximately 1619 MWh, corresponding to a reduction of 3.4 %. Compared with 2021, energy demand in the 2050 policy scenario is approximately 5.2 %, lower.



Total annual GHG emissions decrease from approximately 23.2 thousand tCO₂eq/year in 2021 to approximately 22.9 thousand tCO₂eq/year in the 2050 baseline scenario. With the selected policies, emissions decrease further to approximately 21.9 thousand tCO₂eq/year. Compared with the 2050 baseline scenario, annual GHG emissions decrease by approximately 0.96 thousand tCO₂eq/year, or around 4.2%.

Although the selected policy package produces measurable reductions in both energy demand and GHG emissions, the 2050 policy scenario remains above the illustrative 20 % emission-reduction target used in the simulation. Additional or more ambitious measures would therefore be required, particularly in residential and municipal buildings, private and public transport, and the decarbonisation of electricity and heat supply.

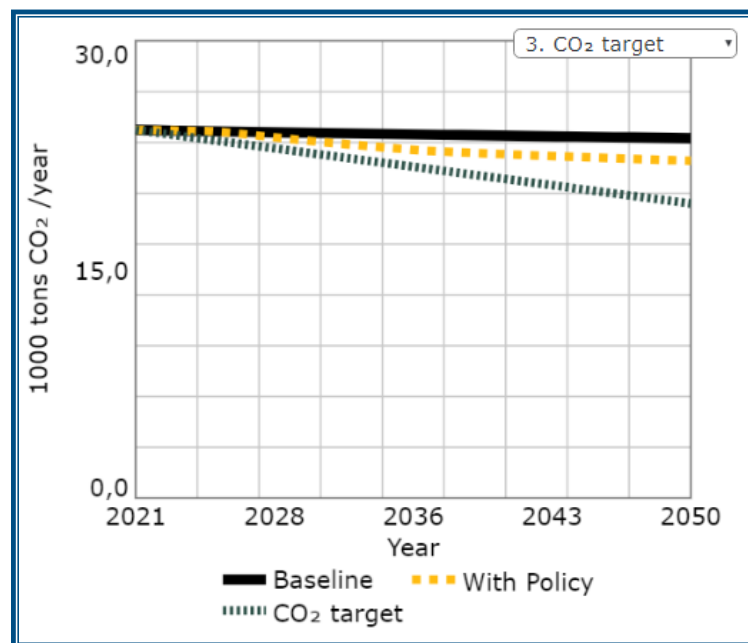


Table 1. Summary Table of Key Quantitative Results (2050)

Sector	Indicator	Results
Municipal buildings	Energy savings	90 MWh/year (2.8 %)
	Emission reduction	21 tCO ₂ /year (1.3 %)
	Renewable generation	0.129 MWh/year
Residential buildings	Energy savings	1524 MWh (4.4 %)
	Emission reduction	729 tCO ₂ (4.3%)
	Renewable generation	–
Public infrastructure	Energy savings	–
	Emission reduction	–
	Renewable generation	–
Other sectors	Energy savings	–
	Emission reduction	–
Municipal fleet	Energy savings	5 MWh/year (1.4 %)
	Emission reduction	1 tCO ₂ /year (0.7 %)
Public transport	Energy savings	–
	Emission reduction	–
Private transport	Energy savings	–
	Emission reduction	–
Waste management	Waste generation reduction	292 t/year (11.8 %)
	Emission reduction	464 tCO ₂ /year (12.4 %)
Local energy production	Energy savings	–
	Emission reduction	–
	Renewable generation	–
Peak emissions from imported electricity	tCO ₂	–

5. LINK WITH PAŁECZNICA PMECPF

5.1. Link between PMECPF and CommitClimate modelling

The table below provides a preliminary mapping between PMECPF and the sectors and measures analysed in the CommitClimate simulation report. The mapping reflects only the policies actually tested in the CommitClimate model.

Pałecznicza PMECPF	CommitClimate modelled sector / measures	Link and added value
Energy self-sufficient municipality / energy management	The model assesses energy demand and CO ₂ emissions across selected sectors: municipal buildings, residential buildings, transport, waste management and public infrastructure.	Strong conceptual link. The Development Strategy includes the objective of improving energy management and moving towards greater local energy self-sufficiency. The CommitClimate model supports this by quantifying energy demand and CO ₂ emission trajectories under selected measures. However, the model does not fully assess local energy production or full municipal energy self-sufficiency.
Municipal infrastructure and municipal buildings	Municipal buildings are included in the model. Tested measures include replacement of light bulbs, ventilation optimisation and small-scale RES-E generation through photovoltaics.	Strong sectoral link. The simulation supports assessment of energy-efficiency and renewable-energy measures in public buildings. This is also linked to the Pałecznicza feasibility study on the School and Kindergarten Complex. However, deep renovation and heating-system replacement in municipal buildings were not modelled.
Housing / residential buildings	Residential buildings are included in the model. The tested policy focuses on renovation of single-family houses, with 3% annual implementation speed and 10% expected savings.	Good link. The modelling supports assessment of residential building renovation and its effect on energy demand and CO ₂ emissions. However, the tested measure provides only limited reductions, indicating that deeper renovation and heating-system transformation may be needed for stronger impact.
Public infrastructure	Public infrastructure is included in the baseline through electricity consumption for public lighting, drinking water preparation and wastewater treatment. No additional public-infrastructure policy measures were tested.	Partial link. Public infrastructure is relevant for municipal climate and energy planning, but the current simulation provides limited additional policy assessment for this sector. Future modelling could include more detailed public lighting, water and wastewater efficiency measures.
Other sectors: commercial, tertiary, industry, construction, agriculture and forestry	Other sectors are included in the general model structure, but energy consumption and GHG emissions were not included in the Pałecznicza baseline inventory and projection; therefore, no policy analysis was conducted.	Limited link. These sectors may be relevant for the municipality's wider energy and climate transition, but they are not assessed in the current simulation due to data and scope limitations.
Transport and mobility	Municipal fleet, public transport and private transport are included in the baseline. The only tested transport policy is passenger car vehicle fleet decarbonisation in the municipal fleet, with electric vehicles as the target	Partial link. The model provides useful baseline information and shows the effect of municipal fleet decarbonisation. However, private transport and public transport are not fully addressed, leaving

	technology. No additional policies were tested for public transport or private transport.	significant potential for future transport-related scenario development.
Energy production, renewable energy and district heating	Local energy production is represented as an aggregated supply-side view of electricity and district heat demand. No detailed generation technologies or additional policies specific to this sector were modelled.	Partial link. Renewable energy and local energy-supply measures are relevant for the Development Strategy and SECAP-type planning, but the current CommitClimate simulation does not fully assess energy production, heating-system transformation or broader supply-side decarbonisation.
Waste management and circular economy-related emissions	Waste management is included in the model. Tested policies include reduction of waste generated and reduction of the amount of waste landfilled, with a shift towards higher recycling.	Good supplementary link. The model quantifies the effect of waste reduction and improved waste treatment structure. This can support waste-prevention and circular-economy-related planning, although waste remains a relatively small contributor to total emissions.
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 climate resilience are outside the main scope of the model.
Climate awareness and education	Not directly modelled. Model outputs may be used for communication and awareness raising.	Indirect link. The CommitClimate results can support stakeholder communication by providing visual and quantitative information on the effect of selected measures, but awareness-raising activities themselves are outside the model scope.
Monitoring and review of the PMECPF	Baseline and policy scenario results up to 2050; comparison of energy demand and CO ₂ emission trajectories.	Strong conceptual link. The model can support monitoring and review by comparing baseline development, policy scenarios and remaining emission-reduction gaps, while recognising that the simulation horizon, baseline year and sectoral scope may differ from formal municipal planning documents.

5.2. Main modelling results relevant for PMECPF review and future development

The CommitClimate simulation results show that the selected policy package produces limited but measurable reductions in both energy demand and GHG emissions compared with the baseline pathway.

In the baseline scenario, total annual energy demand decreases from approximately 48.84 GWh in 2021 to 47.92 GWh by 2050, mainly due to the assumed gradual population decline. This decrease is partly offset by the projected construction of additional municipal and residential buildings. With the selected policy package, annual energy demand decreases to approximately 46.30 GWh by 2050. Compared with the 2050 baseline scenario, this corresponds to annual energy savings of approximately 1 619 MWh, or 3.4%.

Annual GHG emissions decrease from approximately 23.2 thousand tCO₂/year in 2021 to approximately 22.9 thousand tCO₂/year in the 2050 baseline scenario. With the selected policy package, emissions decrease further to approximately 21.9 thousand tCO₂/year. According to the municipality-level

overview, this corresponds to annual emission savings of approximately 960 tCO₂/year, or 4.2%, compared with the 2050 baseline scenario.

At sector level, the quantified reductions are concentrated mainly in residential buildings, the municipal vehicle fleet, municipal buildings and waste management. Residential buildings remain the dominant contributor to both energy demand and GHG emissions in the Pałecznica simulation. The tested residential renovation policy reduces annual energy demand by approximately 4.4 % and emissions by 4.3 % compared with the 2050 sectoral baseline. Although this represents a measurable improvement, deeper renovation, higher renovation rates and heating-system decarbonisation would be required to achieve a more substantial long-term impact.

The results also highlight important gaps in the tested policy package. No additional policy measures were modelled for public infrastructure, private transport, public transport or other sectors. Local energy production is represented as an aggregated supply-side view, and its results reflect changes in electricity and district heat demand generated by policies applied in the end-use sectors. However, no additional policies specifically targeting electricity or heat supply were tested. The simulation therefore does not represent the municipality's full emission-reduction potential but rather demonstrates the effect of the selected and relatively limited set of measures.

In this sense, the CommitClimate modelling results can support the PMECPF monitoring and review process by helping to answer three practical questions:

- Are the existing and planned measures sufficient to reduce energy demand and emissions?
- Which sectors provide the largest reduction potential?
- Where are additional or more ambitious actions needed in future planning cycles?

5.3. Link with the Pałecznica feasibility study

The Pałecznica feasibility study prepared within CommitClimate focuses on a supply and exhaust ventilation system in the School and Kindergarten Complex in Pałecznica. The target sector is public buildings, and the main objective is energy efficiency improvement.

This feasibility study complements the Pałecznica simulation report by providing a more detailed assessment of one locally relevant priority area. It is closely linked to municipal public-building planning, indoor air quality, energy efficiency and the technical condition of public educational facilities.

The feasibility study explains that inefficient gravity ventilation systems in schools may contribute to poorer health and comfort of students and teaching staff, lower quality of the educational process, difficulties in maintaining the building in proper technical condition and possible issues with technical or sanitary requirements.

The planned investment involves the installation of a mechanical supply and exhaust ventilation system, together with related construction, sanitary, electrical and automation works. The study notes that the investment may deliver several types of benefits, including improved indoor air quality, better health and comfort, reduced energy consumption, emission reduction, improved energy balance, lower costs, budget savings, climate education and better management of the building.

This feasibility study adds practical value to the broader modelling exercise by showing how a specific public-building measure can support municipal energy-efficiency and climate objectives. It is particularly relevant because the CommitClimate simulation report also identifies the need for more ambitious measures in buildings and heating systems to achieve deeper emission reductions. The corresponding

feasibility study is available on the CommitClimate platform under the Resources and Training – Feasibility Studies section: <https://br-commitclimate.rtu.lv/resources-and-training/#feasibility-studies>

5.4. Municipality feedback and practical relevance

The Pałecznicza case demonstrates how the CommitClimate CO₂ simulator can support a rural municipality in understanding the structure of local energy demand and emissions and identifying where further policy effort may be needed.

The modelling results are particularly useful because they show that incremental measures alone are not sufficient to achieve deep decarbonisation. While the tested policy package provides measurable reductions, the overall effect remains limited. This finding is relevant for the future development and periodic review of the PMECPF, as it helps identify the need for stronger action in municipal buildings, residential buildings, transport and local energy supply.

The strongest practical relevance of the Pałecznicza simulation is linked to:

- identifying residential buildings as the dominant energy and emission sector in the modelled baseline;
- showing the limited impact of the currently tested residential renovation measure;
- supporting further discussion on deeper renovation and heating-system improvements;
- assessing selected energy-efficiency and small-scale renewable-energy measures in municipal buildings;
- assessing the effect of municipal passenger-car fleet decarbonisation;
- assessing waste-reduction and improved waste-treatment effects;
- linking the simulation results with a concrete public-building feasibility study;
- identifying sectors where further modelling and policy development are needed.

At the same time, the Pałecznicza case shows the importance of improving local data availability and expanding the scope of future scenario analysis. More detailed modelling of transport, local energy production, renewable energy, heating systems, other sectors and more ambitious building-renovation packages would improve the usefulness of future SECAP-related monitoring and review.

5.5. Scope and limitations

The CommitClimate simulation report should be understood as a supporting analytical document. It does not formally amend, replace or update the PMECPF or other municipal climate and energy planning document.

There are also differences in scope and time horizon. The Development Strategy 2030 and the broader municipal planning framework focus primarily on medium-term municipal development priorities, 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 SECAP target achievement, but rather as an additional tool for long-term reflection, monitoring and future planning.

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

Some SECAP areas are only partly covered or not covered by the simulation. Climate change adaptation, climate risk assessment and resilience measures are outside the main scope of the CommitClimate CO₂ model. Local energy production is included in the model structure, but no detailed policy analysis was conducted for Pałecznica due to the available baseline data. In addition, no additional policy measures were tested for private transport, public transport or other sectors.

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 PMECPF review and planning

The PMECPF provides the strategic basis for local energy and climate action. The CommitClimate simulation results can support its future monitoring and review by providing an additional scenario-based perspective on energy demand, emission trends and the potential impact of selected measures.

In practical terms, the model can be used to:

- compare baseline development with policy scenarios;
- identify sectors with the largest emission-reduction potential;
- assess whether selected measures are sufficient to move towards long-term climate objectives;
- highlight where additional or more ambitious measures are needed;
- support discussion on deeper building renovation and heating-system transformation;
- identify sectors where further modelling is needed;
- provide visual and quantitative material for stakeholder communication;
- support future updates or reviews of the PMECPF.

Overall, the CommitClimate Pałecznica simulation report is linked to the mitigation and energy-planning parts of Pałecznica's Municipal energy and climate planning framework, especially in the sectors of residential buildings, municipal buildings, municipal fleet and waste management. It provides a quantitative and scenario-based analytical layer that can complement the existing or emerging planning document and support future municipal climate and energy planning.

At the same time, it should be clearly understood as a supporting tool, not as a formal SECAP/SEAP replacement or amendment. Its main value is to show the limited effect of the currently tested policy package, identify sectors with the strongest untapped potential and highlight where broader and more ambitious measures would be needed for deeper long-term decarbonisation.

6. CONCLUSIONS

The scenario analysis for Pałecznica Municipality shows that the selected policy package produces limited but measurable reductions in both energy demand and greenhouse gas emissions by 2050. However, the overall effect remains insufficient to achieve deep decarbonisation because the tested measures cover only a limited number of sectors and do not introduce major structural changes in transport, heating or energy supply.

Compared with the 2050 baseline scenario, the selected policies reduce annual energy demand by approximately 1 619 MWh/year, or 3.4%, from 47.92 GWh/year to 46.30 GWh/year. Total annual GHG emissions decrease from approximately 22.8 thousand tCO₂eq/year in the 2050 baseline scenario to approximately 21.9 thousand tCO₂eq/year in the policy scenario, corresponding to a reduction of approximately 0.96 thousand tCO₂eq/year, or 4.0 %. Although these reductions are measurable, the results indicate that the selected policy package would not deliver the scale of emission reductions typically associated with long-term decarbonisation pathways. Additional and more ambitious measures would therefore be required, particularly in residential and municipal buildings, private and public transport, and the decarbonisation of electricity and heat supply.

Residential buildings remain the dominant contributor to municipal energy demand and emissions, accounting for approximately 72.3 % of total energy demand and around 71 % of GHG emissions in the 2050 baseline scenario. The tested renovation policy reduces annual residential energy demand by approximately 1524 MWh/year, or 4.4 %, and emissions by approximately 729 tCO₂/year, or 4.3 %. The policy more than offsets the additional demand and emissions associated with the projected construction of new residential buildings. Nevertheless, deeper renovation, a higher renovation rate and heating-system decarbonisation would be required to achieve a more substantial long-term impact.

In the municipal buildings sector, the selected lighting, ventilation and small-scale renewable-energy measures reduce annual energy demand by approximately 90 MWh/year, or 2.8 %, and emissions by approximately 21 tCO₂/year, or 1.3 %, compared with the 2050 sectoral baseline. The policy scenario remains slightly above the 2021 energy-demand level because the total municipal building area increases during the modelling period. Existing solar PV generation already covers most electricity demand for appliances, which limits the additional emission-reduction effect of electricity-efficiency measures once grid-electricity demand reaches zero. More ambitious measures addressing building envelopes and heating systems would therefore be needed to achieve deeper reductions.

The contribution of transport policies to the overall reduction remains limited. Decarbonisation of passenger cars in the municipal vehicle fleet results in energy savings of approximately 5 MWh/year, or 1.4 %, and emission savings of approximately 1 tCO₂/year, or 0.7 %. However, no additional policies were tested for private or public transport. Given the continuing contribution of private transport to municipal energy demand and emissions, this represents significant untapped reduction potential.

No additional policy measures were implemented in the public infrastructure sector, while other sectors, including commercial activities, industry, construction, agriculture and forestry, were not included in the Pałecznica baseline inventory and projection. Local energy production is represented in the model as an aggregated supply-side view of electricity and district heat demand, but no additional policies specifically targeting electricity or heat supply were tested. Consequently, the simulation does not assess the potential effect of broader electricity and heat decarbonisation.

Waste-management policies produce moderate improvements. By 2050, annual municipal waste generation decreases by approximately 292 tonnes/year, or 11.8 %, while associated emissions decrease by approximately 464 tCO₂/year, or 12.4 %, compared with the baseline scenario. Nevertheless, waste management represents a relatively small share of total municipal GHG emissions, limiting its contribution to the municipality-wide reduction.

Overall, the analysis demonstrates that incremental and sector-specific measures can reduce energy demand and emissions but are not sufficient to place Pałecznica on a pathway towards deep decarbonisation. A more comprehensive policy package would require deeper renovation of residential and municipal buildings, transformation of heating systems, measures targeting private and public transport, decarbonisation of electricity and heat supply, and broader sectoral coverage. The CommitClimate results should therefore be used as a supporting tool for identifying remaining policy gaps and informing future municipal energy and climate planning, periodic review, and scenario development.