



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

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This document presents an assessment of future energy demand and CO₂ emissions in Raciechowice 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 no population changes, 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 Raciechowice'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 Raciechowice 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

Raciechowice Municipality has adopted Sustainable Energy and Climate Action Plan (SECAP): *Plan działań na rzecz zrównoważonej energii i klimatu (SECAP) dla Gminy Raciechowice do roku 2030* / Sustainable Energy and Climate Action Plan for Raciechowice Municipality until 2030.

The SECAP was adopted by the Raciechowice Municipal Council on 27 March 2024 through Resolution No. LX/437/2024 as part of the municipality's participation in the Covenant of Mayors initiative and with support from the OwnYourSECAP project. The plan sets out long-term objectives for greenhouse gas emission reduction, climate change adaptation, improvement of energy efficiency, increase in renewable energy use and support for the municipality's transition towards climate neutrality.

According to available project materials, the SECAP aims to reduce CO₂ emissions in the municipality by 50 % by 2030 compared to the 1996 baseline year. The document also supports broader local objectives related to air quality improvement, energy efficiency, renewable energy development and adaptation to climate change.

The CommitClimate simulation report does not replace, formally amend or update the Raciechowice SECAP2030. 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.

The added value of the CommitClimate modelling is that it allows selected policy measures to be tested quantitatively and compared with a baseline development pathway. This helps assess whether selected actions are sufficient to reduce energy demand and CO₂ emissions, and where additional or more ambitious measures may be needed in future planning cycles.

2. Scope of the CommitClimate simulation report

The CommitClimate simulation report for Raciechowice 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 no population change, which results in relatively stable energy demand in several sectors.

The tested policy package focuses mainly on incremental improvements, including lighting replacement in municipal buildings, renovation of single-family houses, renewable energy use in public lighting, reduction of wastewater generation and reduction of municipal waste generation.

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

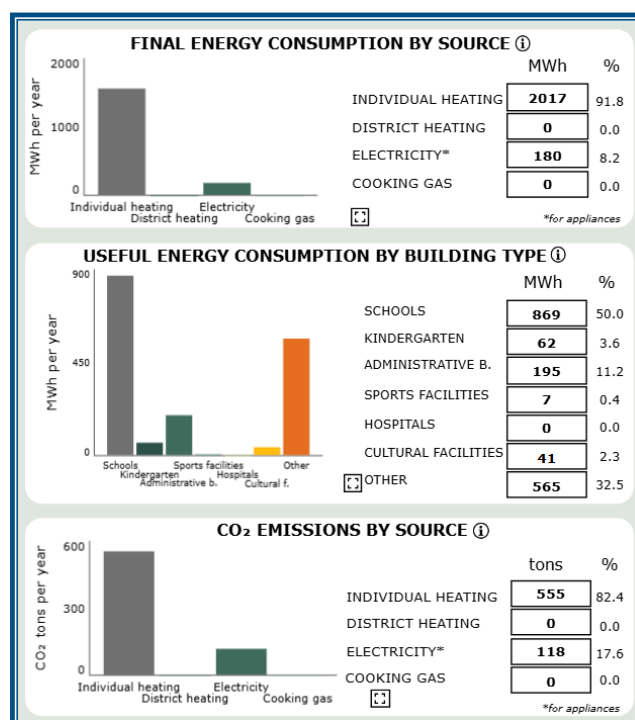
In the 2021 baseline, the total area of municipal buildings in Raciechowice municipality amounts to 12 878 m². Schools account for the largest area, with 6436 m², followed by other municipal buildings (4187 m²), administrative buildings (1444 m²), kindergartens (462 m²), cultural facilities (300 m²) and sports facilities (49 m²). No hospital area is included in the model.

Annual final energy consumption in municipal buildings amounts to approximately 2197 MWh/year. Individual heating accounts for 2017 MWh/year, or 91.8 % of total final energy consumption, while electricity used for appliances accounts for 180 MWh/year, or 8.2 %. No district heating or cooking-gas consumption is included. Electricity used for heating is included under individual heating rather than appliance electricity.

Useful energy consumption by building type amounts to approximately 1739 MWh/year. Schools account for 869 MWh/year (50.0 %), followed by other municipal buildings with 565 MWh/year (32.5 %), administrative buildings with 195 MWh/year (11.2 %), kindergartens with 62 MWh/year (3.6 %), cultural facilities with 41 MWh/year (2.3 %) and sports facilities with 7 MWh/year (0.4 %). The difference between useful energy consumption by building type and final energy consumption by source reflects heating-system efficiency and associated energy losses.

The model uses an average specific heat demand of 121 kWh/m²/year and specific appliance-electricity consumption of 14 kWh/m²/year across the municipal building stock.

Annual CO₂ emissions from municipal buildings amount to approximately 673 tCO₂/year. Individual heating is responsible for 555 tCO₂/year, or 82.4 % of sectoral emissions, while appliance electricity accounts for 118 tCO₂/year, or 17.6 %. As no construction, demolition or other changes in the municipal building stock are assumed, baseline energy demand and emissions remain unchanged through 2050.



Policies

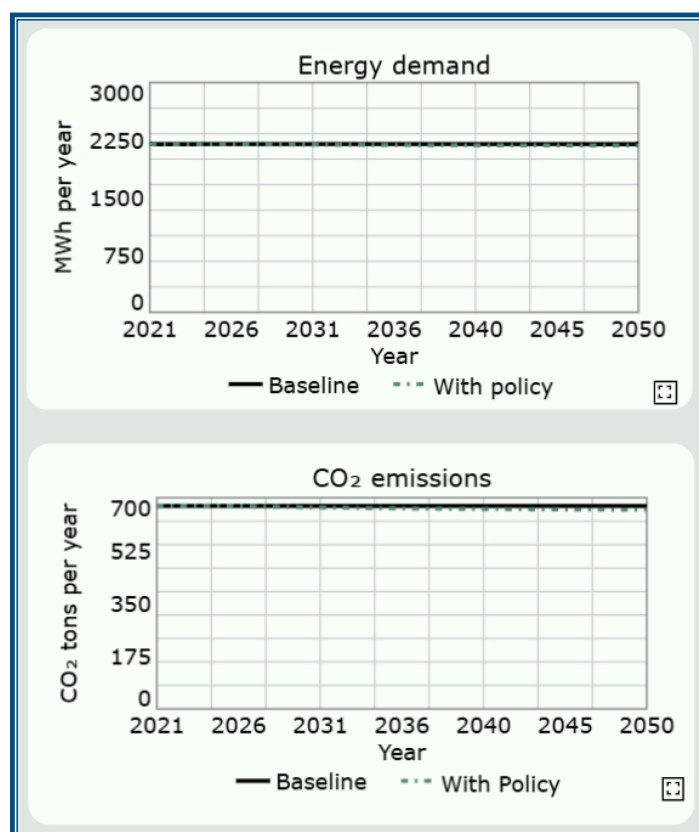
In the municipality buildings sector, the following policy was proposed:

- **Replacement of light bulbs** (*Implementation speed (IS)* 10 %/year, *Expected savings (ES)* 80 %)

The policy is implemented between 2025 and 2050. It affects only the electricity used for lighting and does not change heat demand or the total municipal building area.

By 2050, the policy reduces annual energy demand by approximately 19 MWh/year, from 2197 MWh/year in the baseline scenario to approximately 2178 MWh/year in the policy scenario. This corresponds to an energy-demand reduction of approximately 0.9 %.

Annual CO₂ emissions decrease by approximately 12 tCO₂/year, from 673 tCO₂/year in the baseline scenario to approximately 661 tCO₂/year in the policy scenario, corresponding to a reduction of approximately 1.8 %. The relatively small effect reflects the limited share of lighting electricity in the total energy demand of 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 the 2021 baseline, the total area of residential buildings in Raciechowice municipality amounts to 187 528 m². For modelling purposes, the building area is distributed equally among the four residential building categories.

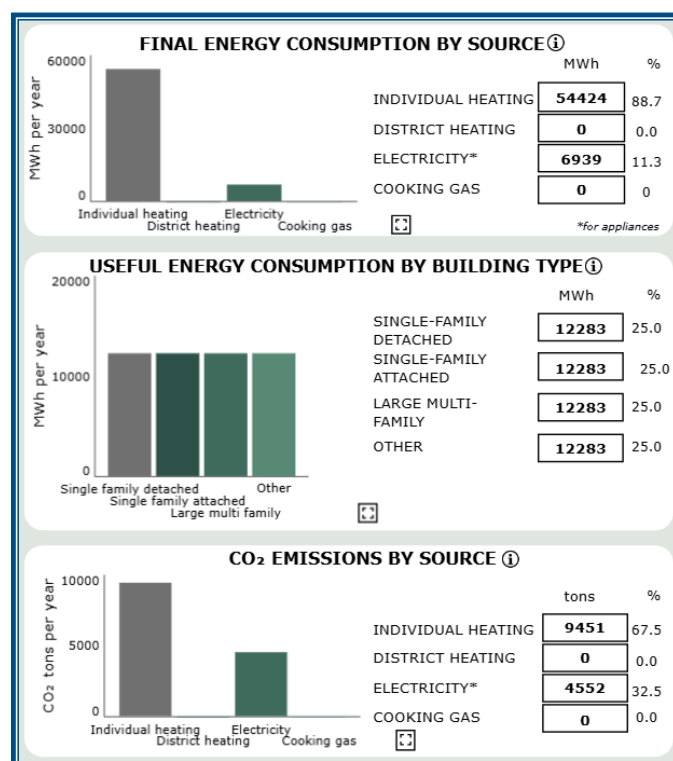
Annual final energy consumption in residential buildings amounts to approximately 61 363 MWh/year. Individual heating accounts for 54 424 MWh/year, or 88.7 % of final energy consumption, while electricity used for appliances accounts for 6939 MWh/year, or 11.3 %. No district-heating or cooking-gas consumption is included in the current residential baseline. Electricity used for heating is included under individual heating rather than appliance electricity.

Useful energy consumption amounts to approximately 49 132 MWh/year. Each of the four residential building categories accounts for approximately 12 283 MWh/year, or 25 % of the total useful energy demand. The difference between useful and final energy consumption reflects heating-system efficiency and associated conversion losses.

The model uses an average specific heat demand of 225 kWh/m²/year and specific appliance-electricity consumption of 37 kWh/m²/year across the residential building stock.

Annual CO₂ emissions from residential buildings amount to approximately 14 003 tCO₂/year. Individual heating is the largest emission source, accounting for 9451 tCO₂/year, or 67.5 % of residential-building emissions. Appliance electricity accounts for 4552 tCO₂/year, or 32.5 %.

Based on the corrected municipality-wide results, residential buildings account for approximately 69.7 % of total modelled energy demand and 57.4 % of total modelled emissions. As no population or residential building-stock change is assumed, baseline energy demand and emissions remain unchanged through 2050.



Policies

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

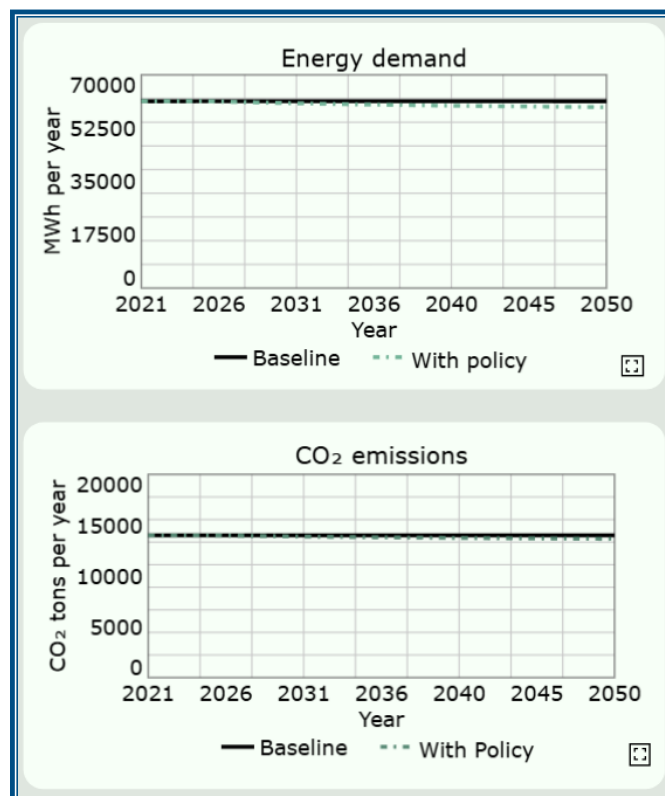
- **Renovation of single-family houses** (*IS 5 %/year, ES 10 %*)

The policy is implemented between 2025 and 2050 and applies to the single-family detached and single-family attached building categories.

By 2050, annual residential energy demand decreases by approximately 1966 MWh/year, from 61 362 MWh/year in the baseline scenario to approximately 59 396 MWh/year in the policy scenario. This corresponds to energy savings of approximately 3.2 %.

Annual CO₂ emissions decrease by approximately 341 tCO₂/year, from 14 003 tCO₂/year in the baseline scenario to approximately 13 661 tCO₂/year in the policy scenario. This corresponds to an emission reduction of approximately 2.4 %.

Following the introduction of the renovation policy in 2025, energy demand and CO₂ emissions gradually decrease as a growing share of the eligible single-family building stock is renovated. The policy scenario remains below the unchanged baseline pathway throughout the remainder of the modelling period. Nevertheless, the relatively modest reduction indicates that broader renovation coverage, deeper energy savings and measures targeting residential heating systems 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.

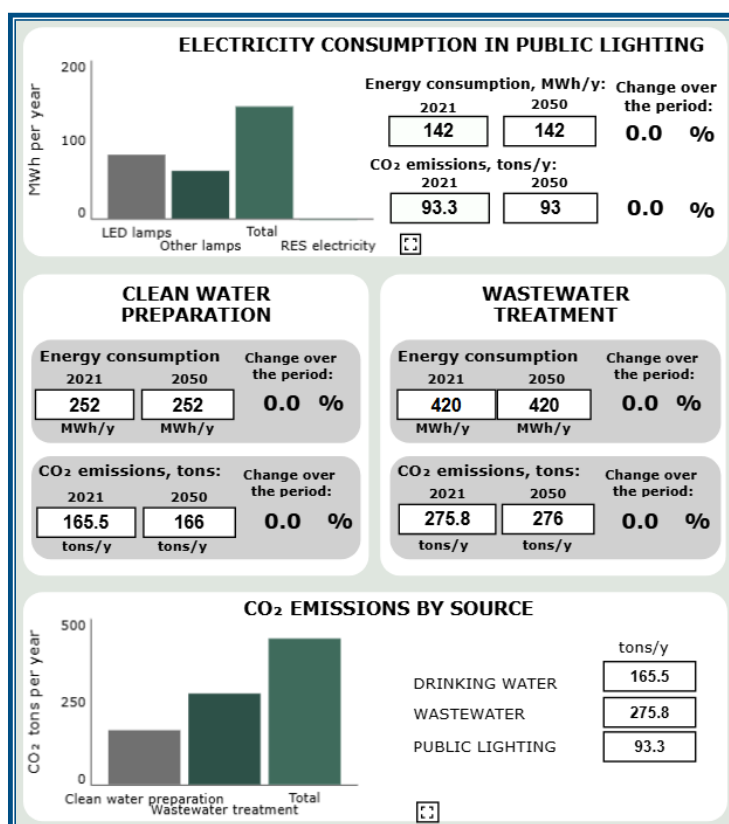
Current situation

In the 2021 baseline, annual electricity consumption in public infrastructure amounts to approximately 815 MWh/year.

Wastewater treatment is the largest electricity consumer, accounting for approximately 420 MWh/year, or 51.5 % of total sectoral energy demand. Clean-water preparation accounts for 252 MWh/year, or 30.9 %, while public lighting accounts for 142 MWh/year, or 17.4 %. The one-MWh difference between the displayed total and the rounded component values results from rounding.

Annual CO₂ emissions from public infrastructure amount to approximately 535 tCO₂/year. Wastewater treatment accounts for approximately 275.8 tCO₂/year, clean-water preparation for 165.5 tCO₂/year and public lighting for 93.3 tCO₂/year.

Based on the corrected municipality-wide results, public infrastructure represents approximately 0.9 % of total modelled energy demand and 2.2 % of total modelled emissions. As no population or activity change is assumed in the baseline, energy consumption and emissions remain unchanged through 2050.



Policies

To assess the potential for reduction of emissions, the following public infrastructure-policies were tested:

- **RES usage in public lighting** (*IS 3 %/year*)
- **Wastewater generation decrease** (*IS 5 %/year*)

Both policies are implemented between 2025 and 2050.

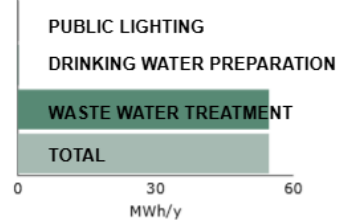
By 2050, annual public-infrastructure energy demand decreases by approximately 55 MWh/year, from 815 MWh/year in the baseline scenario to approximately 760 MWh/year in the policy scenario. This corresponds to energy savings of approximately 6.7 %.

The reduction in final energy demand results from reduced wastewater generation. Renewable electricity used in public lighting does not reduce total electricity consumption; instead, it replaces part of the electricity otherwise supplied by the grid and therefore reduces the associated emissions.

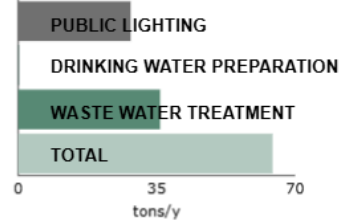
Annual CO₂ emissions decrease by approximately 64 tCO₂/year, from approximately 535 tCO₂/year in the baseline scenario to approximately 471 tCO₂/year in the policy scenario. This corresponds to an emission reduction of approximately 12.0 %.

By 2050, renewable electricity used in public lighting amounts to approximately 43.32 MWh/year, corresponding to approximately 5.3 % of total public-infrastructure energy demand. The combined policies therefore produce a relatively small absolute reduction at municipality level but a measurable improvement within the public infrastructure sector.

ACHIEVED ENERGY SAVINGS



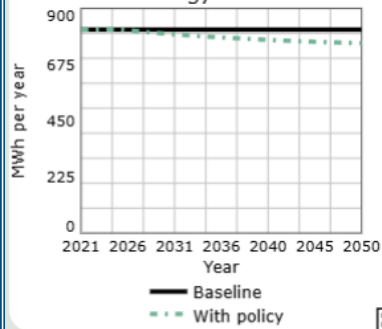
ACHIEVED CO₂ EMISSION SAVINGS



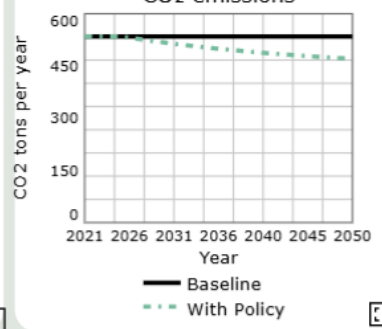
POLICY RESULTS

Energy savings, MWh/y	55	CO ₂ emission savings, tons/year	64	RES electricity, MWh/y	43.32
Energy savings, %	-6.7	CO ₂ emission savings, %	-12.0	RES share, % of electricity	5.3

Energy demand



CO₂ emissions



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

Energy consumption and GHG emissions from commercial and tertiary activities, industry and construction, agriculture and forestry, and other economic activities are not included in the Raciechowiec baseline scenario because sufficiently detailed local input data were not available.

Consequently, the model displays zero energy demand and zero emissions for these activities throughout the modelling period. This should not be interpreted as evidence that the sectors do not consume energy or generate emissions in the municipality. Instead, it represents a data and modelling-scope limitation.

Policies

No policy measures were tested in the Other Sectors module because the corresponding baseline energy consumption and emissions were not quantified.

The potential effects of energy-efficiency improvements, renewable-energy use, fuel switching or other decarbonisation measures in commercial, industrial, construction, agricultural and forestry activities are therefore not represented in the current scenario results. Additional local data would be required to include these sectors in future modelling and to improve comparability with the complete municipal SECAP inventory.

3.5. TRANSPORT

The transport module covers the municipal vehicle fleet, public passenger transport and private passenger transport. Energy demand and CO₂ emissions are calculated using assumptions concerning passenger-travel demand, vehicle use, occupancy, fuel economy and fuel distribution.

The results are modelled estimates rather than calculations based on actual fuel invoices. Goods transport is not quantified because the number of registered trucks is set to zero. Setting the number of trucks to zero reflects a lack of suitable input data and the scope of the model and should not be interpreted as the absence of freight transport in the municipality. Consequently, the results cover passenger transport only and should not be compared directly with a complete territorial transport inventory.

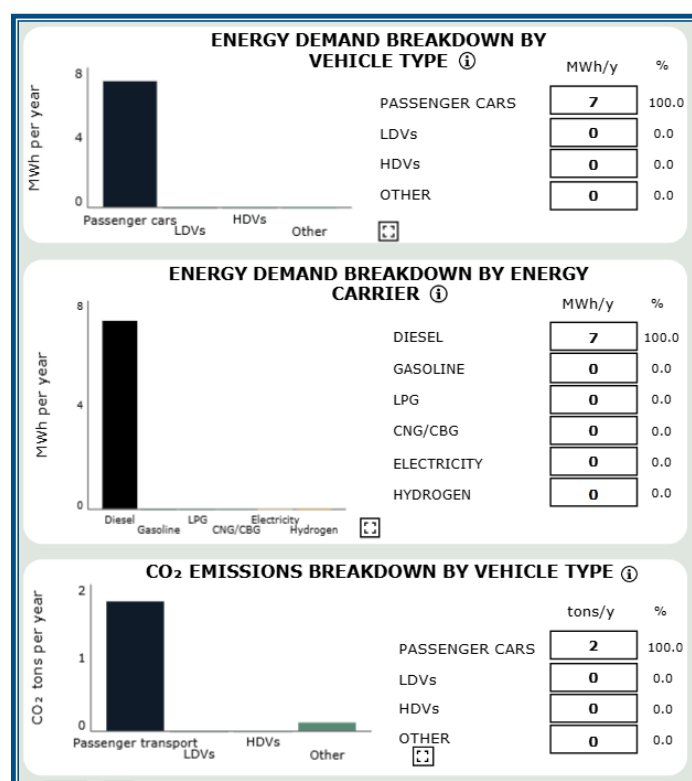
Current situation

Municipal vehicle fleet

The municipal vehicle fleet consists of one diesel passenger car. Based on the assumed annual mileage and vehicle-specific fuel consumption, annual energy demand from the municipal fleet amounts to approximately 7 MWh/year.

Diesel accounts for 100 % of the fleet's energy consumption. Annual CO₂ emissions amount to approximately 2 tCO₂/year. Both the energy demand and emissions from the municipal vehicle fleet are negligible in comparison with municipality-wide totals.

The baseline scenario assumes no change in the municipal fleet, its annual mileage, fuel economy or fuel structure. Energy demand and emissions therefore remain unchanged through 2050.



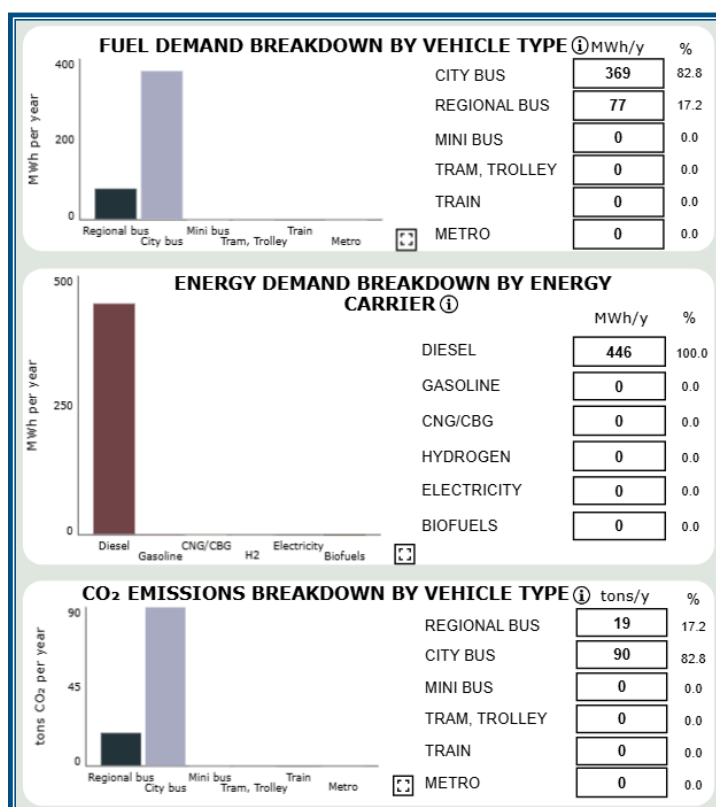
Public transport

Under the current passenger-travel assumptions, annual public-transport demand amounts to approximately 7.5 million passenger-kilometres.

Annual public-transport energy demand amounts to approximately 446 MWh/year. The model assigns 369 MWh/year, or 82.8 %, to the city/local bus category and 77 MWh/year, or 17.2 %, to regional buses. These categories represent bus services used by residents and other commuters; no tram, trolleybus, metro or train energy demand is included.

Diesel supplies 100 % of the modelled public-transport energy demand. Annual CO₂ emissions amount to approximately 109 tCO₂/year, of which city/local buses account for approximately 90 tCO₂/year and regional buses for approximately 19 tCO₂/year.

Public transport represents approximately 0.5 % of total modelled municipal energy demand and 0.4 % of total modelled emissions.



Private transport

Under the current input assumptions, annual private-transport demand amounts to approximately 39.1 million passenger-kilometres. All modelled private-transport energy demand is attributed to private cars.

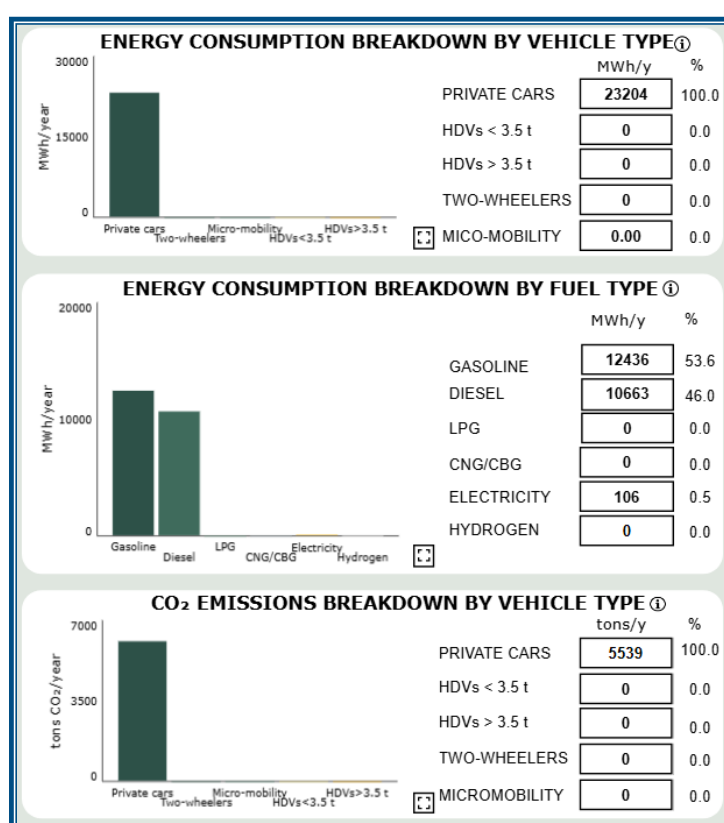
Annual private-transport energy consumption amounts to approximately 23 204 MWh/year, representing approximately 26.4 % of total modelled municipal energy demand. Gasoline is the largest energy carrier, accounting for 12 436 MWh/year, or 53.6 %. Diesel accounts for 10 663 MWh/year, or 46.0 %, while

electricity accounts for approximately 106 MWh/year, or 0.5 %. The one-MWh difference between the displayed total and the sum of the rounded fuel values results from rounding.

Annual CO₂ emissions from private transport amount to approximately 5539 tCO₂/year, corresponding to approximately 22.7 % of total modelled municipal emissions.

The baseline scenario assumes no changes in passenger-travel demand, modal shares, vehicle composition, fuel economy or fuel distribution. Private-transport energy demand and emissions therefore remain unchanged through 2050.

Taken together, the municipal fleet, public transport and private transport account for approximately 23 657 MWh/year, or 26.9 % of total modelled municipal energy demand. Their combined emissions amount to approximately 5650 tCO₂/year, or 23.1 % of total modelled municipal emissions.



Policies

No transport policy measures were tested in the Raciechowice scenario. The policy pathway is therefore identical to the baseline pathway for the municipal fleet, public transport and private transport.

The results consequently do not quantify the potential effects of modal shift, reduced passenger-car use, vehicle electrification, improved fuel efficiency, renewable fuels or public-transport improvements. Goods transport, freight traffic and through-traffic are also outside the quantified scope.

Transport therefore represents one of the most important areas of untapped reduction potential in the current simulation. More detailed passenger- and freight-transport data would be required to develop transport scenarios that are more directly comparable with the complete Raciechowice SECAP inventory.

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 calculation assumes annual municipal waste generation of 357 kg/capita/year. Based on this assumption, approximately 2285 tonnes of municipal waste are generated annually in Raciechowiec municipality.

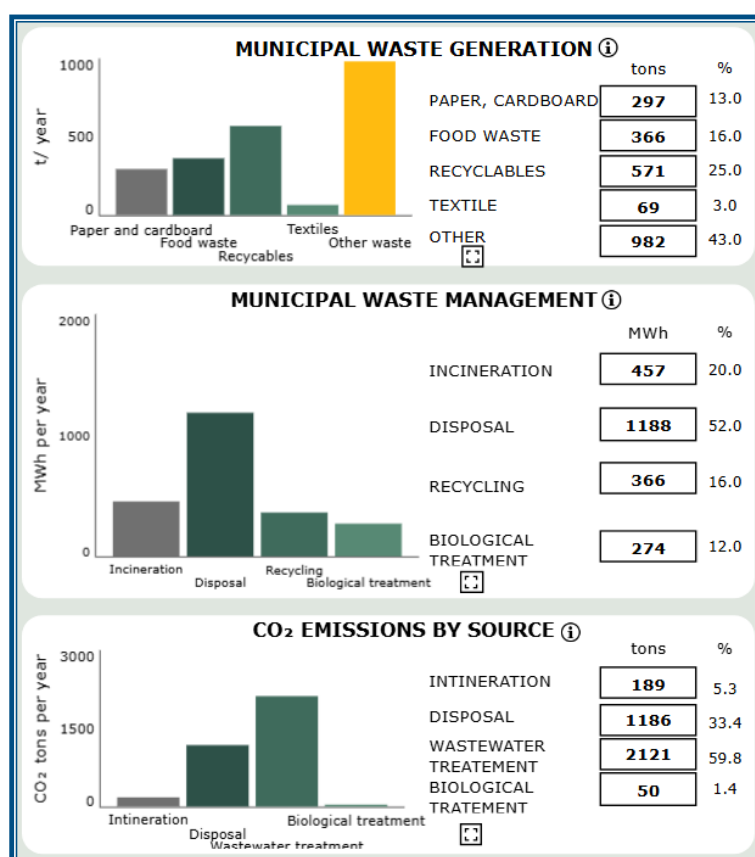
Other waste is the largest waste category, accounting for approximately 982 t/year, or 43 % of total municipal waste. Recyclable materials account for 571 t/year (25 %), food waste for 366 t/year (16 %), paper and cardboard for approximately 297 t/year (13 %), and textile waste for 69 t/year (3 %).

Of the total municipal waste generated, approximately 1188 t/year, or 52 %, is disposed of. Incineration accounts for 457 t/year (20 %), recycling for 366 t/year (16 %), and biological treatment for 274 t/year (12 %).

Annual GHG emissions associated with waste management amount to approximately 3546 tCO₂eq/year.

Waste management accounts for approximately 14.5 % of total modelled municipal GHG emissions. As the baseline scenario assumes no population change and no change in per-capita waste generation, waste composition or treatment shares, annual waste generation and associated emissions remain unchanged through 2050.

Waste-generation and waste-treatment quantities are expressed in tonnes per year. The MWh labels currently visible in parts of the simulator screenshot are legacy display errors and do not represent energy consumption.



Policies

To assess the potential for further reduction of emissions, the following policy was tested:

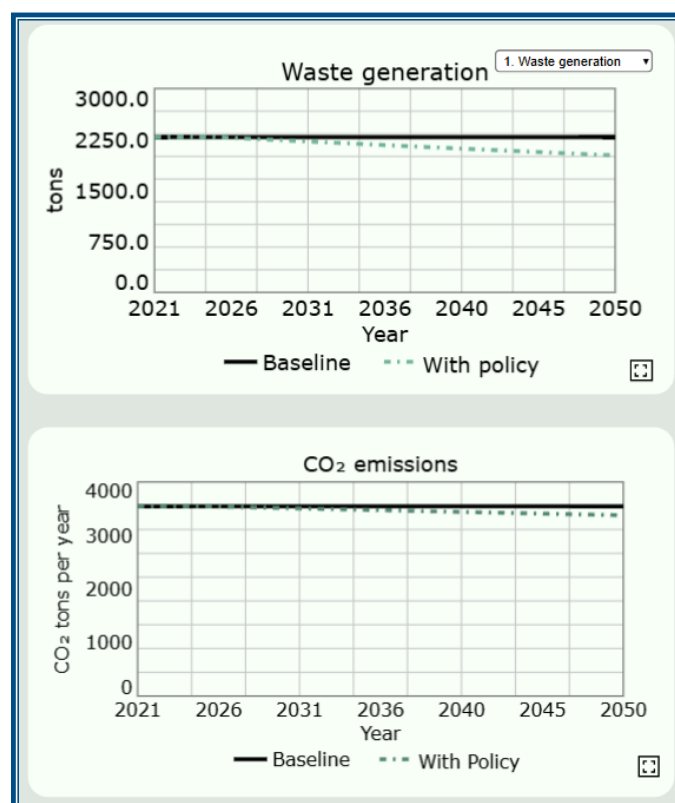
- **Reducing amount of waste generated** (IS 0,5 %/year)

The policy is implemented between 2025 and 2050.

By 2050, annual municipal waste generation decreases by approximately 269 tonnes/year, from 2285 tonnes/year in the baseline scenario to approximately 2016 tonnes/year in the policy scenario. This corresponds to a reduction of approximately 11.8 %.

Annual GHG emissions decrease by approximately 167 tCO₂eq/year, from 3546 tCO₂eq/year in the baseline scenario to approximately 3379 tCO₂eq/year in the policy scenario. This corresponds to an emission reduction of approximately 4.7 %.

The percentage reduction in emissions is smaller than the reduction in total waste generation because the policy reduces the overall amount of waste but does not substantially change the relative composition of waste or the distribution among treatment methods. More substantial emission reductions would require additional measures targeting waste prevention, treatment practices and the most emission-intensive waste-management processes.



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.

Current situation

The Local Energy Production module provides a supply-side representation of the electricity and district heat required to meet energy demand in the end-use sectors. It does not represent an additional energy-consuming sector, and its results must not be added to the municipality-wide totals, as the associated emissions are already allocated to the relevant end-use sectors.

In 2021, end-use electricity demand amounted to approximately 9062 MWh/year. When distribution losses were included, the required electricity supply increased to approximately 9424 MWh/year and was supplied entirely by grid electricity. No district heat demand was included, reflecting the absence of a centralised district-heating system in Raciechowice municipality.

As no district heat demand was specified, the combined electricity and district heat supply, including distribution losses, was equal to the required electricity supply and amounted to approximately 9424 MWh/year in 2021. Grid-electricity emissions were calculated using a fixed emission factor of 0.656 tCO₂/MWh and amounted to approximately 6182 tCO₂/year. No district-heat-related emissions were generated.

By 2050, after the policies selected in the end-use sectors have been applied, end-use electricity demand decreases to approximately 8987 MWh/year, while the required electricity supply including distribution losses reaches approximately 9347 MWh/year. Renewable electricity specified in the public infrastructure sector provides approximately 43 MWh/year, while the remaining approximately 9304 MWh/year is supplied by grid electricity.

No district heat demand or heat-distribution losses are included in 2050. The combined electricity and district heat supply consequently decreases from approximately 9424 MWh/year in 2021 to 9347 MWh/year in 2050, representing a reduction of approximately 0.8 %. Associated annual CO₂ emissions decrease from approximately 6182 to 6103 tCO₂/year, corresponding to a reduction of approximately 1.3 %.

No additional local electricity- or heat-production technologies, energy imports or energy exports were specified. The absence of additional local generation technologies in the simulation results does not indicate their absence in reality. Rather, it indicates that these technologies were not represented in the input data used for the CommitClimate modelling exercise.

Policies

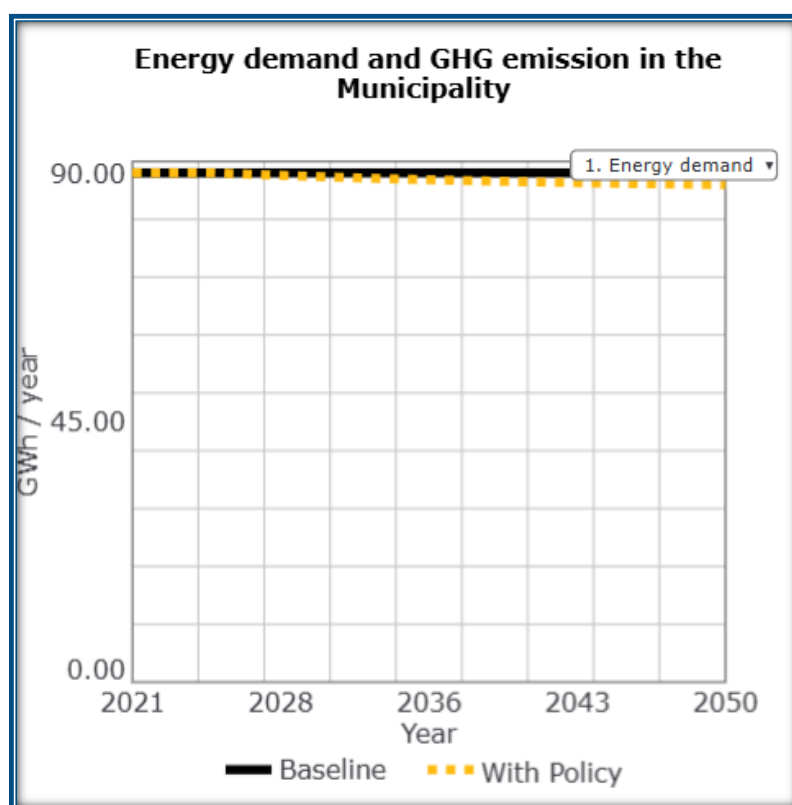
No additional policies specifically targeting local energy production or energy supply were tested in the Raciechowice scenario. Consequently, the baseline and policy pathways displayed on the Local Energy Production policy page are identical, and the sector-specific policy results show zero additional energy savings and zero additional emission savings.

The results should be interpreted as an aggregated electricity-supply view of the changes generated in the end-use sectors rather than as a technology-specific local energy-production pathway. Future scenarios could build upon the renewable energy and energy storage measures already identified in the SECAP by evaluating alternative development pathways, alongside grid-electricity decarbonisation and other supply-side interventions.

4. RESULT OVERVIEW

The simulation results show that total annual energy demand in the baseline scenario amounts to approximately 88.03 GWh/year and remains unchanged through 2050, as no population or activity change is assumed.

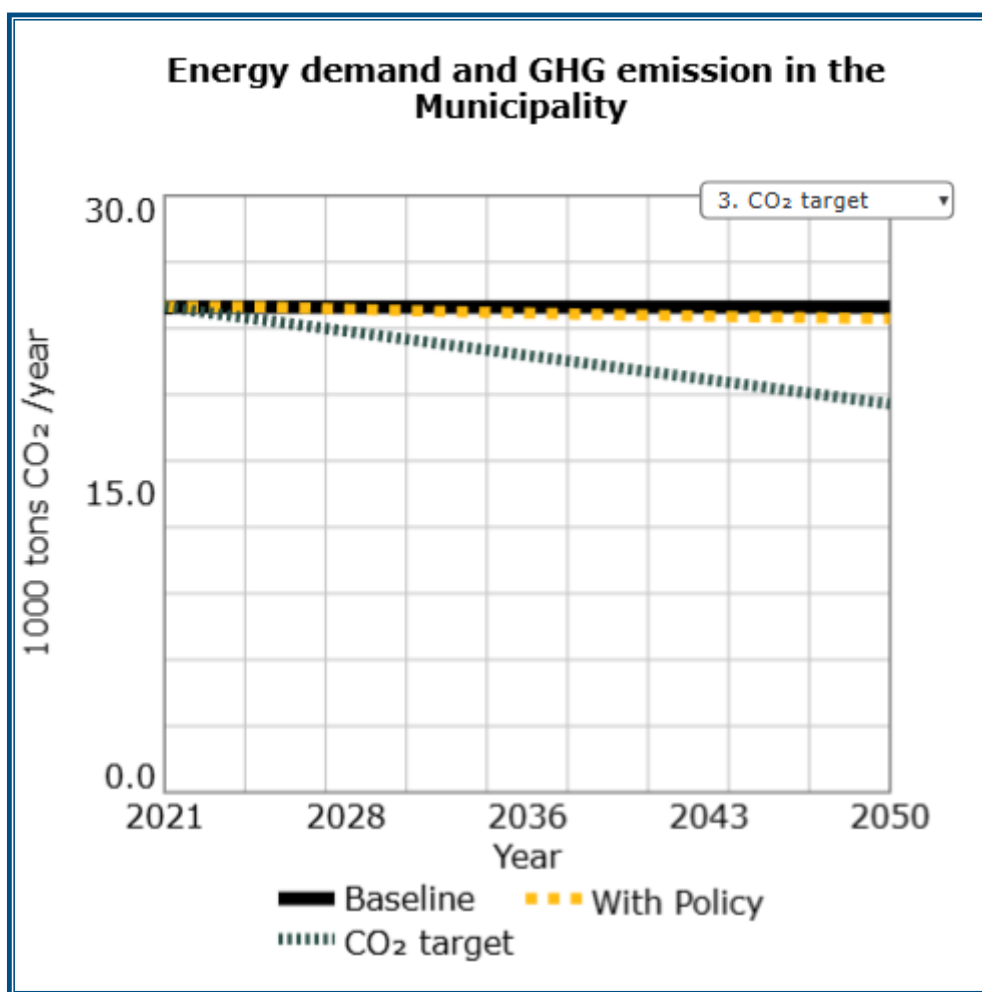
With the selected policy package, annual energy demand gradually decreases to approximately 85.99 GWh/year by 2050. This corresponds to energy savings of approximately 2.04 GWh/year, or 2040 MWh/year, representing a reduction of approximately 2.3 % compared with the baseline scenario.



Annual GHG emissions in the baseline scenario amount to approximately 24.4 thousand tCO₂eq/year and remain stable throughout the modelling period. In the policy scenario, emissions gradually decrease to approximately 23.8 thousand tCO₂eq/year by 2050. This corresponds to annual emission savings of approximately 0.6 thousand tCO₂eq/year, or approximately 2.5 %.

The reductions result from the policies applied in municipal buildings, residential buildings, public infrastructure and waste management. No additional policy effects are generated in transport, other sectors or the Local Energy Production module.

Although the selected policy package reduces both energy demand and emissions, the policy scenario remains above the modelled CO₂ target trajectory. The results therefore indicate that additional or more ambitious policy measures would be required to achieve a substantially greater reduction by 2050.



5. LINK WITH RACIECHOWICE SECAP2030

5.1. Link between Raciechowice SECAP2030 sectors and CommitClimate modelling

The table below summarises how the main Raciechowice SECAP2030 planning areas correspond to the sectors and measures analysed in the CommitClimate simulation report. The comparison is intended to show how the modelling results can complement the SECAP by providing an additional scenario-based perspective on energy demand, emissions and the potential effects of selected measures. The CommitClimate simulation should not be interpreted as a full representation of all measures included in the SECAP.

Raciechowice SECAP2030 planning area	CommitClimate modelled sector / measures	Link and added value
Municipal infrastructure and municipal buildings	Municipal buildings are included in the model. The tested policy focuses on replacement of light bulbs in municipal buildings,	Strong sectoral relevance, but focused policy scope. Municipal buildings account for approximately 2.5 % of modelled energy demand and 2.8 % of emissions. The tested lighting-replacement measure produces only small reductions, while deeper building renovation and heating-system improvements were not included in the selected scenario.
Housing / residential buildings	Renovation of single-family houses was modelled, starting in 2025 and continuing to 2050.	Strong sectoral relevance. Residential buildings are the largest modelled energy-consuming and emission-producing sector. The renovation measure provides the largest quantified energy saving in the tested policy package, but broader renovation coverage, deeper energy savings and heating-system decarbonisation would be required for a substantial reduction.
Public infrastructure	Public infrastructure is represented through electricity consumption for public lighting, drinking water preparation and wastewater treatment. Tested policies include RES use in public lighting and reduction of wastewater generation.	Good link. The model can support evaluation of renewable electricity use in public lighting and efficiency-related improvements in public infrastructure. The absolute reduction potential is small, but the results provide useful evidence for operational and infrastructure-related SECAP 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 Raciechowice baseline inventory and projection; therefore, no policy analysis was conducted.	Partial link. These sectors may be relevant for the municipality's wider energy and climate transition, but the current simulation does not include them due to data and scope limitations.
Transport and mobility	Municipal fleet, public transport and private transport are included in the baseline. No	Partial link. Passenger transport is a major modelled energy-demand and emission

	additional transport policy measures were tested in the Raciechowice simulation.	source, but the current scenario does not include freight transport, through-traffic, modal shift, vehicle electrification, renewable fuels or demand-reduction measures. The transport results therefore do not represent a complete territorial transport inventory.
Energy production, renewable energy and district heating	The Local Energy Production module provides a supply-side representation of the electricity and district heat required to meet demand in the end-use sectors, including distribution losses and the associated CO ₂ emissions. The 2050 pathway shown in this module already reflects the effects of policies applied in the end-use sectors. No additional policies targeting local energy production or energy-supply decarbonisation were tested, and no additional local generation technologies, energy imports or energy exports were specified.	Partial but relevant link. The module provides an aggregated electricity-supply view but does not model a technology-specific local energy-production pathway. Approximately 43 MWh/year of renewable electricity in 2050 originates from the public-infrastructure policy. No additional local-energy policies were tested, and these supply-side results must not be added to the municipality-wide totals.
Waste management and circular economy-related emissions	Waste generation and waste-management-related GHG emissions are included. The tested policy focuses on reducing the amount of waste generated.	Good supplementary link. The model quantifies the effect of reducing waste generation and provides additional analytical support for waste-prevention and circular-economy-related actions.
Climate change adaptation	Not directly modelled.	Partial 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.
Monitoring and review of the SECAP2030	Baseline and policy scenario results up to 2050; comparison of energy demand and CO ₂ emission trajectories.	Strong conceptual link. The model can support SECAP2030 monitoring and review by helping the municipality compare baseline development, policy scenarios and remaining emission-reduction gaps.

5.2. Main modelling results relevant for SECAP2030 monitoring

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

In the baseline scenario, total annual energy demand remains at approximately 88.03 GWh/year through 2050, as no population or activity change is assumed. With the selected policy package, energy demand decreases to approximately 85.99 GWh/year by 2050. This corresponds to annual energy savings of approximately 2.04 GWh, or 2040 MWh, representing a reduction of approximately 2.3 % compared with the baseline scenario.

Annual GHG emissions remain at approximately 24.4 thousand tCO₂eq/year in the baseline scenario. With the selected policy package, emissions decrease to approximately 23.8 thousand tCO₂eq/year by 2050. This corresponds to annual emission savings of approximately 0.6 thousand tCO₂eq, or approximately 2.5 % compared with the baseline scenario.

At sector level, the quantified reductions are concentrated in residential buildings, municipal buildings, public infrastructure and waste management. Residential buildings are the largest modelled energy-consuming and emission-producing sector. The tested single-family renovation measure provides the largest quantified energy saving in the policy package, but the overall reduction remains limited relative to the scale of residential energy demand. Broader renovation coverage, deeper energy savings and heating-system decarbonisation would therefore be important for future SECAP2030 review and implementation.

The lighting-replacement policy tested in municipal buildings produces only a small reduction because lighting represents a limited share of total municipal-building energy demand. Nevertheless, municipal buildings remain relevant for future action because their energy use can be directly influenced by the municipality.

The results also highlight important gaps in the tested policy package. Transport represents a significant share of modelled energy demand and emissions, but no transport policy measures were tested. Goods transport is also outside the quantified scope. In addition, no policy measures were modelled for other sectors or local energy production.

The simulation therefore does not represent the municipality's full emission-reduction potential. Instead, it demonstrates the effect of the selected limited set of measures and identifies the sectors where broader policy coverage, improved data and more ambitious interventions would be needed.

In this sense, the CommitClimate modelling results can support the SECAP2030 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 Raciechowice feasibility study

The Raciechowice feasibility study prepared within CommitClimate focuses on photovoltaic electricity generation combined with energy storage for municipal facilities.

This feasibility study complements the Raciechowice simulation report by providing a more detailed assessment of one locally relevant priority area. It is closely linked to the SECAP2030 objectives related to renewable energy development, improvement of municipal energy self-sufficiency, reduction of electricity-related emissions and lowering of operating costs in public facilities.

The feasibility study adds practical value to the broader modelling exercise by showing how a specific renewable-energy investment option could support municipal energy and climate objectives. It is particularly relevant for Raciechowice because, although municipal buildings represent a relatively small share of total energy demand and emissions, they are among the sectors where the municipality can directly influence energy performance and energy supply decisions. The feasibility study therefore provides an implementation pathway for reducing electricity-related impacts in public facilities and demonstrates how local authorities can translate climate ambitions into actionable investments.

5.4. Municipality feedback and practical relevance

From the perspective of Raciechowice Municipality, the CommitClimate modelling provides useful supporting analytical material for the implementation and future review of the SECAP2030. In particular, the scenario results provide an additional quantitative perspective on the relative importance of different energy- and emission-related sectors and on the potential effect of selected measures.

The results highlight the particularly important role of residential buildings and heating in the municipality's energy transition and support further consideration of more comprehensive building renovation, heating-system transformation and renewable-energy deployment.

The CommitClimate results also complement the practical measures already included in the SECAP. In particular, the feasibility study on photovoltaic generation combined with energy storage provides a more detailed assessment of an investment direction already foreseen in the SECAP for municipal facilities. The modelling results may also complement the municipality's ongoing work on systematic energy monitoring and management.

Overall, Raciechowice Municipality considers the CommitClimate simulation report a useful supporting tool for local energy and climate planning. The results may support future SECAP monitoring, review and update processes, provided that the differences in baseline year, sectoral scope, modelling assumptions and time horizon are taken into account. The report should not be interpreted as a formal replacement or amendment of the adopted SECAP.

The practical relevance of the CommitClimate results is further strengthened by the municipality's ongoing energy-transition activities. In 2026–2028, Raciechowice Municipality is implementing the “EKO-LOGICZNI 2025” project, which includes an analysis of energy consumption in public buildings, preparation of a municipal energy transition strategy, an assessment of renewable-energy potential and CO₂ reduction opportunities, as well as an analysis of energy poverty. The CommitClimate scenario results may provide additional analytical input to these activities, particularly by helping to identify priority sectors, policy gaps and areas where more detailed local data or additional scenario analysis are needed.

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 Raciechowice SECAP2030.

There are differences in both scope and time horizon. The Raciechowice SECAP2030 focuses on actions and targets up to 2030, whereas the CommitClimate simulation provides a longer-term scenario analysis extending to 2050. The model results should therefore not be interpreted as a direct assessment of formal SECAP2030 target achievement, but rather as an additional tool for long-term reflection, monitoring and future planning.

The quantitative results should not be directly compared with the formal SECAP2030 targets without harmonising the baseline year, sectoral coverage, emission-accounting boundaries and time horizon. This is particularly important because the SECAP2030 refers to a 1996 baseline year and a 2030 emission-reduction target, while the CommitClimate simulation uses a different modelling structure and extends the analysis to 2050.

Some SECAP2030 areas are only partly covered or are outside the scope of the simulation. Climate change adaptation, climate-risk assessment and resilience measures are not represented in the CommitClimate CO₂ model. Energy consumption and GHG emissions from the commercial, tertiary,

industrial, construction, agricultural and forestry sectors were not included in the Raciechowice baseline due to data limitations. In addition, no policy measures were tested for the transport sector.

The Local Energy Production module is included in the simulation as a supply-side representation of the electricity required by the end-use sectors. It incorporates distribution losses and calculates the associated emissions using aggregate emission factors. However, it does not include a technology-specific representation of local electricity or heat production, and no additional policies targeting heat-loss reduction, waste-heat recovery, renewable-generation capacity or electricity and district-heating decarbonisation were tested.

The 2050 pathway presented in the Local Energy Production module already reflects changes resulting from policies applied in the end-use sectors. It therefore does not represent an additional emission sector or an independent source of policy savings. Its energy and emission results must not be added to the municipality-wide totals, as the corresponding emissions are already allocated to the relevant end-use sectors.

These limitations should be considered when interpreting the results. Nevertheless, they do not reduce the model's value as a planning-support tool. Instead, they identify areas where improved data availability, broader sectoral coverage and additional scenario development could strengthen future SECAP monitoring and review.

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

The Raciechowice SECAP2030 provides the strategic framework for local energy and climate action. The CommitClimate simulation results can complement its future implementation, 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 CommitClimate 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 may be considered;
- support discussion on deeper building renovation, heating-system transformation, renewable-energy deployment and sustainable mobility;
- identify areas where additional local data or further scenario analysis would be useful;
- provide visual and quantitative material for stakeholder communication;
- support future SECAP monitoring, review and update processes.

The CommitClimate results may also complement the municipality's work on the implementation of an energy management system based on ISO 50001, which is identified in the SECAP as an important element supporting systematic energy monitoring and management. In this context, the scenario results can provide additional analytical information for discussing energy-use patterns, priority sectors and future actions.

Overall, the CommitClimate Raciechowice simulation report provides a complementary analytical perspective to the mitigation and energy-planning parts of the Raciechowice SECAP2030, especially in the

sectors of municipal buildings, residential buildings, public infrastructure and waste management. It can support future municipal climate and energy planning while remaining separate from the formal SECAP monitoring framework.

The report should therefore be understood as supporting analytical material rather than as a formal assessment of SECAP target achievement or as a replacement or amendment of the adopted SECAP. Any use of the quantitative results for SECAP monitoring should take into account differences in baseline year, sectoral coverage, modelling assumptions and time horizon.

6. CONCLUSIONS

The scenario analysis for Raciechowice municipality indicates that the selected policy package produces limited reductions in energy demand and greenhouse gas emissions by 2050. This is mainly attributable to the relatively narrow scope and moderate ambition of the tested measures, as well as the absence of structural changes in several important sectors.

In the baseline scenario, total annual energy demand remains at approximately 88.03 GWh/year through 2050, while annual GHG emissions remain at approximately 24.4 thousand tCO₂eq/year. With the selected policies, energy demand decreases to approximately 85.99 GWh/year and emissions to approximately 23.8 thousand tCO₂eq/year by 2050. The policy package therefore achieves annual energy savings of approximately 2.04 GWh, or 2.3 %, and an emission reduction of approximately 0.6 thousand tCO₂eq, or 2.5 %, compared with the baseline scenario.

Residential buildings are the largest modelled energy-consuming sector, accounting for approximately 70 % of total energy demand and 57 % of total GHG emissions in the baseline scenario. The tested renovation measure reduces energy demand and emissions from residential buildings, but its impact remains limited in relation to the size of the sector. More extensive and deeper renovation, improvements in heating-system efficiency and a transition towards lower-carbon heating sources would therefore offer considerable additional mitigation potential.

Municipal buildings account for approximately 2.5 % of modelled energy demand and 2.8 % of modelled emissions. The tested policy focuses on the replacement of light bulbs and consequently produces only a small reduction. Measures addressing the thermal performance of buildings, heating systems and other major energy uses were not tested and represent additional potential for future action.

Public infrastructure accounts for a relatively small proportion of municipality-wide energy demand and emissions. Nevertheless, the selected measures reduce annual energy demand by approximately 55 MWh, or 6.7 %, and emissions by approximately 64 tCO₂eq, or 12 %. They also result in approximately 43 MWh/year of renewable electricity generation by 2050. Although the absolute contribution is limited, the results demonstrate the benefits of combining demand reduction with renewable electricity generation.

Transport remains an important source of energy demand and emissions in the simulation. However, no transport policies were tested. Furthermore, the module represents passenger transport only, while goods transport and other freight activity were not included. Transport electrification, modal shift, improvements in public transport and measures reducing private-car demand therefore represent significant untested mitigation potential.

Other sectors, including commercial and tertiary activities, industry, construction, agriculture and forestry, were not included because the required input data were unavailable. Their omission constitutes an important limitation and means that the simulation should not be interpreted as a complete territorial energy and emissions inventory.

The Local Energy Production module provides a supply-side representation of the electricity required by the modelled end-use sectors, including distribution losses and the associated emissions. No district heat demand, additional local electricity or heat production, energy imports or energy exports were specified. No policies directly targeting energy supply were tested. Consequently, changes presented in this module arise from policies applied in the end-use sectors and do not constitute additional policy savings.

The waste management policy reduces annual GHG emissions by approximately 167 tCO₂eq, or 4.7 %, while annual waste generation decreases by approximately 269 tonnes, or 11.8 %. Further waste-prevention, reuse, recycling and circular-economy measures could deliver additional reductions.

Overall, the results demonstrate that a limited set of incremental measures produces only modest improvements in municipality-wide energy demand and emissions. Achieving substantially greater reductions would require a broader and more ambitious policy package, including deeper building renovation, heating-system transformation, transport measures, greater renewable-energy deployment and the inclusion of sectors currently outside the model's scope. The modelled policy scenario should therefore be interpreted as an assessment of the selected measures rather than as a complete pathway towards the municipality's long-term climate targets. On its own, the tested package is insufficient to deliver deep decarbonisation, but the results identify the sectors and measures in which stronger interventions could provide the greatest additional impact.

Summary Table of Key Quantitative Results (2050)

Sector	Indicator	Results
Municipal buildings	Energy savings	19 MWh (0.9 %)
	Emission reduction	12 tCO ₂ (1.84 %)
	Renewable generation	–
Residential buildings	Energy savings	1966 MWh (3.2 %)
	Emission reduction	341 tCO ₂ (2.4 %)
	Renewable generation	–
Public infrastructure	Energy savings	55 MWh (6.7 %)
	Emission reduction	64 tCO ₂ (12 %)
	Renewable generation	43.32 MWh
Other sectors	Energy savings	–
	Emission reduction	–
Municipal fleet	Energy savings	–
	Emission reduction	–
Public transport	Energy savings	–
	Emission reduction	–
Private transport	Energy savings	–
	Emission reduction	–
Waste management	Waste generation reduction	269 t (11,8 %)
	Emission reduction	167 tCO ₂ eq (4,7 %)
Local energy production	Energy savings	–
	Emission reduction	–
	Renewable generation	–