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Carbon driven energy equilibrium at the municipal scale – Energy Equilibrium

GoA 1.5 - Test and validate Energy Equilibrium platform

D 1.5 Final report

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Interreg Baltic Sea Region
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ENERGY TRANSITION
Energy Equilibrium

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1 About the Energy Equilibrium project

1.1 Context and challenge

To compensate the variability and non-controllability of seasonally generated renewable energy (RES) (daily fluctuations in solar radiation intensity, wind speed, etc.) development of sufficient energy storage infrastructure in the regions will play a major role in transforming RES supply potential into reality. However, local public authorities that are responsible for creating an enabling policy environment for RES infrastructure development in regions encounter numerous challenges and uncertainties in deploying sufficient energy accumulation that often remain unanswered due to a lack of knowledge and on-site capacity, which in turn significantly hinders the regional path to climate neutrality.

The project aims to identify renewable energy potential in local energy systems and to support local public authorities in decision-making regarding the development of sufficient renewable energy infrastructure in the region, including the integration of energy storage.

1.2 Aim of the Energy Equilibrium project

This project aims to develop an Energy Equilibrium Platform – an interactive and easily applicable tool to support municipalities and energy suppliers in decision-making related to the development of efficient action plans to accelerate local RES utilization in the region. Energy Equilibrium Platform will help municipalities to:

1) Identify the most optimal RES storage development strategy and its impact on energy flexibility in the region;
2) Help to determine the key factors affecting energy equilibrium (balance between the produced and the consumed energy) in the region;
3) Help to develop policy mechanisms and action plans to enhance local RES in the region;
4) Help to anticipate risks and avoid making expensive mistakes (e.g. investing in inappropriate technological solutions).

2 Model verification and approbation

2.1 Aim of verification and approbation

GoA 1.5. is responsible for testing and approbating the model and developing the Energy Equilibrium platform for end users – target groups. The key aim of model testing is to sufficiently prepare for the municipality pilots in Work Package 2. The purpose of the verification and approbation of the Energy Equilibrium platform that is based on system dynamics (SD) model is to determine the validity of the model structure. The accuracy of reproduction of the real behaviour of the model is also assessed in GoA 1.5.

The deliverable of GoA 1.5. resulted in validated prototype of Energy Equilibrium platform which is delivered as a web page so that anyone with a modern web browser and an internet connection can use it. It will be freely accessible to the main target groups in order to be easily piloted in WP2. The model version that was verified and approbated throughout the group model building sessions (in the scope of GoA 1.4.) is accessible here: https://exchange.iseesystems.com/public/testlearntestsagain/municipality-model/index.html#page1

Building an outstanding interface of the Energy Equilibrium platform requires attention to detail and a clear understanding of the target group who are going to use it, therefore Energy Equilibrium platform piloting in municipalities which will be performed in WP2 will be used not only to demonstrate the platform, but also to fine-tune it to best meet the needs of the end users.

2.2 Aim of this report

The main notes from platform testing and validation were summarized and merged into GoA 1.4. deliverable which described the outcomes of the group model building sessions. See more details on the model testing in D 1.4.

However, this report focuses on the model validation approach used in this project. Model validation i.e. Energy Equilibrium Platform validation involves the assessment of the model simulation accuracy and reliability. In order to validate the model accuracy, the model simulation results are evaluated with regard to the historical energy consumption data of municipalities where platform pilots will take place.

This report describes the approach used in order to obtain information and collect historical data on municipality energy infrastructure, energy efficiency, energy consumption and production. This data will be further used in platform pilots to validate Energy Equilibrium platform and produce simulation results for future development scenarios in municipalities. Moreover, this report summarizes the main data obtained from six municipalities and describes the main observed characteristics of municipality energy profile. Furthermore, the report outlines the proposed strategy for municipality pilots and further model validation.

This report will be updated and improved based on the reviews and additional information provided by the municipalities.

3 Factsheets on municipality energy profile

3.1 Description of the approach

The Energy Equilibrium project aims to develop an energy modelling tool for municipalities to determine the future role of energy storage technologies. To achieve this in the first year of project implementation, the project modelling team has developed a data collection method called the "Municipality factsheet". This is an Excel data template that is sent to municipalities and local governments to help them collect data on their energy systems, including energy consumption and generation.

The Municipality Factsheet is and Excel data collection template, created as part of the Energy Equilibrium project, aims to collect data from municipalities regarding their energy infrastructure and consumption patterns. The template consists of seven sheets designed to gather information on key indicators over the past 5 years (2018-2022), covering aspects such as electricity and heat consumption, transportation consumption, electricity and heat production profiles, energy storage, as well as specifics about power plants and heat production installations within the municipal limits.

This energy profile factsheet was organized into seven sections:

1. General indicators;
2. Electricity consumption;
3. Heat consumption;
4. Transport consumption;
5. Electricity production;
6. Heat production;
7. Energy storage.

The following paragraphs summarise the most important segments and data items contained in the "Municipality factsheet" data template. The developed template is also attached to the overall documentation of the developed project deliverables and is available for download on the project website.

The general indicators section encompassed categories such as socio-demographic factors (Table 1.) characterizing the main drivers of energy demand in the municipal region.

Table 3.1.

Socio-demographic parameters

Parameter	**Unit of measure**
Population	Total number of inhabitants
Number of households	Total number of households
* multi-family buildings (apartments)	Number of dwellings
* single-family buildings	Number of dwellings
Total area of the territory under municipal governance	m2

Further municipalities were asked to provide general indicators about different sectors which included main factors driving energy demand in the municipality and characterising the existing energy efficiency level in the buildings.

Table 3.2.

General indicators about different sectors

Parameter	Unit of measure
Municipal buildings	
Total number of municipal buildings	number
Total heating area of municipal buildings	m2
*Total heating area of municipal buildings that are connected to district heating	m2
*Total heating area of municipal buildings that have individual/local heat supply source	m2
The proportion of renovated buildings from the total area of municipal buildings	%
Average specific heat consumption in renovated buildings	kWh/m2 /year
Average specific heat consumption in non-renovated buildings	kWh/m2 /year
Commercial and industrial sector buildings	
Total heating area of commercial sector buildings	m2
Total heating area of industrial buildings	m2
Number of companies	number
Agricultural land	
Agricultural land area	m2

In the next section, specifically addressing electricity consumption, template requested historical data on the municipality's electricity usage across major sector groups (Table 3). This information was asked for the past five years, with additional breakdown on a monthly basis.

Table 3.3.

Municipality electricity consumption profile

Parameter	Unit of measure
Municipality infrastructure	MWh/year, MWh/month
*Municipal buildings & equipment	MWh/year, MWh/month
*Public street lighting	MWh/year, MWh/month
*Municipal transport	MWh/year, MWh/month
*Other (please specify)	MWh/year, MWh/month
Household sector	MWh/year, MWh/month
Industrial sector	MWh/year, MWh/month
Commercial sector	MWh/year, MWh/month
Agricultural and forestry sector	MWh/year, MWh/month
Other sectors (please specify)	MWh/year, MWh/month
Total electricity consumption in municipality	MWh/year, MWh/month

Furthermore, "Heat Consumption" sheet concentrated on obtaining annual data related to heat consumption in sectors of the municipality utilizing district heating (Table 4). Monthly heat consumption data by sectors was also requested.

Table 3.4.

Municipality heat consumption profile for objects connected to district heat supply

Parameter	**Unit of measure**
Municipality infrastructure	MWh/year
*Municipal buildings & equipment	MWh/year
*Other (please specify)	MWh/year
Household sector	MWh/year
Industrial sector	MWh/year
Commercial sector	MWh/year
Agricultural and forestry sector	MWh/year
Other sectors (please specify)	MWh/year
Total heat consumption in municipality	MWh/year

Additionally, template sought general characteristics of heat supply sources for municipal infrastructure objects (Table 5). Template also inquired to provide details about fuel consumption for the five largest municipal objects with individual heat supply.

Table 3.5.

General characteristics of heat supply sources for municipal infrastructure objects

Parameter	**Unit of measure**
Number of objects connected to district heating	number
Total heat consumption of objects connected to district heating	MWh/year
Number of objects with individual heat supply	number
Total heat consumption of objects with individual heat supply system	MWh/year
Total aggregated fuel consumption of objects with **individual heat supply system**	
*Natural gas	1000 m3/year
*Wood pellets	t/year
*Wood chips	t/year
*Diesel fuel	m3/year
*Other (please specify)	

In the following segment, transport consumption, template asked for information on the municipality's fuel consumption for transportation and the number of passenger cars (Table 6). Both annual and monthly data were required.

Table 3.6.

Municipality transport sector consumption profile

Parameter	**Unit of measure**
Municipality transport fuel consumption	
*Electricity	MWh/year
*Petrol	thousand liters/year
*Diesel	thousand liters/year
* Gas	thousand liters/year
*Other (please specify)	

Municipal public transport's fuel consumption	
*Electricity	MWh/year
*Petrol	thousand liters/year
*Diesel	thousand liters/year
* Gas	thousand liters/year
*Other (please specify)	
Private transportation in municipality	
Number of passenger cars registered in the municipal region	Number of vehicles

In the next segment, municipal representatives were requested to provide details on the annual and monthly electricity production from installed power plants, as well as annual data on the currently installed power plants and describr any planned installations for the future (Table 7).

Table 3.7.

Municipality electricity production profile

Parameter	**Unit of measure**
Renewable power plants	Total installed capacity, MW/year Total amount of electricity produced, MWh/year
*Solar PV	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Wind energy	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Biomass CHP	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Biogas CHP	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Hydro power	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Geothermal energy	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Other	Total installed capacity, MW/year Amount of electricity produced, MWh/year
Non-renewable power plants	Total installed capacity, MW/year Total amount of electricity produced, MWh/year
*Natural gas	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Coal	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Nuclear	Total installed capacity, MW/year Amount of electricity produced, MWh/year
*Other	Total installed capacity, MW/year Amount of electricity produced, MWh/year

Further segments requested information on heat production in the municipality. In the segment “Heat production” template asked to give information about the annual installed capacity and the annual and monthly amount of heat produced from district heating (Table 8). Moreover, municipalities were asked to describe planned installations within the next 5 years.

Table 3.8.

Municipality district heating production profile

Parameter	Unit of measure
Renewable power plants	Total installed capacity, MW/year Total amount of heat produced, MWh/year
* Solar thermal	Total installed capacity, MW/year Amount of heat produced, MWh/ year
* Biomass	Total installed capacity, MW/year Amount of heat produced, MWh/ year
* Biogas	Total installed capacity, MW/year Amount of heat produced, MWh/ year
* Other (please specify)	Total installed capacity, MW/year Amount of heat produced, MWh/ year
Non-renewable power plants	Total installed capacity, MW/year Total amount of heat produced MWh/year
* Natural gas	Total installed capacity, MW/year Amount of heat produced, MWh/ year
* Other (please specify)	Total installed capacity, MW/year Amount of heat produced, MWh/ year

Furthermore, template aimed to identify different individual systems in district heating. Template requested to provide general information on district heating supply characteristics (Table 9). Additional data inquiries were prepared to show the different systems of district heating. Template asked to provide information on the top 5 systems that generate the largest amounts of heat in the network.

Table 3.9.

Identification of different individual systems in district heating

Parameter	Unit of measure
Number of district heating providers in municipality	number
Number of individual systems	number
Total length of district heating network	km

Finally, municipality representatives were asked to describe municipality's current status with respect to energy storage systems that have been implemented or vision for future installations in the region (Table 10).

Table 3.10.

Municipality existing situation and plans regarding energy storage

Technology	Instructions for description
Batteries	Please describe whether there is an existing battery system (or systems) in your municipality. Please specify its installed capacity (kW) and whether or not it is connected to the existing PV or wind energy system, or if it is a standalone system. Please describe who is the owner of the system (municipality, private company, municipal capital company, government, or other). **If no battery system is currently implemented in your municipality, please describe any future plans** or discussions regarding battery installation.

Pumped hydro	Please describe whether your municipality has a pumped hydro storage facility. Please specify its installed energy storage capacity (MW). Please describe who is the owner of the system (municipality, private company, municipal capital company, government, or other). Please explain whether the municipality recognizes the advantages of such a system. **If pumped hydro is not currently implemented in your municipality, please describe whether the municipality could implement such technology in the future** and whether the municipality recognizes the potential benefits of pumped hydro storage in the municipality.
Thermal energy storage (please specify)	Please describe whether there is an existing thermal energy system (or systems) in your municipality. Please specify the type of the existing thermal energy storage technology, indicate its installed capacity (MWh) and whether or not it is connected to the existing boiler house or RES production unit. Please describe who is the owner of the system (municipality, private company, municipal capital company, government, or other). **If no thermal energy storage system is currently implemented in your municipality, please describe any future plans** or discussions regarding thermal energy storage installation.
Energy storage in a form of hydrogen	Please describe whether hydrogen is currently being utilized in the municipality (e.g., for public transportation), the quantities used (kg), and how this hydrogen is produced, supplied, and stored in the municipality. **Please describe whether your municipality views hydrogen as a short-term or long-term potential energy source to meet the municipality's energy demand.**
Energy storage in a form of biomethane	Please describe whether biomethane is currently being utilized in the municipality (e.g., for public transportation), the quantities used (m3), and how this biomethane is produced, supplied, and stored in the municipality. **Please describe whether your municipality views biomethane as a short-term or long-term potential energy source to meet the municipality's energy demand.**

3.2 Municipality energy profile general description and data analysis

In the further sections the main data obtained from six municipalities is summarized and the main observed characteristics of municipality energy profile is described. The energy profile descriptions are further provided for the following municipalities: Gulbene municipality (Latvia), Tukums municipality (Latvia) Taurage municipality (Lithuania), Tomelilla municipality (Sweden), Mikołajki Pomorskie municipality (Poland), Wejherowo municipality (Poland). In all these municipalities Energy Equilibrium platform pilots will be performed in Work Package 2.

It should be noted that the report summarises the data received from the municipalities as of January 2024. Updates to the data may follow in the subsequent months of project implementation. Once the data will be supplemented and updated, the existing analysis and description will be improved. Some data inconsistencies in the following segments will be identified and eliminated during the pilots performed in Work Package 2.

3.2.1 Gulbene municipality energy profile

***Disclaimer**: For certain reasons, data for 2019 is missing in specific data items for the Gulbene municipality. Therefore, at certain points in the data analysis, the year 2019 is either excluded or change dynamics is summarized only for the period from 2020 to 2022.*

General parameters and change dynamics

The administrative area of the Gulbene municipality comprises the town of Gulbene and 13 parishes. The Development and Projects Department of Gulbene Municipal Council is responsible for promoting the development of the environment and infrastructure in the municipality.

- Located in the North–East of Latvia in the Vidzeme Region
- Area of 1870 km^2
- Agricultural land area of 608 km^2
- Population of 19.1 thousand inhabitants
- A total of 7.7 thousand households
- 1607 active enterprises

There has been a general decline in the population and the total number of inhabited households in the Gulbene municipality. The general structure of housing in 2022 consists of 55% apartment blocks (multi-family dwellings) and 45% single-family dwellings.

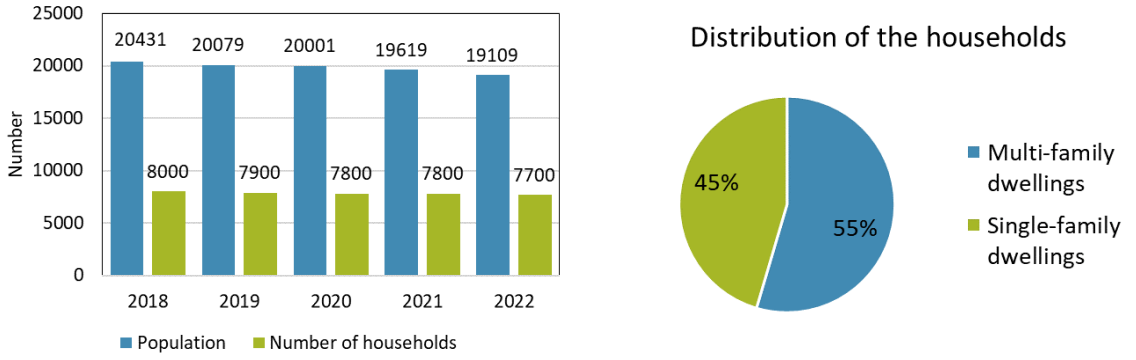


Fig. 3.1. Population and number of households in Gulbene municipality; housing distribution.

There are a total of 105 public buildings under the municipality governance. In 2022, the total heating area of these buildings was 110,107 m2. Over the years, the number of municipal buildings and thus the total heating area of buildings under municipal management has increased slightly.

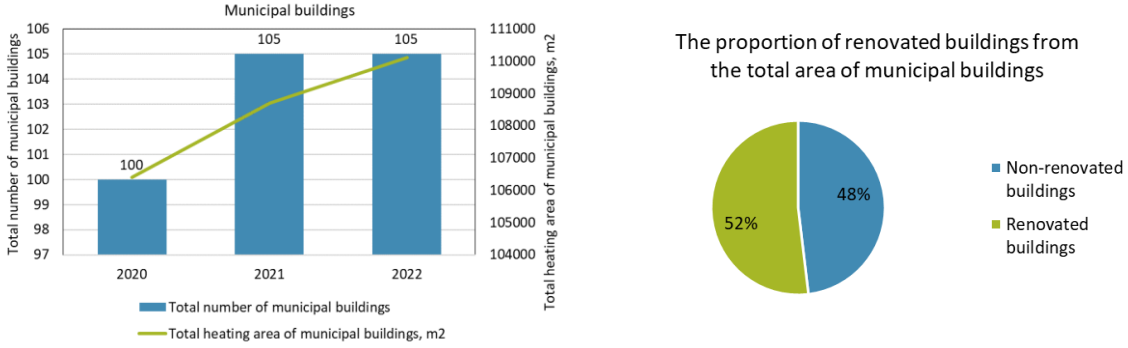


Fig. 3.2. Main characteristics of municipal buildings.

In general, 52% of the municipal building stock has been renovated, while a fairly large proportion of 48% is unrenovated. In general, the share of renovated buildings in the total municipal building stock has fallen from 52.6% in 2020 to 51.9% of renovated buildings in the total area of municipal buildings. The average specific heat consumption in renovated buildings in 2022 was 91.4 kWh/m2/year, while in non-renovated buildings it was 126.8 kWh/m2/year. The average specific heat consumption values vary between years.

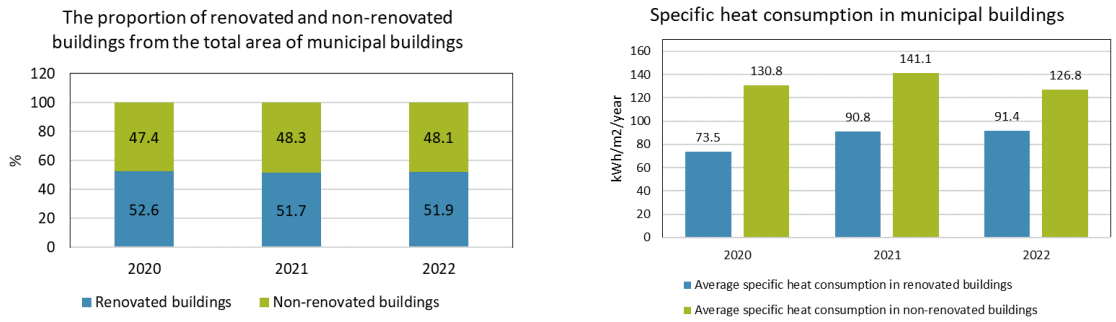


Fig. 3.3. The proportion and specific heat consumption of the renovated and non-renovated buildings.

Electricity consumption

A slight increase in total electricity consumption was observed in the Gulbene municipality, mainly due to rising electricity consumption in the industrial sector. In 2019 and 2020, a significant decrease in electricity consumption was observed, which may have been caused by the Covid restrictions. The largest consumption sector in the Gulbene municipality is industry, which consumed 62% of total electricity consumption in the Gulbene municipality in 2022, followed by households, which accounted for 17% of total electricity consumption.

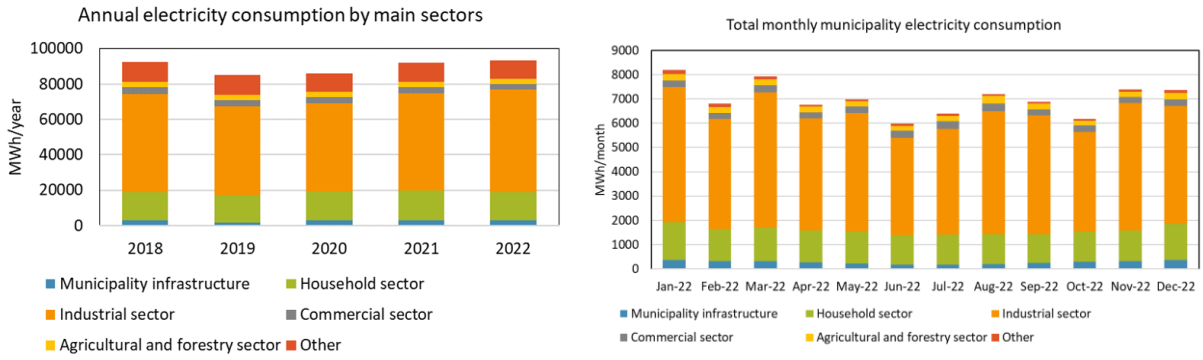


Fig. 3.4. Total annual and monthly electricity consumption in Gulbene municipality by sectors.

Slight fluctuations can be observed in the electricity consumption data on a monthly basis, mainly driven by monthly fluctuations in industrial sector. Overall, higher electricity consumption is observed in the winter months. The highest seasonality, with lower electricity consumption in the summer months, is observed for the electricity consumption of municipality infrastructure objects.

In 2022, the total electricity consumption of municipal infrastructure objects was 3199 MWh, with municipal buildings and facilities being the largest consumer at 2414 MWh. The total electricity consumption of municipal buildings increased by 34% in the period from 2018 to 2022. Public street lighting consumed a total of 505 MWh in 2022, a significant decrease compared to 623 MWh in 2018. The

third largest electricity consumer in the municipal infrastructure is the operation of water supply and wastewater systems, which accounted for 182 MWh of electricity consumption in 2022.

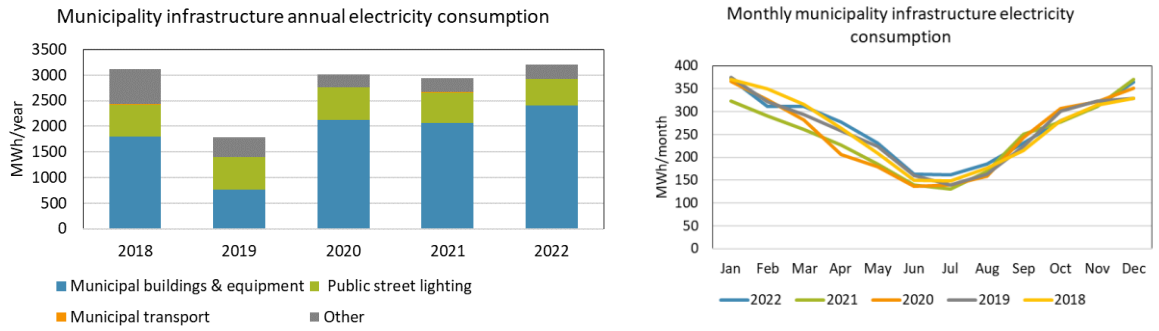


Fig. 3.5. Total annual and monthly electricity consumption of Gulbene municipality infrastructure objects.

District heating consumption

There is only limited data on the total heat consumption of the Gulbene municipality for objects connected to the district heating supply, as the data for the district heating consumption of the industrial sector is not available. Based on the available data, the four main sectors – households, municipal infrastructure, commercial sector and other sectors - consumed 33220 MWh in 2022 where household sector alone consumed 22862 MWh. In general data on district heat consumption in municipality is slightly fluctuating.

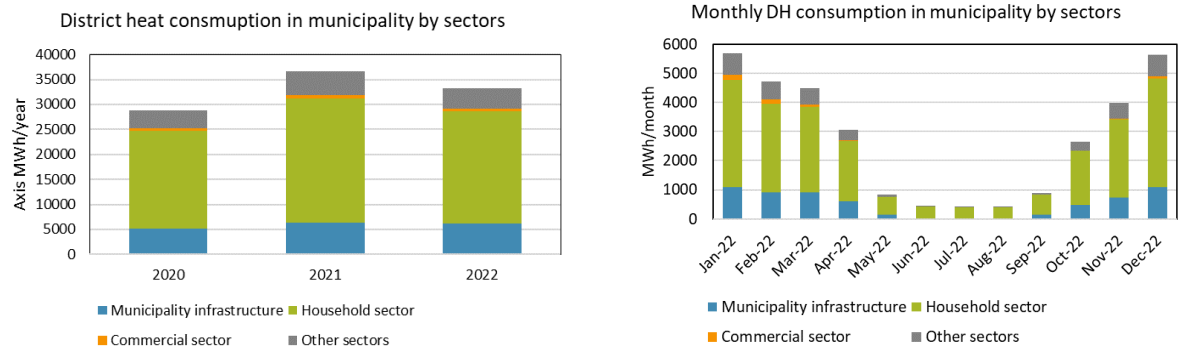


Fig. 3.6. Annual and monthly municipality heat consumption for objects connected to district heat supply by sectors.

The municipal infrastructure objects connected to the district heating system consumed 6774 MWh in 2022, a slight decrease compared to 6306 MWh in 2021. This consumption is almost entirely (6115 MWh) attributable to municipal buildings, while the smaller portion of 59 MWh is consumed by multi-apartment buildings that are wholly owned by the municipality (and are not included in the household consumption group).

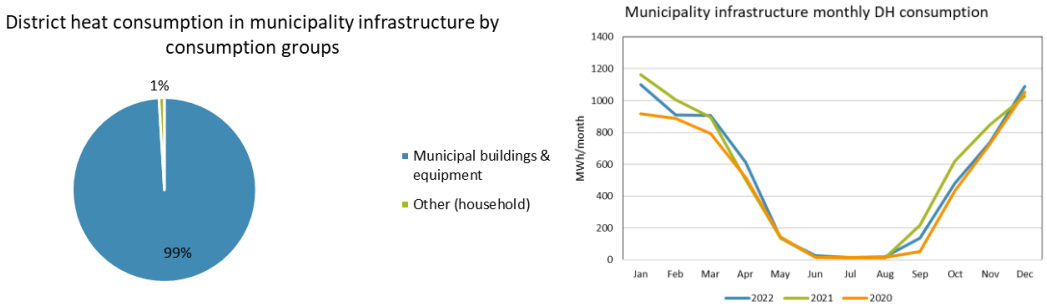


Fig. 3.7. District heat consumption in municipality infrastructure.

The municipality's total heat consumption in 2022 was 11754 MWh. A total of 51 objects, accounting for 51% of the total heating area of the municipal buildings, are connected to district heating. These properties consumed a total of 6174 MWh in 2022.

Table 3.11.

Total heat consumption by the municipal buildings distributed by the heat source

	Number of objects	Total heating area, m^2	Total heat consumption, MWh
District heat	51	55979	6174
Individual heat	54	54128	5580

While a total of 54 municipal buildings has an individual/local heat supply system, which has a total heating area of 54128 m2 and a heat consumption of 5580 MWh. Biomass is the main heat source used in the local heating systems. A total of 5238 tonnes of wood pellets and 5123 m3 of firewood were used to heat these municipal buildings in 2022.

Transport consumption

The total consumption of fuels in the municipality has increased considerably in both main consumption groups – municipal transport and municipal public passenger transport. These consumption groups mainly use fossil fuels such as diesel and petrol. In 2022, 106 thousand litres of diesel and 29 thousand litres of petrol were consumed for municipal transport, which is 22 thousand litres more than in 2021. In addition, 2 MWh of electricity was consumed for municipal transport needs.

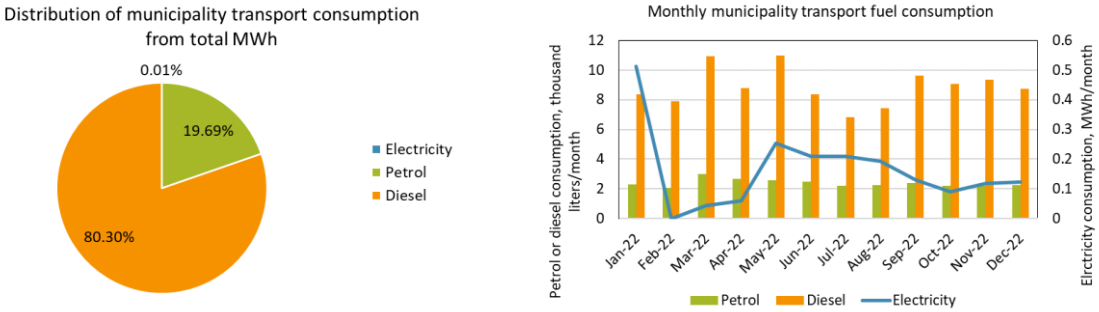


Fig. 3.8. Fuel consumption for municipality transport.

To ensure municipal public transport, 256 thousand litres of diesel were consumed, which corresponds to an increase of 70% compared to 2021. In general, a seasonal factor can be observed in the energy consumption data for transport, with total fuel consumption in transport decreasing in the summer months.

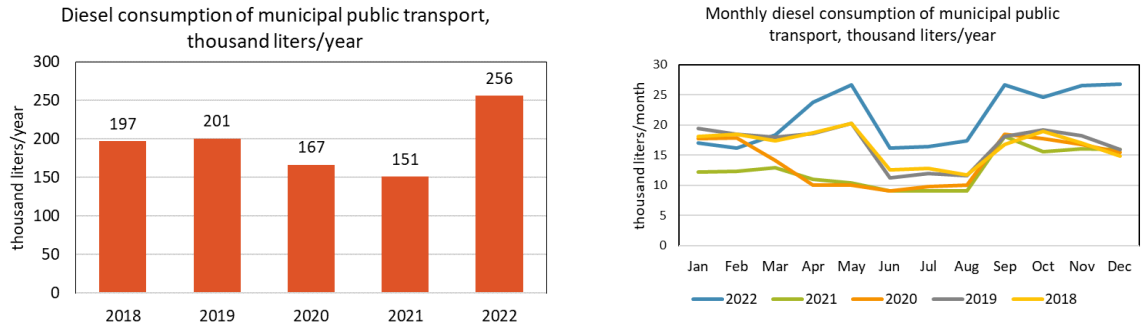


Fig. 3.9. Fuel consumption for municipal public transport.

As far as private passenger transport is concerned, there is no specific data on fuel consumption. However, according to the Road Traffic Safety Directorate (CSDD), the total number of passenger cars registered in the Gulbene region is increasing, reaching 8792 passenger cars in municipal region in 2022.

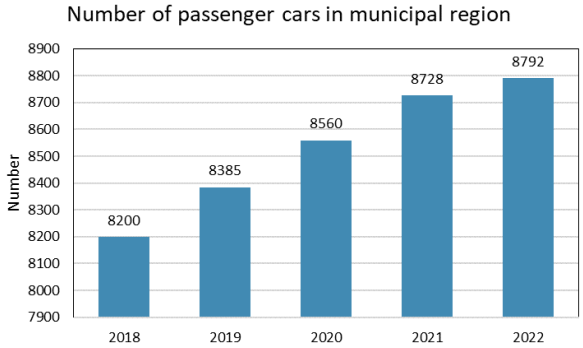


Fig. 3.10. Number of passenger cars in municipal region.

Electricity production

The total installed capacity of renewable power plants in Gulbene municipality in 2022 is 9 MW. Almost half of the total capacity (4.38 MW) is accounted for by installed biomass CHP, followed by hydropower plants with a total capacity of 2.83 MW. In the period from 2018 to 2022, the total installed capacity of biomass CHP (4.38 MW), biogas CHP (0.9 MW) and hydropower (2.83 MW) remained unchanged over the years. However, the total installed capacity of wind energy fell from 0.5 MW in 2018 to 0.25 MW in 2022. On the other hand, solar PV recorded a significant increase from 0.05 MW in 2018 to 0.64 MW of total installed capacity in 2022.

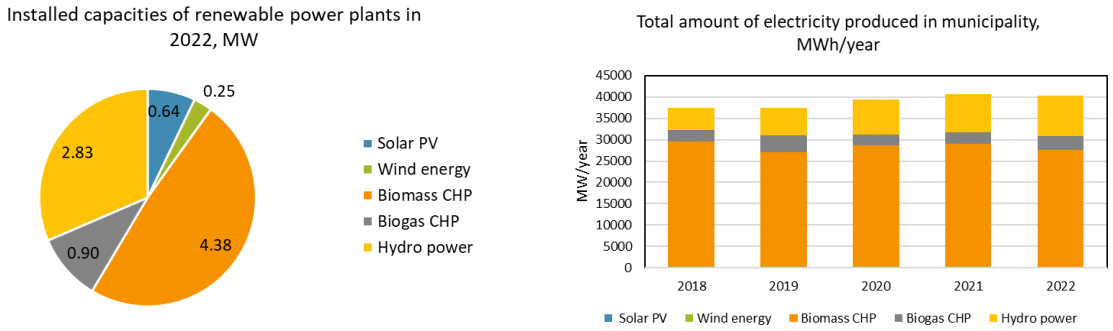


Fig. 3.11. Total installed capacities of renewable power plants and amount of electricity produced.

The total amount of electricity generated from renewable power plants in Gulbene municipality has risen from 37.4 GWh in 2018 to 40.2 GWh in 2022. The most substantial increase in the produced amounts was observed for solar PV energy, which rose from 22 MWh in 2018 to 177 MWh in 2022. The share of biomass CHP in total electricity generation from renewable energies is 68% in 2022.

For all variable energies such as solar PV, wind energy and hydropower plants, the strongest seasonal fluctuations in monthly electricity generation are observed. Biomass CHP is able to compensate for the fluctuations in variable energy resources and its monthly production is consistent. Wind energy production in the municipality is inconsistent and fluctuates considerably. The largest amounts of electricity from hydropower are generated from January to June, while for solar energy from June to September.

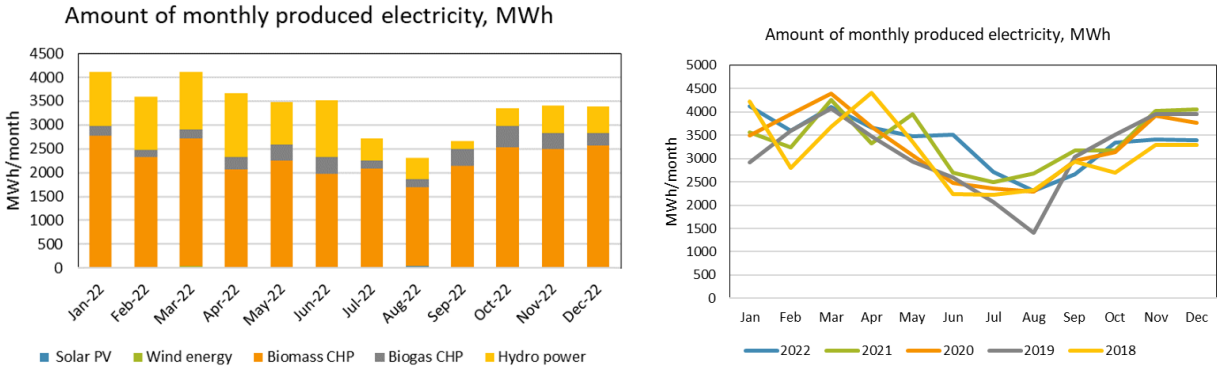


Fig. 3.12. Amount of monthly produced electricity by renewable power plants.

District heating

In Gulbene municipality there are a total of 3 district heating providers in the municipal region. The total length of the district heating network is 20.4 kilometres. The heat generation of the district heating providers is based entirely on biomass boilers.

Table 3.12.

Main characteristics of district heating system in Gulbene municipality

Parameter	Value
Number of district heating providers in municipality	3
Number of individual systems	6
Total length of district heating network, km	20.4

The total installed capacity of biomass boilers in the district heating network fell from 29.6 MW in 2018 to 15.6 MW in 2020 and remained unchanged until 2022. As a result, the amount of heat generated by biomass boilers in the district heating network also fell from 38 GWh in 2018 to 35 GWh in 2022.

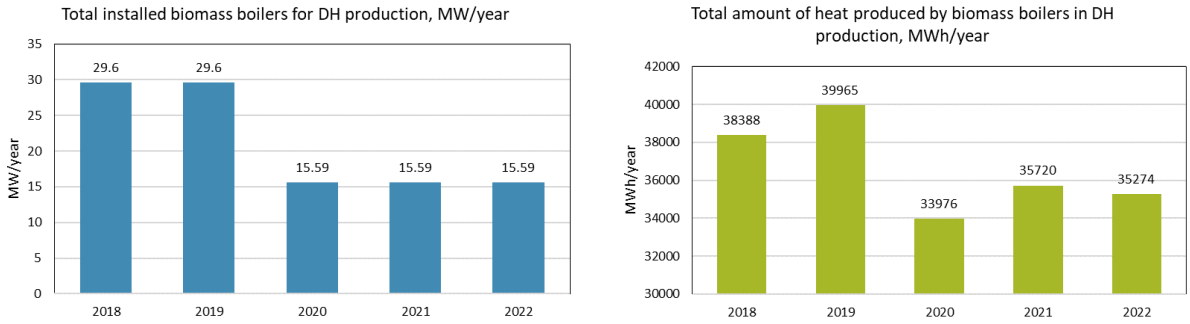


Fig. 3.13. Total installed capacities and amount of produced heat by of biomass boilers in district heating network of Gulbene municipality.

Heat generation is characterised by strong seasonality. In the summer months, when space heating is not required, the load for water heating is maintained. Therefore, the total heat load is highest in the cold months of the year.

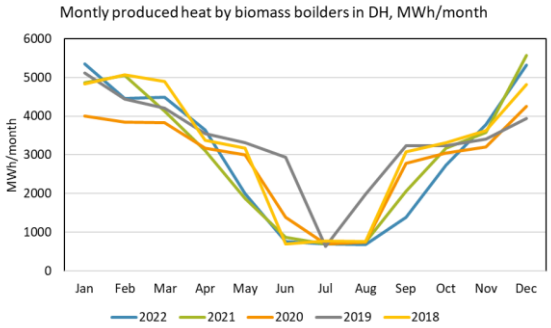


Fig. 3.14. Monthly produced heat by biomass boilers in district heating.

Energy storage

Batteries

To the best of the Municipality's knowledge, there exists a modest battery system in the Gulbene region, owned by the Gulbene Municipality itself. The system has a capacity of 9,072 kWh. While some private companies in the area are contemplating or have initiated the construction of solar PV stations, it is noteworthy that these initiatives do not currently incorporate accompanying battery systems. A shift in perspective has occurred over the past few years, as the notion of constructing batteries was not previously considered. However, the present discourse revolves around this topic due to the advancements in technology and the increasing affordability of battery systems.

Pumped hydro storage

Currently, there is no existing energy storage system in the Gulbene region. The establishment of such a system necessitates a suitable landscape and ample space, attributes that are not readily available in Gulbene county. Consequently, the construction cost of such a system would be prohibitively high. As of now, there is no ongoing discussion within the Gulbene municipality regarding the implementation of an energy storage system due to these constraints.

Thermal energy storage

In the Gulbene region, there is currently a absence of large thermal energy storage facilities. However, the Gulbene Municipality has established smaller units within individual boiler houses, particularly within pellet boiler systems, with an approximate capacity of 50 kW. Conversations regarding larger thermal storage facilities have not been initiated. Moving forward, the Gulbene Municipality is intending to engage in discussions with the Gulbene town district heating provider. The objective is to leverage surplus electricity generated from the solar PV station in the Administration building to heat the central heating system's water.

Hydrogen and biomethane

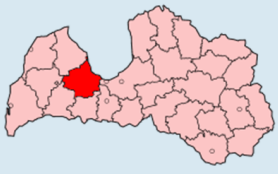
Presently, there are no systems of this nature established in the Gulbene region. The Gulbene Municipality does not currently have plans to implement such a system. This decision is influenced by the absence of requisite infrastructure for utilizing hydrogen and biomethane in the Gulbene region. Furthermore, the technology remains relatively expensive and is still in the early stages of exploration and development.

3.2.2 Tukums municipality energy profile

***Disclaimer**: Due to the merge of the municipalities in 2020 it is very challenging to analyse adequately the change dynamics in Tukums municipality energy consumption and characteristics data. Therefore, most of the data is summarized only for the period from 2021 to 2022. However, in some places larger time frame is provided. During the Energy Equilibrium platform validation more detailed investigation on provided data reliability and included scope and boundaries should be performed. It remains to be clarified which data positions contain data for merged Tukums municipality region and which do not. Some data regarding electricity consumption of municipal buildings provided by Sadales tīkli were inconsistent with the previously supplied data from the municipality. During the project pilots it need to be clarified which data represent more accurately the situation in the region.*

General parameters and change dynamics

The administrative area of the municipality of Tukums comprises the town of Tukums and 10 parishes. On 1 July 2021, the municipality of Tukums was enlarged when the municipality of Engure, the municipality of Jaunpils and the municipality of Kandava were merged to form the municipality of Tukums. The Development and Projects Department of Tukums Municipal Council is responsible for promoting the development of the environment and infrastructure in the municipality.



- Located in the West of Latvia in the Kurzeme Region
- Area of 2450 km^2
- Population of 43.9 thousand inhabitants
- A total of 17.3 thousand households
- 3485 active enterprises

After the merger of municipalities, overall population under Tukums municipality governance has increased. However, in general population in Tukums municipality has decreased from 44.4 thousand in 2021 to 43.9 thousand in 2022. The general structure of housing in 2021 consists of 34% apartment blocks (multi-family dwellings) and 66% single-family dwellings. The total number of households remained unchanged from 2021 to 2022 and totalled 17.3 thousand households.

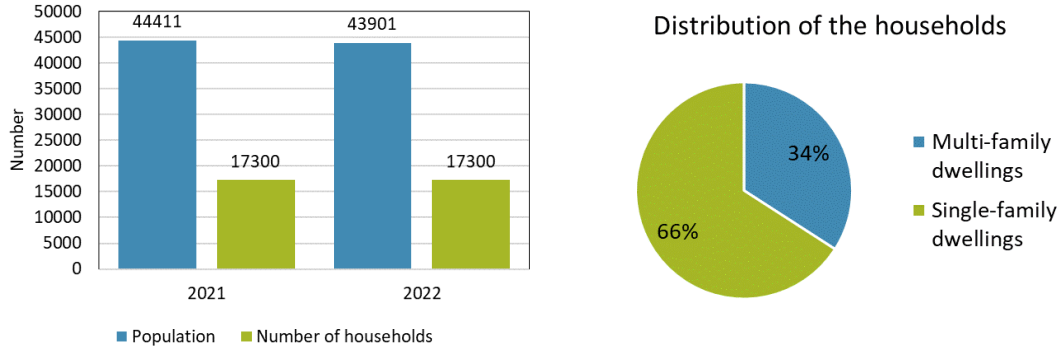


Fig. 3.15. Population and number of households in Tukums municipality; housing distribution.

There are a total of 118 public buildings under the municipality governance. In 2022, the total heating area of these buildings was 175 389 m2.

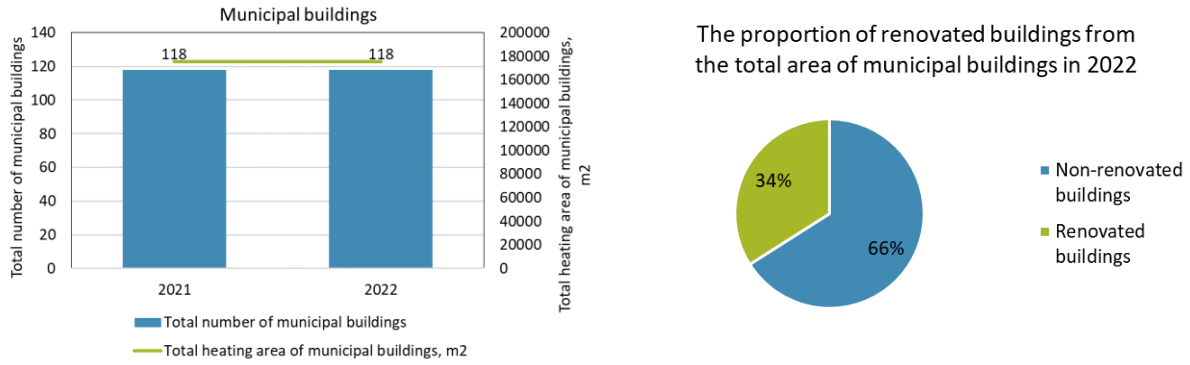


Fig. 3.16. Main characteristics of municipal buildings.

In general, 34% of the municipal building stock has been renovated, while a majority of total area of municipal buildings namely 66% in 2022 is unrenovated. In general, the share of renovated buildings in the total municipal building stock has increased from 23% in 2020 (before merger of municipalities) to 34% in 2022 (after merger) of renovated buildings in the total area of municipal buildings. The average specific heat consumption in renovated buildings in 2022 was 103.9 kWh/m2/year, while in non-renovated buildings it was 147.64 kWh/m2/year.

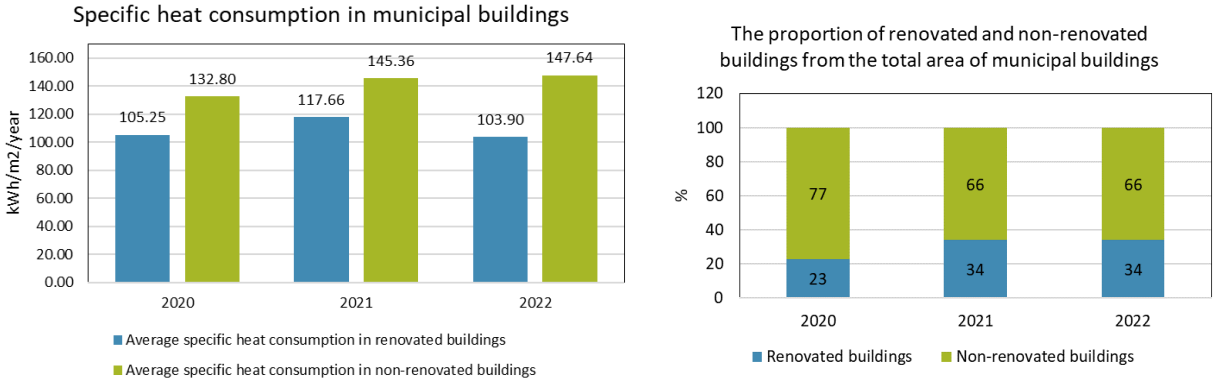


Fig. 3.17. The proportion and specific heat consumption of the renovated and non-renovated buildings.

Electricity consumption

Data for electricity consumption in the municipal region is compiled based on municipality provided data and Sadales Tīkli supplied data. Data for municipality buildings and public street lighting is taken from Tukums municipality data sources, however, data for other municipality consumption groups and sectors is compiled from Sadales Tīkli supplied information.

Due to limited data availability, the latest data on electricity consumption by main sector in the municipality of Tukums was not available. Therefore, the current distribution summarises the situation in 2018, before the merger of the municipalities. The largest consumption sector in the Tukums municipality is households sector, which consumed 30% of total electricity consumption in the Tukums municipality in 2018, followed by industry, which accounted for 29% of total electricity consumption. Municipality infrastructure accounted for 5% of total electricity consumption in Tukums municipality in 2018. Total electricity consumption in 2018 in Tukums municipality amounted to 91602 MWh.

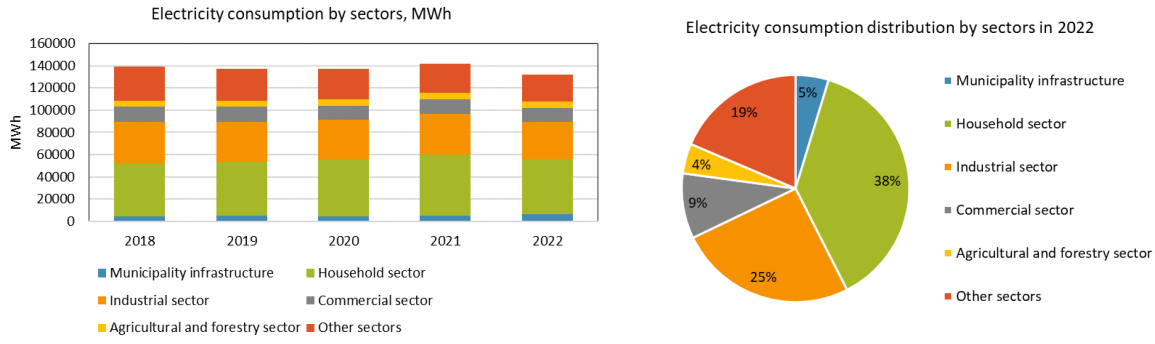


Fig. 3.18. Total electricity consumption distribution by sectors in Tukums municipality.

In 2022, the total electricity consumption of municipal infrastructure objects was 6216 MWh, with municipal buildings and facilities being the largest consumer at 4875 MWh. The total electricity consumption of municipal buildings increased from 3239 MWh in 2018 to 4875 MWh in 2022. Public street lighting consumed a total of 969 MWh in 2022, a slight decrease compared to 1106 MWh in 2021. The electricity consumption of municipal transport has decreased over the period. Other consumers such as water supply and sewerage, industrial and municipal household electricity consumption accounted for 372 MWh in 2022.

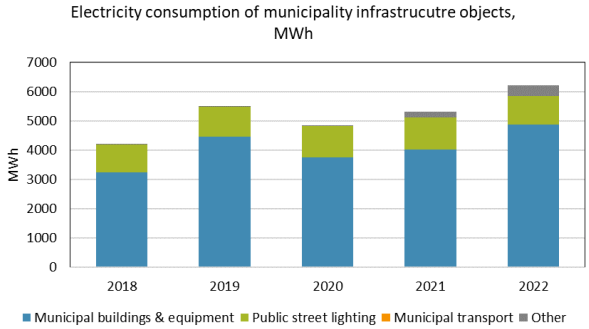


Fig. 3.19. Total annual electricity consumption of Tukums municipality infrastructure objects.

District heating consumption

As no data is available on district heating consumption by sector, the total heat consumption for objects connected to the district heating supply is only summarised for municipal infrastructure properties. Based on the available data, municipal infrastructure properties consumed 13777 MWh in 2022. The average monthly heat consumption for objects connected to the district heating supply is 1685 MWh in the months from October to April and 102 MWh from May to September.

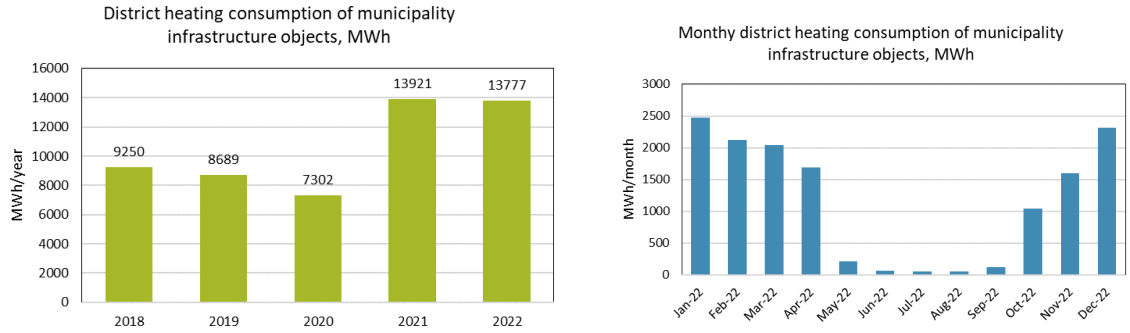


Fig. 3.20. Annual and monthly municipality heat consumption for municipal infrastructure objects connected to district heat supply.

A total of 72 objects, accounting for 80% of the total heating area of the municipal buildings, are connected to district heating. These properties consumed a total of 13 844 MWh in 2022.

Table 3.13.

Total heat consumption by the municipal buildings distributed by the heat source

	Number of objects	Total heating area, m2	Total heat consumption, MWh
District heat	72	13844	97319
Individual heat	44	3522	46776

While a total of 44 municipal buildings has an individual/local heat supply system, which has a total heating area of 3 522 m2 and a heat consumption of 46 776 MWh. Natural gas is the main heat source used in the local heating systems. A total of 63 899 thousand m3 of natural gas, 2236 m3 of firewood and 190 tons of wood pellets were used to heat these municipal buildings in 2022.

Transport consumption

The total consumption of fuels in the municipality has increased considerably for municipal transport. There are no data available for municipal public passenger transport fuel consumption in Tukums municipality. Municipal transport mainly uses fossil fuels such as diesel and petrol.

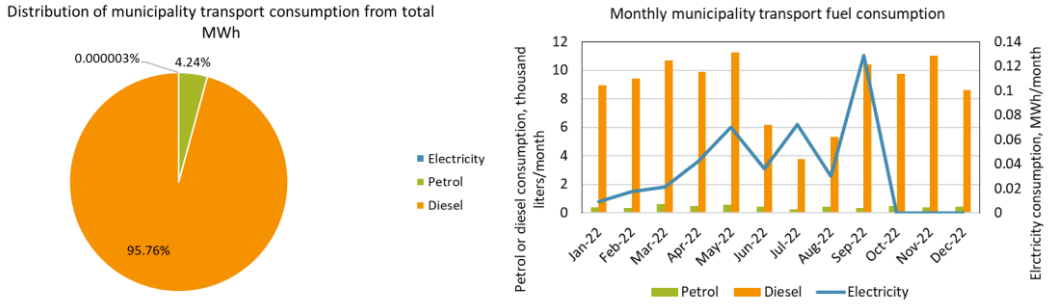


Fig. 3.21. Fuel consumption for municipality transport.

In 2022, 105 thousand litres of diesel and 5 thousand litres of petrol were consumed for municipal transport, which is 35 thousand litres more than in 2021. In addition, 0.42 MWh of electricity was consumed for municipal transport needs.

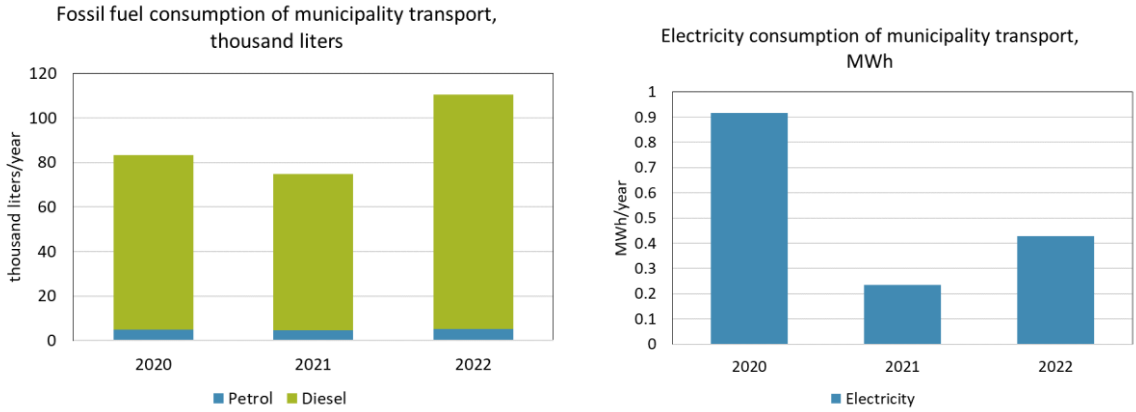


Fig. 3.22. Annual fuel consumption for municipality transport.

Electricity production

The total installed capacity of renewable power plants in Tukums municipality in 2022 is 9.2 MW. Almost half of the total capacity (4.28 MW) is accounted for by installed solar PV, followed by biomass CHP with a total capacity of 2.87 MW, biogas CHP (1.5 MW), and hydropower (0.69 MW). In the period from 2018 to 2022, the total installed capacity of biogas CHP remained unchanged over the years. However, total installed capacity of solar PV experienced a sharp increase in 2022. Installed solar PV increased from 0.11 MW in 2018 to 4.28 MW in 2022. Toal installed capacities of biomass CHP and wind energy has decreased significantly during the period.

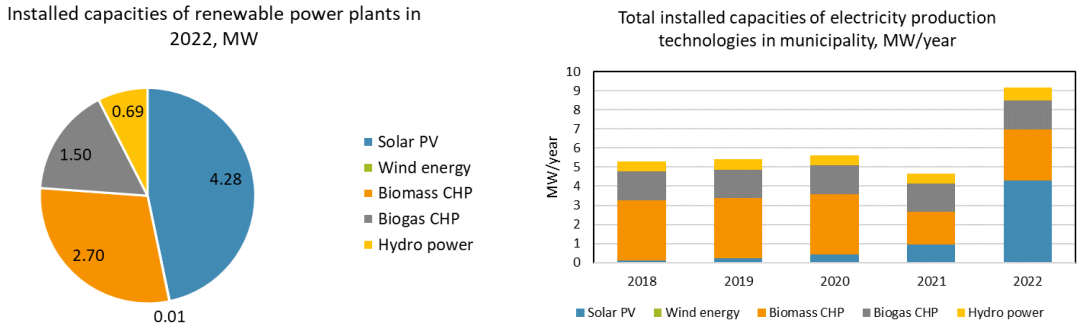


Fig. 3.23. Total installed capacities of renewable power plants.

The total amount of electricity generated from renewable power plants in Tukums municipality has decreased from 26.3 GWh in 2018 to 15.8 GWh in 2022. The most substantial decrease was observed for the power produced from biomass CHP. Majority of the produced electricity in 2022 came from biogas CHP (10.7 GWh), followed by biomass CHP (3.1 GWh). Solar PV accounted for 1.1 GWh of produced electricity in 2022.

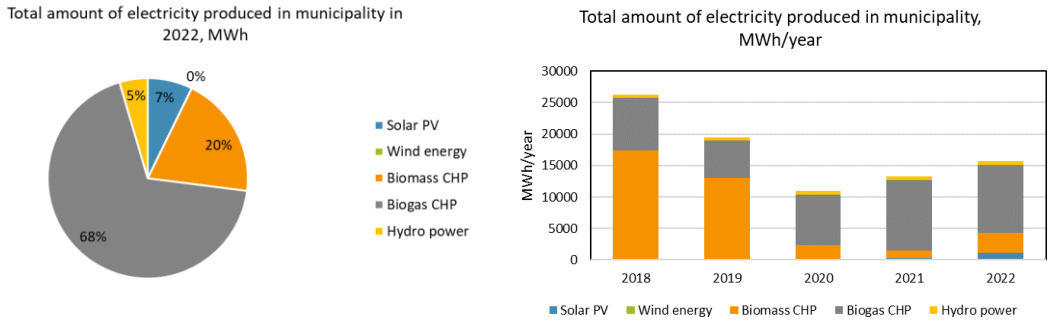


Fig. 3.24. Total amount of electricity produced in municipality.

For all variable energies such as solar PV, wind energy and hydropower plants, the strongest seasonal fluctuations in monthly electricity generation are observed. Biomass CHP and biogas CHP are able to compensate for the fluctuations in variable energy resources and its monthly production is consistent.

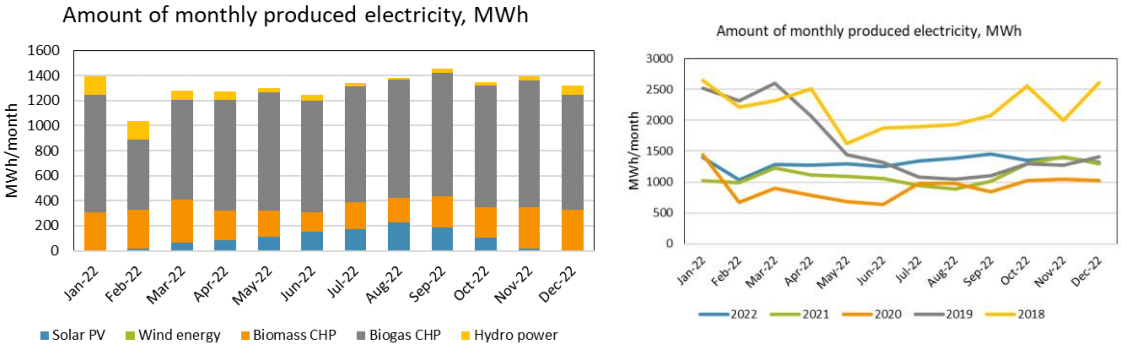


Fig. 3.25. Amount of monthly produced electricity by renewable power plants.

Heat production

According to the data provided by the municipality, total installed capacity of district heating and local boiler houses amounts to 48.96 MW, where highest share is recorded by biomass (wood chips, wood pellets, and firewood) with 47.9 MW, followed by natural gas (0.82 MW) and propane gas (0.25 MW). However, it remains to be clarified whether the current aggregated data includes Engure district. Moreover, it remains to be clarified which of the systems are attributed to the district heating and which to individual/local heat source technologies.

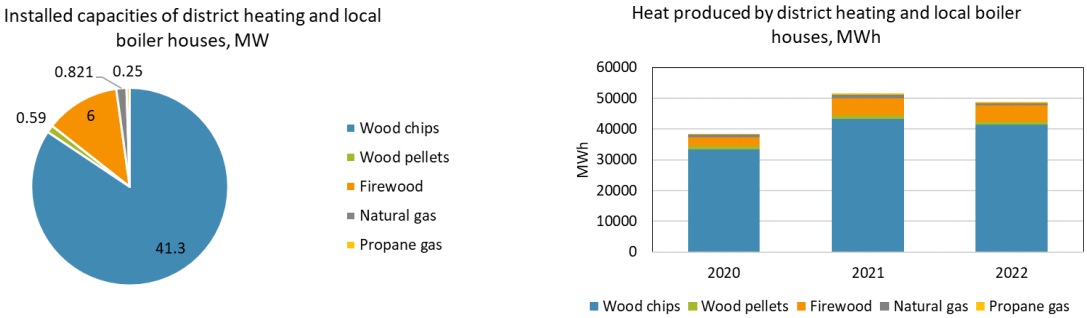


Fig.3.26. Heat production technology distribution in Tukums municipality.

Since there were identified missing data positions for generated heat in 2018-2020, then data for heat produced by district heating and local boiler houses summarizes values for the period from 2021 to 2022. Overall in 2022 total heat produced reached 47.6 GWh, a slight decrease from 50.1 GWh recorded in 2021.

Energy storage

Regarding the survey of existing or planned energy storage technologies in the region, Tukums municipality has indicated that there are currently no such systems in municipalities.

3.2.3 Taurage municipality energy profile

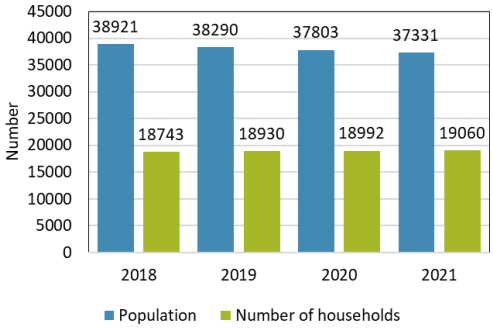
***Disclaimer**: During the preparation of this report certain inconsistencies in summarized data for Taurage municipality were identified. The identified issues will be discussed and eliminated during the municipality pilot and model validation activities in the scope of Work Package 2.*

General parameters and change dynamics

There are 8 elderships in the Taurage district municipality: Batakiai, Gaurė, Lauksargiai, Mažonai, Tauragė district, Tauragė city, Skaudvilė, Žygaičiai. Tauragė Region Municipality Administration is responsible for enhancing the development of the environment and infrastructure in the municipality.

- Located in the western part of Lithuania
- Area of 1179 km^2
- Agricultural land area of 592 km^2
- Population of 37.3 thousand inhabitants
- A total of 19 thousand households
- 1198 active enterprises

There has been a general decline in population in the Taurage municipality, but the total number of households has increased slightly. The general structure of housing in 2021 consists of 41% apartment blocks (multi-family dwellings) and 59% single-family dwellings. The distribution of households was obtained based on the proportion of households supplied by proportion from Taurage county which includes 4 municipalities.



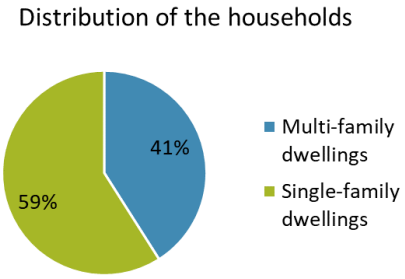
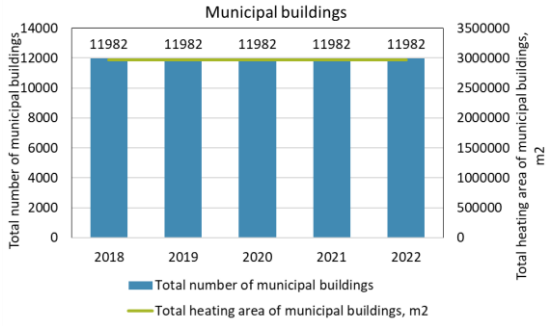


Fig. 3.27. Population and number of households in Taurage municipality; housing distribution*.

There are a total of 11 982 public buildings under the municipality governance. In 2022, the total heating area of these buildings was 2 966 934.5 m^2. The data show no change in the number of municipal buildings and thus the total heating area of buildings under municipal management over the years.



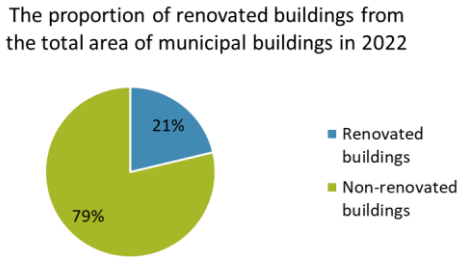
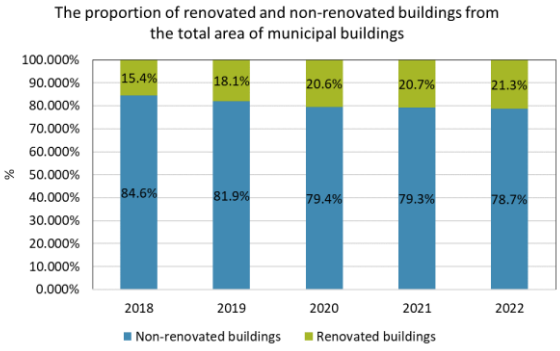


Fig. 3.27. Main characteristics of municipal buildings.

In general, 21% of the municipal building stock has been renovated, while majority of 79% is unrenovated. In general, the share of renovated buildings in the total municipal building stock has increased from 15.36% in 2018 to 21.28% in 2022 of renovated buildings in the total area of municipal buildings. The average specific heat consumption in renovated buildings in 2022 was 45 kWh/m2/year, while in non-renovated buildings it was 68.4 kWh/m2/year. The available data show no change in the average specific heat consumption values over the years.



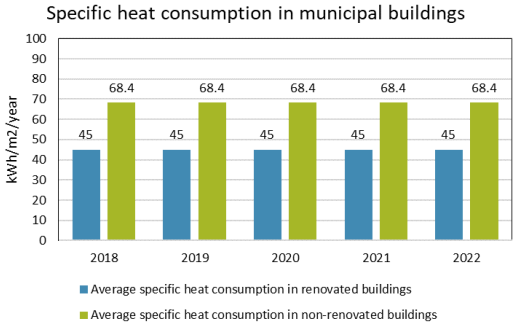


Fig. 3.29. The proportion and specific heat consumption of renovated and non-renovated buildings.

Electricity consumption

A slight increase in total electricity consumption was observed in the Taurage municipality, mainly due to rising electricity consumption in households and industrial sector. In 2019 and 2020, a significantly lower total electricity consumption was observed in the municipality, possibly due to the Covid restrictions. The electricity consumption of the municipal infrastructure in the municipality of Taurage has decreased by 7% compared to the consumption data of 2022 and 2019. The largest consuming sector in Taurage municipality is households, which consumed 38% of total electricity consumption in Taurage municipality in 2022, followed by the industrial sector, which accounted for 32% of total electricity consumption, and the commercial sector, which accounted for 27%. No data is available on electricity consumption in agriculture and forestry sector.

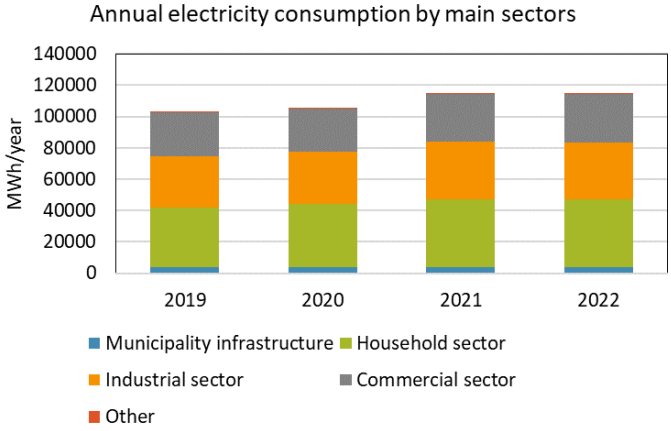


Fig. 3.30. Total annual electricity consumption in Taurage municipality by sectors.

In 2022, the total electricity consumption of municipal infrastructure objects was 3762 MWh, with municipal buildings and facilities being the largest consumer at 2766 MWh. The total electricity consumption of municipal buildings increased by 1% in the period from 2018 to 2022. Public street lighting consumed a total of 899 MWh in 2022, a significant decrease compared to 1232 MWh in 2018. Electricity consumption of municipal transport is increasing on annual basis.

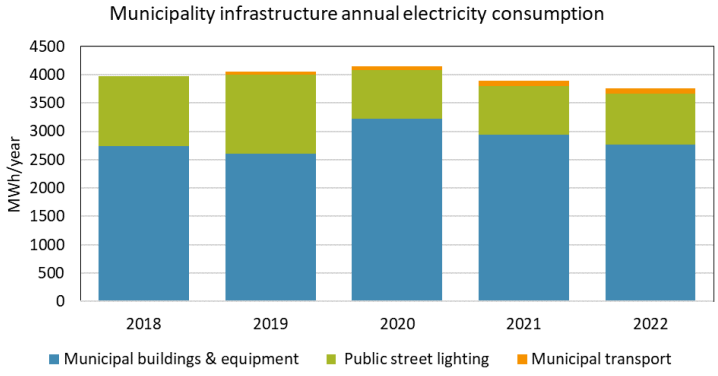


Fig. 3.31. Municipality infrastructure electricity consumption.

District heating consumption

Based on the available data, the total heat consumption from district heating sources in the municipality of Taurage has slightly decreased from 58465 MWh in 2018 to 55503 MWh in 2022. Households accounted for the highest share of total heat consumption in 2022 at 75%. In general, the data on district heating consumption in the municipality fluctuates slightly.

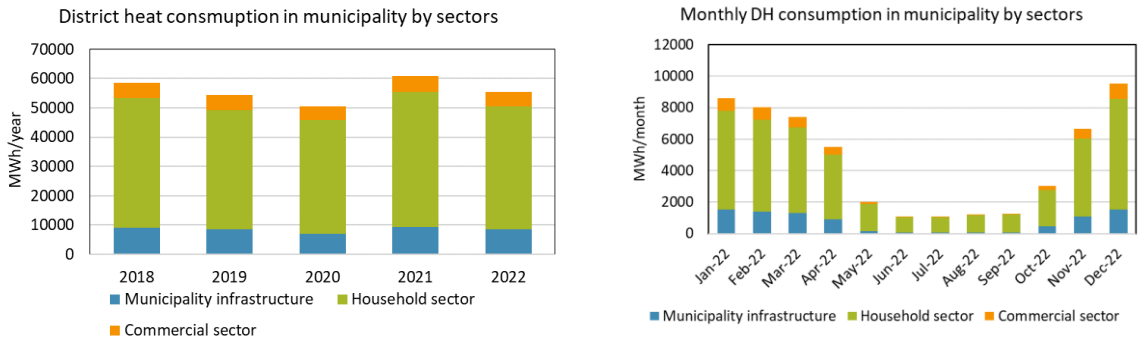


Fig. 3.32. Annual and monthly municipality heat consumption for objects connected to district heat supply by sectors.

The municipal infrastructure objects (consisting entirely of municipal buildings) connected to the district heating system consumed 8662 MWh in 2022, a slight decrease compared to 9303 MWh in 2021. Municipality infrastructure accounted for 16% from total heat consumption of objects connected to district heat supply.

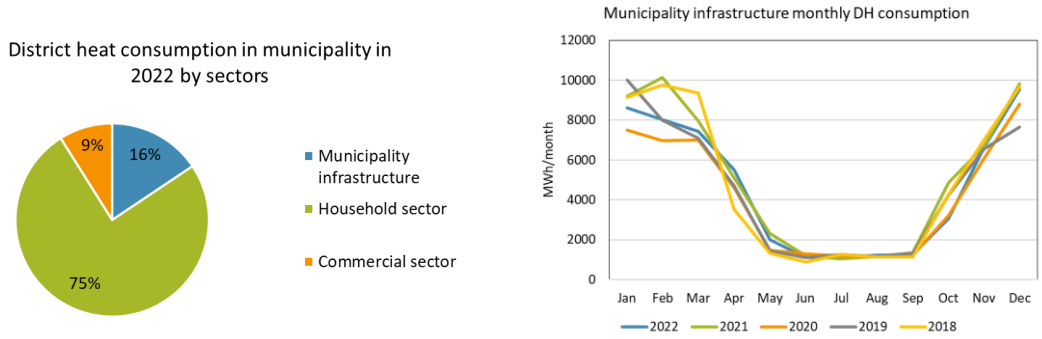


Fig. 3.33. District heat consumption in municipality by sectors and monthly consumption of municipal infrastructure DH consumption.

Data on heat distribution between district heating and individual heat consumption is obtained from data used as background for producing RES Actions Plan of Taurage District Municipality. A total of 403 objects, accounting for 487 270 m2 of the total heating area of the municipal buildings, are connected to district heating. These properties consumed a total of 55 503 MWh in 2022.

Table 3.14.

Total heat consumption by the municipal buildings distributed by the heat source in 2022.

	Number of objects	Total heating area, m^2	Total heat consumption, MWh
District heat	403	487 270	55503
Individual heat (boiler-houses of municipal objects)	1181	1 285 531	4292
Individual heat (residents)	9698	1 194 134	207508

While majority - a total of 1181 municipal buildings have an individual/local heat supply system, which has a total heating area of 1 285 531 m2 and a heat consumption of 4292 MWh. Biomass (wood, wood waste, wood pellets, wood briquettes) is the main source of heat used in local heating systems and accounts for 85% of the total heat consumption of buildings with individual heat supply.

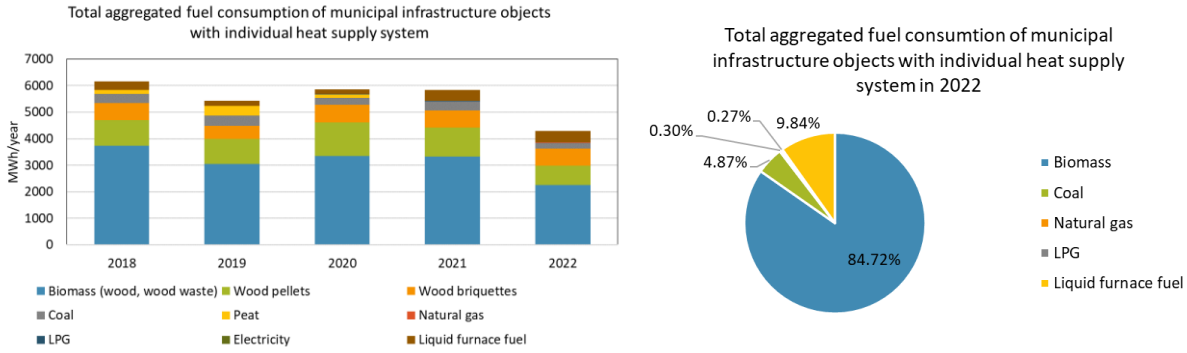


Fig. 3.34. Total aggregated fuel consumption of municipal infrastructure objects with individual heat supply system

The total heat consumption of municipal infrastructure objects with individual heat supply fell from 6164 MWh in 2018 to 4292 MWh in 2022. The sharpest decline was observed in the consumption of biomass and peat, while the consumption of natural gas, LPG and liquid furnace fuels increased slightly between 2018 and 2022.

Transport consumption

In total, municipal public transport consumed 14,593 MWh in the Taurage municipality in 2022. The majority of this, namely 14,447 MWh, was diesel consumption, while 146 MWh was electricity consumption.

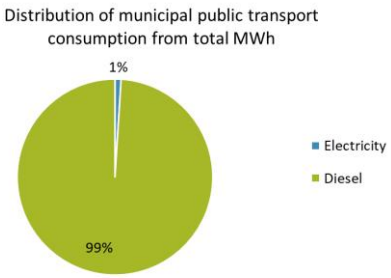


Fig. 3.35. Fuel consumption of municipal public transport distributed by the main sources used.

The diesel consumption of municipal public transport has increased significantly over the period, from 94 thousand litres in 2018 to 114 thousand litres in 2022. Diesel consumption on a monthly basis fluctuates significantly over the years.

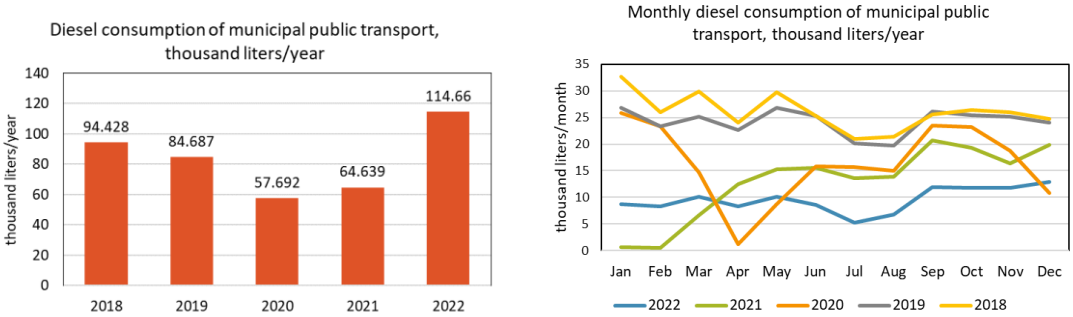


Fig. 3.36. Annual and monthly diesel consumption of municipal public transport.

The electricity consumption of municipal public transport has risen significantly from 59 MWh in 2020 to 146 MWh in 2022. Monthly electricity consumption for public transport needs is inconsistent and fluctuates considerably.

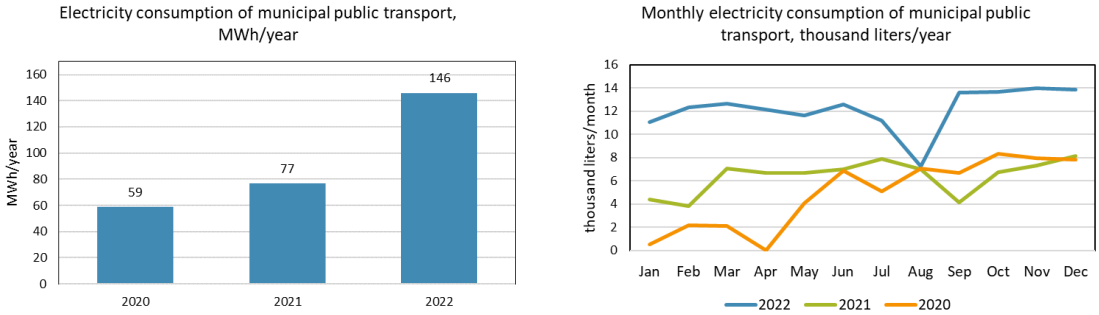


Fig. 3.37. Annual and monthly electricity consumption of municipal public transport

There is no specific data on the fuel consumption of private passenger cars. However, the total number of passenger cars in the Taurage municipality has increased. In 2022 there were a total of 29 449 private passenger cars.

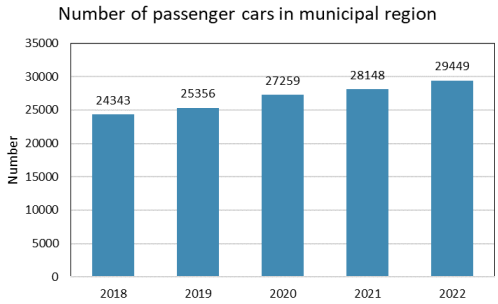


Fig. 3.38. Number of passenger cars in municipal region.

Electricity production

Total installed capacity of renewable power plants in Taurage municipality in 2022 is 56.12 MW. A vast majority of total capacity (50.54 MW) is accounted for wind energy followed by hydropower plants with a capacity of 3.01 MW, solar power plants with a capacity of 2.37 MW, and biogas CHP with a capacity of 0.2 MW. In the period from 2018 to 2022 total installed capacity of solar PV grew from 0.12 MW in 2018 to 2.37 MW in 2022. Wind energy, biogas CHP and hydropower capacities remained unchanged over the period.

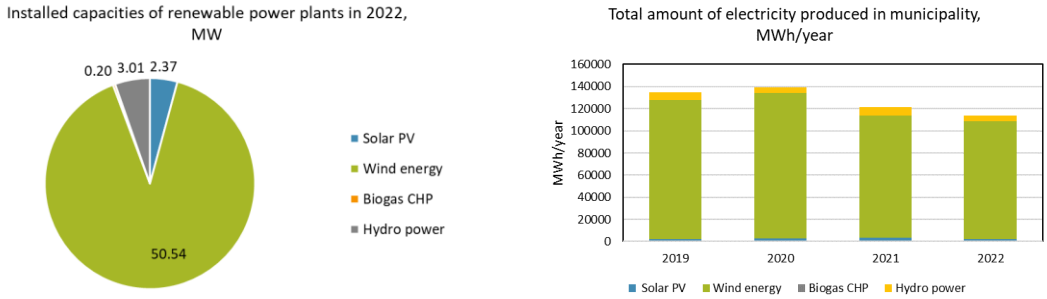


Fig. 3.39. Total installed capacities of renewable power plants and amount of electricity produced.

The total amount of electricity generated from renewable power plants in Taurage municipality has decreased from 135 GWh in 2019 to 114 GWh in 2022. Decrease was observed for mostly all power plants in municipality, but it can be explained by the variable nature of weather.

For all variable energies such as solar PV, wind energy and hydropower plants, the strongest seasonal fluctuations in monthly electricity generation are observed. The highest fluctuation in electricity produced due to seasonality factor is observed for solar power and hydropower. Wind energy production amounts are observed to be lower in summer months.

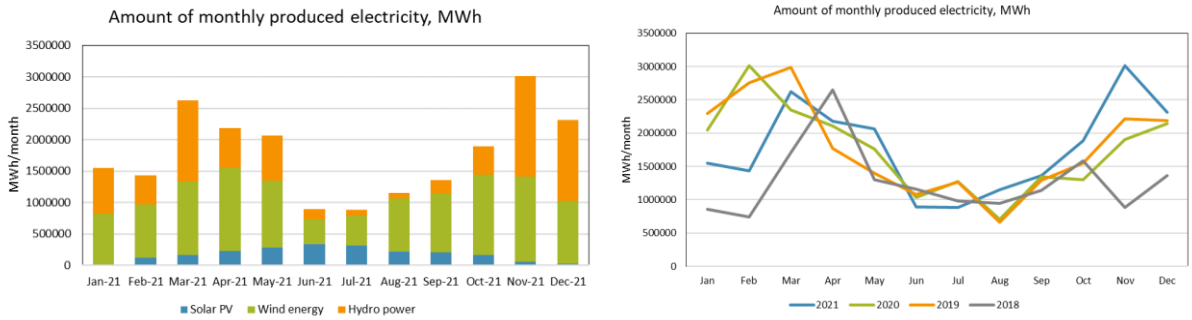


Fig. 3.40. Amount of monthly produced electricity by renewable power plants.

District heating

In Taurage municipality there are a total of 2 district heating providers in the municipal region. The total length of the district heating network is 27.8 kilometres. The heat generation of the district heating providers is based on biomass boilers and fossil fuels such as heavy fuel, oil shale and marked diesel.

Table 3.15.

Main characteristics of district heating system in Taurage municipality

Parameter	Value
Number of district heating providers in municipality	2
Total length of district heating network, km	27.8

The total installed capacity of biomass boilers in the district heating network in 2022 is 32.27 MW, while the majority, namely 54.18 MW, is accounted for by heavy fuel oil, oil shale and diesel. The data shows that the capacities of heat generation technologies in DH have remained unchanged over the period from 2018 to 2022. All the heat generated in DH is largely produced by biomass boilers, which accounted for 75677 MWh in 2022, while other fossil fuels accounted for 803 MWh.

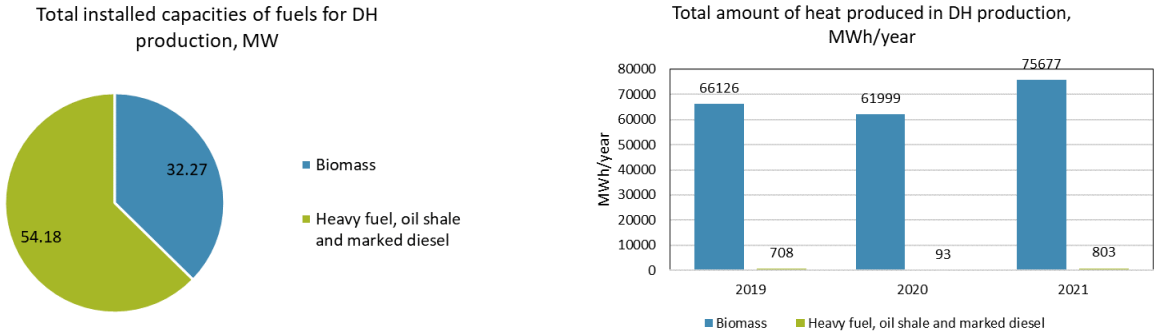


Fig. 3.41. Total installed capacities and amount of produced heat in district heating network of Taurage municipality distributed by fuels used.

The average monthly heat production of biomass boilers in the district heating supply amounts to 2011 MWh in the months from May to September and 8303 MWh in the rest of the months (April to October), with the highest production being achieved from November to February.

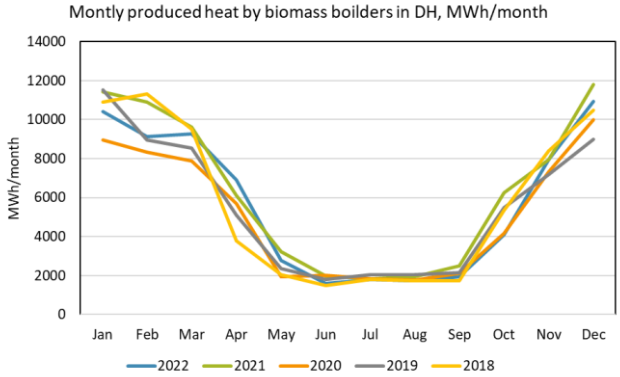


Fig. 3.42. Monthly produced heat by biomass boilers in district heating.

Energy storage

Batteries

There is no installed such technology in municipality, and the municipality has no plans to install batteries. According to the Taurage municipality, no information is available on individual small batteries (<=10 kW).

Pumped hydro storage

There is no installed such technology in municipality, and municipality has no plans on installing this technology.

Thermal energy storage

There is no installed such technology in municipality, there are no thermal energy storages in Taurage municipality, however, Taurage DH company has plans for installation of 2,000 m3 thermal water-based storage.

Hydrogen and biomethane

There is no installed such technology in municipality, and municipality has no plans on installing it.

3.2.4 Tomellila municipality energy profile

***Disclaimer**: As of January 2024, many missing data positions were identified during the preparation of data summary for Tomelilla municipality. The municipality is in the process of data collection for missing positions and update of the data collection template "Municipality factsheet". This version of the description might contain some inconsistencies which remain to be clarified with the municipality.*

General parameters and change dynamics

Tomelilla municipality is situated in the county of Skåne. Tomelilla town is also the name of the municipality's central locality and the seat of its municipal government.

- Located in Skåne County in southern Sweden
- Area of 397 km^2
- Agricultural land area of 250 km^2
- Population of 13.8 thousand inhabitants
- A total of 6.4 thousand households

There has been a general increase in the population and the total number of inhabited households in the Tomellila municipality. Total number of inhabitants in Tomellila municipality increased from 13557 in 2018 to 13812 in 2022. Moreover, the number of households increased by 164 over the period.

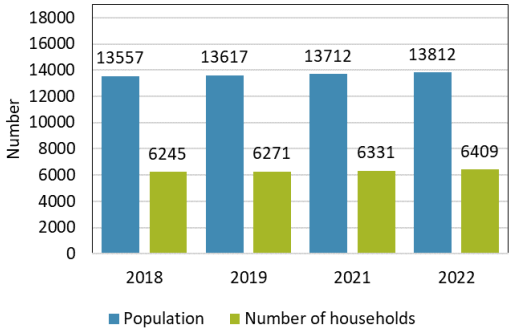


Fig. 3.43. Population and number of households in Tomellila municipality.

There are total of twenty-five municipal buildings with a total heating area of 45831 m2 which according to the data remained unchanged over the period from 2018 to 2022. There are currently no data on proportion of buildings that are renovated. However, the average specific heat consumption in renovated buildings in 2022 was 150 kWh/m2/year, while in non-renovated buildings it was 130 kWh/m2/year.

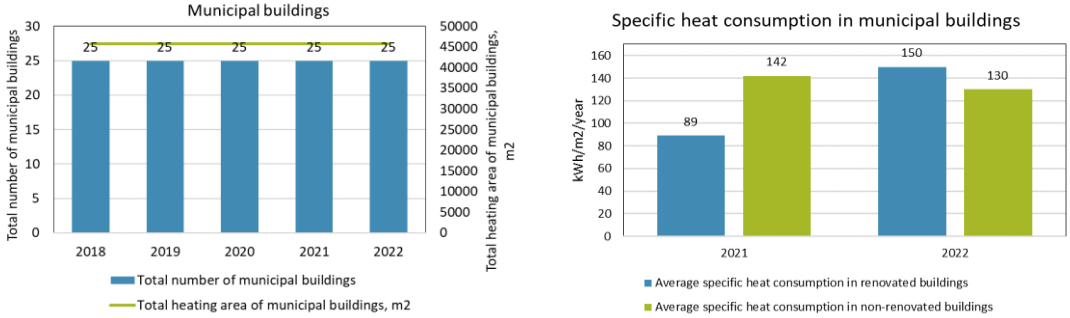


Fig. 3.44. Municipal buildings and specific heat consumption of municipal buildings in Tomellila.

Electricity consumption

A gradual decrease in total electricity consumption was observed in the Tomellila municipality over the period from 2018 to 2022. Total electricity consumption decreased from 173.7 GWh in 2018 to 171.2 GWh in 2021. The largest consumption sector in the Tomellila municipality is households sector, which consumed 38% of total electricity consumption in the Tomellila municipality in 2021, followed by industry, which accounted for 33% of total electricity consumption. Due to missing data positions of electricity consumption in industrial sector in 2020 and in household, commercial and agricultural sectors in 2022, current data summary (in Fig. 3.44.) excludes years 2020 and 2022.

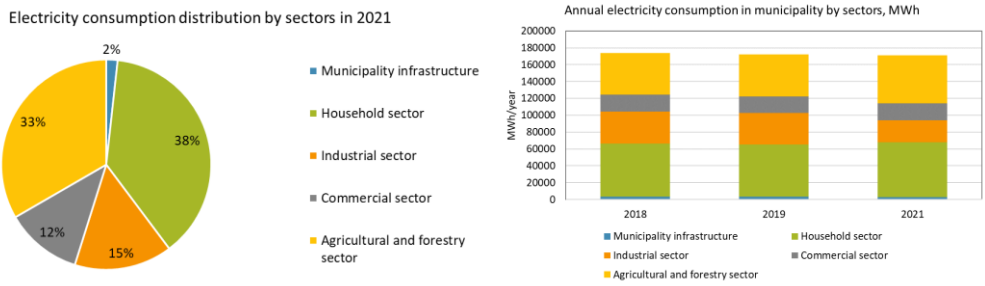


Fig. 3.45. Total electricity consumption in Tomellila municipality by sectors.

Municipality infrastructure consumes only 2% from total electricity consumption in the municipality in 2021. A gradual decrease in municipal electricity consumption was observed over the period from 2018 to 2022. Total electricity consumption of municipality infrastructure decreased from 3161 MWh in 2018 to 2850 MWh in 2022.

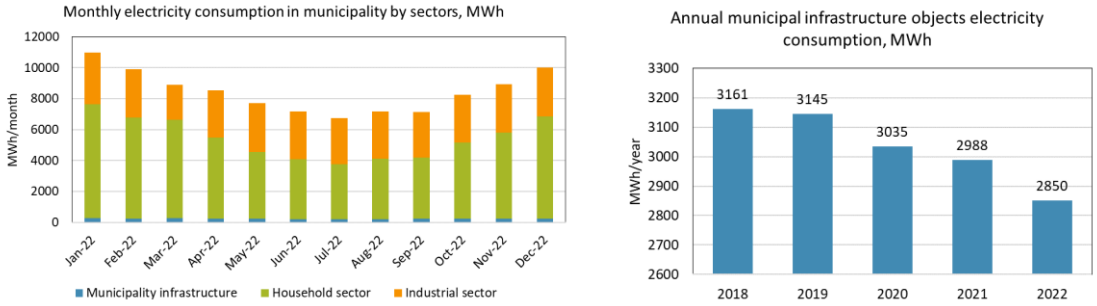


Fig. 3.46. Total monthly electricity consumption in Tomellila municipality in 2022 and annual municipal infrastructure electricity consumption.

District heating consumption

There is only limited data on the total heat consumption of the Tomellila municipality for objects connected to the district heating supply. Data for the district heating consumption for all sectors, except agriculture and other consumers was fully available for years 2020 and 2021.

Based on the available data, the four main sectors – households, municipal infrastructure, commercial sector and industrial sectors - consumed 39.7 GWh in 2021 where household sector alone consumed 17.5 MWh, followed by commercial sector with 13.5 GWh. Municipal infrastructure accounted for 16% of total consumption or 6.4 GWh. Industrial sector accounted for the lowest share and in 2021 consumed 2.3 GWh.

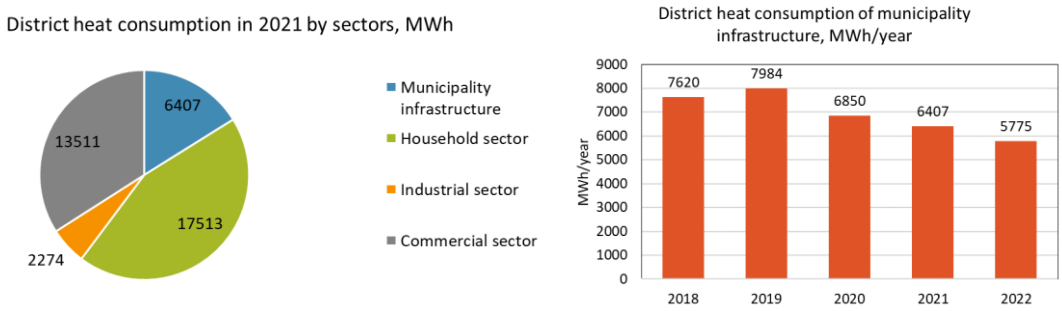


Fig. 3.47. Heat consumption for objects connected to district heat supply by sectors in 2021 and annual district heat consumption of municipality infrastructure.

In general municipal infrastructure objects connected to the district heating system experienced a decrease in heat consumption from 7.6 GWh in 2018 to 5.8 GWh in 2022. According to the provided data, thus consumption is entirely attributable to municipal buildings. On monthly basis average consumption of municipal buildings in the months from April to October is 503 MWh while average consumption from May to September equals to 104 MWh.

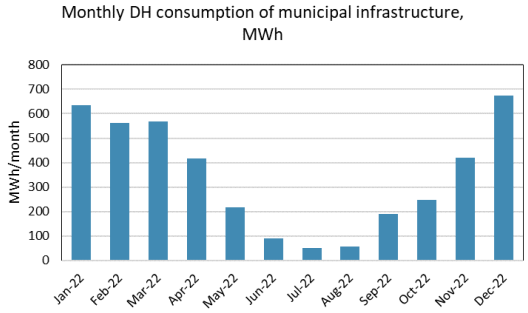


Fig. 3.48. Monthly heat consumption for municipal infrastructure objects connected to district heat supply in 2022.

A total of 15 objects, accounting for 63% of the total heating area of the municipal buildings, are connected to district heating. These properties consumed a total of 29 GWh in 2022.

Table 3.16.

Total heat consumption by the municipal buildings distributed by the heat source

	Number of objects	Total heating area, m^2	Total heat consumption, MWh
District heat	15	29030	4126
Individual heat	4	16801	1649

While a total of 4 municipal buildings has an individual/local heat supply system, which has a total heating area of 16801 m2 and a heat consumption of 1.6 GWh. Biomass is the main heat source used in the local heating systems. However, there are several inconsistencies in these data which remain to be clarified with the municipality.

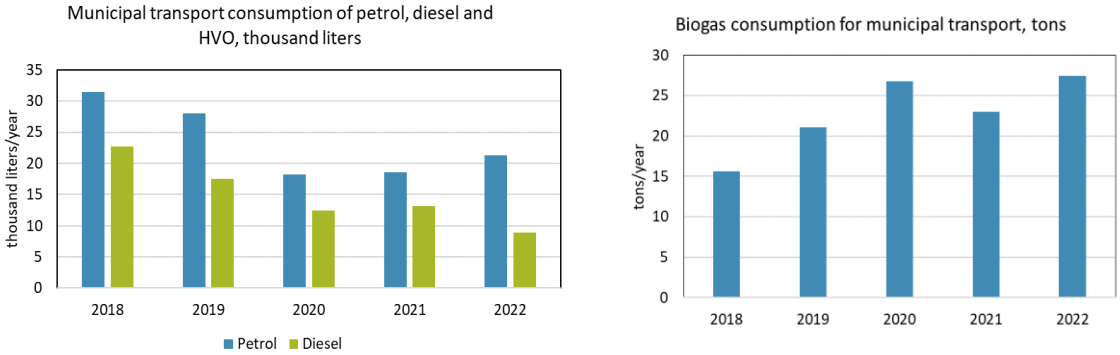


Fig. 3.49. Petrol, diesel, and biogas consumption for municipality transport.

Transport consumption

According to the provided data, as of January 2024 municipality transport energy consumption data was available only for the municipality transport fuel consumption. It remains to be clarified whether Tomellila municipality has data and information on public transport energy consumption in the region. The total consumption of fuels in the municipality has increased considerably in municipal transport. However, a considerable decarbonization trend is observed in municipal transportation.

In 2022, the majority of energy to meet municipal transport needs was provided by fossil fuels such as petrol (21.28 thousand litres) and diesel (8.86 thousand litres). However, there has been a significant increase in the consumption of non-fossil fuels. In 2022, municipal transport in the municipality of Tomelilla consumed 2.5 MWh of electricity, 36803 thousand litres (unit of measure remains to be clarified) of HVO and 27.46 tonnes of biogas.

The overall petrol and diesel consumption in municipality has gradually decreased in the period from 2018 to 2022. The gradual decrease of fossil fuels was replaced by the increased use of biogas, HVO, and electricity. Biogas consumption increased from 15.6 tons in 2018 to 27.4 tons in 2022. Additionally, beginning in 2021, HVO and electricity consumption for municipal transportation became apparent.

As far as private passenger transport is concerned, there is no specific data on fuel consumption. However, according to the provided data, the total number of passenger cars registered in the Tomellila municipality region is increasing, reaching 8139 passenger cars in municipal region in 2022. Total number of passenger cars has increased from 7937 in 2018 to 8139 in 2022.

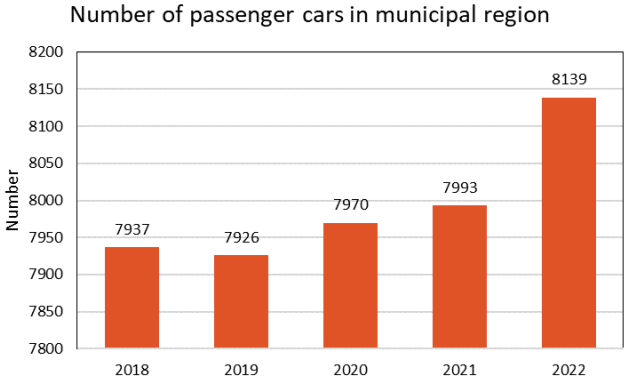


Fig. 3.50. Number of passenger cars in municipal region.

Electricity production

From 2018 to 2022, the total installed renewable power plants increased from 30.63 MW to 35.93 MW. During the period, wind energy capacity remained constant at 29 MW, whereas solar capacity increased fourfold. More precisely, the number of solar power plants that were installed escalated from 1.6 MW in 2018 to 6.9 MW in 2022.

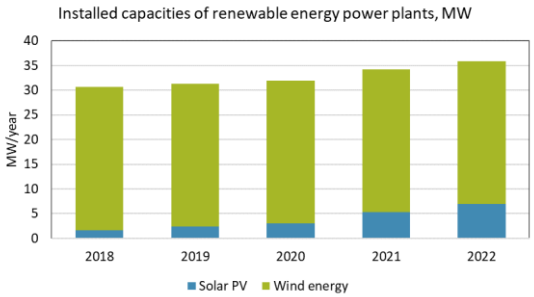


Fig. 3.51. Total installed capacities of renewable power plants

There was limited data available on the amount of produced electricity from renewable energy sources. However, according to the data available in 2021, wind energy generated nearly 50 GWh and solar PV contributed 3.7 GWh. Generation of electricity via wind turbines has exhibited variability throughout the years. According to the provided data, municipality indicated 100 MWh of electricity produced from biomass CHP which uses wood chips and operates in district heating (to be clarified).

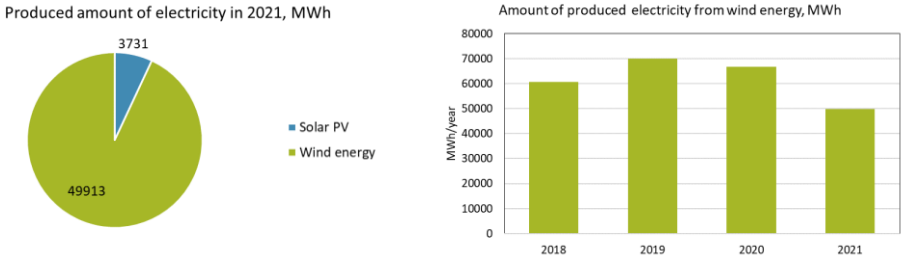


Fig. 3.52. Total installed capacities of renewable power plants

District heating

Regarding the municipality district heating production profile, there was no data provided for the installed capacities of heat production plants. According to the data on amount of heat produced in district heating, municipality has indicated a substantial amount of heat produced from biogas plant. Biogas production has increased from 31 GWh in 2018 to 42.8 GWh in 2022. The plant uses sticks and treetops from the final felling of forestry.

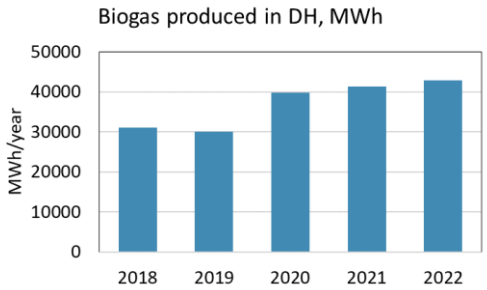


Fig. 3.53. The amount of produced heat by of biogas plant in DH network of Tomellila municipality.

In Tomellila municipality there is 1 district heating provider in the municipal region. The total length of the district heating network is 37 kilometres.

Table 3.17.

Main characteristics of district heating system in Tomellila municipality

Parameter	Value
Number of district heating providers in municipality	1
Total length of district heating network, km	37

Energy storage

Batteries

There are currently no existing battery systems in the municipality. The municipality are currently developing an overview plan for the municipality, where energy production and consumption should be covered. Currently, there are no plans to include a goal for installed battery capacity in the overview plan, and there are no other planned installments in the municipality. This might change with more available information. Region Skåne, a self-governing administrative region where Tomelilla municipality is located, has developed a roadmap for energy supply in Skåne to 2030. Although Region Skåne is responsible for the roadmap, they have limitied power to implement it. The power lies with municipalities, grid owners, and energy producers. In the road map, demand-side flexibility and batteieries are presented as soultions to lack of capacity in the grid system. However, there are no explicit goals on how much installed capacity should be installed until 2030.

Pumped hydro storage

Tomelilla municipality does not have a pumped hydro storage facility. The potential to implement such technology in the future has not been explored. Tomelilla municipality has limited knowledge on the subject, but it is worth noting that there are no lakes or large water sources.

Thermal energy storage

There is currently no thermal energy storage installed in the municipality, and there are no future plans or discussions currently.

Hydrogen and biomethane

There is currently no hydrogen being utilized in the municipality, to the municipalitie's knowledge. The municipality is interested in exploring hydrogen's long-term potential but are still in an early stage of exploring options and potential interest groups. There is currently no biomethane produced in the municipality, and currently no short or long-term plans to meet municipality energy demand.

3.2.5 Mikołajki Pomorskie municipality energy profile

***Disclaimer**: As of January 2024, many missing data positions were identified during the preparation of data summary for Mikołajki Pomorskie municipality. Some of the provided data seem unreliable and needs to be checked by the municipality. Some data which seemed unreliable were excluded from the current version of municipality data analysis. This version of the description might contain inconsistencies which remain to be clarified with the municipality.*

General parameters and change dynamics

Gmina Mikołajki Pomorskie is a rural gmina (administrative district) in Sztum County, Pomeranian Voivodeship, in northern Poland. Its seat is the village of Mikołajki Pomorskie, which lies approximately 12 kilometres south-east of Sztum and 67 km south-east of the regional capital Gdańsk.

- Located in Sztum County, in northern Poland
- Area of 91.6 km^2
- Agricultural land area of 78.2 km^2
- Population of 3.4 thousand inhabitants
- A total of 885 households
- 239 active enterprises

In the municipality of Mikoajki Pomorskie, both the total number of households and the population have decreased marginally. The municipality of Mikołajki Pomorskie experienced a decline in its total population from 3624 in 2018 to 3454 in 2022. Additionally, the quantity of households experienced a decline from 897 to 885 during the analysed period.

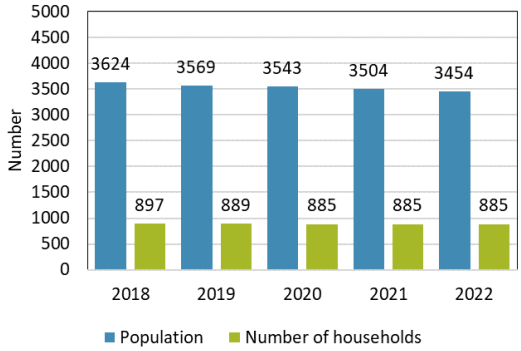


Fig. 3.54. Population and number of households in Mikołajki Pomorskie municipality

According to the provided data, there are total 10 municipal buildings under the governance of Mikoajki Pomorskie municipality. Total heating area of these buildings is 5945.6 m2, where all of the buildings have individual/local heat supply source (with a boiler room in the basement). According to the provided information, as of 2022 all buildings are renovated, and their average specific heat consumption is 263.47 kWh/m2. Even though this data seems unreliable, according to the provided information, this average specific heat consumption is very high, but these are the only data the commune has at its disposal.

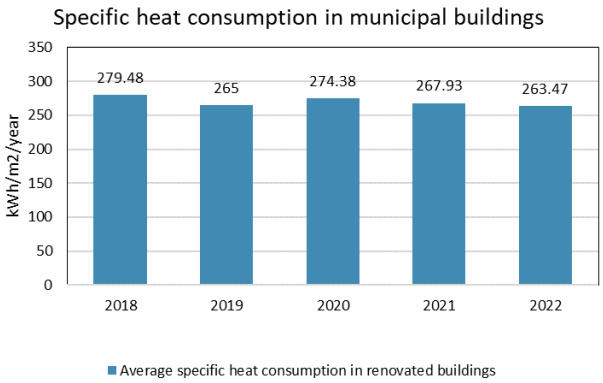


Fig. 3.55. Average specific heat consumption of municipal buildings in Mikołajki Pomorskie municipality.

The buildings owned by the Mikołajki Pomorskie Commune are also municipal apartments. They are not included in the summary described above (except for buildings with municipal apartments in Cieszymów 1B and 1C) because the tenants heat their apartments on their own. These buildings are not connected to the heating network or to any common local boiler room. Each of these apartments has a central heating boiler installed with a power (on average) of up to 5 kW and each tenant supplies fuel personally. It may be firewood or coal with various calorific values. These boilers are mostly class 3 or lower. The commune does not know the average specific heat consumption for these apartments. These are 7 buildings 100% owned by the Commune. There are a total of 18 apartments with a total area of 1,065.80 m². These are buildings where thermal modernization was carried out in 2010-2016. Walls insulated with 10-15 cm polystyrene, windows and doors replaced. However, with potentially poor insulation of the ceilings. In addition, there are 4 apartments with a total area of 200.66 m² in 4 buildings, where the commune is a co-owner (in various shares) of these buildings.

Electricity consumption

Mikołajki Pomorskie municipality has provided annual data on electricity consumption for the main municipal infrastructure consumption groups – municipal buildings and public street lighting. Electricity consumption data for households, industrial and commercial sectors was obtained from the low-emission economy plan of the Mikołajki Pomorskie Commune.

According tot he aggregated electricity consumption data, total electricity consumption in Mikołajki Pomorskie municipality in 2022 reached 3617 MWh. A slight increase in total electricity consumption was observed in the Mikołajki Pomorskie municipality, mainly due to rising electricity consumption in the households, industrial, and commercial sectors. The largest consumption sector in the Mikołajki Pomorskie municipality is households, which consumed 56% of total electricity consumption in the Mikołajki Pomorskie municipality in 2022, followed by industrial sector, which accounted for 22% of total electricity consumption. The commercial sector accounted for 9% of total electricity consumption in 2022, while municipal infrastructure objects accounted for 12%.

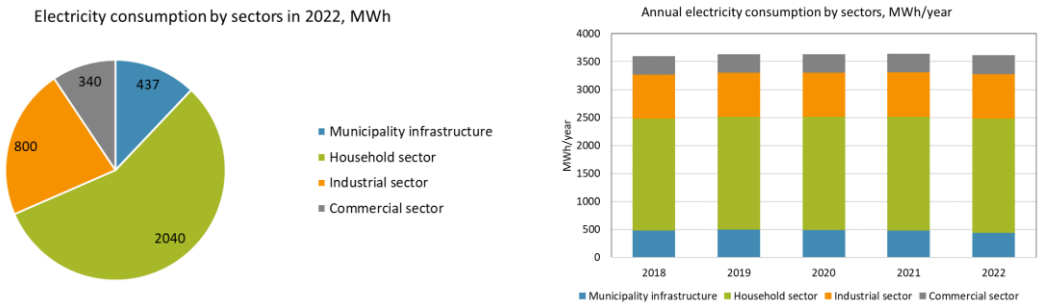


Fig. 3.56. Total annual electricity consumption in Mikołajki Pomorskie municipality by sectors.

Municipality infrastructure electricity consumption decreased from 478 MWh in 2018 to 437 MWh in 2022. Highest decrease was achieved due to efficiency improvements in buildings. Electricity consumption from public street lighting generally remained consistent over the period with mild fluctuations observed.

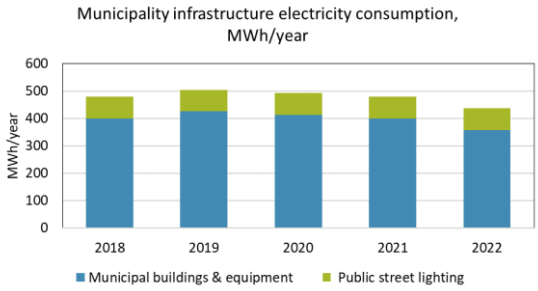


Fig. 3.57. Total annual electricity consumption of municipality infrastructure object in Mikołajki Pomorskie municipality.

Heat consumption

According to the information provided, there are no district heating networks in the municipality of Mikołajki Pomorskie. The municipality has provided data on heat consumption from local heat sources for 2022, according to which the municipal infrastructure consumed 717 MWh, of which 85 MWh for municipal buildings and 633 MWh for aggregated consumption of the health centre, cultural centre, fire station, school and kindergarten. There are no data for other sectors such as industrial, commercial, agricultural sector, and others.

Transport consumption

There were no data provided on transport consumption by the municipality. According to the provided information, there is no municipal transport in the commune of Mikolajki Pomorskie. Data on the number of registered cars is available only at the county (powiat in Polish) level, not at the commune level. Moreover, the county authorities refused to provide the commune with general data (referring to legal regulations regarding government statistics).

Electricity production

According to the supplied data, the total installed capacity of renewable power plants in Mikołajki Pomorskie municipality in 2022 is 45.1 MW. The vast majority of the total capacity (38.1 MW) is accounted for by installed wind turbines, followed by solar PV with a total capacity of 7 MW. In the period from 2018 to 2022, the total installed capacity of both solar and wind energy increased considerably. Solar PV capacity has increased from 2 MW in 2018 to 7 MW in 2022. While wind energy increased from 15 MW in 2018 to 38.1.MW in 2022. Moreover, three wind turbines (each 4 MWh) have been launched since September 2023. According to the information provided, 12.6 MW of installed electrical capacity (new wind farm) will be available from September 2023.

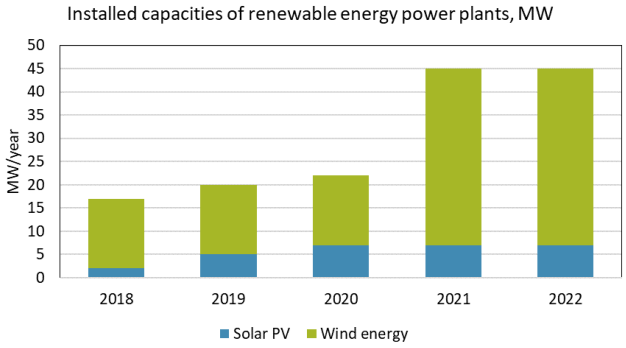


Fig. 3.58. Total installed capacities of renewable power plants in municipality.

Heat production

As indicated previously, there are no heating networks in the Mikołajki Pomorskie commune. The entire heat supply for buildings in the municipality is generated by individual/local heat supply sources. For 2022, the municipality has stated heat generation from light fuel oil of 94 MWh and from hard coal of 22756 MWh.

Municipality were asked to clarify from what heating plants current indicated heat produced (in the "Municipality factsheet") is supplied. In the case of single-family buildings, the predominant source is internal hard coal boilers. For multi-family buildings, the heat is primarily derived from building boiler rooms utilizing hard coal. Municipal buildings, which encompass structures such as the municipal office, generally rely on building boiler rooms fueled by coal, with the exception of the municipal office, which utilizes fuel oil for its heating requirements.

There are no data available for the past five years to study the change dynamics.

Energy storage

Batteries

Considerations and discussions regarding the installation of energy storage facilities mainly concern the fact that their installation by the commune government could only be possible with significant funding for this investment from external sources.

Pumped hydro storage

Does not exist.

Thermal energy storage

Does not exist.

Hydrogen and biomethane

In the commune, a private entrepreneur (a private agricultural plant with dairy animal breeding and agricultural cultivation) plans to build a biogas plant in the future to obtain electricity.

3.2.6 Wejherowo municipality energy profile

Disclaimer*: As of January 2024, many missing data positions were identified during the preparation of data summary for Wejherowo municipality. The municipality is in the process of data collection for missing positions and update of the data collection template "Municipality factsheet". This version of the description might contain some inconsistencies which remain to be clarified with the municipality.*

General parameters and change dynamics

Wejherowo municipality is located on the Reda River – on the border of the Kashubian Lake District. Wejherowo municipality is a part of the Gdańsk agglomeratio, the seat of the Wejherowo County and rural commune of Wejherowo. Wejherowo is the capital of the district and the seat of the Wejherowo District Office.

- Located in on the border of the Kashubian Lake District, northern Poland
- Area of 26.9 km^2
- Agricultural land area of 4.1 km^2
- Population of 46.4 thousand inhabitants
- A total of 19.3 thousand dwellings

There has been a general decline in the population and total number of dwellings in the Wejherowo municipality in the period from 2018 to 2022. The total number of dwellings has fluctuated slightly over the last three years.

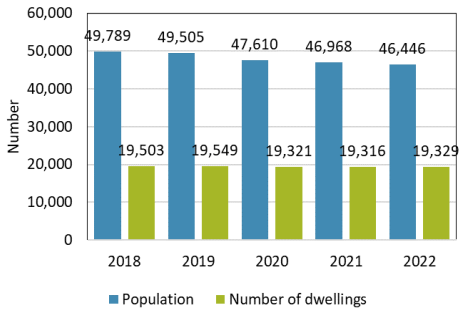


Fig. 3.59. Population and number of households in Wejherowo municipality

There are approximately 9,000 buildings in the city. The commune owns (100% ownership) only a small part of the buildings and has 66 residential buildings and 18 public buildings, which is approximately 1% of all buildings in terms of quantity, and approximately 5% in terms of surface area (according to the heated area). The remaining buildings are owned by the District Office, housing cooperatives, housing communities, companies or private owners. In the city there are also buildings for special purposes (related to the country's defense) in which military units are located. There are also a number of residential buildings (owned by housing communities) in which the municipality has partial shares, i.e. some of the apartments still belong to the municipality, and some have been purchased and now have private owners.

There are a total of 84 public buildings under the municipality governance in 2022. In 2022, the total heating area of these buildings was 78,424 m2. Over the years, the number of municipal buildings and thus the total heating area of buildings under municipal management has decreased slightly.

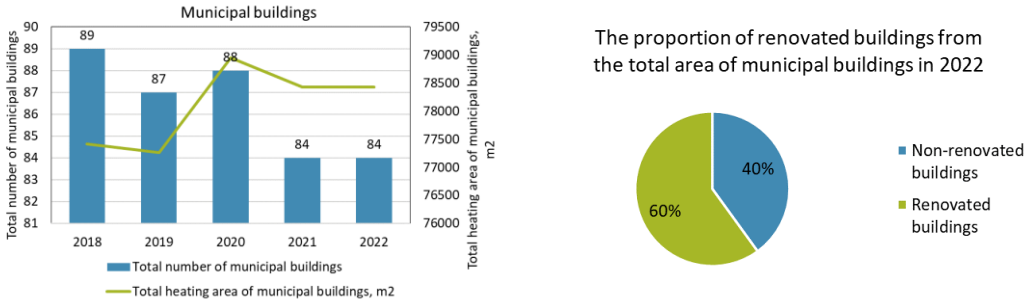


Fig. 3.60. Main characteristics of municipal buildings.

In general, 60% of the municipal building stock has been renovated, while a proportion of 40% is un-renovated. In general, the average share of renovated buildings in the total municipal building stock has increased from 55% in 2018 to 60% of renovated buildings in the total area of municipal buildings in 2022. The average specific heat consumption in renovated buildings in 2022 was 92 kWh/m2/year, while in non-renovated buildings it was 155 kWh/m2/year. The average specific heat consumption values vary between years.

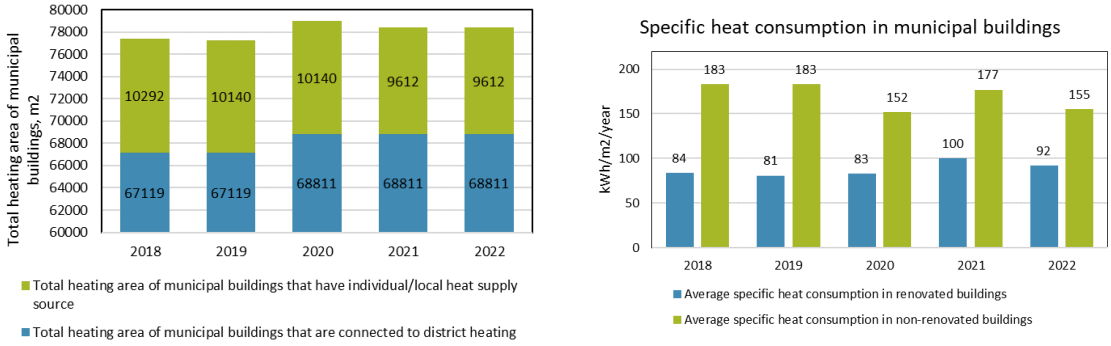


Fig. 3.61. The proportion and specific heat consumption of the renovated and non-renovated buildings.

In the case of the Wejherowo municipality, there is a specific situation with residential buildings undergoing thermal renovation and being the property of the municipality. A significant part of municipal residential buildings come from the pre-war period or from the 19th century, and their thermal modernization is carried out taking into account the requirements of the conservator of monuments. For this reason, the energy indicators that can be achieved as a result of renovation are lower than in public buildings, where there are no such technical restrictions.

Electricity consumption

A slight decrease in total electricity consumption was observed in the Wejherowo municipality, mainly due to decrease in electricity consumption in the industrial and commercial sector. Municipality infrastructure electricity consumption has been slightly fluctuating over the period and in 2022 reached 7269 MWh. The largest consumption sector in the Wejherowo municipality is industrial and commercial sector, which consumed 51% of total electricity consumption in the Wejherowo municipality in 2022, followed by households, which accounted for 40% of total electricity consumption.

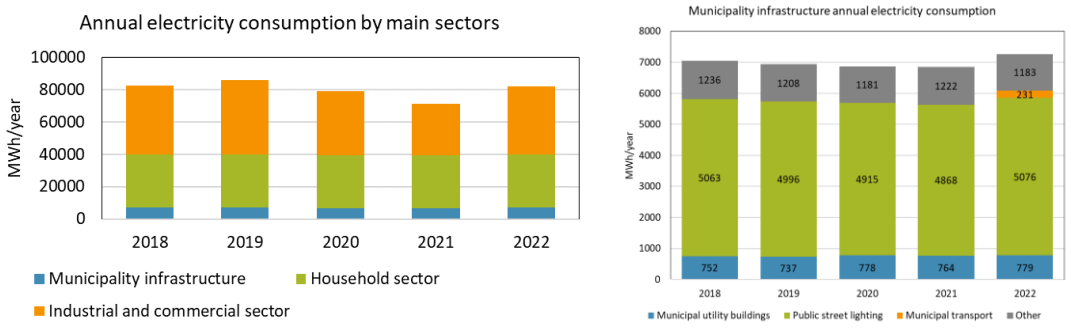


Fig. 3.62. Total annual electricity consumption in Wejherowo municipality by sectors and by municipality owned infrastructure objects.

Total municipal electricity consumption is determined by the four main consumers – municipal utility

buildings, public street lighting, municipal transport, and others. Other consumers are electrical heating in the buildings (accounting for 416 MWh in 2022) and municipal residential buildings and building of Wejherowo Social Housing Society (accounting for 767 MWh in 2022). Public street lighting is the largest electricity consumer from municipal infrastructure object accounting for 70% from total electricity consumption of the municipality in 2022, followed by other consumers (16%), municipal utility buildings (11%), and municipal transport (3%).

District heating consumption

Based on the available data on the total heat consumption of the Wejherowo municipality for objects connected to the district heating supply, the four main sectors – households (residential buildings), municipal infrastructure, commercial sector and industrial sector - consumed 88.2 GWh in 2022 where household sector alone consumed 51.3 GWh. In general data on district heat consumption in municipality is slightly fluctuating.

Fig. 3.63. Annual and monthly municipality heat consumption for objects connected to district heat supply by sectors.

The municipal infrastructure objects connected to the district heating system consumed 6749 MWh in 2022, a slight decrease compared to 7099 MWh in 2018. More than two thirds of this consumption (4819 MWh) is attributable to municipal utility buildings while smaller portion of 1930 MWh is consumed by municipal residential buildings & Wejherowo Social Housing Society (WTBS) that are wholly owned by the municipality (and are not included in the household consumption group).

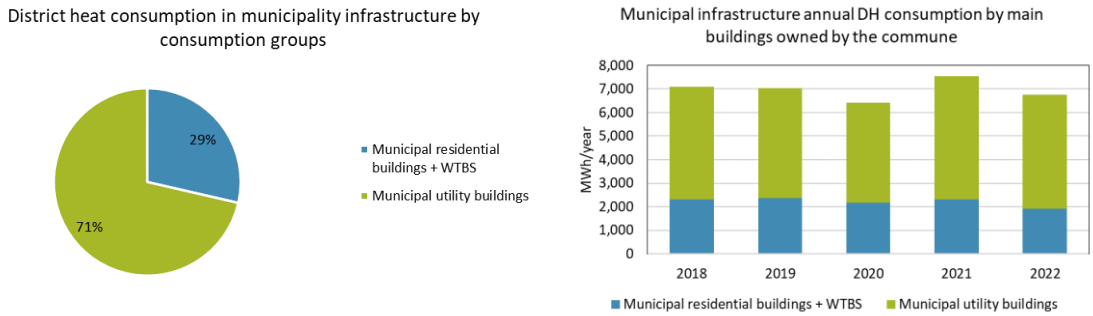


Fig. 3.64. District heat consumption in municipality infrastructure.

A total of 44 objects, accounting for 88% of the total heating area of the municipal buildings, are connected to district heating. These properties consumed a total of 6749 MWhin 2022.

Table 3.18.

Total heat consumption by the municipal buildings distributed by the heat source

	Number of objects	Total heating area, m^2	Total heat consumption, MWh
District heat	44	68811	6749
Individual heat	40	9612	2410

While a total of 40 municipal buildings has an individual/local heat supply system, which has a total heating area of 9612m2 and a heat consumption of 2410 MWh. Electricity, natural gas, and coal are the main heating sources used in the local heating systems. A total of 415.5 MWh of electricity, 137 tones of coal, and 143.6 thousand m3 were used to heat these municipal buildings in 2022.

Transport consumption

In Wejherowo municipality public transport services provide municipal transport company that is 100% owned by the Wejherowo municipality. In 2022 public transport consumed 826 thousand liters of diesel and 231 MWh of electricity. In 2023 the public transport company purchased additional 2 electric buses. From 2024, it is planned to replace the rolling stock with hydrogen buses (the first hydrogen bus has already been tested for 2 weeks on the city streets). In general, diesel consumption of municipal public transport has been slightly fluctuating over the years. However, an overall diesel consumption has decrease from 842 thousand liters in 2018 to 826 thousand liters in 2022.

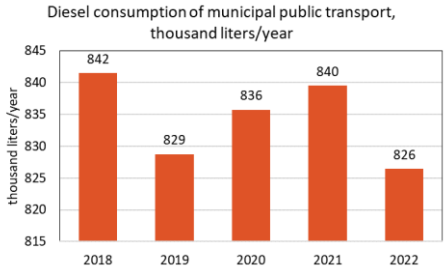


Fig. 3.65. Fuel consumption for municipality public transport.

As far as private passenger transport is concerned, there is no specific data on fuel consumption. However, according to the available data the total number of passenger cars registered in the Wejherowo region is increasing, reaching 32550 passenger cars in municipal region in 2022.

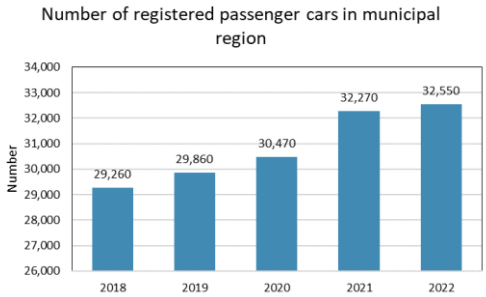


Fig. 3.66. Number of passenger cars in municipal region.

Electricity production

There is a natural gas Rols-Roys cogeneration engine with a total installed capacity of 6.5 MW. It is owned by District Heating Enterprise Ltd. (OPEC Gdynia) where municipality of Wejherowo holds almost 6% of shares in the company. Over the period from 2018 to 2022 the total installed capacity of natural gas cogeneration engine remained unchanged.

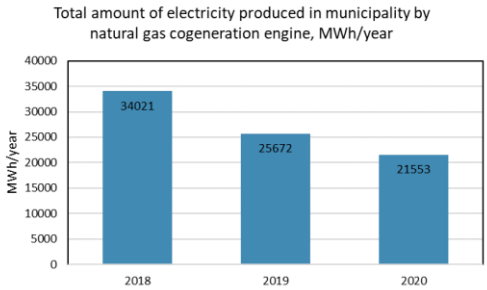


Fig. 3.67. Total electricity produced of natural gas engine in municipality.

In 2020 total produced electricity by natural gas cogeneration engine amounted to 21.5 GWh which is a significant decrease from 34 GWh in 2018. There are no renewable power generation technologies installed by the municipality. According to the provided information there are only small photovoltaic installations (micro-installations) with a capacity of 4-5 kW, which are individual sources installed in private buildings (mainly single-family residential houses).

District heating

In Wejherowo municipality there is 1 district heating provider in the municipal region. The total length of the district heating network is 46 kilometres.

Table 3.19.

Main characteristics of district heating system in Wejherowo municipality

Parameter	Value
Number of district heating providers in municipality	1
Number of individual systems	1
Total length of district heating network, km	46

The total installed capacity of heat production technologies remained unchanged over the period from 2018 to 2022. Heat was produced by natural gas CHP plant (Rols-Roys cogeneration engine) with the thermal capacity of 6 MW and coal fueled boilers with the total capacity of 42.89 MW.

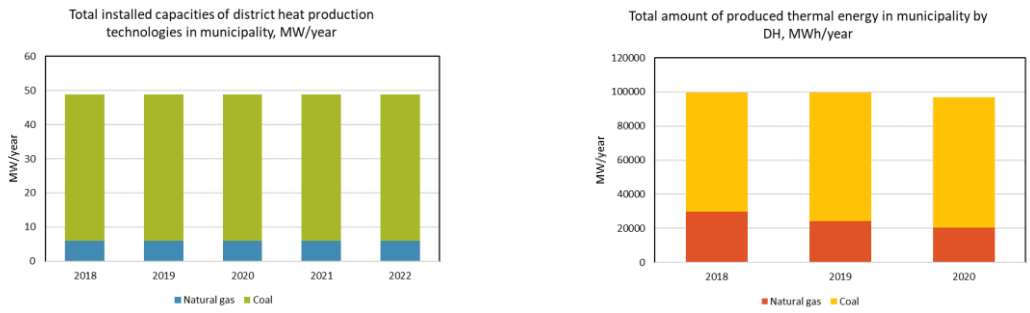


Fig. 3.68. Total installed capacities and amount of produced heat by in district heating network of Wejherowo municipality distributed by the resources used.

The amount of total produced thermal energy reduced from 99.7 GWh in 2018 to 96.9 GWh in 2020. The coal accounted for 79% of total produced heat in district heating in Wejherowo in 2020. According to the provided data, there are no renewable energy sources used in district heating of Wejherowo municipality.

All public buildings and some residential buildings owned by the commune are supplied with heat from the municipal heating system, but some of them have individual sources of hot water (mostly electric heaters). Individual sources in the case of municipal buildings include dual-function gas furnaces, electric heating, electric hot water heaters and coal-fired tiled stoves. The sources are installed in individual apartments. It is not possible to obtain data from individual residents. In these cases, the data that municipality prepared was obtained on the basis of our own estimated calculations, taking into account statistical data on energy consumption in buildings depending on the construction period and the thermal modernization works actually carried out.

Energy storage

Batteries

Currently, there is no such system in the Wejherowo municipality.

Pumped hydro storage

There is no pump hydro storage facility in the Wejherowo municipality. However, the city of Wejherowo is the capital of Wejherowo County, in which (approximately 20 km from the city) there is the largest pumped-storage power plant in Poland (the "Żarnowiec" power plant). It is located in Czymanowo on Lake Żarnowieckie (see photos next to the table). The upper water reservoir of the power plant is the Czymanowo reservoir. It is an artificial lake with an area of 135 ha and a capacity of 13.8 million m3. The lower reservoir is Lake Żarnowieckie. The power plant is equipped with four identical reversible hydro sets with the following power: for turbine operation 4 x 179 MW = 716 MW; for pump operation 4 x 200 MW = 800 MW. The owner of the power plant is PGE Energia Odnawialna S.A., which is also the operator of this power plant. The municipality is aware of the benefits of having a pump hydro storage facility, but it does not have the technical and natural possibilities to build such a storage in its area.

Thermal energy storage

Currently, there is no thermal energy system in the municipality. However, the possibilities of building such a system are being considered and discussed in District Heating Enterprise Ltd. (OPEC Gdynia), in which the municipality of Wejherowo has shares.

There are plans to use geothermal energy as a lower source of heat for the installation of a heat pump with a planned capacity of 5 MW (construction of an underground water intake from Quaternary formations through 20 intake wells to obtain water in the amount of a maximum of 1099 m3/h for the operation of a geothermal installation).

Hydrogen and biomethane

The Municipal Transport Company (MZK) in Wejherowo is planning a complete reorganization of its transport rolling stock and the introduction of zero-emission buses. There are already 4 electric buses

in operation in the city (the introduction of which is a transitional stage), and ultimately it is planned to switch urban transport to buses powered by hydrogen fuel (the first hydrogen bus has already been tested practically in the city for a period of 2 weeks in December 2023).

By 2035, it is planned to purchase 27 zero-emission buses powered by hydrogen fuel (possible purchases of hybrid electric buses with a hydrogen expander are also taken into account).In order to secure supplies of hydrogen to power the hydrogen cells of the bus, the City of Wejherowo and MZK signed a Letter of Intent with Grupa LOTOS Gdańsk. It was assumed that in the initial period, one refueling station, which will be supplied with hydrogen by Grupa LOTOS, will be sufficient for the needs of MZK.

To become completely independent from external hydrogen supplies, it is also planned to invest in the construction of its own hydrogen production and refueling station. It is planned to adapt the bus depot to the needs of operating zero-emission rolling stock and equip it with renewable energy sources - photovoltaics, wind turbines, electrolyzers - for additional hydrogen production through water electrolysis, and the construction of a hydrogen refueling station for hydrogen supplied by LOTOS. Optionally, it is also possible to consider the operation of devices for the production of hydrogen through steam reforming of natural gas - blue hydrogen.

3.3 Challenges and opportunities in municipality energy data collection

Designed a template for the collection of energy data "Municipality factsheet" functioned as the primary data collection instrument and could be utilised as a foundational data collection strategy for energy infrastructure in municipal regions. Developing a template that can be universally applied to all municipalities is difficult due to the unique circumstances that exist in each region. Nonetheless, the objective of this endeavour was to create and implement a functional template that could function as a foundation for data collection in municipal settings and could be readily modified in the future.

The project revealed a notable observation, indicating that some municipalities are currently lacking awareness regarding the location of their data and are unfamiliar with the essential characteristics of their energy systems. This signifies a crucial gap in data management and underscores the need for increased awareness and understanding within the municipalities.

One of the significant challenges we encountered during the project pertained to acquiring all the necessary data. We found ourselves grappling with the issue of insufficient data, which impeded our efforts to compile a comprehensive dataset. Overcoming this challenge necessitates a concerted effort to address data scarcity issues and develop strategies to enhance data accessibility for a more effective and thorough data collection process.

Data on energy consumption and production is vital for informed decisions on resource allocation, ensuring a reliable and sustainable energy supply. It also identifies trends, promotes efficient energy use, and supports climate change mitigation by advocating cleaner energy sources, making data collection and analysis the project's foundational step.

Filling the "Municipality factsheet" for project municipalities disclosed challenges as opportunities and possibilities which were summarized below.

Positive Aspects:

- Municipalities that have integrated centralized energy management systems have a well-established data collection process in place.
- Municipalities understand the significance of data in the planning of energy sector development.
- Municipalities have shown a strong interest in cooperation and data acquisition.
- They possess energy data for which they hold responsibility.
- Engaging in such projects as Energy Equilibrium signals municipalities' keen interest in matters related to energy efficiency and energy storage.
- Strong connections with municipal utilities, including district heating, public transport, and water supply companies, are maintained.

Challenges:

- Obtaining data on energy production is challenging due to limited access and difficulties in communicating with distribution networks and heat network operators.
- Providing precise figures at the municipal level can be challenging as well as obtaining data on an hourly basis is a difficult, if not impossible, task.
- A standardized system for data collection concerning energy production and usage, particularly for municipalities, is lacking.
- Information concerning sectors like households and agriculture, which fall outside the scope of municipal infrastructure, is severely limited or entirely absent. As a result, assumptions must form the basis for any analysis in these areas.
- Discontinuities in the data occur when systems change, improvements are made, or there is a turnover in responsible personnel. These disruptions can also impact subsequent data analysis.
- Limited data accessibility can lead to decreased responsiveness due to a combination of resource limitations, administrative hurdles, privacy concerns, and the need for compliance with various legal and regulatory requirements.

4 Plan for the pilots and further model validation

Historical data on the municipalities' energy infrastructure will serve as the main input for the project pilots that will be carried out in the next implementation steps. The project team has designed a pilot plan that will consist of seven main steps:

1. Data formatting adjustment to the model template (CSV files).
2. Identification of outliers and missing data positions.
3. Data import into the model.
4. Model optimization and data adjustment.
5. Model validation based on historical data (modelling is done only in the positions where data was available. In the missing data segments modelling can be performed based on the assumptions).
6. Identification of positions that cannot be validated (due to following reasons - there is a mistake in the model; there is a mistake in the data; there was an unpredictable event (e.g. reform) where the dynamics cannot be adequately evaluated.
7. An individual meeting is held with the municipality representatives to discuss the results.

In general, platform pilots and tests are divided into two main approaches – detailed pilots and general pilots. Detailed pilots will be carried out for municipalities in the project partnership that have provided completed data templates with data on energy profiles in their municipalities. Detailed pilots will provide more specific results for selected municipalities and insights for the development of the roadmap as well as help to recalibrate the model in a targeted manner. Detailed pilots will be carried out in the following municipalities:

- Gulbene Municipality & Gulbene energy service
- Tukums Municipality
- Taurage district municipality
- Tomelilla municipality
- Mikołajki Pomorskie Commune
- Wejherowo municipality

General pilots will be carried out for the municipalities that have expressed their interest in platform utilization and testing such as associated partners Nowa Karczma municipality, Sztum municipality, and many others from different BSR countries. The aim of the general pilots is to test and pilot platform for project target groups outside the core project partnership to gain valuable insights and feedback and to prepare platform to be used by any municipality in BSR.

Table 4.1.

Preliminary plan for Energy Equilibrium platform pilots and finalization of the output

1st round of pilots	**1 week for one municipality.** Pilot sequence: Gulbene & Gulbene energy service, Tukums, Taurage, Tomelilla, Wejherowo, Mikolajki.
Model adjustment	**Model improvement based on the responses provided by the municipalities** (the timeline might be extended depending on whether changes should be made in the figures, assumption or model structure).
2nd round of pilots	**Second iteration with the same 7 steps.** When municipality looks at the results, some responses might appear, then the model will be recalibrated.
General pilots	**Model testing of municipalities who did not fill data template** – general tests of the tool and feedback exchange.
Finalization	**Improvement of the model structure and interface (user UX)** to finalize the main output to be available to all BSR municipalities public.

Further model validation will continue during the platform pilots, where model validation will be performed using municipality data will be analysed. The model will be calibrated to improve the accuracy of the simulation results. The notes from the pilots, which contain the key observations from the validation and verification tests, will be summarised and described in the WP2 deliverables.