British Embassy Baku

UNDP

EFFICIENT USE OF ENERGY AND MINIMISING ENERGY LOSS in Residential Buildings in the Cities of **GANJA AND BARDA**

Acknowledgement

This report was made possible due to support and expertise of many individuals and organizations. The United Nations Development Programme would like to thank the British Embassy in Azerbaijan, Presidential Administration of the Republic of Azerbaijan, Executive Authorities of Ganja and Barda, Ministry of Ecology and Natural Resources, and other government agencies for their inputs at all stages of report development.

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I. INTRODUCTION

The demand for energy in the Republic of Azerbaijan is increasing. In order to benefit from global experience, new technologies will need to be introduced for the production of energy.

Along with modern oil and gas power plants, the installation and operation of alternative power plants for the use of renewable energy sources in energy production is growing rapidly. Now about 100 MW energy from wind turbines and from more than 10 small hydropower plants transmit power to grids. The construction of 25 small hydropower plants in Upper Karabakh is included in the plans of AZERENERJI OJSC. Contracts have been concluded with ACWA Power for the installation of 240 MW wind power equipment and with MASDAR for the construction of a 300 MW solar power plant.

90% of the electricity generated is produced by thermal power plants

Along with modern oil and gas power plants, the installation and operation of alternative power plants that use renewable energy sources in energy production is growing rapidly. The power grid is currently connected to more than 10 small hydropower plants and five wind turbines, which produce a cumulative energy supply of 100MW. Additional renewable energy plants are planned, including 25 small hydropower plants in Upper Karabakh with a total installed capacity of 123 MW, operated by AzerEnerji OJSC, a 240MW wind power plant installed by ACWA Power and a 300MW solar power plant constructed by MASDAR.[1]

1. MASDAR is a leading developer and operator of utility-scale renewable energy projects, community grid projects, and energy services consultancy. Retrieved from: https://news.masdar.ae/en/news/2020/01/09/14/39/masdar-signs-agreement-to-develop-landmark-solar-project-in-azerbaijan

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I. INTRODUCTION

About 90% of the electricity generated in Azerbaijan is produced by thermal power plants using natural gas. The remaining 10% comes from renewable energy power plants.

Although Azerbaijan is very rich in renewable energy sources and is growing rapidly, the development of alternative power plants is still limited. The main reason for this is that the production costs for alternative energy sources outweigh the selling price of standard electricity and gas. Therefore, when developing economic development strategies, the social situation of the population should also be considered.

13|15% of energy is lost in the distribution networks

The initial construction cost of a solar or wind power plant is approximately EUR 5,000-5,400 and EUR 3,500, respectively, per each installed capacity of 1kW, and the payback period is a minimum of 25-30 years. This prohibitive cost of constructing new, alternative power plants should therefore be compared with the cost of installing energy efficient technologies in the existing residential sector and public buildings, since the extensive use of new insulation building materials, modern electrical equipment and heating systems is less expensive and can considerably reduce energy and gas consumption. At present, adopting measures that target energy efficiency and more efficient, less wasteful uses of

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generated energy, are more beneficial and practical than the construction of new power plants.

Two important aspects need to be considered. Firstly, the development of alternative energy helps the country meet its obligations under the Paris Agreement, demonstrating the political will of the Government to reduce global GHG emissions (even though Azerbaijan's GHG emissions are very small), and helps develop local expertise in the sphere of alternative energy, reducing pollution, enhancing air quality, etc. Secondly, the Government must consider the economy, especially with the current need to restore the liberated territories, which requires huge investment. The fact that Azerbaijan already has excessive capacity in producing electricity should also be taken into account and, as such, determinative cost-benefit analyses on alternative energy production and energy efficiency measures will need to be undertaken. Since energy efficiency and the more efficient, less wasteful use of generated energy would currently appear to be a more viable option than the construction of new and alternative power plants, further careful examination, additional statistics and accurate calculations are required to obtain a clearer picture.

The potential for energy efficiency in Azerbaijan is significant, especially in the residential sector. The main housing stock in Azerbaijan was constructed in the 1960s and new construction seldom meets modern energy efficiency requirements.

About 15-20% of the electricity produced in the energy system of Azerbaijan is used for the internal needs of the power stations, while 13-15% of energy is lost in the distribution networks.

Given the large amount of money spent on the production and delivery of electricity, and the GHG emissions resulting from the production of electricity, new measures to improve the efficiency of energy usage in the residential sector must be investigated and implemented.

According to global statistics, 35-40% of total energy consumption is in the residential sector. This indicates the enormous potential for reducing energy loss and for using energy far more efficiently within this sector. To unlock this potential in Azerbaijan, the following studies should be carried out:

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I. INTRODUCTION

1. Conduct an analysis of five-year data (excluding the years affected by the COVID-19 pandemic) of electricity generated and consumed nationwide.
2. Define the collected energy consumption data for the selected Ganja City and Barda District Centre.
3. Compare the data to ascertain the level of efficient (or inefficient) use of electricity and gas consumption.
4. Recommend how to improve energy efficiency in residential buildings, and how to implement these changes through legislation, capacity building, awareness raising and demonstration pilot projects.

The efficiency of buildings and individual apartments is determined by analysing the following data:

- Energy consumed per square metre in the housing stock;
- Energy consumed per one household (family) in the housing stock;
- Grouping of buildings per their structure type;
- Identifying energy per square metre (or per one person) depending on the type of energy (heating, hot water supply, lighting, etc.)

The current study aims:

1. Identify monthly energy (electricity and non-gas) and gas consumption in the residential sector within the boundaries of Ganja City and Barda District Centre.
2. Identify energy consumption per individual (or 1 m² of living space) in the residential sector.
3. Identify the potential for improved energy efficiency (loss reduction) in the residential sector.

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II. ELECTRICAL POWER GENERATION AND CONSUMPTION IN THE REPUBLIC OF AZERBAIJAN

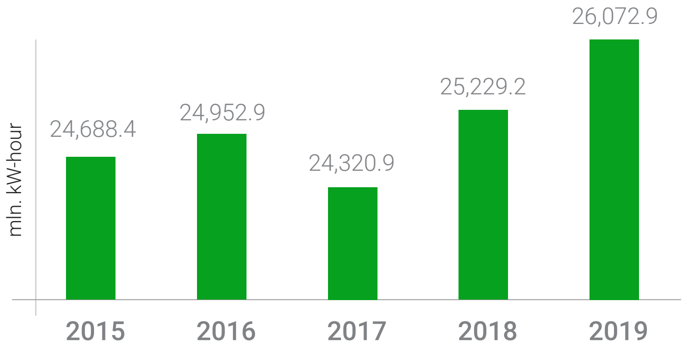
Installed capacity of power plants in the Republic of Azerbaijan[2] by the end of 2020:

- Thermal power (includes steam, gas and combined) . . . . 4,675,600 MW
- Gas-generator power plants . . . . 856,100 MW
- Hydropower . . . . 1,159,980 MW
- Small hydropower plants . . . . 14,560 MW
- Wind power . . . . .100 MW
- **Total . . . . 6,806.24 MW**

Power plants in the Nakhchivan Autonomous Republic distribute the generated energy only within the borders of their territory.

The total electricity generation of power plants in the Republic of Azerbaijan is described in Figure 1.1 *(source - AR State Statistics Committee. Energy in Azerbaijan. Statistical collection. 2020. Table 3.1.18)*

Figure 2.1: Total electricity generation of power plants in the Republic of Azerbaijan



Source: *State Statistical Committee (2020). Energy in Azerbaijan. Table 3.1.18*

2. Energy generated from power plants in the Nakhchivan Autonomous Republic is only distributed within the borders of the territory.

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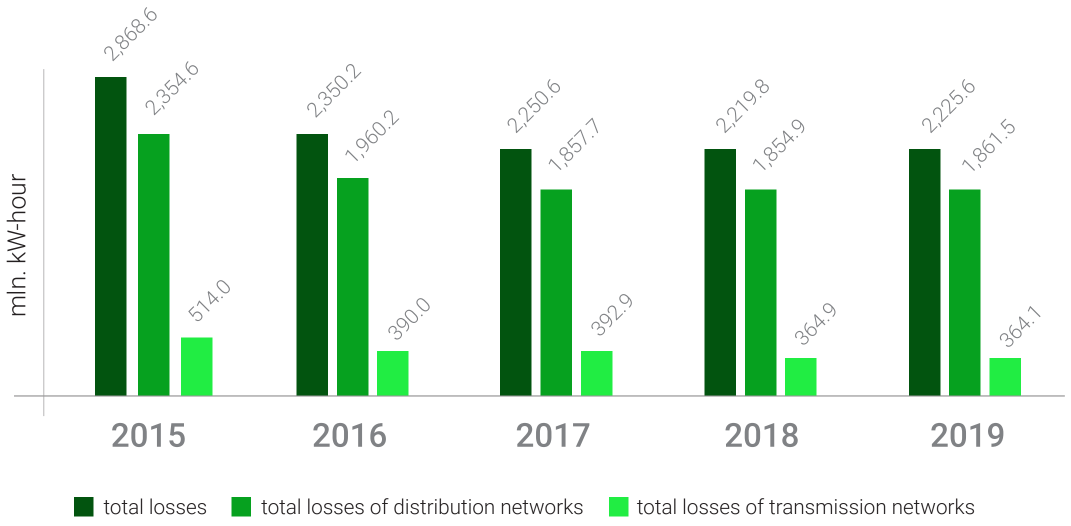
Electricity in Azerbaijan is currently generated by gas and oil-fueled power plants (steam and steam-gas and gas-generator) and from renewable sources (hydropower, wind, solar and waste incineration).

Electricity generated by power plants is “gross”. The net electricity delivered to the consumer is calculated by deducting the losses from transmission networks (from power plant to transformer substation) and distribution networks (from transformer substation to consumer) and the consumption of the power plant, from the “gross”. These network losses are reflected in the reports of the electrical power producer, AzerEnerji OJSC.

Figure 2.2: Network energy loss (2015-2019)



Source: *State Statistical Committee (2020). Energy in Azerbaijan. Table 3.1.18*

The normal energy loss from distribution networks within city limits is around 5-7%, however in Azerbaijan the loss is around 14%, predominantly due to outdated and overused electrical wiring. Repair work, undertaken during the past few years, has resulted in a reduction in the energy loss in distribution networks, from 14% to 10%.

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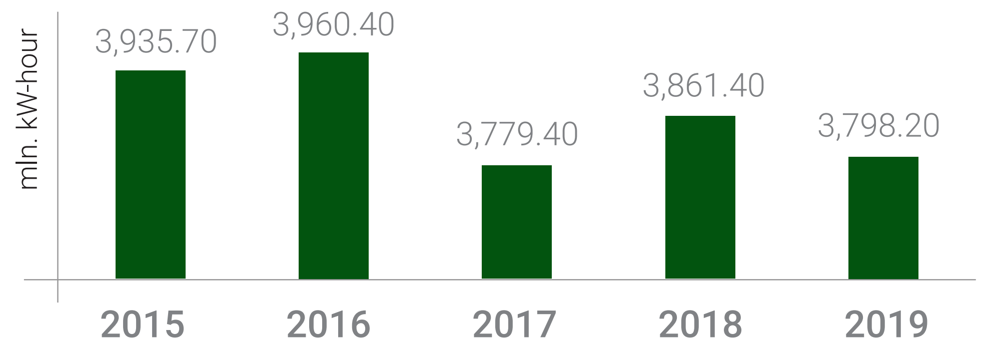
Figure 2.3: Power plant consumption of generated energy (2015-2019)



Source: *State Statistical Committee (2020). Energy in Azerbaijan. Table 3.1.18*

Table 2.1: Volume of electricity supplied for consumption after deducting internal power plant consumption and losses from total energy generation (2015-2019)

Years	Energy generated	PPs internal (special) consumption	Distribution networks losses	Energy consumed
2015	24 688,4	3 935,70	2 868,6	17 884,10
2016	24 952,9	3 960,40	2 350,2	18 642, 30
2017	24 320,9	3 779,40	2 250,6	18 290,90
2018	25 229,2	3 861, 40	2 219,8	19 148,00
2019	26 079,9	3 798,20	2 225,6	20 049,10

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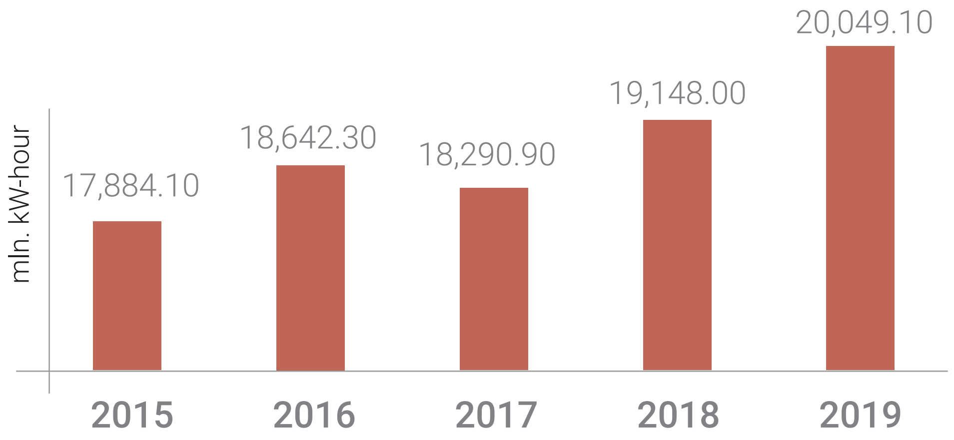
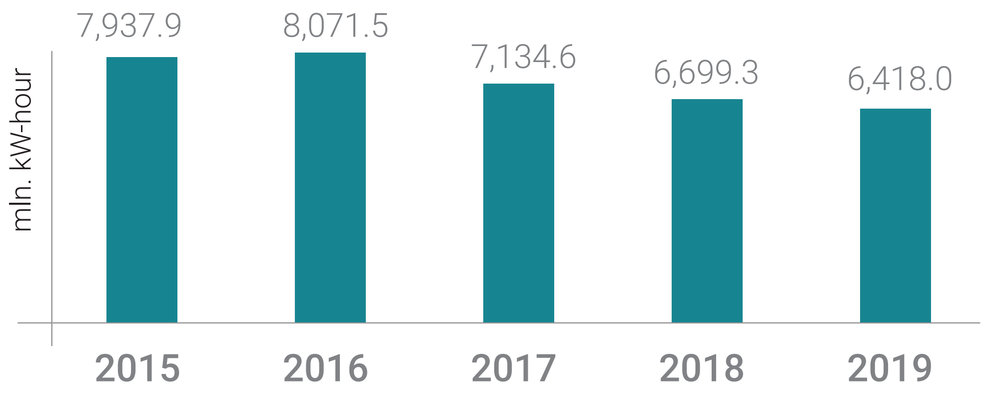
Figure 2.4: Volume of electricity supplied for sale



Source: *State Statistical Committee (2020). Energy in Azerbaijan. Table 3.1.18*

Figure 2.5: Electricity consumption in individual apartments



Source: *State Statistical Committee (2020). Energy in Azerbaijan. Table 3.1.18*

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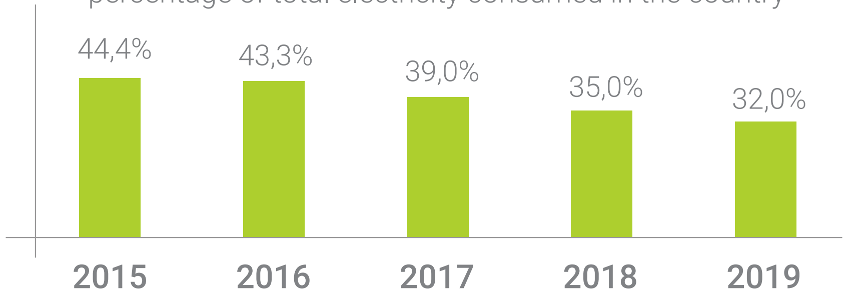
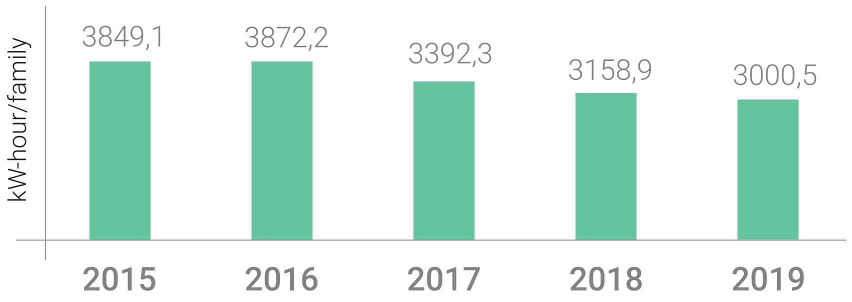
Figure 2.6: Annual electricity consumption by residential buildings as a percentage of total electricity consumed in the country



Source: *State Statistical Committee (2020). Energy of Azerbaijan.*

Several reasons may have contributed to the lowered share of electricity consumption in the residential sector. Two obvious reasons are more energy-efficient behavior due to the increased tariffs such as the introduction of different rates for limited and unlimited usage, in particular during the last years, and also enhanced awareness of the population. Among other reasons could be significant growth of consumption of energy by other sectors, first of all, industry, infrastructure and agriculture; and also using for heating and cooking cheaper in comparison with electricity natural gas. The similar trend is observed in the households. To investigate the impact of each detailed research is required.

Figure 2.7: Annual electricity consumption per household in residential buildings (in housing/apartments) and individual apartments



Source: *State Statistical Committee (2020). Energy of Azerbaijan. Table 1.2*

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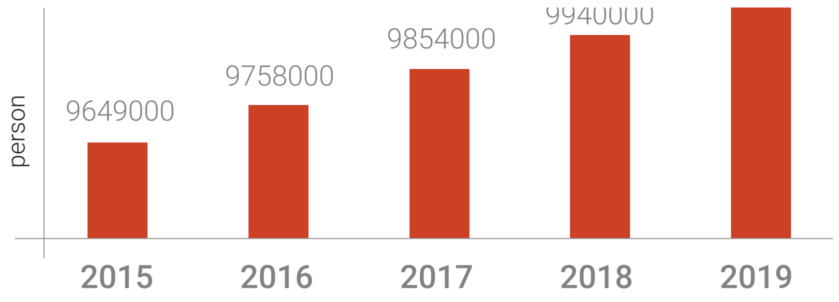
The statistics shown in Figure 2.7 were calculated as yearly totals and included in the statistical database. The data does not reflect variations due to seasonal differences.

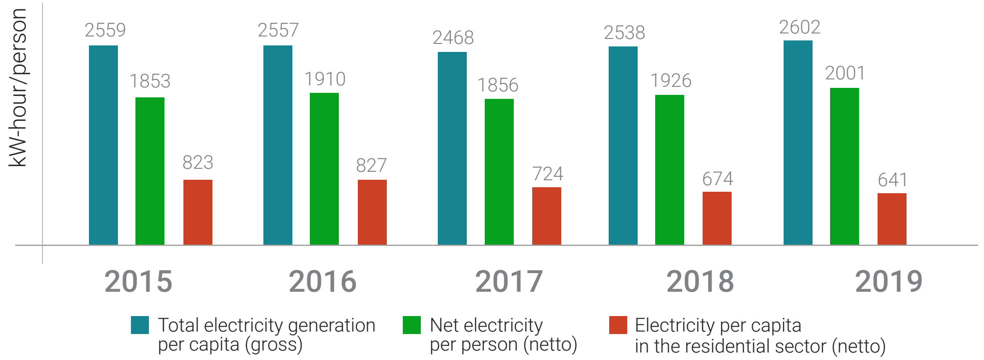
A number of statistics were adapted to reflect annual totals for use in the study and interpreted accordingly.

Figure 2.8: Population of Azerbaijan 2015-2019 (million)



Source: *State Statistical Committee*

Figure 2.9: Total annual electricity generation per capita in Azerbaijan, net (sold) volume and changes in the average, annual, specific data used in the housing stock:



Source: *State Statistical Committee (2020). Energy of Azerbaijan.*

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As evident from the Figures, the absolute amount of energy used per person and the amount of energy used as a percentage of the total and net energy used per person within the residential sector is decreasing over time. However, it still represents 34.9% of the overall consumption according to the Fourth National Communication; therefore, improvements in the energy efficiency of residential buildings have the potential to reduce overall consumption significantly.

According to the data collected for the Fourth National Communication, currently being prepared, 34% of electricity is used in the residential sector. In statistics, the data for electricity consumption per household is normally calculated by using the "gross" total of the energy generated. Since this study analyses energy consumption in the residential sector, the "net" consumption is calculated by deducting the internal (power plant) energy consumption and the losses from the energy distribution systems from the total consumption. This information is not available in the statistical data, therefore the calculation was made taking the following into consideration:

(1) Living space per capita in apartment buildings and private houses is different: 8 12 m² in apartment buildings and 20 m² in private houses.

(2) Statistics are only available for energy usage per household, the study required energy usage per person.

(3) The number of families in Azerbaijan were determined through an analysis of the statistics shown in Figures 2.7 and 2.9.

The resulting calculations are shown in Table 2.2

Table 2.2: Energy Consumption in the Residential Sector (2015-2019)

Years	Household's annual energy demand, kW/hour energy demand	Energy demand per capita, kW/hour energy demand	Family composition, person
2015	3 849,1	823	4,7
2016	3 872,2	827	4,7
2017	3 392,3	724	4,7
2018	3 158,9	674	4,7
2019	3 000,5	641	4,7

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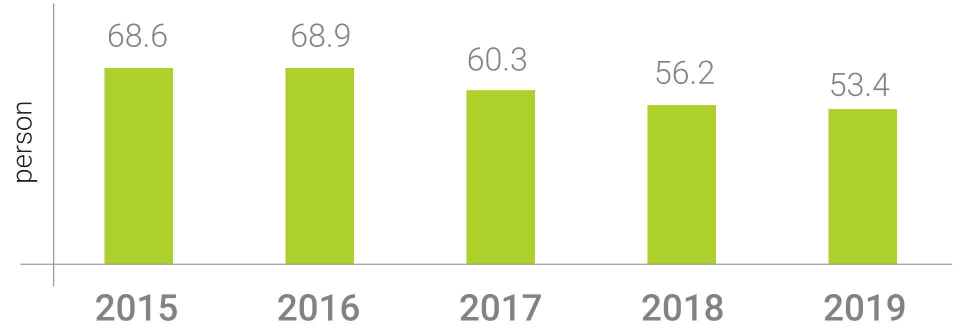
The average monthly demand per person can then be determined based on the consumption of electricity per person per year in residential buildings (Figure 2.10).

Figure 2.10: Average monthly energy use per person



The downward trend in average monthly demand can be explained by climate change. During the last seven years, the winter season was much warmer than previously. During the last three consecutive years, no freezing temperatures have been observed in Baku. The only exception has been noted in 2020 when two times the temperature went slightly below "0". Due to the COVID-19 pandemic, this year cannot be considered as "usual", i.e. reference year. Figure 3.10 below reflects that recent years brought milder winters and the earlier arrival of hot weather. Thus, decreasing the demand for energy.

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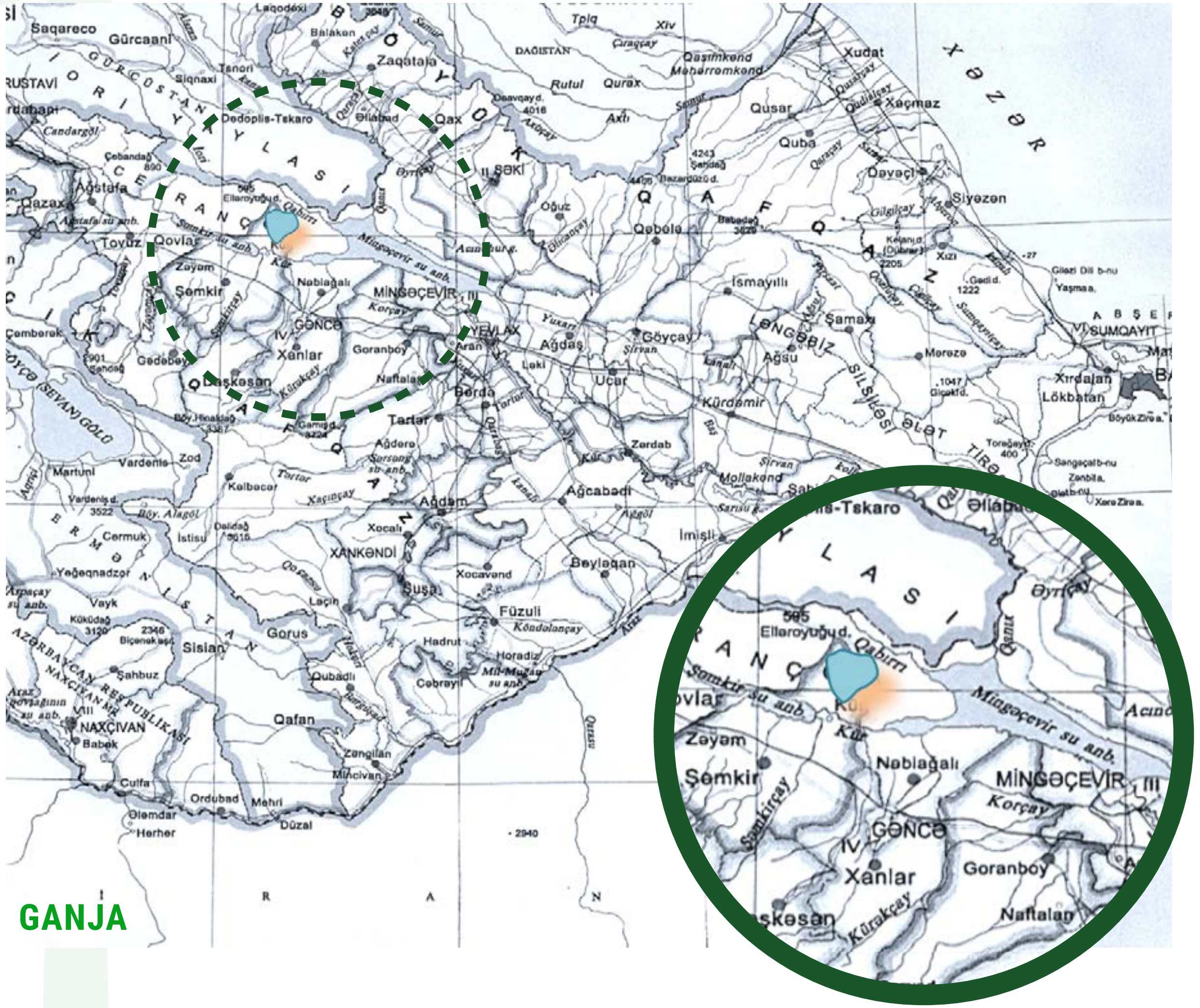
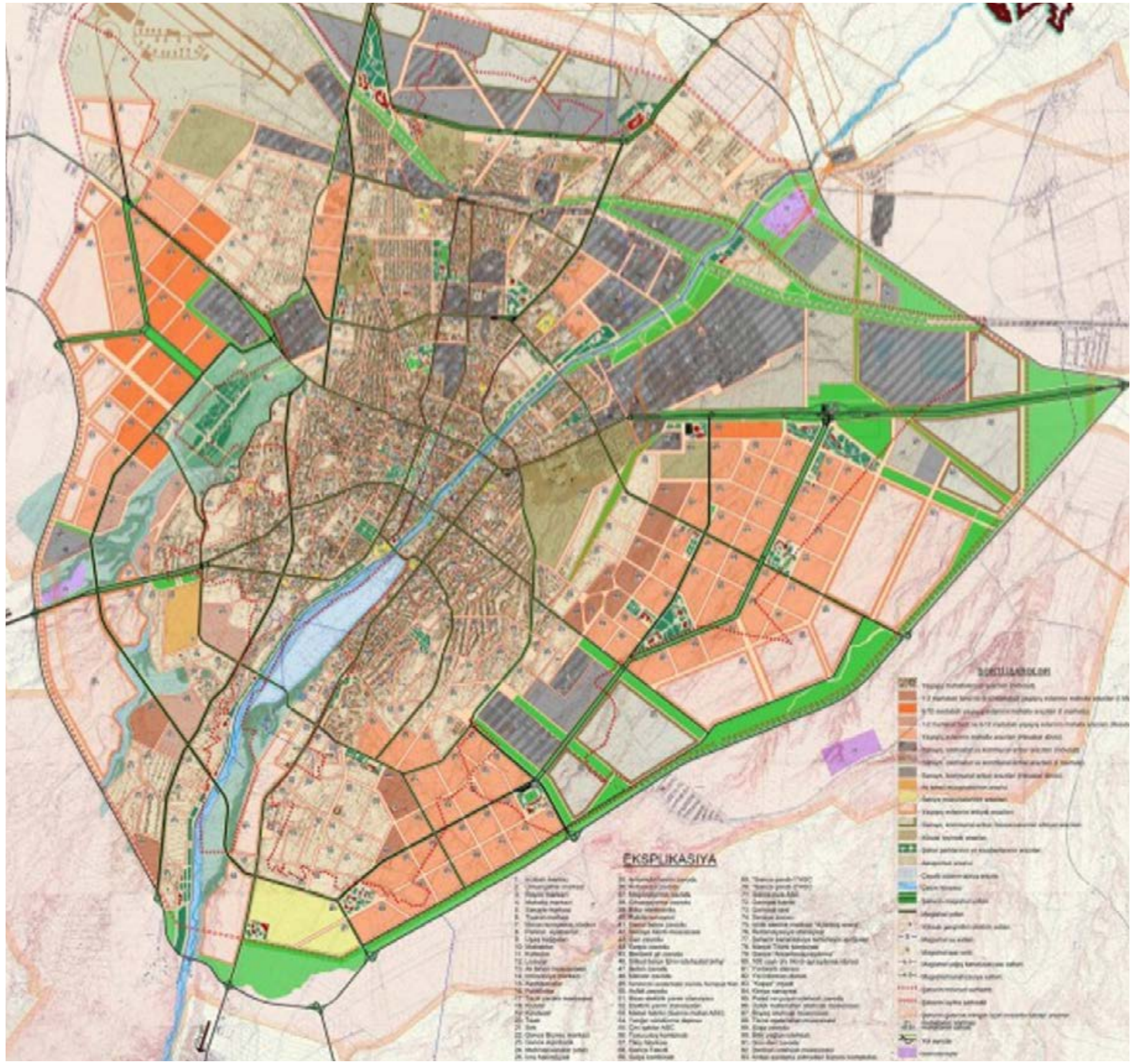
III. ELECTRICITY AND NATURAL GAS CONSUMPTION IN THE RESIDENTIAL SECTOR IN GANJA

Figure 3.1: Ganja city on the administrative map of the Republic of Azerbaijan



MASTER PLAN OF GANJA CITY



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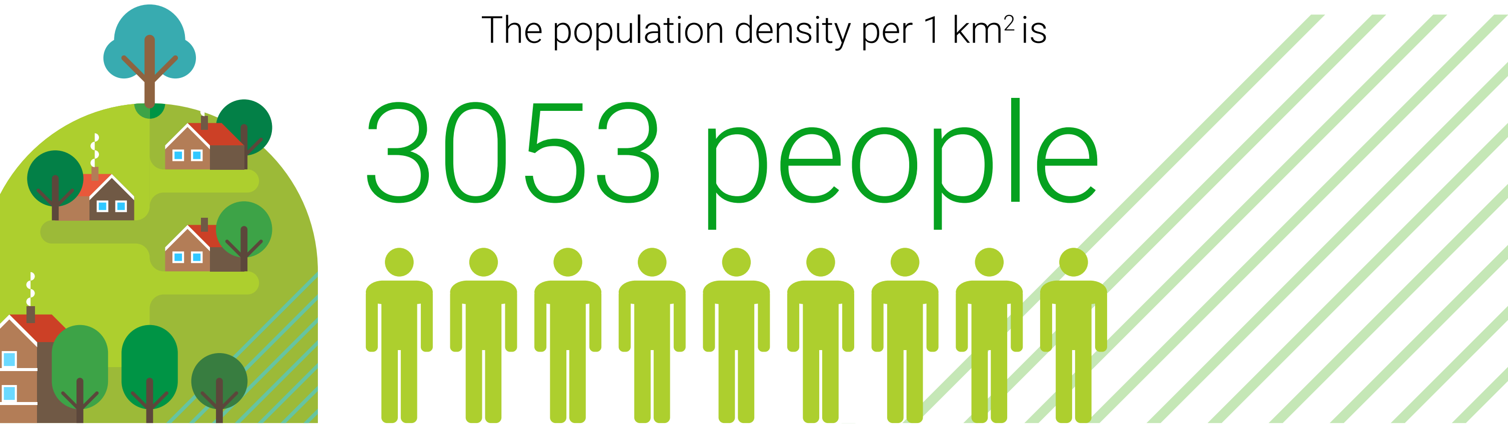
The city of Ganja covers a total area of 110 km² and is divided into two districts: Nizami, which includes two administrative territories and three residential areas (New Ganja, Mahrasa Garden and Gulustan) and Kapaz, which includes two administrative territories and six settlements (Hajikand, Javadkhan, Mahsati, Natavan, Sadilli, and Shikhzamanli). [3]

According to State Statistical Committee, the population of Ganja city is 335,800, of which 153,300 live in Nizami district and 182,500 in Kapaz.The population density per square kilometre is 3,053 people. Kapaz district covers an area of 70.64 km² and the population density is 2,583 people per square kilometre, while Nizami district covers 39.25 km² and has a population density of 3,905 people per square kilometre. Ganja city has 49 high schools, seven vocational schools, and 30 medical institutions with 1,435 beds.



3. According to the official data of the Ganja City Executive Power

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HOUSING STOCK

The residential sector in Ganja consists of apartments and individual buildings.

Table 3.1: Ganja city housing stock (2014-2018)

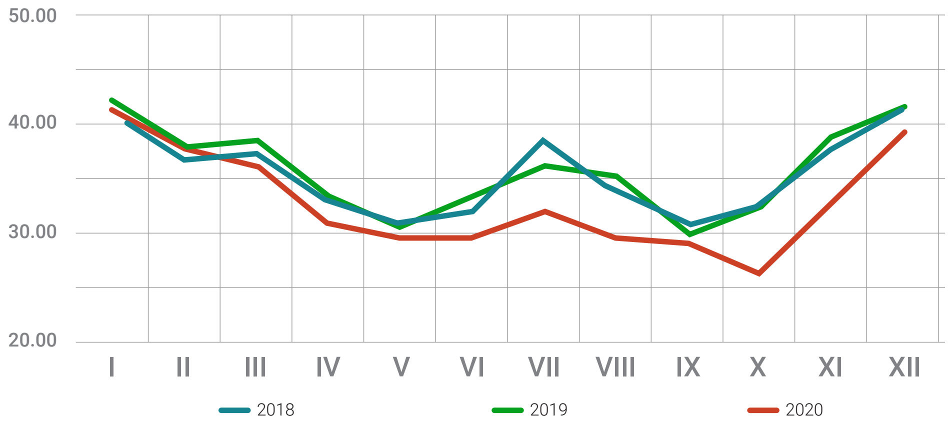
	2014	2015	2016	2017	2018
Number of population, thousands	328.4	330.1	331 .4	332.6	334.0
All housing stock, total area, thsd m²	5983.3	6020.0	6078.9	6098.5	6631.9
Average total area per resident, m²	18.2	18.2	18.3	18.3	19.9

Source: *State Statistics Committee (2018). Ganja City. Socio-economic indicators*

USE OF ELECTRICITY IN THE RESIDENTIAL SECTOR

The city provides electricity to the residential sector from 20 power transmission stations and 1,039 transformer substations. When consecutive years are compared, the highest consumption of electricity was in July 2018, while the lowest was recorded in October 2020 (Figure 3.3).

Figure 3. 3: Monthly residential sector electricity consumption (2018-2020)



The change trend in electricity consumption in 2018/2020 is shown in Figure 2.2

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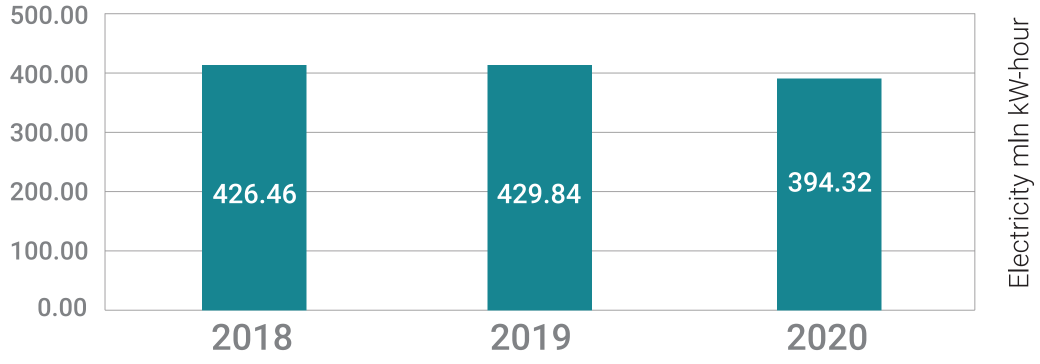
The change in electricity consumption from 2018-2020 (Figure 3.4) can again be explained by the milder winters and earlier arrival of warm weather, brought about by the changing climate (Figures 3.10).

Figure 3.4: Changes in annual electricity consumption per subscriber in the residential sector (2018-2020)



Source: *Ganja Regional Electricity Network 2018-2020 .*

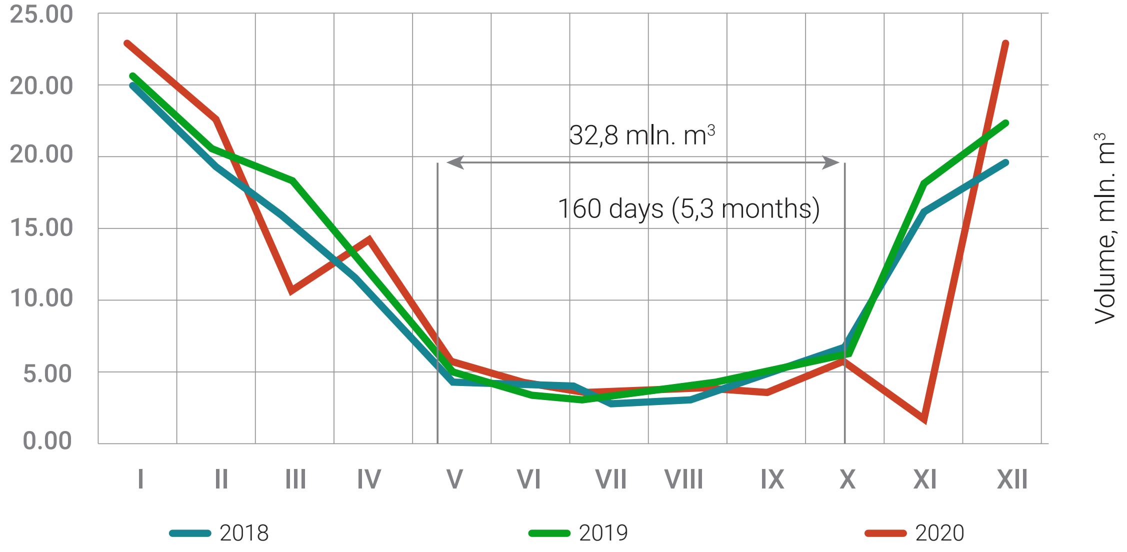
By analysing the data from the Ganja Regional Electricity Network, the electricity consumption per square metre and per person in 2018 can be calculated as follows:

- Per 1 m² area
  426,455,884 (kW·hour): 6,631,900 (m²) = **64.3 kW·hour/ m²/1 year**
- Per 1 person
  426,455,884 (kW·hour): 334,000=**1,277 kW·hour/ person/1 year**

SEASONAL USE OF NATURAL GAS IN THE RESIDENTIAL SECTOR

Gas consumption in the residential sector is highest in the winter months when the heating systems are turned on. From the beginning of May to mid-October, the consumption is minimal and relatively stable, with only 32.8 mln. m³ gas consumption recorded between 2018-2020.

Figure 3.5: Residential Sector gas consumption 2018-2020



Source: *Ganja City Gas Department (2020)*

Gas consumption in the warmer six months of the year amounted to 19.9% in 2018, 18.5% in 2019, and 20.7% in 2020. Thus, around 80% of gas consumption is during the winter months (Figure 3.6).

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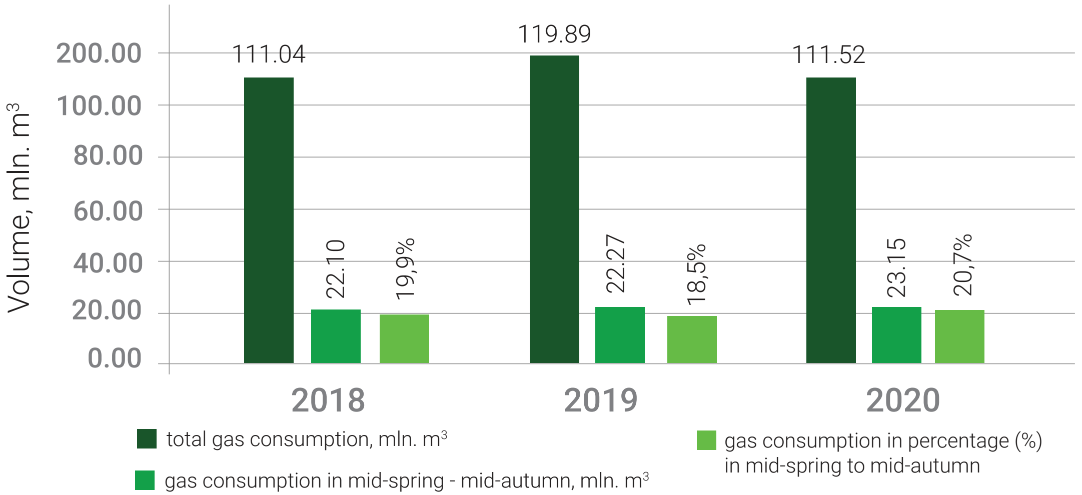
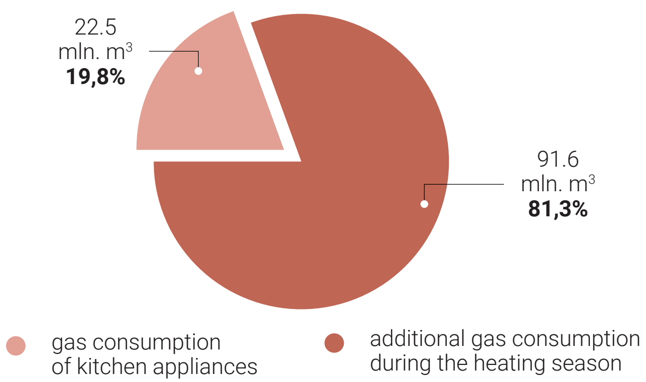
Figure 3.6: Annual gas consumption by season (2018-2020)



Source: *Ganja City Gas Department (2020)*

Figure 3.7: Gas usage by purpose

Depending on seasonal variations, gas usage in the residential sector between mid-May to mid-October (five months) is predominantly for kitchen appliances only (Figure 3.7).



Average gas consumption per capita for Ganja city in 2018-2020 is as follows:

- Annually: 340 m³ / person
- From mid-spring to mid-autumn: 94 m³ / person

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GAS USAGE PER RESIDENTIAL BUILDING TYPE

The housing stock in the city of Ganja comprises five different types of building and individual apartments:

Type 1: 5-floor, usually 4-block apartment buildings made of reinforced concrete panels, late 1960s construction.

Type 2: 5-floor, 4-block apartment buildings made of Absheron limestone, late 1960s construction.

Type 3: Multi-floor concrete monolithic buildings.

Type 4: Individual 1-2-floor old stone houses, usually with thick walls. The living space per capita in these houses usually does not exceed 8-12 m².

Type 5: Private new 2-4 floor houses, mostly built of limestone. New-build private houses often have more than 20 m² of living space per person.

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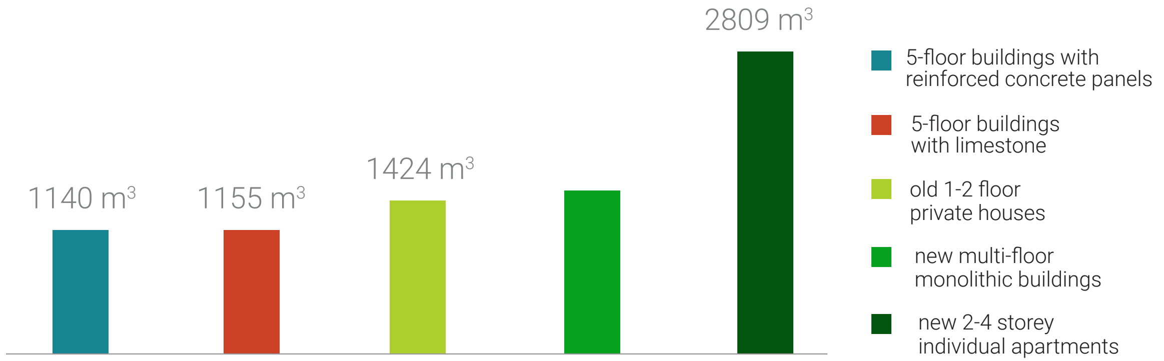
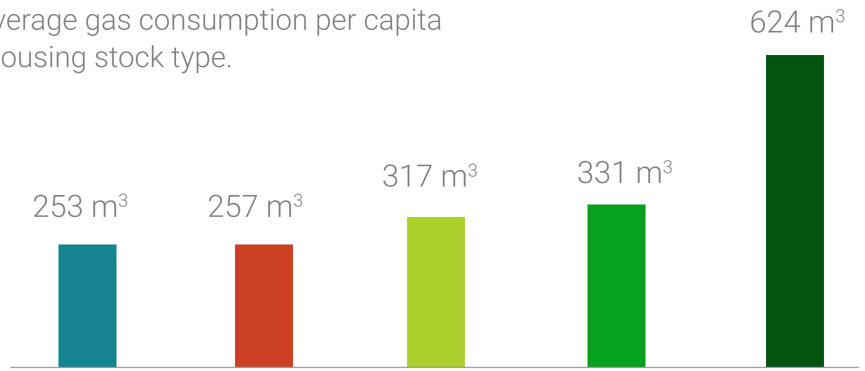
Figure 3.8: Average gas consumption per person, by type of housing (2018-2020)



To calculate the annual, average gas consumption per capita amount, based on type of building and private houses/individual apartments, a family unit was considered to be 4.7 members.

Figure 3.9: Average gas consumption per capita per year per housing stock type.



New-build, 2-4 floor private houses were found to have the highest gas consumption. In this type of house, the area per person is usually more than 20 m². In addition to the smaller area per person to heat, within a multifloor apartment block, the heating from one apartment helps to heat the apartments above and shared internal walls help prevent heat loss from individual household apartments. Since the number of new-build, private housing is increasing, more energy is being required for heating purposes.

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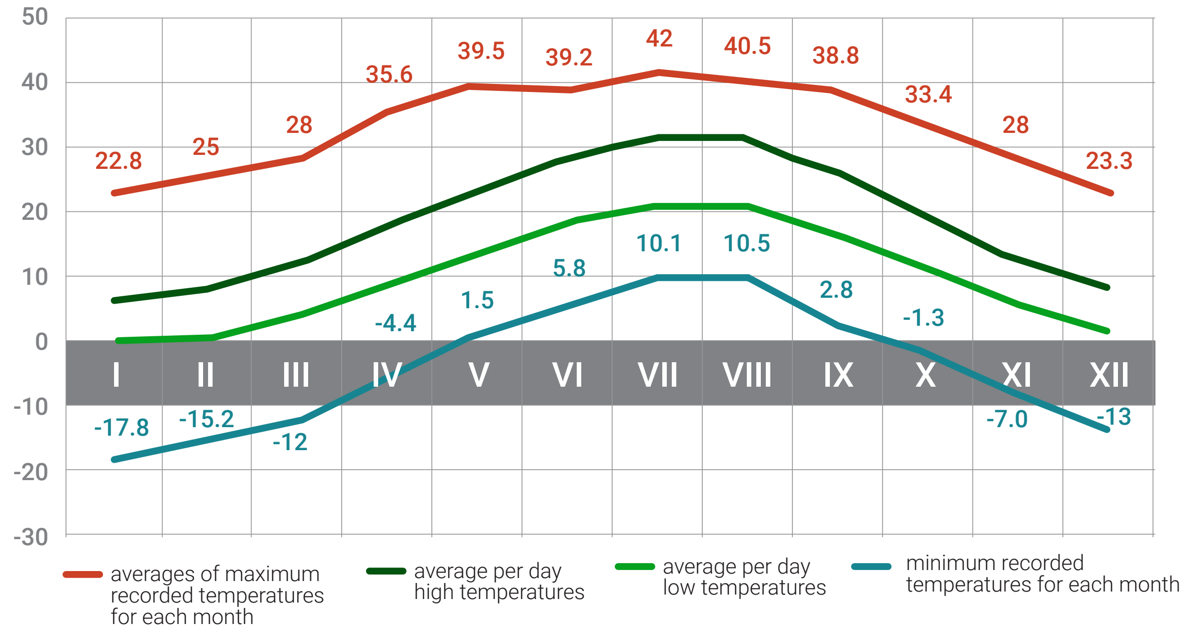
NATURAL GAS CONSUMPTION IN BUILDINGS WITH CENTRALISED HEATING

There are 17 centralised boilers in Ganja. Most of them are connected to schools and hospitals. Due to the lack of statistical data on heat transfer capacity, the supply of this type of heating energy is not reflected in existing studies and therefore could not be analysed for this Report.

CLIMATE CONDITIONS

The climate in Ganja is considered to be Humid Subtropical.4 The average temperature for the year is 13.6°C, with the warmest month being July (25.6°C) and the coolest month being January (2.1°C).

Figure 3. 10: Annual temperature changes, Ganja meteorological station



4. Köppen-Geiger Climate Classification, retrieved from: https://www.weatherbase.com/weather/weather-summary.php3?s=592476&cityname=Ganja,+Azerbaijan

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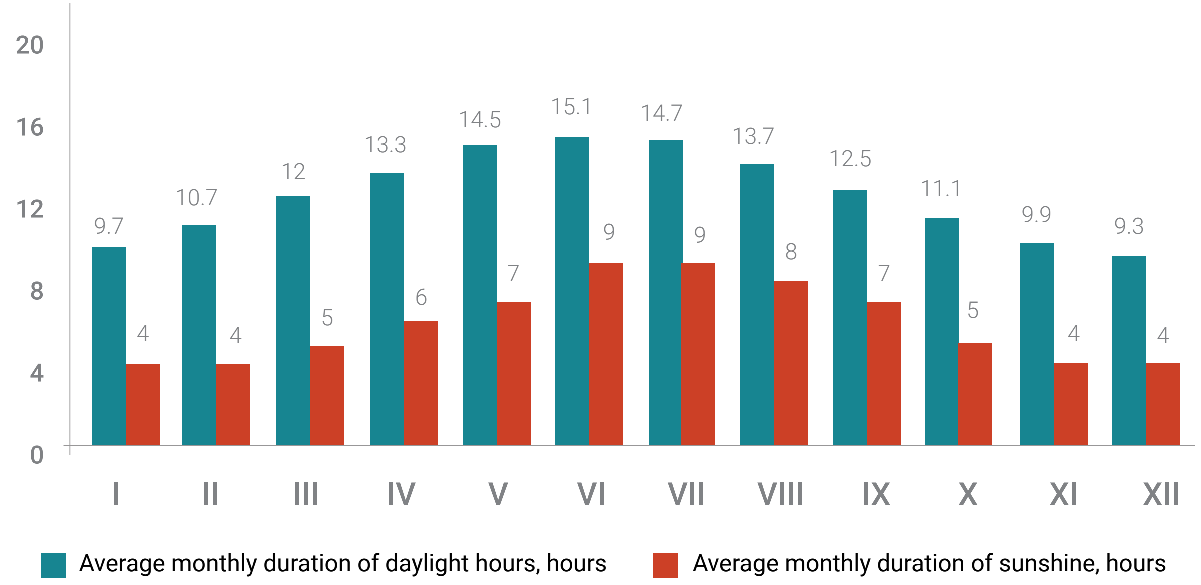
The average monthly indicators of daylight from sunshine in Ganja City are shown in Figure 3.11. During the summer months, especially in June and July, the sunshine hours are about 60% of the daylight hours, whereas in winter this falls to 40%. This leads to increased demand both for heating and lighting in the winter period.

Figure 3.11: Hours of daylight, hours of sunshine (average/monthly)



Based on long-term observations, Figure 3.10 indicates that from mid-May to mid-October, the average monthly minimum temperature remains above 15ºC. This is consistent with the monthly gas consumption. It was also observed that absolute temperatures occasionally drop to 2ºC, although this is rare.

Figure 3.10 additionally indicates that the absolute minimum temperature during the winter months reached below -17ºC. Demand for electricity and gas is obviously higher in severe cold weather. Therefore, implementing measures that ensure the efficient use of heating energy and reduce energy losses in apartments would significantly reduce the pressure on the electricity and gas distribution systems.

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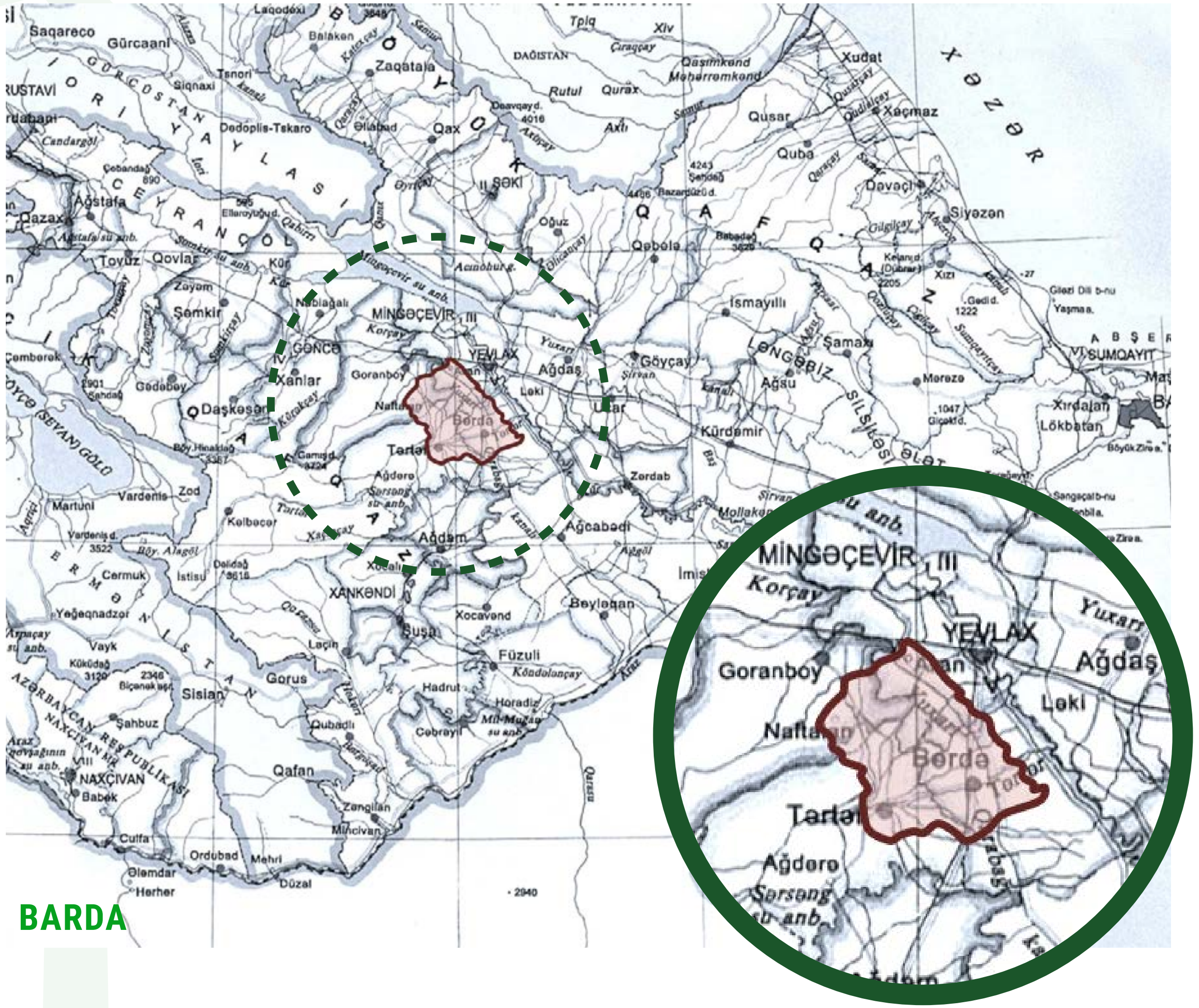
IV. ELECTRICITY AND NATURAL GAS CONSUMPTION IN THE RESIDENTIAL SECTOR IN BARDA

Figure 4.1: Barda district on the administrative map of the Republic of Azerbaijan



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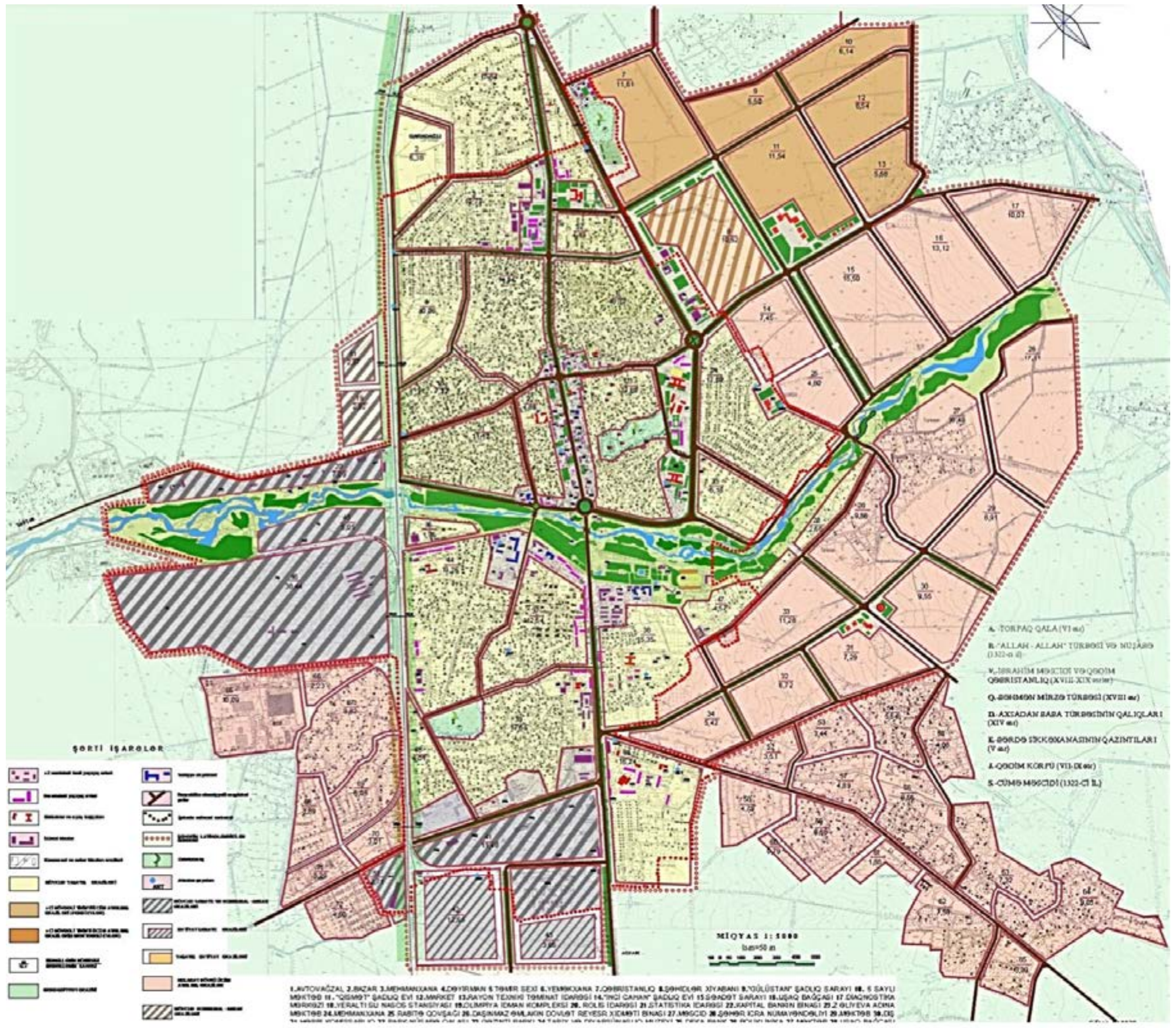
MASTER PLAN OF BARDA DISTRICT CENTER



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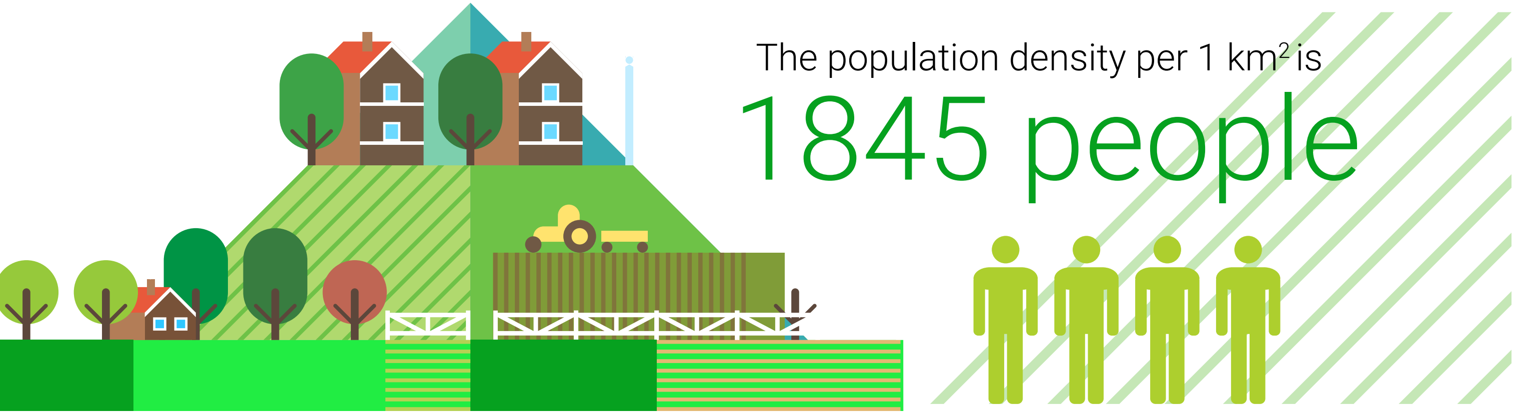
Barda city covers a total area of 21.8 km2. By the end of 2019, the population of Barda city was 40,222, with a population density of 1,845 people per square metre.

There are nine high schools, two vocational schools and 10 medical institutions in the city.

The population of the District at the end of 2018 was 156,355.[5]



5. According to the Barda District Executive Power

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HOUSING STOCK

The residential sector in Barda consists of apartment blocks and individual buildings (Table 4.1)

Table 4.1: Housing Stock

Housing Stock	Number	Area, m^2
Apartment Stock		41 325
1-floor	478	
2-floor	33	
5-floor	25	
8-floor	1	
9-floor	1	
Total	538	
Apartments	2226	
Population	8980	
Area per capita		4,6
Individual Houses	7262	
Living area		575 025
Population	31 242	
Area per capita		18,41
Total living area		**616 350**

Source: *State Statistical Committee (2018). Barda. Socio-economic indicators*

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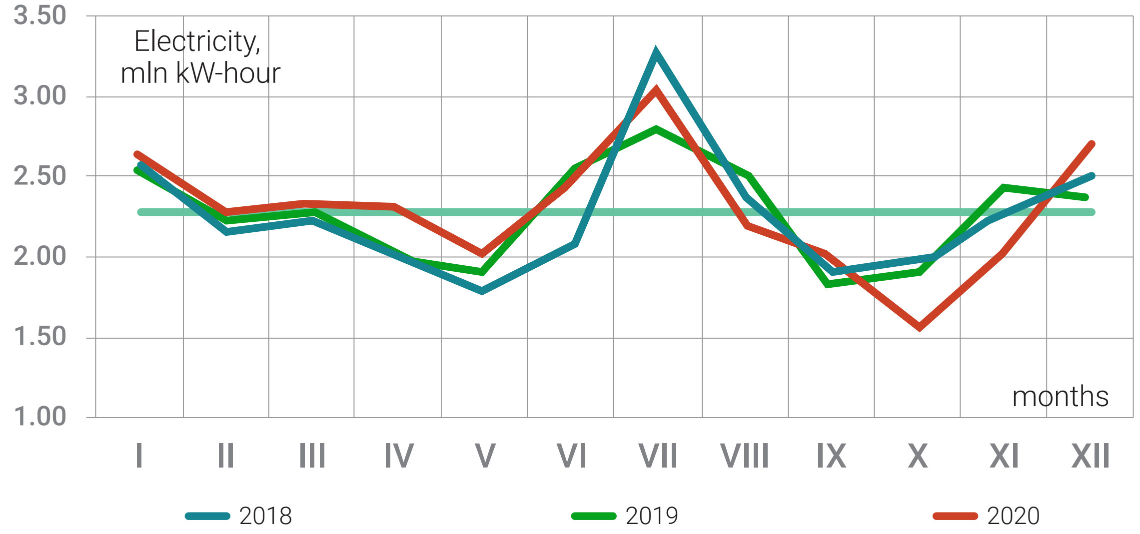
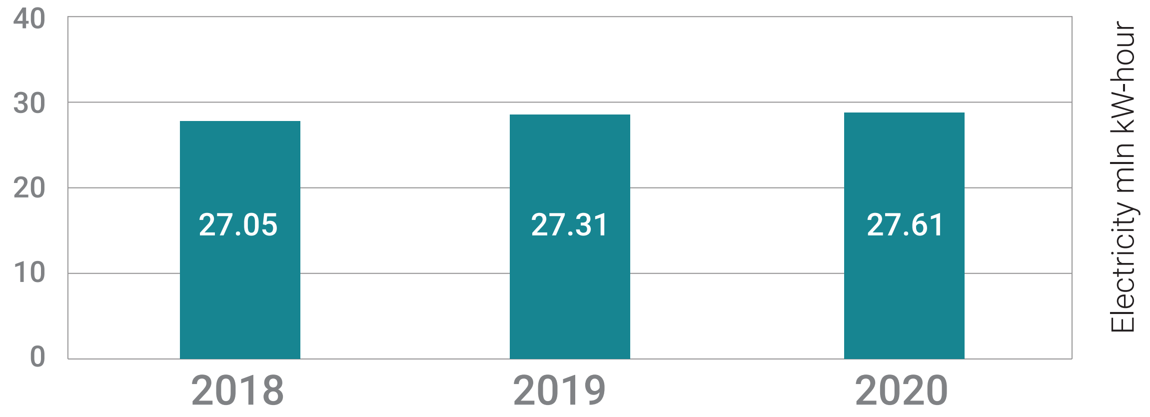
Figure 4.3: Monthly residential sector electricity consumption (2018-2020)



Source: Barda Regional Electric Network

Figure 4.4: Changes in electricity consumption (2018-2020)



An analysis of the data from the Barda Regional Electric Network indicated the following electricity consumption per square metre and per person in the residential sector in 2019:

- Per 1 m² area
  27,314,162 (kW·hour) : 616,350 (m²) = **44.3 kW·hour/ m²/1 year**
- Per capita
  27,314,162 (kW·hour) : 40,222 = **175 kW·hour/ person**

One more factor is growing, - though, slowly, and not across all geographic areas and "vertical strata" of population, - incomes of population. But factoring this variable may require more in-depth and more accurate studies.

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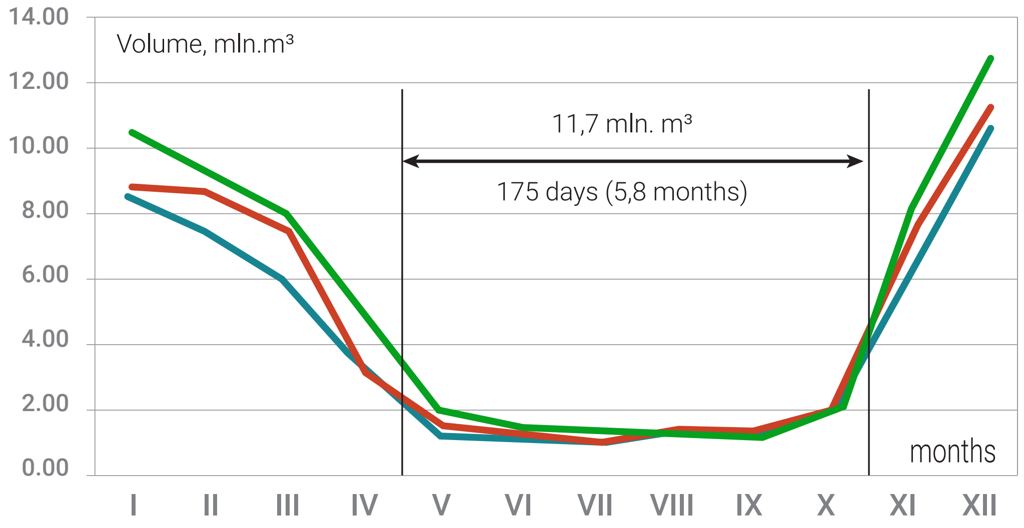
SEASONAL USE OF NATURAL GAS IN THE RESIDENTIAL SECTOR

While it was possible to obtain data on natural gas consumption for the entire Barda region, data specifically related to Barda city was not available.

Figure 4.5: Seasonal Gas Consumption in Barda District (2018-2020)



Source: Barda Regional Electric Network

Gas consumption in Barda District tends to be low from the beginning of May to mid-October and shows little fluctuation. During this period, gas consumption was around only 11.7 million m³.

Consumption suddenly increases as the winter months arrive, which can be explained by the use of heating appliances in apartments in the residential sector.

Similar to Ganja, gas consumption in Barda is low during summer months; however, slightly higher than in Ganja. Total gas consumption in mid-spring and mid-autumn varied over the past three years, as follows: 21.6% in 2018, 20.5% in 2019, and 21.6% in 2020 (Figure 4.6). The gas consumption in Ganja fluctuates between 18% to 20%, while in Barda it is around 21% to 22%; this indicates that Barda residents use more gas than those in Ganja.

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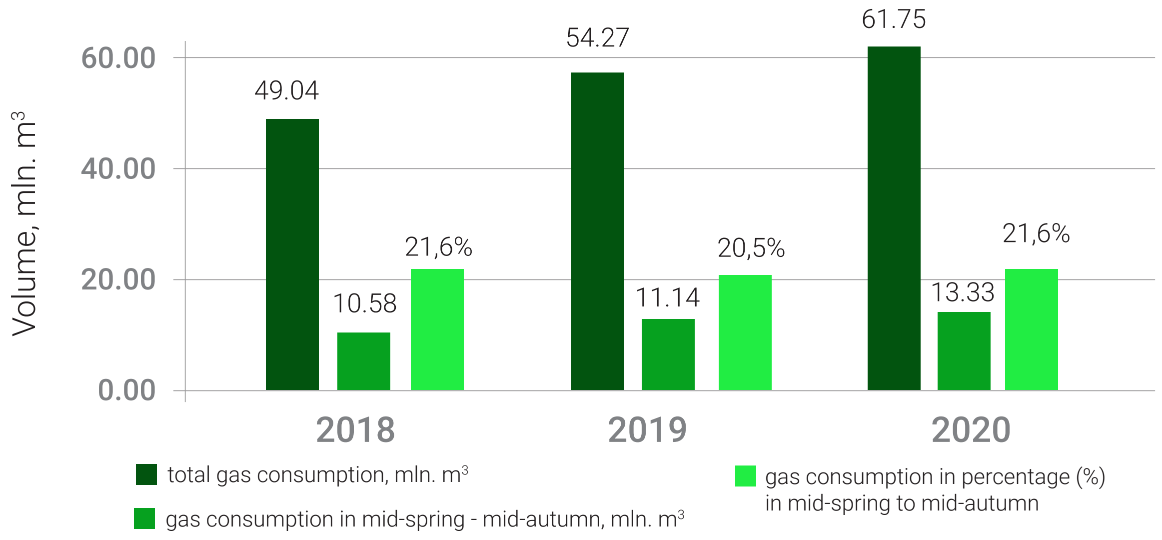
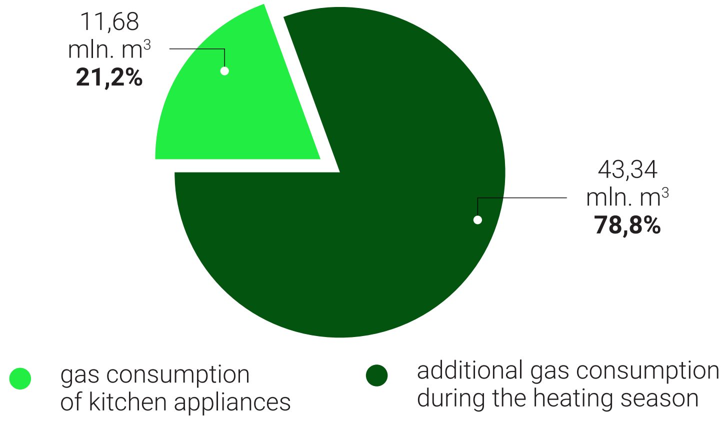
Figure 4.6: Total gas consumption (annual, mid-spring, mid-autumn).



The higher gas consumption in 2020 can be explained by the additional demand for heating by those residents usually working outside Barda, who had to remain at home due to the COVID-19 pandemic.

Depending on seasonal variations, during the five months from mid-May to mid-October gas consumption in the residential sector is normally associated with the use of kitchen appliances.

Figure 4.7: Gas usage, by purpose



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The gas consumption per capita for Barda district and its city centre can be calculated as follows:

- Annually: 351.9 m³ / person
- In mid-May to mid-October: 74.7 m³ / person

USE OF NATURAL GAS BASED ON RESIDENTIAL BUILDING TYPE

The housing stock in Barda comprises four different types of building and individual apartments:

Type 1: 5-floor, 4-block apartment blocks made of Absheron limestone.

Type 2: Multi-floor monolithic buildings.

Type 3: Private, 1-2-floor old stone houses, usually with thick walls. The living space per person in these houses usually does not exceed 8-12 m².

Type 4: Private new 2-4 floor houses, mostly made of limestone. The new-build, private houses often have more than 20 m² living space per person.

Data was not available per building type, thus it was not possible to determine the specific energy and gas consumption for each type.

NATURAL GAS CONSUMPTION IN BUILDINGS WITH CENTRALISED HEATING SYSTEMS

There are five centralised boiler stations in Barda district centre, however, the data on gas consumption and heat production in boiler stations is not recorded separately and thus could not be analysed for this Report.

V. COMPARATIVE ANALYSIS

The specific data of electricity usage in the residential sector determined from the results of the study conducted in Ganja and Barda are described in Table 5.1. As indicated, the residents of Ganja use 1.9 times more electricity per person and 1.45 times more per square metre in comparison with Barda. Furthermore, the lowest per capita and per square metre electricity usage is also found in Baku. This can be explained by a higher awareness of energy efficiency in Baku and the better energy efficiency of buildings in Baku.

Table 5.1: Comparison of annual electricity usage by using average data for three last years

Per capita, kW.hour/1 person/year	GANJA	BARDA	BAKU	AZERBAIJAN
Per capita, kW hour/1 person/1 year	1277	679	620*	732**
Per square meter, kW·hour/m²/1 year	64,3	44,3	35,1	-

* The volume of electricity used in the residential sector in Baku is 4,712,000,000 × (~ 0.3) = 1,413.6 million. kW·hour

** Average index for 2015-2019 (see Table 1.2)

Source: State Statistical Committee (2018)

As can be seen, per capita electricity consumption in Ganja is almost double that consumed in Barda, and 1.7 times higher than the national average. The data in Table 5.1 also indicates that electricity consumption in Ganja is higher than in Baku and Barda. While electricity is used more efficiently in Barda, the potential exists for further energy savings.

Table 5.2: Gas consumption for the residential sector in Ganja and Barda (Annual/Summer)

	GANJA		BARDA	
	Annually	In summer	Annually	In summer
Per capita, kW hour/1 person/1 year	340	67,0	352	74,7
Per square meter, kW·hour/m²/1year	17,2	3,4	15,4	3,3

Source: State Statistical Committee (2018)

This difference can be explained as follows:

- Taking into account the comparative sizes of Ganja and Barda, there are very few centralised boiler stations in Ganja. (approximately half the number for the size of population) which means individual apartments/houses must consume more energy
- More electrical appliances are used in apartment buildings (4-5 floor panel and stone houses) in Ganja compared to Barda during the heating season.
- New more efficient heating systems (combi boilers) are rarely used in Ganja.
- Energy inefficient incandescent bulbs are still used for lighting in Ganja.
- Balconies in apartment buildings in Ganja have been converted into additional rooms, making the other rooms in the apartments dark and thus requiring additional lightning. This is less common in Barda

The data in Table 5.1 also indicates that electricity consumption in Ganja is higher than in Baku and Barda. While electricity is used more efficiently in Barda, the potential exists for further energy savings.

V

While gas consumption in the residential sectors of Ganja and Barda during the summer months is predominantly for the use of kitchen appliances, almost five times more gas is used in the winter for heating purposes. This is mostly due to the use of traditional gas stoves ("Gazelle" stoves) to heat private homes, which do not convert gas to heat efficiently.

One of the first ways to improve the efficient use of gas in the sector is to use the new, energy-saving, "Combi" type gas appliances.

The data in Table 5.3 indicates the natural gas consumption when converted to kW and Joule on the basis of heat capacity.

Table 5.2: Gas consumption for the residential sector in Ganja and Barda (Annual/Summer)

	GANJA		BARDA	
	Annually	In summer	Annually	In summer
Per capita, kW.hour/1 person/year	3161	623	3272	695
Per square meter, kW·hour/m²/1 year	160	32	143	31
Per capita, Joule/1 person/1 year	11 386	2 244	11 788	2 502
Per square meter, Joule/m²/1 year	576	114	516	110

A combination of the data in Tables 5.2 and 5.3, provides a calculation of the electricity and gas energy per capita in Ganja and Barda:

- In Ganja - 3,501 kWh.hour/1 person/1 year
- In Barda - 3,624 kWh.hour/1 person/1 year

Even though the usage of the electric energy in Ganja is 1.7 times higher than in Barda, due to significant higher usage of natural gas in Barda, the total energy use in Ganja is lower. Therefore, at the first glance Ganja seems more energy efficient; however, it should be taken into account that Barda is rural area with some portion of the population engaged in agricultural activities by running greenhouses and involved in animal husbandry. All these business activities require usage of natural gas for heating in Barda. That is why it is considered that the electric energy is ineffectively used in Ganja, and the substantial reduction of electric energy usage could be achieved with concomitant saving for family budget.

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For every square metre of living space:

- In Ganja - 177.2 kW.hour/1 m²/1 year
- In Barda - 158.4 kW.hour/1 m²/1 year

It should be noted that in these figures the main portion consists of gas consumption.

In Table 5.3, gas consumption was converted to electricity equivalent and total figures were calculated; the data indicating that gas is more preferred for heating apartments in Barda.

When compared to European Union countries, the minimum amount of electricity usage per square metre is 30 kW·hour/m²/1 year (Romania), while the maximum is 170 kW·hour/m²/1 year (Norway). • In Russia, this indicator is 41 kW·hour/m²/1 year and the energy used for heating and lighting is 239 kWh/m²/1 year. This shows that in neighbouring Russia there is much lower energy usage per m2 than in Barda/Ganja (41KW hour/m2/1 year compared to 177.2 /158.4 kW.hour/1 m²/1 year

There is a clear need to use electricity and heat in Ganja and Barda in a more energy efficient manner. It is therefore recommended that the City and District Executive Powers develop a programme identifying specific measures to improve the efficient use of energy in existing buildings in the residential sector.

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VI. MEASURES TO PREVENT ENERGY LOSSES

In multi-floor buildings without thermal insulation, energy losses occur mainly in four areas: from the outer walls (35%), from the walls leading to the stairwell (25%), from the external ceiling (25% from the roof) and from the windows (15%) (Figure 6.1). Energy loss from the internal walls of apartments within a building is far less than from external walls, since adjacent walls are heated on both sides and no energy is lost from the partition walls. Heat rises, so heating from lower apartments helps heat higher apartments.

Figure 6.1: Direction and approximate percentage of loss, non-energy efficient building

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Materials that provide thermal insulation are usually used in the construction of private houses. In such houses, energy loss is mainly from the outer walls (35%), from the main entrance (15%), from the external ceiling (25%, the roof), from the floor to the ground (15%) and from the windows (10%) (Figure 6.2).

Figure 6.2: Direction and approximate percentage of loss, non-energy efficient private house

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VII. PLANNING ENERGY EFFICIENCY MEASURES IN GANJA AND BARDA

ENERGY EFFICIENCY AREAS

Studies in Ganja and Barda indicate that energy consumption is about five times higher in the cold season due to the demand for gas used to heat apartments and houses. The data on the consumption of gas in Ganja and Barda exceeds the total national per capita average. Due to the lack of centralised heating systems, most homes rely on gas stoves for heat and these are predominantly used in private houses. The installation and use of modern heating devices is limited due to their relatively high installation and running costs.

The second factor in energy efficiency is the loss of energy through walls and windows in apartments. The walls of existing multi-floor buildings are made of either concrete or limestone. The thermal conductivity of these two materials is very high:

- Reinforced concrete - 1.92 Vt/m·°C
- Limestone - 1.16 Vt/m·°C

The thermal conductivity of other building materials is much less:

- Expanded clay-concrete - 0.2-0.8 Vt/m·°C
- Aerated concrete - 0.2-0.4 Vt/m·°C
- Gypsum - 0.5 Vt/m·°C
- Bricks (porous) - 0.5-0.6 Vt/m·°C

In newly built, modern, multi-floor buildings, the walls are made of porous bricks, which increases the energy efficiency of these buildings.

Air bubble plastic can also play a role in energy efficiency:

- Heat transfer coefficient of at 30°C - 0.028 Vt/m·°C
- at -20°C frost - 0.023 Vt/m·°C

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Since new, individual houses continue to be built using energy inefficient limestone, the opportunity to reduce heat loss and save energy is lost.

Plastic and double-glass windows are used in newly built private houses and multi-floor buildings. This design significantly prevents heat loss and increases energy efficiency. However, the majority of previously built, multi-store buildings, have old, wooden, and single-glass windows.

The third factor is the limited use of LED lamps for the lighting of apartments. Although the purchase cost of these lamps is relatively high, they can play a major positive role in energy savings and are more cost effective in the longer term for consumer.

Insulation, roof structure, internal wall treatments; entrance design for multi-floor apartment buildings are all further factors that improve energy efficiency and should all be considered when determining energy efficiency measures.

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VII

ENERGY EFFICIENCY MEASURES

The following measures are recommended for achieving energy efficiency in the residential sector.

1. In existing, multi-floor, reinforced concrete panel and stone buildings:

- Replacement of stairwell windows with plastic and double-glazed windows
- Installation of wall insulation (internal and external) and floor insulation – including cavity wall insulation.
- Replacement of stairwells entrance doors with locking doors
- Installation of insulation layers on the roofs (foam or expanded clay layer). Attic structures (wood carcass + steel sheet) are the preferred option

2. In newly built, multi-floor buildings:

- Walls should be made of either porous brick (most energy efficient) or air-concrete blocks
- Include wall insulations
- Windows should be made of plastic and double glass only
- Internal walls should be plastered with gypsum (whitewash) mortar
- Staircases should have plastic windows and locked entrance doors
- Roofs should be of “attic” type only
- Newly built private houses:
- Walls should be made of either porous brick (more energy efficient) or air-concrete blocks
- Windows should be made of plastic and double glass only
- Internal walls should be plastered using gypsum (whitewash) mortar
- Warm insulation layers must be provided for the installation of the first floor
- When selecting external wall coating, preference should be given to materials with an air layer (when putting on steel profiles) and include insulation
- Cooling is also a priority, given climate change, thus preference should be given to ‘cool roof’[6] installation.
- It should be noted that, since multi-floor apartment buildings have higher energy efficiency than private houses, more public investments could be made in those buildings.

6. A cool roof is one that has been designed to reflect more sunlight and absorb less heat than a standard roof. Cool roofs can be made of a highly reflective type of paint, a sheet covering, or highly reflective tiles or shingles. Standard or dark roofs can reach temperatures of 65.5°C (150°F) or more in the summer sun.

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3. Heating systems of houses and apartments:

- Prohibit use of old-fashioned heaters and ovens
- Test the use of ground source heat pumps and smart heating systems, as used in Europe.
- Instead of old-fashioned Introduce the use of new, modern, separate heating systems in individual buildings by educating the population and introducing the “modernisation of the heating system” loan (financial support).
- Establish service and repair centres for the operation of new separate heating systems and provide vocational education to train personnel.

4. Enable the widespread use of LED lamps:

- Establish reception points for used non-LED lamps.
- Replace used non-LED lamps with new ones at discounted prices.
- Introduce energy efficiency labelling (like “Green label”) and standards for household appliances.

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VIII. RECOMMENDATIONS TO IMPROVE THE POTENTIAL AND ENABLING ENVIRONMENT FOR ENERGY EFFICIENCY

Under the Paris Agreement, Azerbaijan committed to decreasing its GHG emissions by 35% from the 1990 baseline. However, the latest UNFCCC NDC Synthesis Report[7] indicates that the previously agreed Nationally Determined Contributions (NDCs) will not be sufficient to keep the global temperature rise below 2C, and ideally below 1.5C, by the end of the century. Thus, nations must redouble their climate efforts and increase their voluntary obligations if they are to reach the goal of the Paris Agreement.

In this regard, Azerbaijan is currently reviewing its NDC obligations to determine if an increased contribution is possible. However, the NDC for Azerbaijan is currently quite ambitious and serious work must be undertaken for its implementation.

The building sector in Azerbaijan contributes to a large share of the country's GHG emissions. Without the implementation of measures to improve energy efficiency in this sector, Azerbaijan will be hard pressed to meet its current NDC obligations.

Based on the findings of this study, attention should focus on the following key actions to enhance energy efficiency in buildings in Azerbaijan.

Drafting and approving legislation and institutional arrangements that create the necessary enabling environment for improvements in energy efficiency.

- Enhancing the capacity of the relevant state agencies, their staff, and experts, to ensure all stakeholders share a common vision and fully understand the energy efficiency concept.
- Raising the awareness of the population on the benefits of implementing energy efficiency measures, to ensure public support for the Government and the policies introduced in this regard.
- Implementing pilot demonstrating projects in line with the Green cities concept.

Strengthening the legislation base and institutional arrangements

While several positive changes have taken place in recent years, work remains to be done. First, the implemetation of new laws on alternative energy and energy efficiency should be accelerated.

Second, while the Construction Code of Azerbaijan[8] contains the provision that "Constructed structures should meet the requirements of energy resources savings and energy efficiency", there is no operational mechanism to enforce it. However, other provisions, such as architectural design and building safety are strictly enforced by the State Committee on Urban Planning and Architecture and the Ministry of Emergency Situations respectively. There are a few examples in Azerbaijan where private developers or government agencies have constructed their buildings in accordance with the energy efficiency requirements, but this is rare. A publication on green buildings regulations/code detailing how buildings should meet the energy resources savings and energy efficiency requirements of the Construction Code should be developed and published. It should explain the standards that all new buildings must meet and what needs to be done when retrofitting improvements to existing buildings. The public labelling of a building's energy efficiency should also be transparent to residents.

Legislation on energy efficiency must therefore be adopted and energy efficiency measures should become a requirement in the construction code during the design stage and should also be verified after the building has been constructed.

Third, an area that needs to be critically improved is statistics. As noted in this Report, one of the issues encountered during the study was the lack of segregated data by building type. This absence of comprehensive data hinders the efficient development of policies on energy efficiency.

Enhancing human capital in the field of energy efficiency

Without a sufficient number of qualified specialists, conducting energy audits of buildings, both at the design and post-construction stages, will not be possible. Therefore, in parallel with the legislation formulation and adoption process, broad and targeted training of energy auditors should take place in Azerbaijan. Since only a small number of specialists have received training through projects implemented by international organisations, including UNDP, this training must be rapidly increased to ensure the adequate energy auditing of the extensive construction works needed for Azerbaijan's 10 million population. Furthermore, to negate the issue of conflict of interest between State agencies and private construction developers, objective and independent auditors are needed to verify data. Therefore, a mechanism should be introduced related to the establishment and functioning of independent, energy monitoring bodies and businesses.

7. Nationally determined contributions under the Paris Agreement, Retrieved from https://unfccc.int/sites/default/files/resource/cma2021_02E.pdf

8. Construction Code of Azerbaijan pp. 57.2.6 Retrieved from: http://e-qanun.az/framework/46958

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Another area that requires improvement is vocational education, which lags behind the needs of the private sector in the energy efficiency market. The construction business lacks workers who are both skilled and better informed about the benefits of implementing energy efficiency measures. It would therefore be beneficial to introduce a training programme on energy efficiency in construction for the 100-150 currently-enrolled technicians at the Ganja State Vocational Training Center for Industry and Technology. This is a measure that can be implemented in cooperation with the private sector.

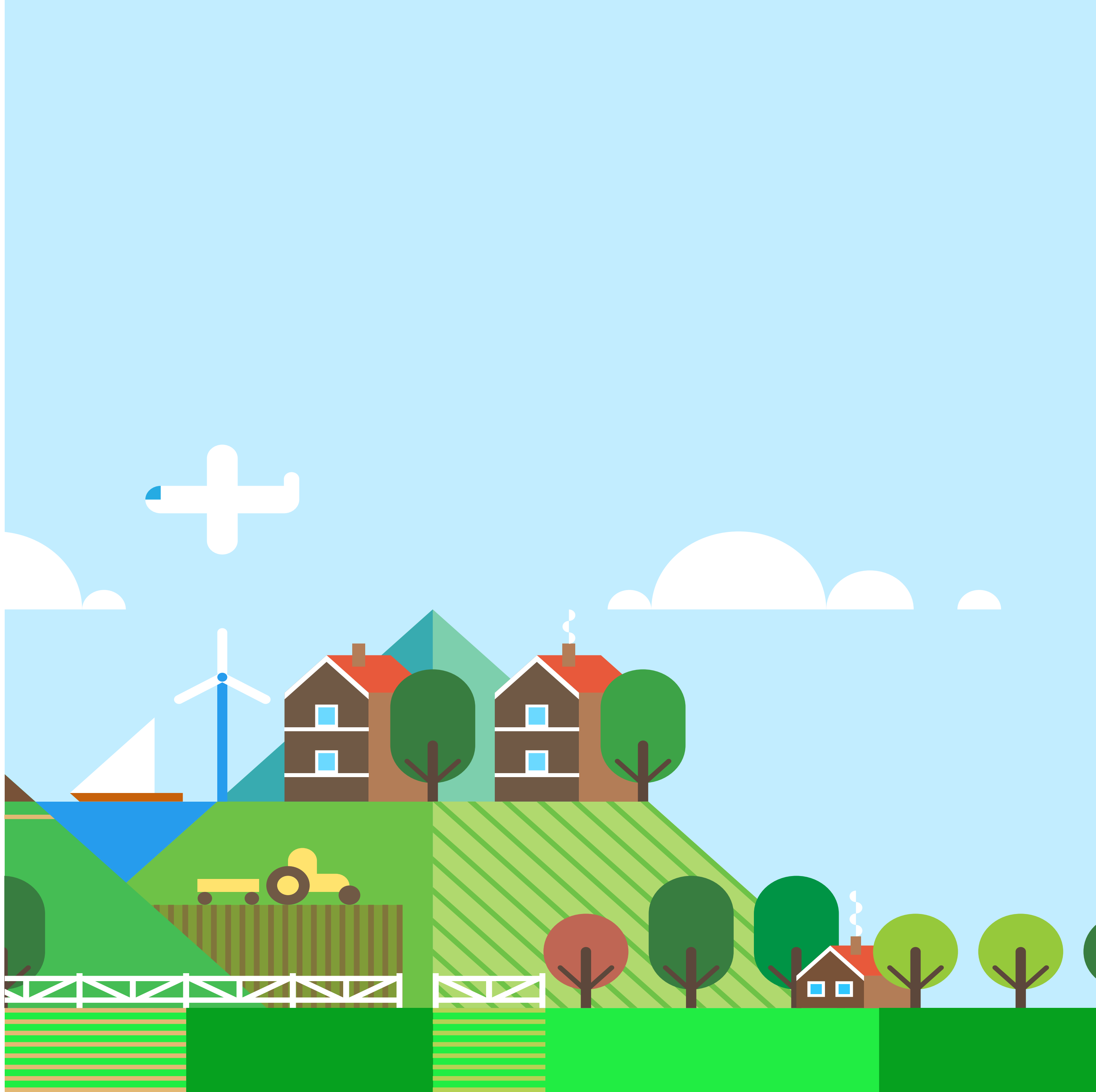
Raising public awareness

The small public awareness campaign conducted in Ganja and Barda for the study revealed an extremely low awareness of energy efficiency measures among the local population. Since in many buildings residents pay a fixed price for utilities, when energy efficiency measures are put in place in buildings, the residents must be informed about the new measures and advised how to change their behaviour to ensure the energy savings are achieved. For example, when an energy-efficient boiler is installed providing hot water and air conditioning, the residents must be shown how to adjust the thermostats on both rather than resorting to opening windows for cooler air and wasting hot water, which will obviously negate any potential energy savings.

Finally, in addition to public awareness campaigns, the Government can introduce smart metering; make it mandatory for utilities companies to educate and inform their customers about energy efficiency; and introduce financial incentives (subsidies, grants or energy taxes, lower import duties on energy efficient equipment, lower tariffs during non-peak hours) to retrofit energy saving mechanisms into existing homes.

Implementing Green City pilot projects that focus on energy efficiency

Most energy efficiency measures and pilot projects implemented by international organisations target Baku. Given the low level of public awareness on energy efficiency in other cities, as evidenced in Ganja and Barda, the logical first step forward would be to conduct pilot demonstration-type projects in these two locations, as well as in the conflict-affected areas in and around Nagorno-Karabakh, capitalising on the existing good relations with local authorities and responding to the needs of local communities, leading by example through investment in energy efficient public buildings and, importantly, contributing to the global drive to reduce GHG emissions.



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