KHARKIV

SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN OF KHARKIV

TILL 2030

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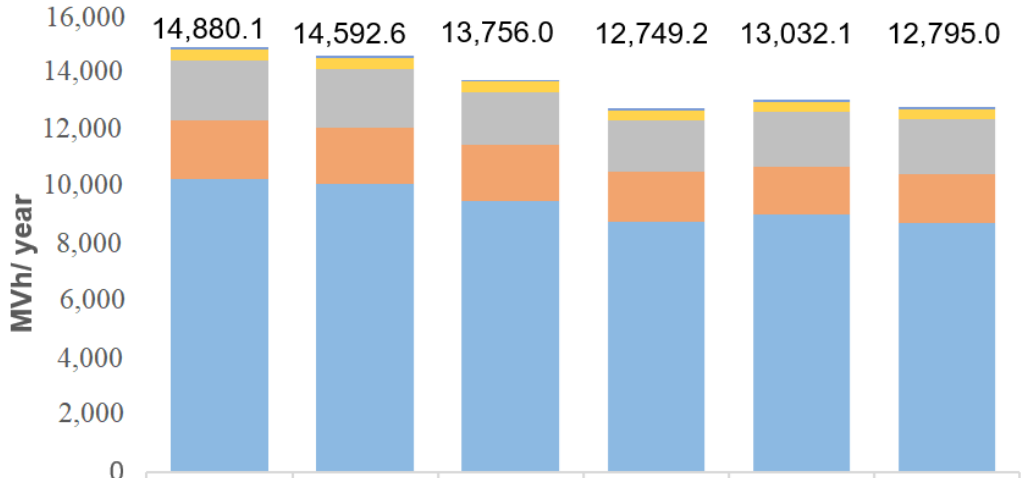
List of Abbreviations Used

AEE	Alternative Energy Sources
AEMS	Automated Electricity Metering System
BEI	Baseline Emission Inventory
PPP	Public-Private Partnership
EE	Energy Efficiency
IHP	Individual Heat Point
CE	Coefficient of Efficiency
SPS	Sewerage Pumping Station
STP	Sewerage Treatment Plant
IFI	International Financial Institutions
ES	Emergency Situation
PJSC	Public Joint-Stock Company
SECAP	Sustainable Energy (and Climate) Action Plan
FER	Fuel and Energy Resources
DDP	District Dispatching Point
NHP	Natural Hydrometeorological Phenomena
MT	Means of Transport
LLC	Limited Liability Company
MSW	Municipal Solid Waste
CDO	Central Dispatching Office
CHSS	Centralized Heat Supply System
CHS	Centralized Heat Supply
GIZ	German Agency for International Cooperation
USAID	United States Agency for International Development

SUMMARY

The Sustainable Energy and Climate Action Plan is a strategic document, which is aimed to increase energy efficiency in budgetary institutions and establishments of the city, residential buildings, public and municipal transport, public lighting, the tretiary sector (small and medium-sized enterprises, service industry), at the city's municipal enterprises and in the sector of municipal solid waste managment.

During the SECAP development, analysis and evaluation of the current situation in the fields of fuel-energy resourses production and consumption in the city were performed. The dynamics of energy consumption over six years was analyzed (2012-2017) to compile the energy balance of Kharkiv (Figure 1).

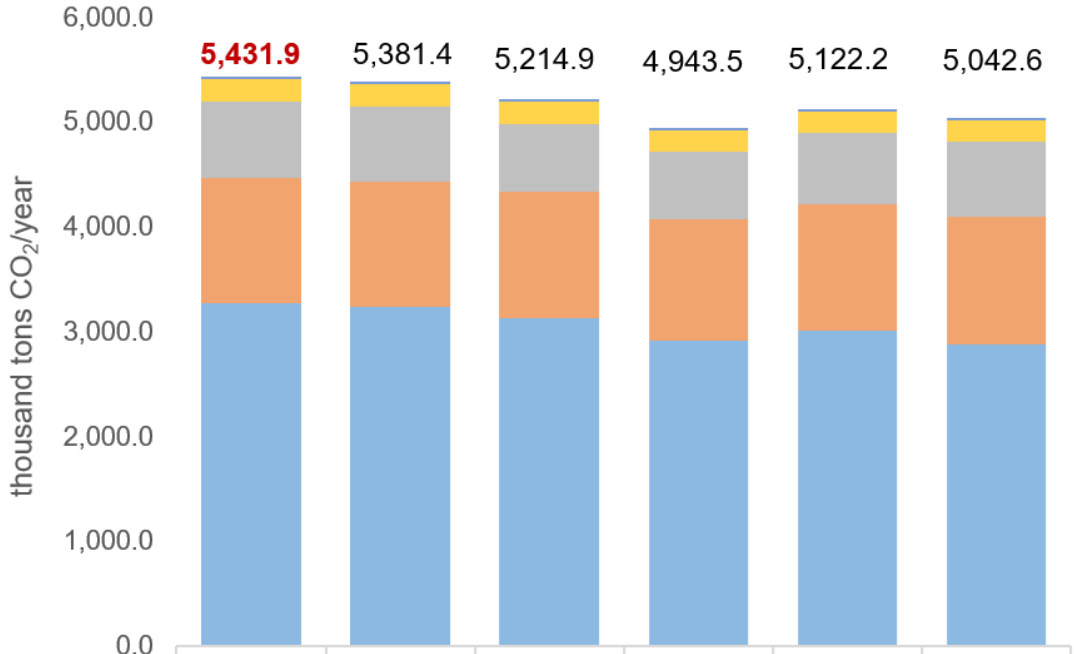


	2012	2013	2014	2015	2016	2017
Municipal public lighting	25.9	26.5	27.4	32.8	30.7	31.3
Transport	396.1	382.8	366.0	350.5	344.3	341.3
Municipal buildings, equipment/facilities	2,098.2	2,066.9	1,864.8	1,791.4	1,913.2	1,939.6
Tertiary sector	2,057.4	2,003.1	1,961.7	1,800.9	1,674.8	1,711.0
Residential buildings	10,302.5	10,113.3	9,536.1	8,773.6	9,069.1	8,771.8

Figure 1 Dynamics of energy consumption in 2012-2017 in selected sectors in consolidated units

Based on the received consumption of the main types of energy resoures, the Baseline Emission Inventory of CO_2 emissions in 2012-2017 was calculated by the selected sectors: municipal buildings (public buildings which are financed by the city and district budgets), residential sector, passanger (public transportation about Kharkiv) and municipal transport, street lighting, tertiary sector, heat supply (ME "Kharkivski teplovi merezhi"), water supply and sewerage (ME "Kharkivvodokanal") (Figure 2).

The baseline year for evaluation of the current level of CO_2 emissions for Kharkiv is 2012. The use of 2012 as the baseline year is explained by the availability of complete and reliable information for this period on the consumption of all types of energy and the most representative and stable functioning of the city's economy. The Baseline Emission Inventory in the absolute measurement in 2012 is 5 431.9 thousad tCO2/year or 3.7 tCO_2/year for 1 inhabitant.



	2012	2013	2014	2015	2016	2017
Municipal public lighting	23.6	24.1	25.0	29.9	28.0	28.5
Transport	217.9	213.7	207.0	200.8	200.2	199.5
Municipal buildings, equipment/facilities	723.4	711.3	652.5	638.2	685.6	722.8
Tertiary sector	1,195.8	1,203.0	1,202.2	1,157.5	1,197.6	1,210.7
Residential buildings	3,271.1	3,229.4	3,128.2	2,917.0	3,010.9	2,881.0

Figure 2 Dynamics of CO_2 emissions in 2012-2017 in selected sectors

According to the emission structure of the baseline year 2012, the main sectors that generate CO_2 emissions are: the residential buildings sector – **60.2%** of the total emissions; the tertiary sector – ***22.0%,*** heat supply and water supply/ sewerage enterprises – ***11.1%,***municipal buildings – ***2.2%***, transport – ***4.0%,***public lighting– ***0.4%.*** (Figure 3). These sectors were in the focus of attention in preparation of the list of energy efficient projects and measures included in the city's SECAP.

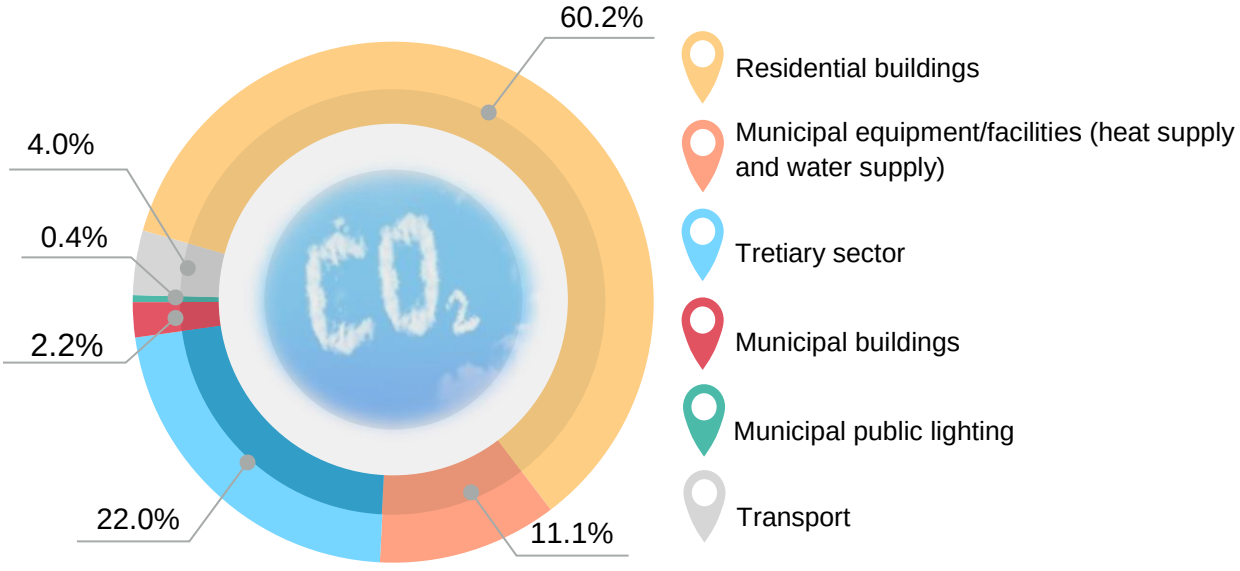


Figure 3 Share of CO_2 emissions according to emission sources in 2012 baseline year.

In view of the above, the strategic goal and specific objectives of the SECAP are determined as follows:

The strategic goal of Kharkiv SECAP is ensuring comfort of living in Kharkiv for citizens by mitigating the negative effects of climate change, improving the quality of services provided while reducing the energy consumption in the urban infrastructure and reducing CO_2 emissions.

The SECAP tospecific objectives are:

- to reduce CO_2 emissions by 2030 in the determined sectors by at least **31.3**%, or **1,700,200** ton/year (Figure 4).

- to cut down the consumption of all major energy resources by **5,001,500 MWh*/year.**

- to increase the share of electricity and heat production from renewable sources and use of highly efficient cogeneration by **395,300** MWh/year (**2.65%**) by the selected sectors, as well as additionally **22,100** MWh/year through utilization of landfill gas and production of to electricity from it after the construction of a waste recycling plant.

- to raise the citizens' awareness of and responsibility for sustainable use of fuel and energy resources.

- to attract investments in energy saving and energy efficient projects.

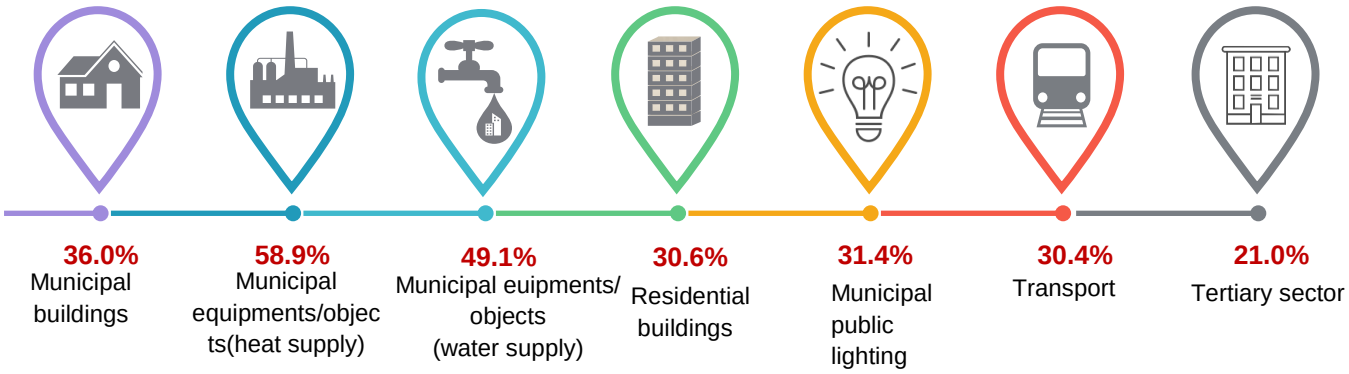


Figure 4 Expected reduction of CO_2 emissions by selected sectors

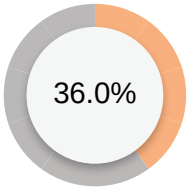
The summary calculation of CO_2 emissions reduction by sectors is given in Table 1.

Table 1

Summary calculation of CO_2 emissions reduction by sectors by 2030

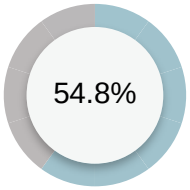
No.	Sectors included in BEI	Total emissions in baseline 2012 t/year	Emissions reduction, t/year	CO_2 emissions decrease, %
1.	Municipal buildings, equipment/*facilities*	**723,378.34**	374,437.79	51.8
1.1.	*Municipal buildings*	**117,868.30**	42,461.17	36.0
1.2.	*Municipal equipment/facilities*	**605,510.04**	331,976.62	54.8
2.	Residential buildings	**3,271,135.67**	1,000,553.48	30.6
3.	Municipal public lighting	**23,629.01**	7,411.30	31.4
4.	Transport	**217,903.67**	66,153.99	30.4
5.	Tertiary sector	**1,195,816.81**	251,659.24	21.0
	Total	**5,431,863.50**	**1,700,215.81**	**31.3**

The implementation of the strategic goal and the specific objectives set forh in the Action Plan is planned through energy saving measures and information campaigns on energy saving topics in the selected sectors:



Municipal buildings, equipment/facilities (municipal buildings)

Energy efficiency improvment in budget institutions of the city through development and improvement of the energy management system, implementing measures aimed at ensuring efficient technical operation, maintenance, restoration and improvement of operational qualities of buildings, their comprehensive thermal retrofit. Educational courses/programs in educational institutions and other informational and educational measures are proposed, too.

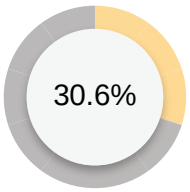


Municipal buildings, equipment/facilities (heat supply)

Improving reliability of the heat supply system in Kharkiv by its retrofit: reconstructing boiler houses, eliminating uneconomical boiler houses, replacing the piplines of the heating networks with pre-insulated ones, transitioning from the four-pipe heating system to a two-pipe one and local hot water preparation at the consumer's IHP, constructing cogeneration stations, introducing systems of automation, dispatching and commercial electricity metering (SCADA), installing heat metering devices at consumers'.

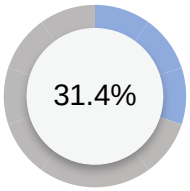
Municipal buildings, equipment/facilities (water supply)

Improving reliability of the water supply system in Kharkiv through its renewal: reconstructing the existing pumping stations for water supply and distribution in Kharkiv with replacement of technically worn-out sections of water supply and distribution networks, introducing the technology and equipment for water disinfection, increasing reliability and useful life of water removal networks by sanation with modern materials and technologies.



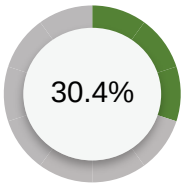
Residential buildings

Conducting energy audits and issuing energy efficiency certificates for residential buildings, ensuring their proper technical operation, conducting current and major repairs, comprehensive thermal retrofit of residential buildings. Carrying out informational and explanatory work among the citizens on energy efficiency.



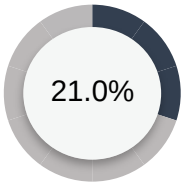
Municipal public lighting

Reconstructing the external lighting system, increasing its energy efficiency and automation, ensuirng an adequate level of lighting in the entire city.



Transport

Development of the city's electric transport network is identified as a priority in ensuring the quality and efficiency of passenger transportation. To achieve this goal, it is necessary to adapt the complex transport scheme of Kharkiv, to ensure renewal of the rolling stock of the city's electric transport (trolleybuses, trams and metro cars), development of the metro. To retrofit the power supply management system for urban electric transport. Along with the development of the city's electric transport, promotion of bicycle transport and construction of bicycle paths are provided for. The city bus requires quantitative and qualitative optimization, as well as incentives for carriers to renew their rolling stock.



Tertiary sector (small and medium businesses, service sector)

Ensuring energy efficient operation of buildings and equipment, retrofitting the lighting system, conducting thermal sanation of building enclosures, installing heat energy metering and regulating devices, modernizing technological equipment.

A significant factor in the deterioration of the ecological condition of the city is environmental pollution with waste generated in the process of economic and social activity. Within the SECAP framework, a number of measures are planned on solid waste management, assurance of their complete and timely collection, removal and treatment. So, Kharkiv is implementing a project on construction of a complex for municipal solid waste treatment with a system of landfill gas collection, recycling and use for electricity generation in Derhachi. In order to solve the problem of municipal solid waste management in the city, as well as to ensure effective operation of the municipal solid waste treatment complex under construction in Derhach, it is proposed to additionally implement organizational, informational, educational, regulatory and procedural measures.

The planned amount of funds to be allocated for implementation of energy efficient projects in the selected sectors of the SECAP is **49.1 billion UAH** (Table 2).

Table 2

Amount of investment required for implementation of energy-saving measures in Kharkiv to meet the commitments under the SECAP till 2030

	Sectors	Investment, thous. UAH	% in total
1.	Municipal buildings,equipment/facilities, including		
1.1.	*Municipal buildings*	5,311,783.5	*10.8*
1.2.	*Municipal equipment/facilities*	8,451,947.5	*17.2*
2.	Municipal buildings	15,268,239.3	*31.1*
3.	Municipal public lighting	822,890.0	*1.7*
4.	Transport	14,743,528.9	*30.0*
5.	Tertiary sector (small and medium-sized enterprises and service industry)	3,367,400.8	*6.9*
6.	Municipal solid waste managment	1,136,150.9	*2.3*
	Total	**49,101,940.8**	

The evaluation of Kharkiv's suseptibility to climate change was conducted by way of detailed analysis of seven groups of indicators that enable

evaluation the city's suseptibility to the main negative effects of climate change, such as (1) heat stress, (2) flooding; (3) reduction of areas and disturbance of the species composition of urban green zones; (4) natural hydrometeorological phenomena; (5) potable water quality deterioration and quantity reduction; (6) increase in the number of infectious and allergic manifestations; (7) disruption of the proper operation of the city's energy systems.

By the results of the evaluation, Kharkiv is the most susceptible to heat stress and to potable water quality deterioration and quantity reduction. Moderately high suseptibility is identified for increase in the number of infectious and allergic manifestations, as well as the city's green zones and energy systems. Moderate suseptibility is established for flooding and natural hydrometeorological phenomena.

In order to adapt the city to climate change, a complex of relevant recommendations was developed, which includes organizational and management measures; architectural planning recommendations and restrictions; engineering and technical measures, plans and projects to increase energy efficiency of the urban infrastructure (SECAP projects), an information and information and educational campaign.

The Sustainable Energy (and Climate) Action Plan of Kharkiv till 2030 contains five sections:

- The first section is devoted to the prerequisites (descriptive and analytical part) for the SECAP development and the description of the relevant regulatory framework;

- The second chapter describes the current state of the city's energy infrastructure, analyzes the production, supply and consumption of energy resources, and draws up the energy balance of the city.

- The third section calculates a baseline emission inventory and identifies the main sources of CO_2 emissions in the town;

- The fourth section contains a susceptibility evaluation and measures to adapt the city to climate change***;***

- The fifth section contains a description of specific measures in the context of programs and projects, describes the administrative structure of the SECAP implementation, and also determines the planned measures in the field of the use of alternative energy sources, conducting information campaigns in the field of energy saving, climate and the environment protection, and identifies the expected sources of financing.

It should be noted that SECAP can be adjusted in accordance with the changing situation in the city and the introduction of new energy-saving measures that will make Kharkiv more energy-efficient, and the life of citizens more comfortable.

INTRODUCTION

The global warming problem and the annual trend of climate change towards environmental degradation have led the European community to set ambitious climate change mitigation goals in the form of the “20-20-20 to 2020” initiative.

New signatories from Ukraine are now committing to reduce CO_2 emissions by at least 30% by 2030 and adopt an integrated approach to tackle the problem of mitigation and adaptation to climate change.

Given the importance of this issue, Kharkiv has joined the Covenant of Mayors, an initiative of the European Commission, which is aimed to unite European local authorities into a voluntary association to jointly combat global warming. By signing this agreement, Kharkiv has set a goal to reduce its own CO_2 emissions by at least 30% by 2030, thus contributing to the development of an environmentally friendly economy and improving the quality of life. One of the tasks that are defined within the framework of the signed “Covenant of Mayors” with the aim of achieving the declared objectives is appropriate strategic document “Sustainable Energy (and Climate) Action Plan for Kharkiv for the period until 2030” (further - SECAP), which will serve as a guideline for planning the city’s energy policy and a setting to form priorities and measures focused on energy saving processes.

In the general context, SECAP illustrates how CO_2 reduction objectives can be achieved

It should be noted that SECAP can be adjusted in accordance with the changing situation in the city and the introduction of new energy-saving measures that will make Kharkiv more energy-efficient, and the life of citizens more comfortable.

KHARKIV

DESCRIPTIVE-ANALYTICAL PART

РОЗДІЛ 1. ОПИСОВО-АНАЛІТИЧНА ЧАСТИНА

Kharkiv is a city located in the northeast of Ukraine in Slobozhanshchyna. It is the Scientific Center of Ukraine and the administrative center of the Kharkiv region.

Kharkiv is the only city in Ukraine with a full set of awards from the Council of Europe: Diploma, Honorary Flag, European Table, and Prize of Europe.

Kharkiv has been a three-time winner in the ranking of *fDi Magazine* (an international specialised division of the *Financial Times*) "European Cities and Regions of the Future" for Cost Effectiveness, which indicates Kharkiv's recognition on the international level as an open city with the best prospects for attracting foreign investment, as well as a city that is recognized in the world community.

For four years in a row (2015-2018), Kharkiv received the "12 Stars" Award for participation in the European Local Democracy Week, a pan-European event aimed at promoting local democracy and involving citizens in local decision-making, coordinated by the Congress of Local and Regional Authorities of the Council of Europe.

Experts of *Kyiv Smart City Forum* recognized Kharkiv as "The Most Comfortable City for Life" in 2019 and "The Best Innovative City of UKRAINE" in 2018. *Kyiv Smart City Forum* is one of the most important events in Eastern Europe dedicated to promotion of smart technologies and implementation of innovative solutions in cities.

City flag

Coat of arms of the city

1.1. General characteristics of Kharkiv

1.1.1 Brief historical background

Kharkiv was founded in 1654 by Ukrainian Cossacks and peasants, who built a fortress on these lands to protect the southern borders of the state from the invasion of nomads.

Today Kharkiv is one of the largest cities in Ukraine. There are more than 2,000 avenues and streets, alleys and squares in Kharkiv. Kharkiv is the largest industrial, scientific, educational, trade and transport center of Ukraine. The products of Kharkiv enterprises, including such knowledge-intensive as modern planes, turbines, tanks, are well known in the world market. The first university in Eastern Ukraine was opened in Kharkiv, the first newspapers and magazines in the Ukrainian language were published. Kharkiv was the first to go on the Ukrainian radio air; Kharkiv scientists were the first in Europe to split the atom nucleus. Here the theory of superconductivity was studied and the first radio telescope was designed. Numerous scientific schools, created in Kharkiv, became world famous. Life and activity of three Nobel laureates I. Mechnikov, S. Smith (Kuznets), L. Landau are connected with Kharkiv.

Kharkiv is recognized as the capital of Ukrainian students - there are more than 60 higher education institutions.

Kharkiv has rich cultural traditions. There are a significant number of theaters, cinemas, museums in the city; there is a dolphinarium, a circus, and a zoo, too. Kharkiv offers wide opportunities for

practising many kinds of sports: there are 850 athletic fields, 19 swimming pools, more than 40 tennis courts, and a golf club.

Kharkiv is a multinational city with representatives of many nations living here since ancient times, national schools, theatres and musical groups working here.

Kharkiv has always been attractive for the world's business and scientific community because it has everything for a successful business: high-tech enterprises, qualified personnel, intellectual potential, well-developed and diverse infrastructure. Kharkiv is well landscaped with 110 parks and squares; the large ones are the Central Gorky Park, Shevchenko Gardens, Artem Park, Forest Park, and Botanical Gardens. Kharkiv also plays a significant role as a transport center with the railroads radiating in 8 directions and the large Pivdenna railroad station itself.

Kharkiv is connected by airlines with a number of cities of Ukraine, CIS and Europe. The modern airport was built in 1954. The suburban and intercity bus network has 290 routes.

1.1.2 Geographical location and climatic conditions

Kharkiv is located in the northeastern part of Ukraine on the watershed of the Dnieper and Don river systems and on the border of the forest-steppe and steppe landscape zones.

Geographical coordinates of the city are:
- 50°00'21" North latitude, 50°00'21" East longitude.
The highest point above sea level: - *202 m (Piatykhatky)*
The lowest point above sea level: - *94 m (Novoselovka).*
Kharkiv's length:
- from north to south - 24.3 km
- from west to east - 25.2 km
Area of the city - *350 km²*

Figure 1.1.2.1 Map of the Kharkiv region

Kharkiv lies on a watershed rise in the valley of Kharkiv, Lopan, Udy, and Nemyshlya rivers. These small rivers converge in the territory of modern Kharkiv and then inflow (through Udy) lower to Seversky Donets.

Administratively, the territory of modern Kharkiv is divided into 9 districts:

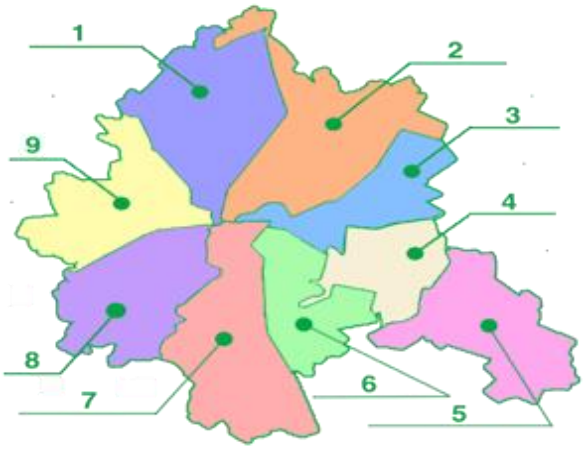


Figure 1.1.2.2 Administrative districts of the Kharkiv

1. Shevchenkivskyi
2. *Kyevskyi*
3. Moskovskyii
4. *Nemyshliansky i*
5. Industrialnyii
6. *Slobidskyii*
7. Osnovianskyi
8. *Novobavarskyii*
9. *Kholodnohirskyii*

From the point of view of its relief, Kharkiv is divided into 4 low-lying and 4 elevated areas.

The city is located on 5 hills and has a height difference between the upper and lower points of more than 115 meters. Therefore, the cold air in winter moves from the top to the bottom, usually into the river valleys, and lowers the temperature there.

The climate of Kharkiv is moderately continental with a moderately cold and

alternating winter and a long, steady, timely arid and hot summer.

Precipitations in the city are distributed evenly enough by seasons. More precipitations fall during the summer months as is characteristic for all temperate zones. The wettest month is July, with normal rainfall of 67 mm. In general, the evaporation rate is higher than that of humidification; therefore, there is a problem of insufficient soil moisture (soil drought) in the city.

Atmospheric drought is also common.

Information on average monthly air temperature in Kharkiv during the year is presented in Figure 1.1.2.3.

Detailed information on average monthly air temperatures in 2012-2017 and the main climate indicators for Kharkiv is given in Appendix 1.

Average annual temperature:
- *+8.1°C*

Average maximum per year:
- *+21.3°C*

Average minimum per year:
- *-4.6°C*

Average annual rainfall:
- *515 mm*

Average annual wind speed:
- *4.0 m/s*

Annual average air humidity:
- *74%*

Estimated temperature of the coldest five-day period:
- *-23°C*

Average heating season duration:
- *179 days*

Normative average heating season temperature:
- *-1.0°C*

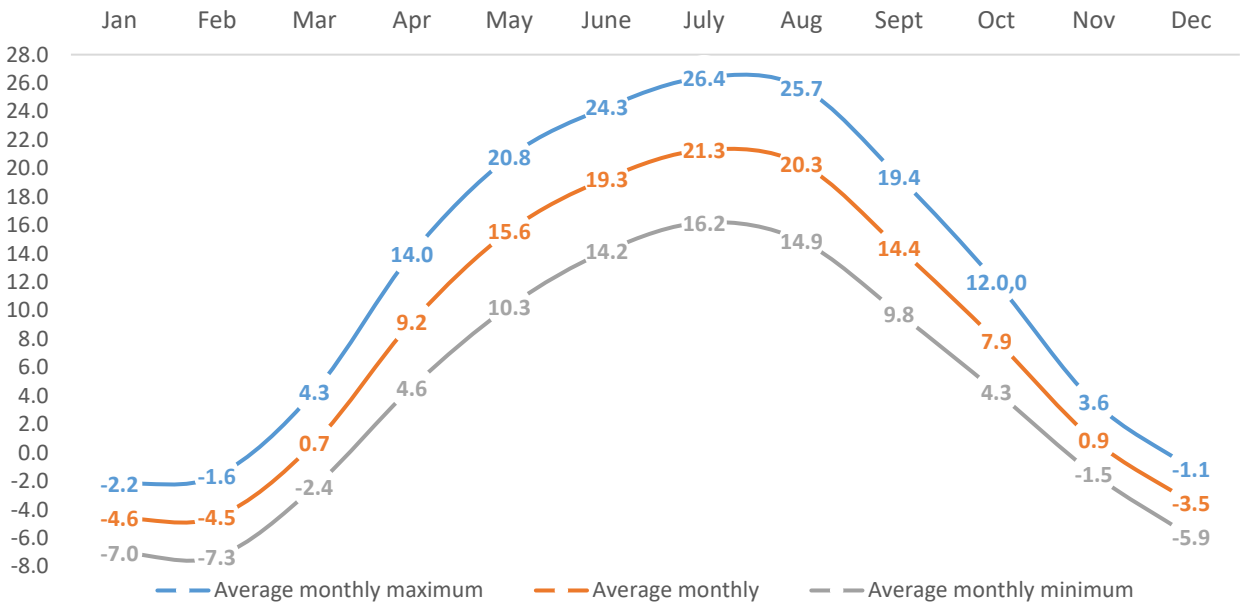


Figure 1.1.2.3 Average monthly air temperature in Kharkiv

1.1.3 Population of Kharkiv

The age structure of the Kharkiv population is characterized by a high level of the population older than the working-age (22.3%). Also, the city is characterized by an indicator of the proportion of persons younger than the working age (13.4%) which is one of the lowest among the regional centers in Ukraine and one of the highest indicators characterizing the working age population share – 64.3%.

Population size in Kharkiv as of 01/01/2018:
- *1,430,500 people, which is 53.8% of the total population in the Kharkiv oblast*

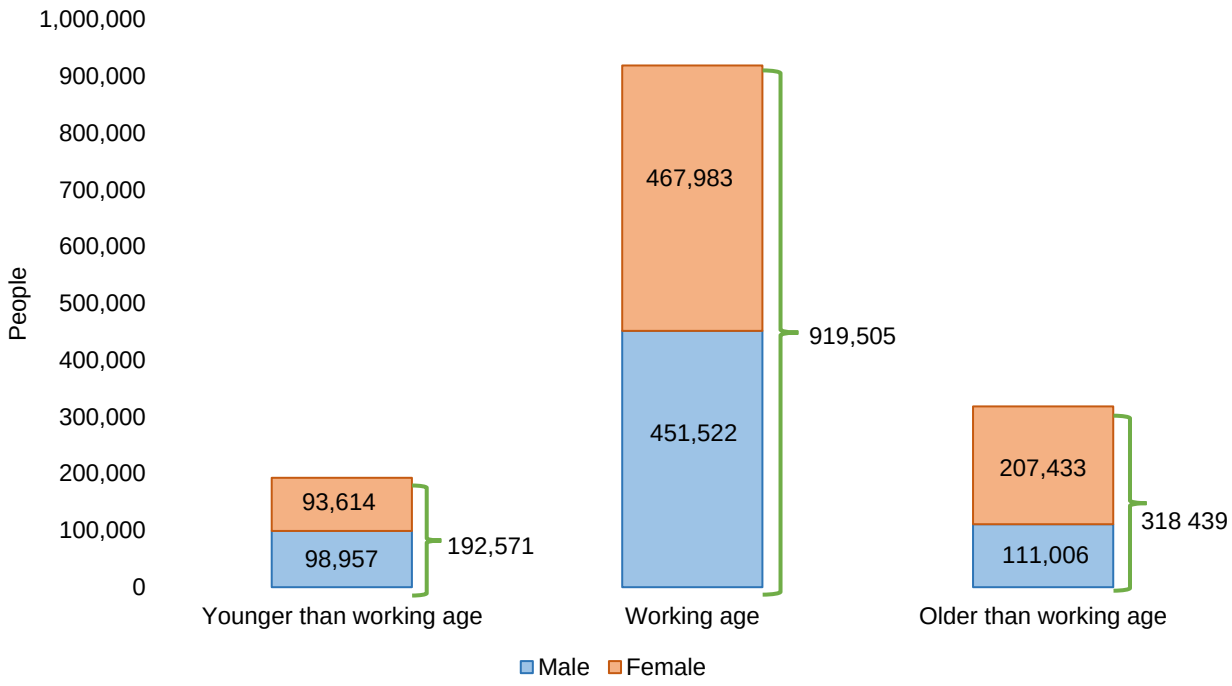


*Figure 1.1.3.1 Distribution of the resident population by gender and age **

*** Note:** Detailed information on the distribution of the resident population by gender and age as of January 1, 2018, is given in Appendix 2.

Table 1.1.3.1

Resident and de facto population in Kharkiv in 2012-2017.

Indicator	Measurement unit.	Years					
		2012	2013	2014	2015	2016	2017
De facto population	thousands of people	1,451.0	1,451.1	1,449.7	1,449.3	1,438.9	1,450.1
Resident population	thousands of people	n/a	n/a	1,432.2	1,429.8	1,419.5	1,430.5

1.1.4 Evaluation of the economic potential of Kharkiv

Kharkiv is a large industrial center of Ukraine.

The basis of the production potential of the city is formed by the enterprises of high-tech industries:

- power engineering
- electrotechnical industry
- transport and agricultural engineering
- instrument making
- radio electronics
- aerospace industry

According to statistics, in 2017, there were **17,314** small, medium and large companies carrying out their economic activity in the city.

The main number of these enterprises (99.9%) is small and medium businesses, of which **743** are medium businesses (4.3% of the total number of enterprises) and **16,563** are small businesses (95.6% of the total number of enterprises). In total, the city's small and medium-sized businesses employ **230,740** people.

Large businesses account for 0.1% of the total number of all enterprises.

In 2017, small and medium-sized businesses sold products (goods, services) in the amount of **196.2 billion UAH**. By types of their economic activity, the largest number of

small and medium-sized businesses is concentrated in the service sectors, wholesale and retail trade.

Intermediate consumption goods (raw materials) prevail in the structure of sales of industrial products in Kharkiv: there are 23.3% of them; and the volume of short-term use products (food, household industry) makes up 27% of the structure of sales The share of consumer durables (engineering products, etc.) is only 3%.

Also, **91,814** individual entrepreneurs carry out their economic activity in the city, who sold products (goods, services) for the total amount **42.5 billion UAH.**

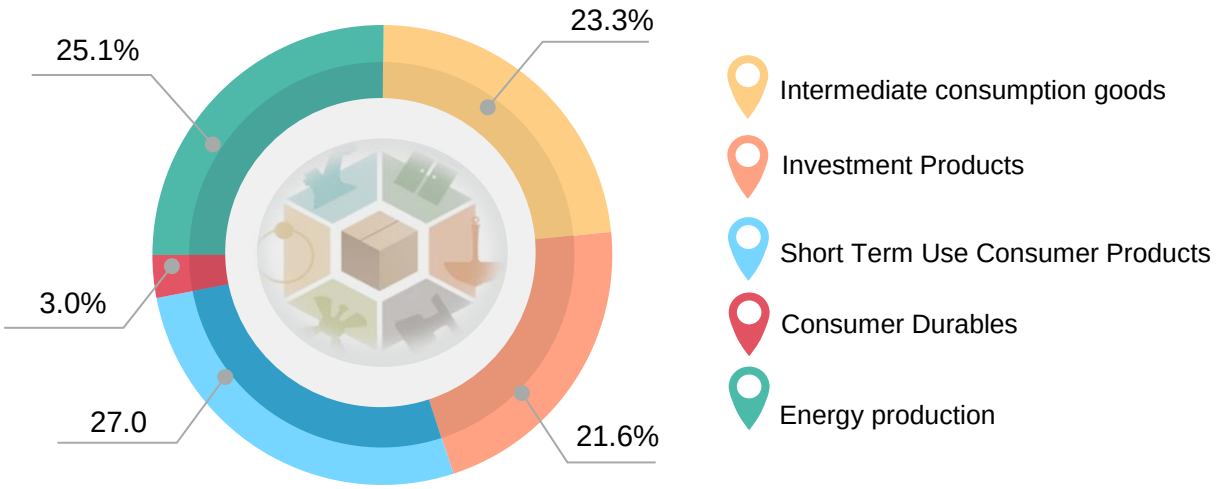


Figure 1.1.4.1 Structure of sales of products by Kharkiv enterprises, in % to the total volume

Detailed information on the main indicators of socio-economic development of Kharkiv 2012-2017 is given in Appendix 3.

Leading Kharkiv enterprises:

In the field of engineering:

○ *OJSC "Turboatom", SE "Plant Electrovazhmash", OJSC "FED", OJSC "Plant "Pivdenkabel", GP "Plant named after V.O.Malyshev", JSC" Kharkiv Bearing Plant ", JSC" KhMBZ "Svet Shakhtera"*

In the food industry:

○ *Corporation "Biscuit-Chocolate", JSC "Khladoprom", SE "HZShV", LLC "Kharkiv Meat Processing Plant", LLC "Saltovsky Meat Processing Plant"*

In the field of health protection:

○ *- LLC Pharmaceutical Company "Zdorovye", OJSC Kharkiv Pharmaceutical Enterprise "Zdorovya Narodu", CJSC Stoma, OJSC "Pharmstandard-Biolik"*

KHARKIV

ENERGY GENERATION, SUPPLY AND CONSUMPTION ANALYSIS

CHAPTER 2. ANALYSIS OF ENERGY PRODUCTION, DELIVERY AND CONSUMPTION

2.1 Energy balance of Kharkiv by types of energy resources

2.1.1 Heat supply

Centralized heat supply to consumers in Kharkiv is implemented by the municipal enterprise "Kharkiv Heating Networks". The main consumers of heat energy in Kharkiv are the population, industrial enterprises, budgetary institutions (public sector), as well as other consumers (shops, offices, etc.). Information on the distribution of thermal energy consumption by categories of consumers in Kharkiv during 2012 – 2017 is shown in the figure 2.1.1.3.

6,059 apartment houses with a total area of **24.6** mln m^2 as well as **2,085** buildings of various organizations, institutions and enterprises, **186** medical institutions, **202** preschool educational institutions and **256** general educational institutions are connected to the centralized heat supply system of the city.

Heat energy transportation to consumers is carried out through the main and distribution heating networks operated by a municipal enterprise. The heat energy distribution to the needs of heating and hot water supply is carried out through central and individual heating points.

Also, the municipal enterprise "Kharkiv Heating Networks" purchases part of the heat energy for its further delivery to final consumers in the enterprises of JSC "Kharkivska TETZ-5" (CHP-5) geographically located in the village of Podvirky in the Dergachevsky district of Kharkiv region. The heat capacity of Kharkiv CHP-5 is up to 1,400 Gcal/h.

The utility company "Kharkiv Heating Networks" operates:

- *249 boiler houses and CHP-3*
- *208 central heat points (CHP)*
- *88 individual heat points (IHP)*
- *11 pumping stations (total capacity over 25 MW)*
- *1628.3 km of heating networks in two-pipe equivalent*

The own sources' installed heat capacity of the municipal enterprise "Kharkiv Heating Networks" is more than 4,300 Gcal/h.

The heat energy production is carried out in accordance with the approved temperature schedules depending on the ambient temperature

11 pumping stations with a total capacity of more than 25 MW are used to ensure the heating networks capacity and to create the necessary hydraulic modes in the centralized heat supply system.

Information on heat production is given in table 2.1.1.1. in the figure 2.1.1.1. The structure of the annual balance of thermal energy in the city in 2017 is shown in the figure 2.1.1.2.

Table 2.1.1.1

Heat production, mln Gcal

Parameter name	Years					
	2012	2013	2014	2015	2016	2017
Heat production *	7.4	7.2	6.6	6.3	6.7	6.5

*** Note:** The data are given taking into account the heat energy purchased at PJSC "Kharkivska CHP-5".

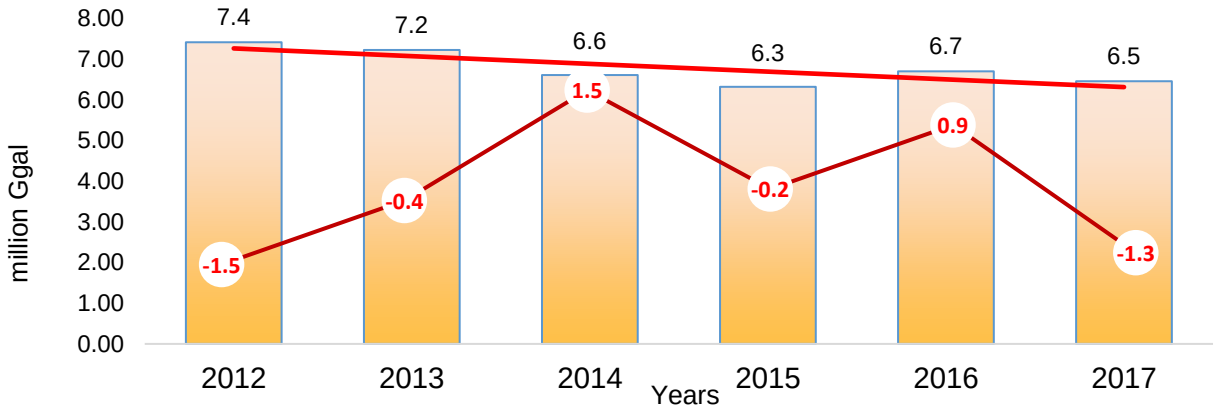


Figure 2.1.1.1 Heat production and average air temperature during the heating period (°C) in Kharkiv in 2012 – 2017.*

*** Note:** To a large extent, a gradual decrease in heat production during 2012-2017 is due to the increase in average air temperature during heating periods. Detailed information on the duration of the heating seasons in 2012-2017 and the average air temperature for the heating period is given in Appendix 4.

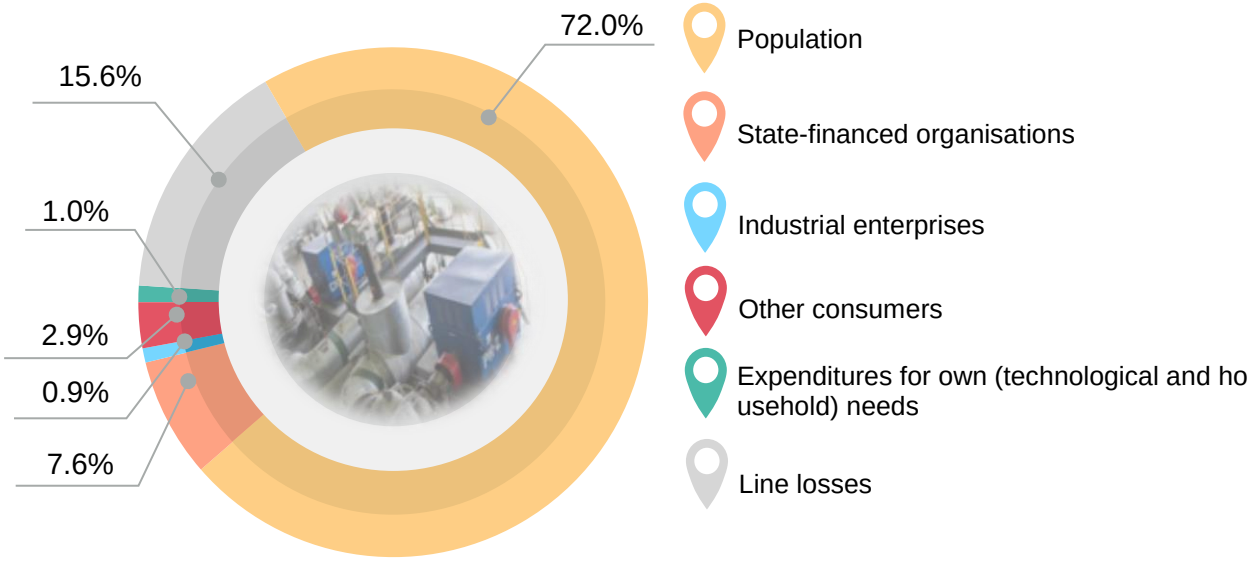
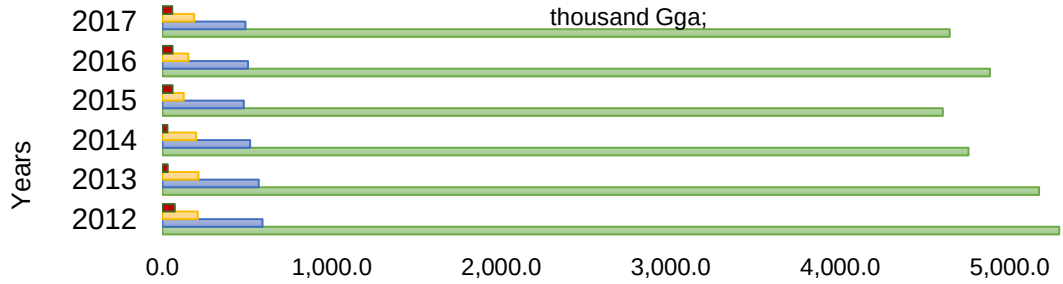


*Figure 2.1.1.2 The annual structure balance of heat production in Kharkiv in 2017**

*** Note:** Detailed information on the production, losses and productive supply of heat energy and hot water in Kharkiv in 2012 – 2017 is given in *Appendix 4.*



	2012	2013	2014	2015	2016	2017
Industry	73.6	32.0	29.1	59.6	60.2	58.4
Other consumers	208.6	213.3	198.8	125.9	153.7	187.4
Budget sphere	590.8	568.8	518.1	480.4	505.2	490.2
Populatoion	5,292.8	5,173.9	4,757.3	4,605.9	4,884.3	4,646.6

Figure 2.1.1.3 Distribution of heat consumption by consumer categories in Kharkiv 2012-2017

* **Note:** Detailed information on the distribution of heat consumption in Kharkiv by categories of consumers is given in *Appendix 4.*

The municipal enterprise “Kharkiv heating networks” consumes a significant amount of energy resources, primarily gas and electricity, to ensure reliable heating for Kharkiv. Information on the volumes and dynamics of energy consumption is given in table 2.1.1.2.

Table 2.1.1.2

Dynamics of consumption of primary energy and water heat production in Kharkiv in 2012-2017

Indicator	Measure-ment unit	Years					
		2012	2013	2014	2015	2016	2017
Gas consumption	thous. m^3	744,438.6	699,796.6	622,789.0	595,619.2	639,147.9	628,836.1
Electricity consumption	thous. kWh	203,828.4	206,403.3	190,814.3	189,479.7	182,038.1	130,766.3
Coal (fuel oil) consumption	t	121.2	107.8	118.6	98.2	93.2	92.0
Potable water consumption networks	thous. m^3	6,819.4	6,853.0	6,779.9	7,106.9	7,823.5	4,183.5

Evaluation of the current state and perspective development directions of the heat supply system of Kharkiv:

Current situation

- - A significant wear-out percent of technological equipment of boiler stations (54%) and a significant part of their service life spent (over 20 years).
- - More than half of the heat energy for the city is generated in boilers with physical wear rate more than 70%.
- - Low reliability of heating mains and their outdated insulation. Line losses make up 16%.
- - Depreciation of the heating networks of the city is:
- - main heating system – 62%
- - distribution heating system -71%
- - 55.1 km of heat and steam networks (3.4% of their total length) is in a dilapidated and emergency condition.
- The need for renovating networks is at least 100 km annually; in fact, 28 km is replaced on the average.
- There is the need to update the existing heat supply scheme of the city
- The imperfection of the existing automation system for managing production processes and monitoring the energy resources consumption
- The problem of providing end users with heat metering devices.

Directions for the development *

- Reconstruction of boiler stations and modernization of boiler equipment (boilers, heat exchangers, installation of modern frequency control pumps, and regenerative heat exchangers), including using alternative (renewable) energy sources.
- Increase in the percentage of heat energy use obtained through the construction of cogeneration plants.
- The elimination of inefficient boilers with the redistribution of load on other boilers and CHPs.
- The gradual replacement of worn heating lines with pre-insulated pipelines.
- Development of the existing automated dispatching control system at all production facilities of the utility company “Kharkiv Heating Systems”.
- Installation of Individual Heat Points at end users with automated hot water units.
- Introduction of 100% heat consumption commercial accounting by end users.
- Improvement of the existing heat supply scheme of the city

***Note:** The directions have been formed on the basis of existing programs and strategies for the development of the enterprise «Kharkiv Heating Networks».

2.1.2 Gas supply

Gas supply of Kharkiv is provided by Regional Gaz Company "Kharkivmiskhaz".

The main gas consumers in Kharkiv are the municipal enterprise "Kharkiv Heating Networks", other heat supply enterprises (autonomous boiler houses, roof boiler stations, except those that provide the public sector institutions with heat energy), state-financed organisations, the population (gas stoves, preparation of hot water, and heating), industrial enterprises and other consumers (shops, offices, etc.). The total number of subscribers on 01/01/2018 accounted for **510,600**.

The information about distribution of gas consumption due to cathegories of consumers in Kharkiv during the 2012–2017 is shown in Figure 2.1.2.1.

The structure of gas consumption by major consumer groups in Kharkiv in 2017 is shown in Figure 2.1.2.2

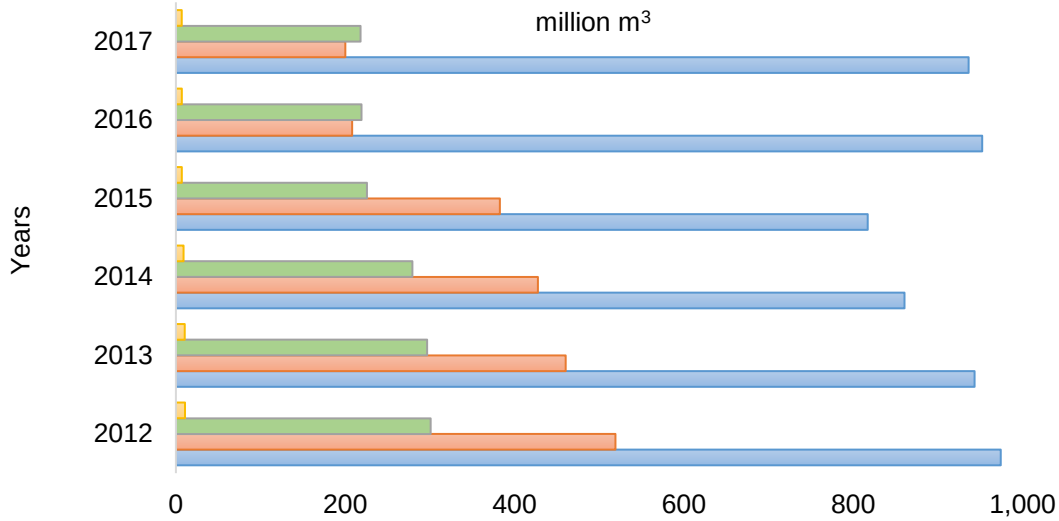
The gas supply system of the city is multistage with gas supply to consumers through high, medium and low pressure distribution gas pipelines.

As of 01.01.2018, technical losses in networks and costs for technological needs amounted to **20,237,200 m^3** gas per year.

PJSC "Kharkivgaz" operates:

- *225 km of high pressure gas pipelines*
- *791 km of medium pressure gas pipelines*
- *4,285 km of low pressure gas pipelines*
- *315 units of gas control points*
- *2,015 units of cabinets gas control points*

Detailed information on the technical and operational characteristics of the gas supply system being operated in Kharkiv is given in *Appendix 5*.



	2012	2013	2014	2015	2016	2017
Budget sector	10.7	10.4	9.0	7.0	7.0	6.9
Population	301.0	296.8	279.4	225.6	219.0	218.1
Industrial enteprisesand other consumers	519.1	460.3	427.6	382.6	208.2	200.1
Heat supple enterprises	974.2	943.3	860.5	817.1	952.3	936.3

*Figure 2.1.2.1 Natural gas consumption by major consumer groups in Kharkiv during 2012-2017 *.*

*** Note:** Detailed information on the natural gas consumption by major consumer groups Kharkiv during 2012-2017 is given in Appendix 5.

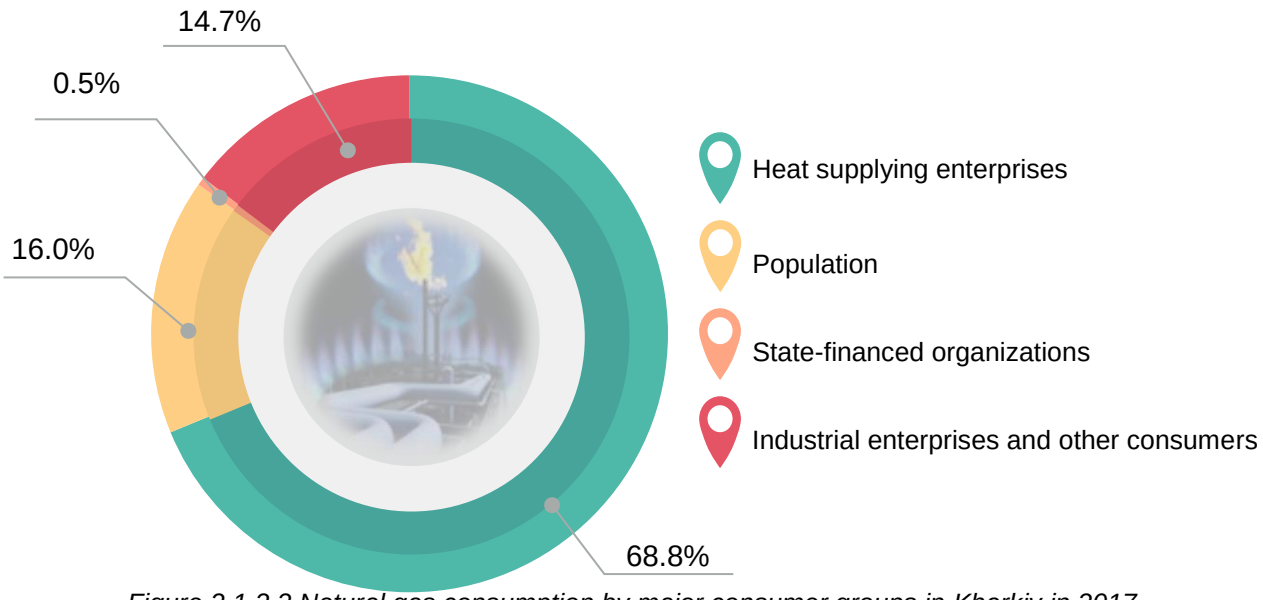


Figure 2.1.2.2 Natural gas consumption by major consumer groups in Kharkiv in 2017.

2.1.3 Power Supply

Power supply in Kharkiv is provided by Joint-Stock Company Kharkivoblenergo. JSC Kharkivoblenergo is one of the largest energy distribution companies in Ukraine; it ensures the electric power transmission and supply to end users.

As of 01/01/2018 the company had **606,600 service receivers,** of which individuals were **588,200**, and legal entities were **18,200**.

Among the largest consumers are: the municipal enterprise "Kharkivvodokanal", the municipal enterprise "Kharkiv Heat Networks", the municipal enterprise "Kharkiv Metro", the municipal enterprise "Mis'kelektrotransservis", SE "Plant "Elektrotyazhmash", SE "Plant named after V.A. Malyshev", OJSC" Turboatom", etc.

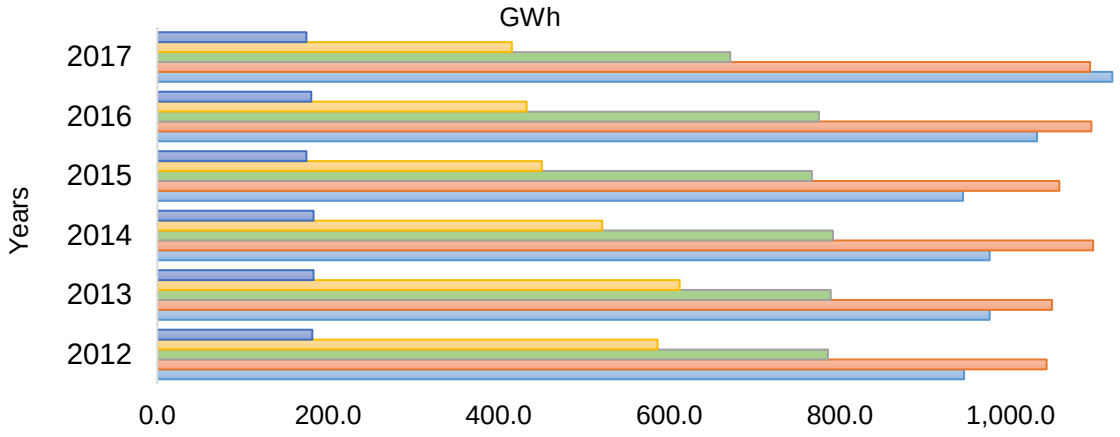
The information about distribution of power consumption due to cathegories of consumers in Kharkiv during the 2012-2017 is shown in Figure 2.1.3.1.

The structure of power consumption by major consumer groups in Kharkiv in 2017 is shown in Figure 2.1.3.2

JSC "Kharkivoblenerho" operates:

- *Transformer substations*
  - *110 kV - 30 units.*
  - *35 kV - 1 unit.*
  - *6-10 kV - 2243 units.*
- *Electrical distribution points:*
  - *6-10 kV - 228 units*
- *Length of power lines*
  - *10 kV - 934.4 km*
  - *6 kV - 3,223.9 km*

Detailed technical and operational information of power supply systems in Kharkiv is given in Appendix 6.



	2012	2013	2014	2015	2016	2017
Budget sphere	181.6	183.1	183.1	174.7	180.4	174.7
Industrial enterprises	586.3	612.2	521.4	450.7	432.8	415.5
Municipal enterprises	785.8	789.3	792.0	767.2	775.6	671.4
Population	1,042.3	1,048.7	1,096.8	1,057.2	1,094.8	1,093.3
Other consumers	945.5	975.6	975.6	944.3	1,031.2	1,119.3

*Figure 2.1.3.1 Consumption of electrical energy by the main groups of consumers in Kharkiv in 2012-2017 *.*
*** Note:** Detailed information on the consumption of electrical energy by major consumer groups in Kharkiv during 2012-2017 is given in *Appendix 6.*

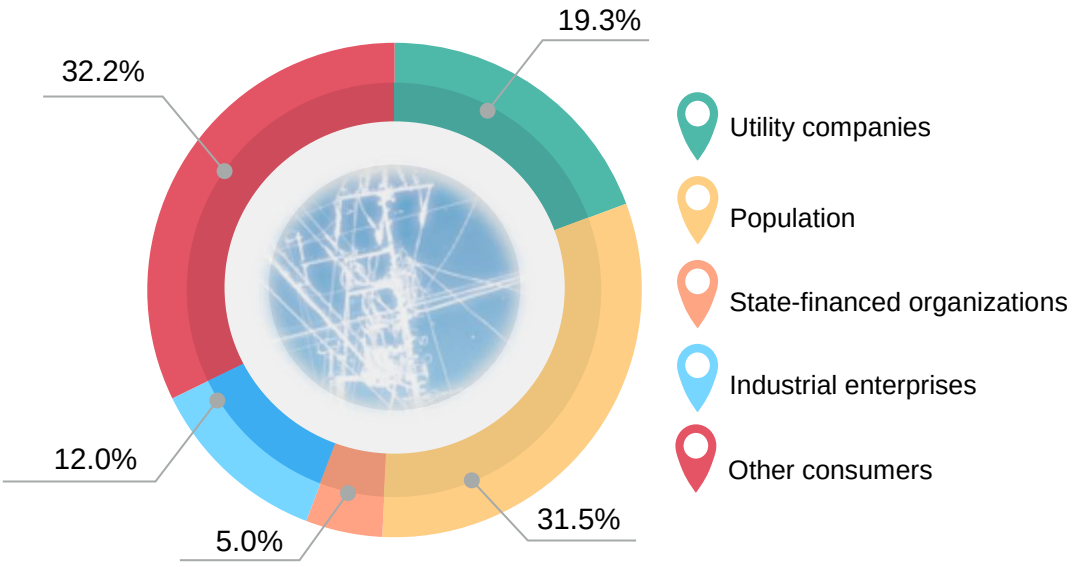


Figure 2.1.3.2 The structure of the electric energy consumption by the main groups of consumers in Kharkiv in 2017.

2.1.4 Water supply and sanitation

Centralized potable water supply and sewerage in Kharkiv is provided by the municipal enterprise “Kharkivvodokanal”.

The municipal enterprise “Kharkivvodokanal” is an enterprise responsible for the smooth operation of one of the largest in Ukraine complexes of water supply and sewerage networks and facilities, which provides potable water and a drainage system for residents of Kharkiv and Kharkiv region.

In addition, the company performs inter-basin and intra-basin transfer and regulation of water resources of the Seversky Donets river basin for the Kharkiv, Luhansk and Donetsk regions (700 mln m3 in year).

Water supply of Kharkiv is carried out from three independent water supply sources located at a considerable distance both among themselves and from Kharkiv:

The first water supply source located at 40 km from Kharkiv is the Sivers’ky Donets River with a Pechenizhske water reservoir having a capacity of **383 mln m^3** of water, from which water is fed with first stage pumping stations for its treatment at the Kochetok waterworks Further, potable water is supplied to Kharkiv through 5 main water lines with a diameter of **900-1600 mm**. The waterways were built from 1936 to 1982. Their total length is **162.1 km.**

Facilities and water lines of the Kochetok water treatment works are operated by the Water Treatment Complex “Donets”, which is a separate subdivision of the municipal enterprise “Kharkivvodokanal” (the municipal enterprise “Donets”). Kochetok water treatment works has a significant percentage of wear: at an average, it constitutes 70.2%.

The second independent source of water supply located 140 km from Kharkiv is Krasnopavlivsk water reservoir with a capacity of **410 mln m^3**, where water enters from the Dneprodzerzhinsk reservoir through the channel “Dnipro-Donbas”.

The mode of operation of the Krasnopavlivsk reservoir provides for double water exchange within a year.

Water is fed from the Krasnopavlivsk reservoir using the first stage pumping station through **1400 mm** diameter water pipes with a total length of **39.6 km** to water treatment plants located on the site of the second feeding stage. Then, purified potable water is supplied to Kharkiv through two lines of main pipelines with a diameter of **1200-1400 mm** and a total length of **221.2 km**, built in 1983-1990.

It should be noted that throughput of the water lines has significantly changed during their operation time due to the scale incrustation on the internal surface of the pipelines and a significant increase in their hydraulic resistance. The complex of buildings and water conduits has an average wear rate of 50%. The existing facilities and water treatment technology need to be upgraded.

Operation of the main water pipeline structures from the Dnipro-Donbas channel to Kharkiv is carried out by the Dnipro water treatment complex being a part of the separate subdivision of the municipal enterprise “Kharkivvodokanal” (WTC Dnipro).

Third independent water supply of Kharkiv is artesian wells with a depth of 30 m to 800 m. Artesian water supply line is an integral part of the water supply system of Kharkiv, which includes **7** water intakes of artesian water with second stage pumping stations and **32** water intake wells, of which **10** are in working condition.

Artesian water supply of Kharkiv requires recovery and further development.

The artesian wells and pumping equipment are operated by the production division of the Artesian water supply and pumping stations administration of the municipal enterprise Kharkivvodokanal.

Water supply and distribution system in Kharkiv is represented by II-IV stage pumping stations and V stage booster pumping stations.

All stations of II-IV stages and most of the pressure booster stations have been built and put into operation until 1990. Due to the long expired service life of the process and electrical equipment, it is outdated and worn out. The total design capacity of water pumping stations is **4,459,300** m^3 per day.

Sewerage system in Kharkiv is completely separate and decentralized. The storm sewer system is separated from the water disposal system. Wastewater is transported to sewerage treatment plants using pumping stations and main collectors.

Miunicipal wastewater treatment plants consist of two biological treatment complexes: city wastewater treatment facilities number 1 and city wastewater treatment facilities number 2 located in the southern part of the city.

The total design capacity of the treatment plants is **1,050,000 m^3 per day.**

Detailed information on the technical and operational characteristics of the water supply and wastewater system in Kharkiv is given in *Appendix 7*.

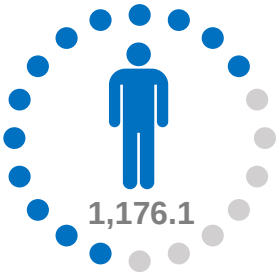
The utility company "Kharkivvodokanal" operates:

- *Water supply network with a length of 2 680.2 km*
- *Sewer network with a length of 1,659.4 km*
- *34 tanks with a total water volume of 460,500 m^3*
- *The water supply and distribution system in Kharkiv city includes 14 II-IV stage pumping stations and 130 V stage booster pumping stations. In general, the company operates more than 150 booster pumping stations*
- *Main sewerage pumping station with a total capacity of 1.5 mln m3/day and 29 sewer pumping stations*

Number of water supply subscribers, thous. units

Number of subscribers for sewerage services, thousands units

Population number(Water services), thous. people

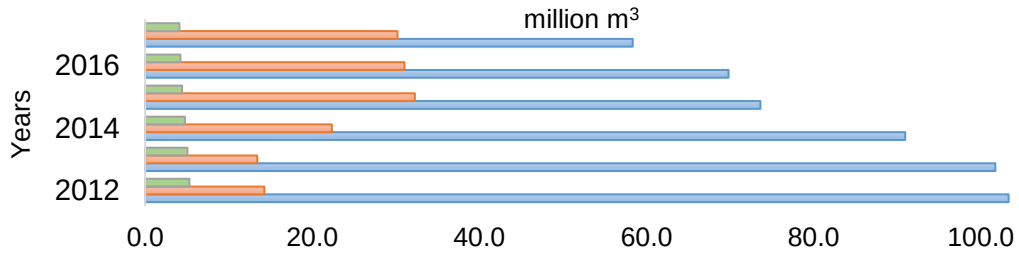


Population number(Water sewerage), thous. people

*** Note:** Information on the number of subscribers and population number in Kharkiv serviced by the municipal enterprise "Kharkivvodokanal" is given as of 01.01.2018.

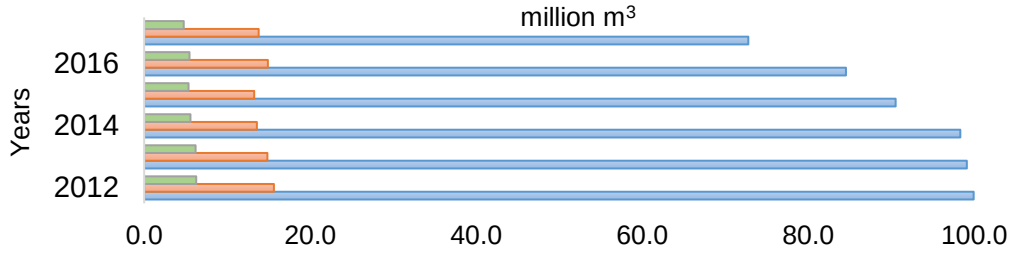
The information on volumes of water supply and removal due to categories of consumers in Kharkiv during 2012-2017 is shown in Figures 2.1.4.1. and 2.1.4.2.

The structure of water supply and removal volumes for the major consumer groups in Kharkiv in 2017 is shown in Figures 2.1.4.3 and 2.1.4.4.



	2012	2013	2014	2015	2016	2017
Budget shpere	5.3	5.0	4.7	4.4	4.2	4.1
Other consumers	14.3	13.4	22.4	32.3	31.0	30.2
Population	103.4	101.8	91.0	73.6	69.8	58.4

Figure 2.1.4.1 The trends in water supplying the consumers of all categories in Kharkiv in 2012-2017.



	2012	2013	2014	2015	2016	2017
Budget shpere	6.3	6.2	5.6	5.3	5.5	4.8
Other consumers	15.6	14.8	13.6	13.3	14.9	13.8
Population	99.9	99.1	98.3	90.5	84.5	72.8

Figure 2.1.4.2 The trends in water disposal volumes for consumers of all categories in Kharkiv in 2012-2017.

*** Note:** Detailed information on the water supply and sanitation volume in Kharkiv by categories of consumers is given in *Appendix 7.*

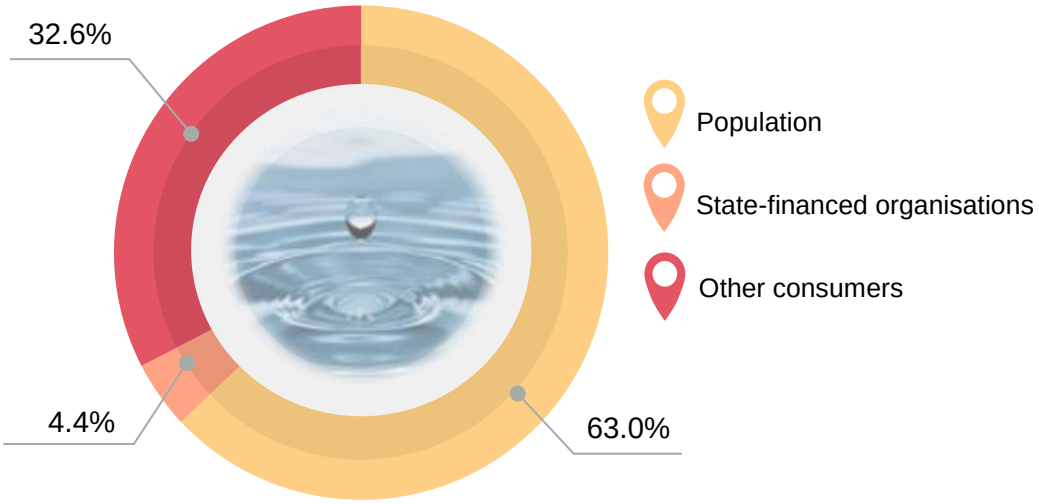


Figure 2.1.4.3 Structure of water supply to major consumer groups in Kharkiv in 2017.

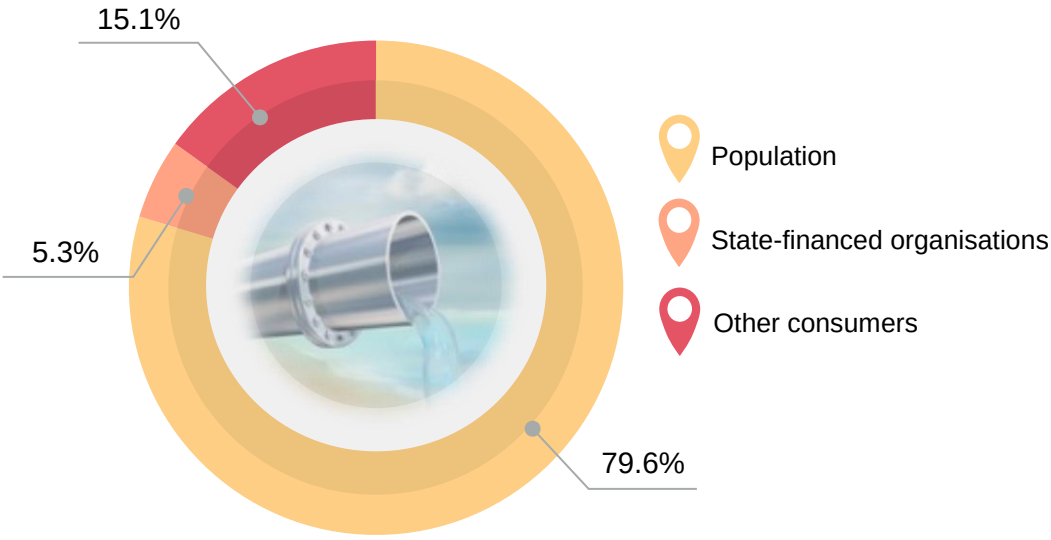


Figure 2.1.4.4 Structure of water disposal volumes with breakdown of main groups of consumers for Kharkiv in 2017.

The municipal enterprise Kharkivvodokanal consumes a significant amount of electrical energy to ensure reliable water supply and disposal for Kharkiv. Information on the volumes and trends of electric energy consumption is given in table 2.1.4.1.

Table 2.1.4.1

Total electricity consumption of the municipal enterprise “Kharkivvodokanal”in 2012-2017

No	Indicator	Electricity consumption by years, MW*h/year					
		2012	2013	2014	2015	2016	2017
1	Electricity spent on the potable water production	267,690	258,328	254,791	244,907	242,641	240,316
2	Electricity consumption for potable water supply	273,048	263,425	255,320	246,554	245,010	243,363
3	Electricity spent on wastewater treatment	64,402	61,601	63,199	59,326	59,297	59,192
4	Electricity consumption for water disposal	66,191	62,872	63,424	59,717	59,684	59,590

Evaluation of the current state and perspective development directions of the water supply and sewerage system in Kharkiv:

Current situation

- Unsatisfactory ecological condition of surface waters in the Seversky Donets River and Krasnopavlivsk water reservoir.
- A significant percentage of deterioration of the water supply network (55%) and the sewer network (80%).
- The need to restore and further develop the artesian water supply system,
- Pumping stations are in working condition, but the pumping equipment exhausted its standard service life and needs to be upgraded
- High energy consumpton of existing technological processes and the use of obsolete equipment,
- The potential danger of objects where drinking water is disinfected by organochlorine compounds and the need to reduce formation of the latter in water.
- The imperfect sewerage and sludge treatment system,
- Investment projects are aimed at improving the water disposal situation are mainly focused on environmental problems, what significantly narrows the circle of potential investors,
- Inconsistency of existing tariffs for centralized water supply and water disposal services with the existing cost.

Directions of development *

- Modernization of the Kochetok waterworks and facilities of the utilities company Dnipro".
- Carrying out a complete modernization of II – IV stage pumping stations for the introduction of their frequency regulation and the modernization of the energy sector with the relaying of emergency sections of the water pumping station power cables.
- Restoration and development of existing underground water sources with an increase in the capacity of the artesian water supply system to 147,050 m^3/day.
- The increase in annual volumes of relaying and rehabilitation of water supply networks.
- Carrying out a complete modernization of the municipal wastewater treatment plants No. 1 and No. 2, bringing the quality of biological wastewater treatment in accordance with applicable regulations.
- Reconstruction and modernization of the chlorine facilities.
- Improvement of the automatic process control system of water supply and wastewater facilities, development of the existing enterprise information system. Introduction of 100% process and commercial energy and water metering.
- The extension of the centralized water supply system to the areas where it is absent, in accordance with the objectives of the general plan of town development.
- Updating the fleet of special machines and mechanisms

*** Note:** Directions of development are formed on the basis of existing programs and strategies for the development of the municipal enterprise "Kharkivvodakanal".

2.2 Main energy consumers of in the city

2.2.1 State-financed organisations

In Kharkiv, there are **548** state-financed organisations (occupying **784** buildings) funded from the city and district budgets. The total area of buildings is **2,059,500** m^2. The buildings financed from the city and district budgets include: pre-school, general education and nonschool educational establishments; hospitals, clinics; music and art schools, palaces of culture, libraries; children's youth sports schools, etc. Among the buildings, the largest share is occupied by educational institutions – **73.6%** (with a total area of **1,518,300** square meters) and health care establishments – **22.5%** (total area – **463,800** m^2).

The main part of buildings occupied by state-financed organisations consumes heat energy and hot water from the district heat supply system of the city. The water supply and disposal system is centralized.

Existing buildings have large heat losses through building envelopes because their thermal performance does not meet modern requirements and is 2-2.5 times worse than standard ones (Figure 2.2.1.7).

General characteristics of buildings in the public sector

- *Work and social policy:*
  - *15 buildings with a total area of 10,000 m²*
- *Culture:*
  - *133 buildings with a total area of 67,4000 m²*
- *Health care:*
  - *181 buildings with a total area of 463,800 m²*
- *Education:*
  - *455 buildings with a total area of 1,518.3 m²*

Utilities of the buildings also need modernization and reconstruction.

Detailed information on the characteristics of budgetary organization buildings, as well as information on the consumption of energy resources and cold water is given in *Appendix 8.*

Energy and cold water consumption trends for state-financed organizations of the public sector in Kharkiv is shown in Figure 2.2.1.1- 2.2.1.6.

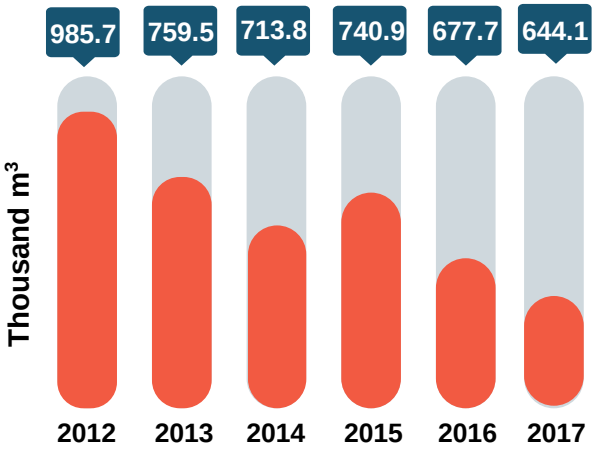


Fig. 2.2.1.1 Trends of natural gas consumption volumes in 2012 – 2017

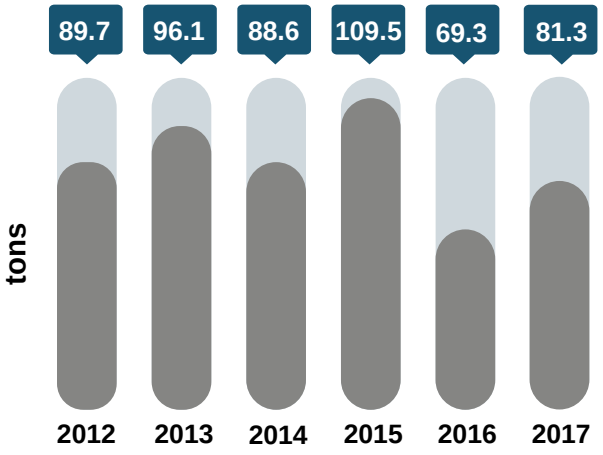


Fig. 2.2.1.2 Trends of coal consumption amounts in 2012 – 2017

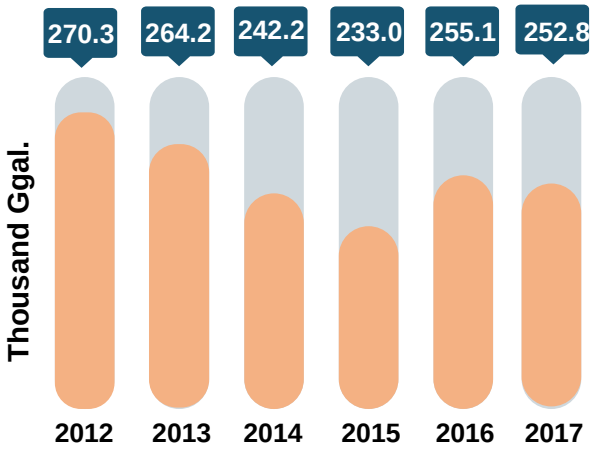


Fig. 2.2.1.3 Trends of heat consumption in 2012 – 2017.

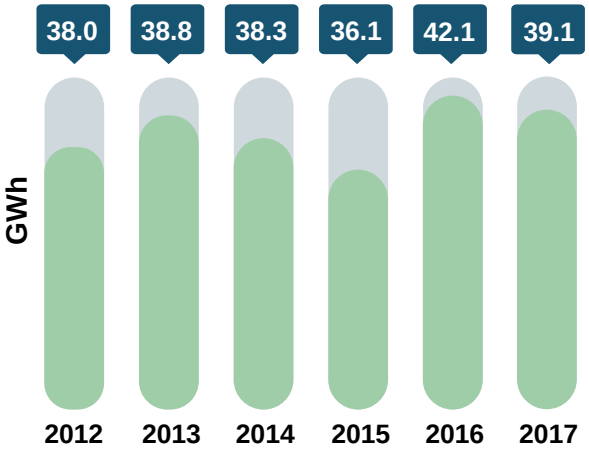


Fig. 2.2.1.4 Trends of electricity consumption in 2012 – 2017

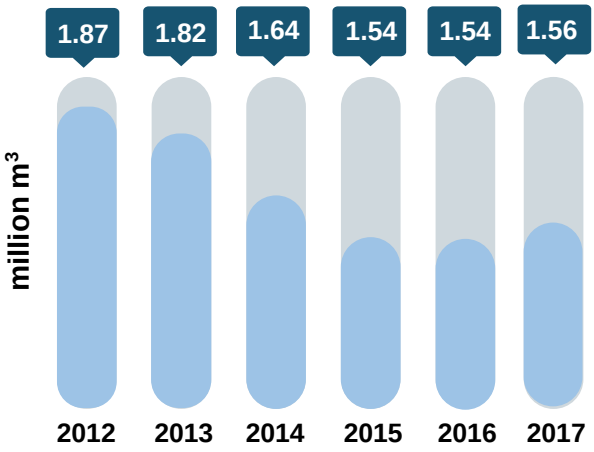


Fig. 2.2.1.5 Trends of water supply in 2012 – 2017

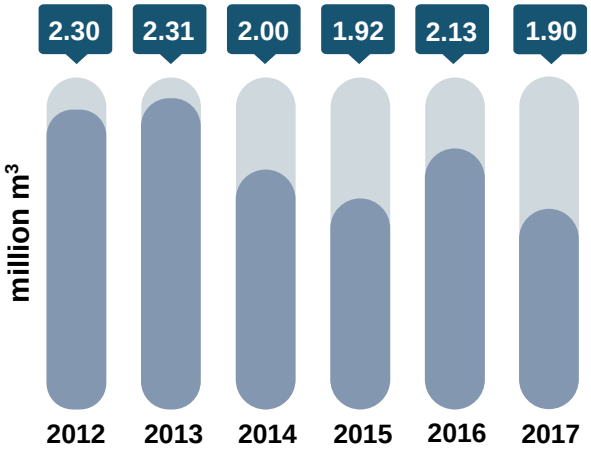
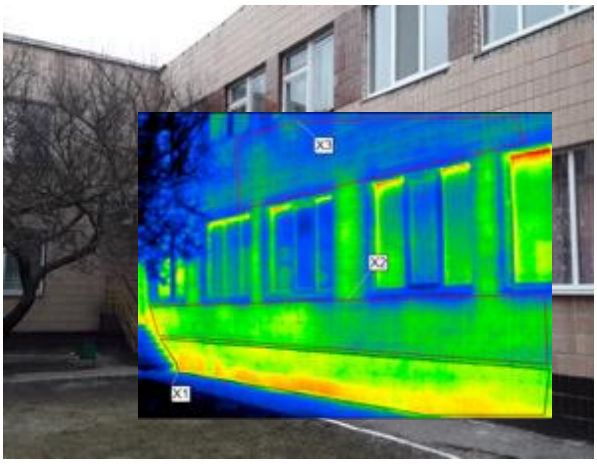
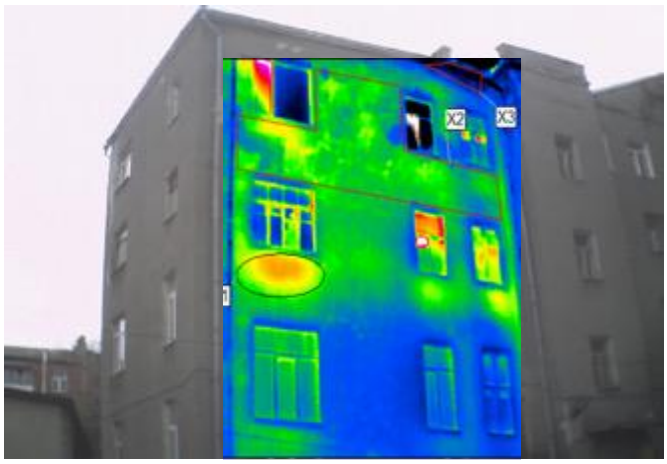


Fig. 2.2.1.6 Trends of water disposal volumes in 2012 – 2017

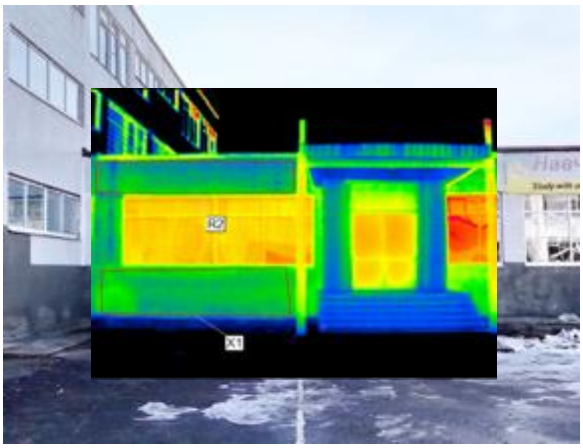
*** Note:** Detailed information on the consumption of energy resources and water supply/sewerage by state-financed organisationss in Kharkiv is given in *Appendix 8*.



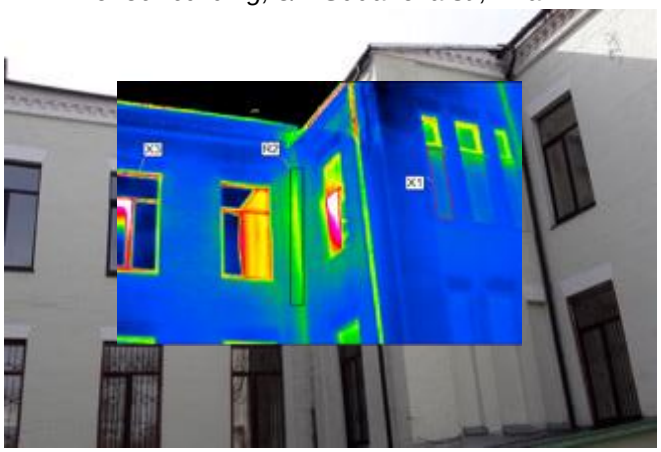
a. "DOU No.6" building, 4, Krivomazova st., Kharkiv



b. KUOZ "Kharkiv municipal otolaryngological hospital No. 30" building, 5/7 Gudanova st., Kharkiv



c. "Kharkiv General Education school No. 16" building, 5, Prodolna st., Kharkiv



d. KUOZ "Kharkiv Clinical Hospital No.14" building, 5, O.Honchara st., Kharkiv

Figure 2.2.1.7. Thermal imaging survey results for envelopes of buildings of state-financed organisations, Kharkiv

Evaluation of the current state of buildings occupied by state-financed organisations of the city and promising areas for their further renovation:

Current situation

- There is no effective control over the consumption of energy resources in the state-financed organisations of the city.
- Thermal performance of enclosing structures does not meet modern requirements DBN V.2.6.-31-2016. On average, the existing thermal performance is less than the standard in 2-2.5 times
- Wooden windows and a significant part of metal-plastic windows installed in buildings do not meet modern requirements for heat transfer resistance.
- There is no automatic systems regulation of heat energy consumption depending on the ambient temperature. In addition, there is a hydraulic and thermal imbalance of heating systems.
- The existing thermal insulation of the distribution pipelines of the heating and hot water supply systems is predominantly in an unsatisfactory condition, is partially damaged, and in some cases is completely absent.
- Existing mechanical suction-and-exhaust ventilation systems are predominantly inoperable.
- State-financed institutions and establishments of the city carry out current and capital repairs, but their volumes are not sufficient to prevent the gradual destruction of the protecting structures and engineering systems

Directions of development *

- The introduction to the state-financed organisations of the city of the energy management system and monitoring of energy and water consumption.
- Energy audits and certification of buildings
- The introduction of an effective building maintenance system including an increase in the volume of current and capital repairs in order to prevent the destruction of enclosing structures and engineering systems.
- Conducting gradual and integrated thermal modernization of buildings occupied by public sector institutions aimed at the reconstruction of enclosing structures and engineering systems.
- Introduction of energy efficient measures to public buildings with the use of alternative energy sources.
- Ensuring compliance of the public sector institutions with sanitary standards and basic microclimate parameters on air temperature, light level, air exchange rate, and hot water temperature.
- Introduction to state-financed organisations in the city of information and educational activities on the respect for the effective consumption of energy resources.
- The introduction into the educational process in schools of courses and elective classes on energy saving and energy efficiency.

*** Note:** The directions are based on the existing programs in the city and prospctive plans of modernization of budgetinstitutions of the city.

2.2.2 City's housing stock

As at 01/01/2018, the housing stock of Kharkiv accounted for **8,955** houses (excluding private residential houses), of which:

- **8,046** houses with a total area **2.85 mln m²**, maintained by the utility enterprise "Zhylkomservis".
- **549 –** condominium houses.
- **360** houses that are on the balance sheet and maintained by enterprises, institutions and organizations of Kharkiv.

The vast majority of housing in the city was built according to the mass series designs in 1960-80s.

In general, the physical deterioration rate of the housing stock today is much higher than the rate of its capital repair and modernization.

According to the results of surveys devoted to the technical condition of the municipal enterprise Zhylkomservis municipal enterprise, the wear coefficient for the technical condition of the housing stock is more than **63%.**

Almost entire housing stock is characterized by the problem of technical and moral aging of walling, as well as engineering systems and equipment of buildings: heating systems, hot and cold water supply, sewerage, water disposal, electricity supply, lighting, ventilation, and elevator facilities .Worning out of hydro and thermal insulation of roofs and building envelopes leads to their leakage and freezing.

Depreciation or lack of thermal insulation of pipelines for heating and hot water supply leads to a significant loss of heat energy in houses. No less acute is the problem of excessive air infiltration due to the poor condition of wooden windows and door blocks in hallways, in attics, and basements.

Information about the years of construction and number of floors of residential buildings in Kharkiv, maintained by the municipal enterprise “Zhilkomservice” is given in Table 2.2.2.1, as well as in Figure 2.2.2.1 and 2.2.2.2.

Table 2.2.2.1

Information about the years of construction and number of floors of residential buildings in Kharkiv, maintained by the municipal enterprise “Zhylkomservis”

Number of floors	Years					Total
	1900-1960	1961-1980	1981-1990	1991-2000	2001-2017	
1 floor	1,844	27	4	0	0	**1,875**
2-4 floors	2,592	180	10	8	0	**2,790**
5 and more floors	525	1,879	666	212	99	**3,381**
Total	**4,961**	**2,086**	**680**	**220**	**99**	**8,046**

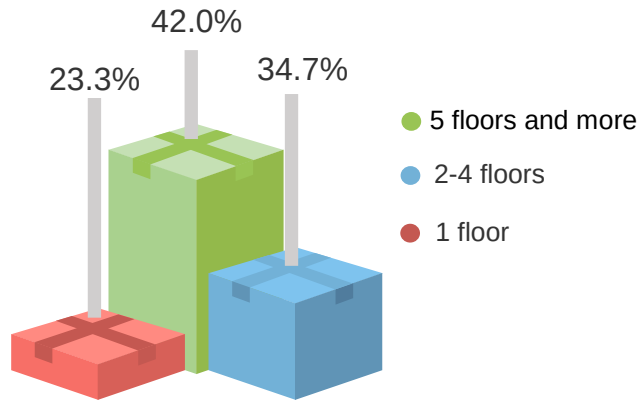


Figure 2.2.2.1 Distribution of residential buildings by number of floors

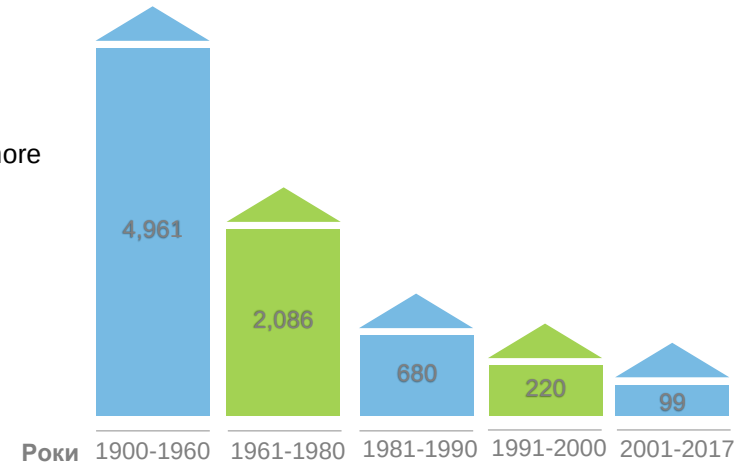


Figure 2.2.2.2 Distribution of residential buildings by years of construction

One of the directions of reforming relations in the housing sector, and stimulating the formation of the housing ownership institution is the creation of apartment buildings co-owner associations as non-profitable organizations for sharing, maintaining and managing houses and house territories.

As of 01/01/2018, in Kharkiv there are created and functioning 549 condominiums (Figure 2.2.2.3).

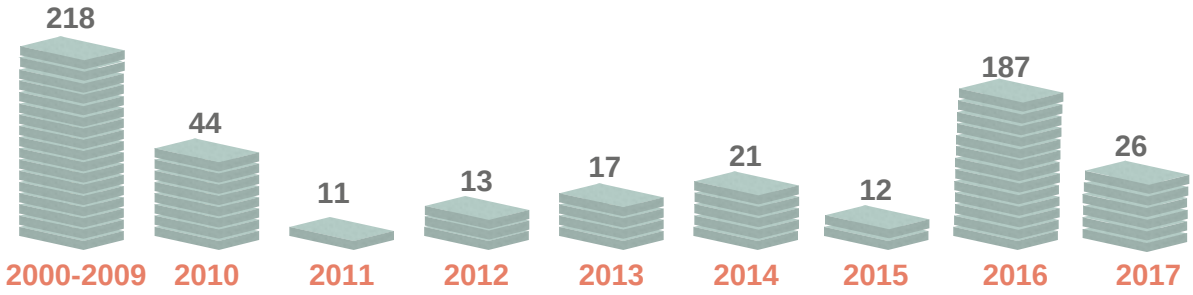


Figure 2.2.2.3 Trends of condominium creation in Kharkiv during 2000 – 2017

Consumption of fuel and power resources and water by the housing stock in Kharkiv is shown in Figures 2.2.2.4-2.2.2.7 and in *Appendix 9.*

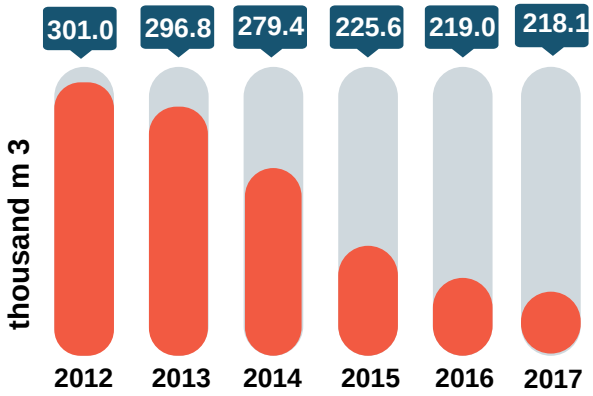


Fig. 2.2.2 .4 Trends of natural gas consumption in 2012-2017

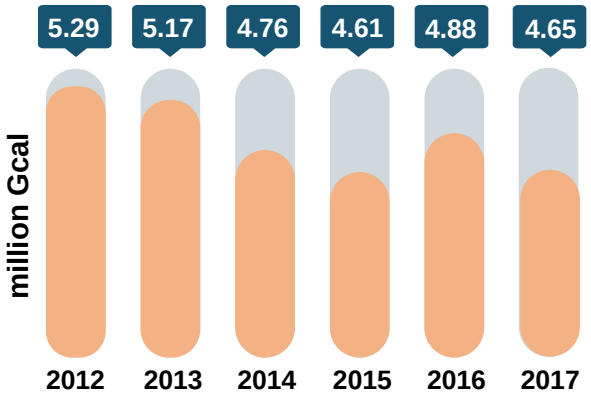


Fig. 2.2.2.5 Trends of heat consumption in 2012 – 2017

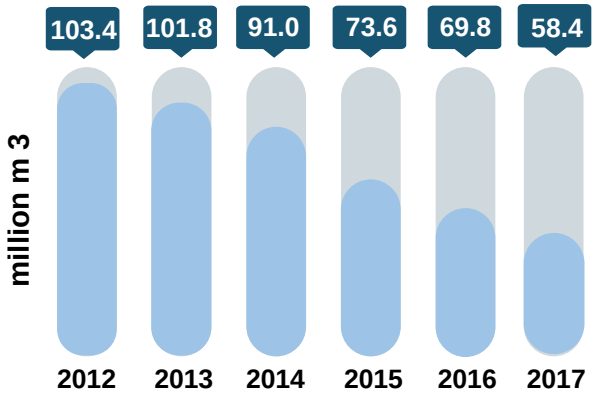


Fig. 2.2.1.4 Trends of water supply volumes in 2012 – 2017

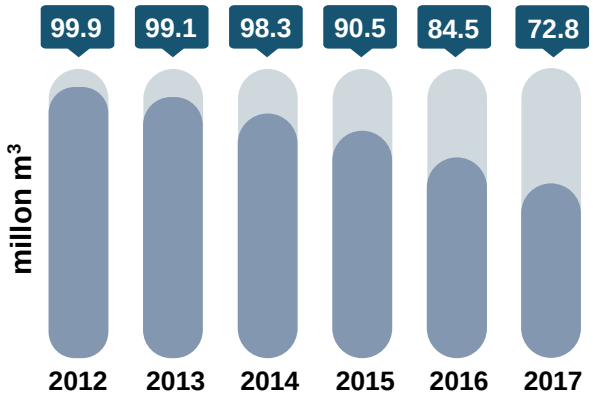


Fig. 2.2.1.7 Trends of sanitation volumes in 2012 – 2017

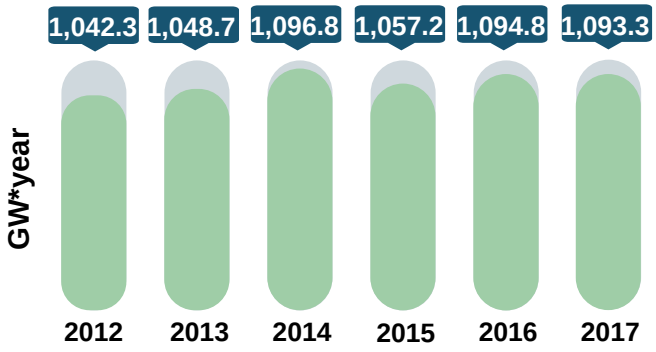


Fig. 2.2.1.6 Trends of electricity power consumption in 2012 – 2017

Evaluation of the current state of the Kharkiv housing stock and promising directions for its further modernization:

Current situation

- Physical deterioration of the housing fund of the city is more than 63%.
- Heat-shielding characteristics of enclosing structures of residential buildings do not meet state building standards.
- Significant technical and moral obsolescence of engineering systems: heating, electricity, water supply/disposal, elevator facilities.
- Lack of means for regulating the consumption of energy resources, primarily heat energy.
- Energy unefficient incandescent bulbs are mostly used for lighting of public spaces.
- Most of the housing fund is not equipped with apartment-level and apartment block level metering devices for energy and water resources.
- The provision of state subsidies provides residents with financial support, but does not contribute to improving the technical condition of buildings.
- The problem of the lack of the necessary financial resources for current and capital repairs leads to the gradual destruction of the housing fund of the city.
- The municipal budget allocates funds for capital repairs of the housing fund of the city; however, co-owners of apartment buildings are reluctant to take part in the renovation of their own buildings under co-financing terms

Directions of development *

- Energy audits and certification of residential buildings.
- Gradual implementation of integrated housing stock thermomodernization
- The increase in current and capital repairs to ensure efficient maintenance of the housing stock and improvement of its technical condition.
- Installation of individual heat points with weather-dependent regulation and local hot water preparation units, including within the framework of projects implemented by the utility company “Kharkiv Heating Networks”.
- Holding awareness-raising campaigns for the population of the city on the economical use of energy resources.
- Introduction of systematic work with co-owners of apartment buildings for their promotion to co-financing of energy efficient measuress in their own houses.A gradual decrease in the share of capital financing repairs of apartment houses from the city budget.
- Attracting funds from the Energy Efficiency Fund to modernize buildings.
- Introduction of 100% commercial metering of energy resources and water by installing apartment-level and apartment block level metering devices, including the installation of distribution centers for heat metering (with horizontal wiring of the heating system in houses).

*** Note:** The directions are based on the existing programs in the city and future development plans and modernization of the city's housing stock.

2.2.3 Public transport

The main volume of passenger traffic in Kharkiv is carried by electric transport: Metro, trolleybuses and trams. Also, the city passenger flow is serviced by a large number of bus routes, where both buses and route taxis operate.

The municipal electric transport is one of the most important sectors of the city, which provides the needs of the population in transportation. The basis of the passenger transport system of Kharkiv is Kharkiv Metro which has a large capacity, high speed and the ability to carry out regular communications along the main passenger-forming directions of the city The share of the Metro in the transportation of passengers by public transport of Kharkiv is **41.2%.**

There are two trolleybus depots to ensure the transportation of passengers by trolleybuses in the city; those depots are municipal enterprises: the municipal enterprise Trolleybus Depot No. 2 and the municipal enterprise Trolleybus Depot No. 3.

Tram transportation is carried out by two municipal tram depots: the municipal

enterprise “Zhovtneve tram depot” and the municipal enterprise “Saltovske tram depot”.

Total length of trolleybus and tram routes is **715.4** km. Power supply of the electric transport is carried out by **59** traction substations.

The maintenance of the urban ground electric transport track facilities, the contact network, and also the development of tram and trolleybus lines, the reliable power supply of ground electric transport and road safety, as well as the manufacture and sale of monthly tickets for traveling in urban electric transport is performed by the municipal enterprise “Mis’kelektrotransservis”.

Urban passenger traffic is also serviced by a large number of bus routes, where both buses and minibuses run.

2.2.3.1 Kharkiv trolleybus transport

The trolleybus network of the city is unique and covers almost all areas of the city.

Several types of rolling stock are in operation on the trolleybus routes of the city: trolleybuses of models ZiU-682, LAZ E301, LAZ E183, and also Škoda 14TgM.

To ensure the passenger traffic quality growth, its safety, regularity, comfort and accessibility in the city, the rolling stock of trolleybuses is gradually updated. Particularly, in order to create unimpeded urban living space for people with disabilities and other people with limited mobility, since 2011 the rolling stock has been completed with low-floor trolley buses.To date, 73 low floor trolleybuses have been operated on fixed routes.

According to the prospects for the development of the trolleybus network, it is planned to develop a trolleybus network in the following directions:

- Zhukovskogo Ave.
- North Saltovka (Akademika Pavlova st.- Lesya Serdyuka st. - Natalii Uzhvi st.y) Rohanska st.

General characteristics of the trolleybus network (as of 01/01/2018):

- *There are 23 trolleybus routes in Kharkiv city*
  - *The total length of trolleybus routes – 372.75 km*
  - *The longest route – No.3 (31.55 km)*
- *The shortest route is No. 7 (5.2 km)*
- *The total number of trolley buses on routes – 162 units*
  - *The average age of the rolling stock – 11.3 years*
  - *Number of passengers carried – 141.7 mln passangers (in 2017), including:*
  - *The municipal enterprise “Trolleybus depot No. 2” – 76.4 mln passengers.*
  - *The municipal enterprise “Trolleybus depot No. 3” – 65.3 mln passengers.*

Detailed information about the characteristics of passenger trolleybus transportations in Kharkiv is given in *Appendix 10.1.*

2.2.3.2 Kharkiv tram transport

Municipal enterprise “Zhovtneve tram depot.”

The repair workshop and the open parking of the tram depot make it possible to operate up to 200 trams. At the beginning of the 2018 there were **134** passenger cars of rolling stock in the depot; they were of following types 71-619 KT, T3-SU, T-3, T3-T3A.

The enterprise transports passengers along seven tram routes of the city: 1, 3, 6, 7, 12, 20, 27.

In 2017, **46.4 mln** passengers were transported, of them:

- full payment passengers – **17.3 mln** (37.3%)

- passengers of subsidy categories – **29.1 mln** (62.7%).

The municipal enterprise *“Saltivske tram depot”.* The depot occupies a significant area - more than 20 hectares (design capacity – 300 cars).

At the beginning of 2018, the enterprise operated 142 rolling stock cars of the following types: T3-SU, T3-T3M, T3-T3A,T6A5, T6B5, T3-ВПА, T3- VNPP.

The depot provides transportation along seven tram routes: 5, 8, 16, 16a, 23, 26, 27.

In 2017, the company transported **57.9** mln passengers, of them:

- full payment passengers – **21.6** mln (37.3%)
- passengers of subsidy categories – **36.3** mln (62.7%).

Detailed information about the characteristics of passenger transportation by trams in Kharkiv is given in *Appendix 10.1*.

General characteristics of the tram network (as of 01.01.2018):

- *There are 13 tram routes in Kharkiv city*
  - *The total length of tram routes - 342.7 km*
  - *The longest route is No. 26 (47.6 km*
- *The shortest route is No. 1 (5.2 km)*
- *The length of the lines – 217.6 km The total number of trams on routes – 199 units*
- *The average age of the rolling stock – 31 years*
- *Number of passengers carried – 104.3 mln (in 2017)*

Detailed information on the electric energy consumption by urban public electric transport (trolley buses and trams) and the consumption of other types of fuel by municipal electric transport enterprises of the city is given in Figure 2.2.3.1-2.2.3.2. in *Appendix 10.1.*

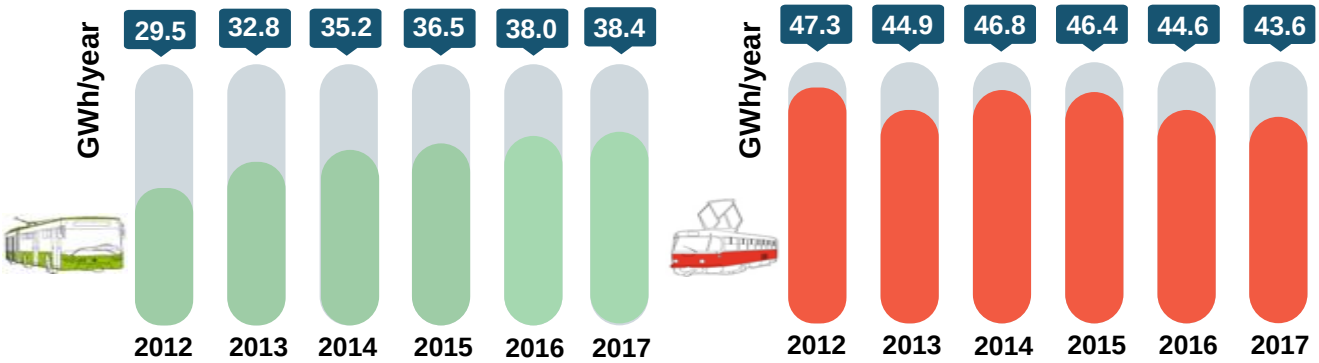


Figure 2.2.3.1 Electricity consumption by urban public electric transport (trolley buses and trams) in Kharkiv in 2012 – 2017

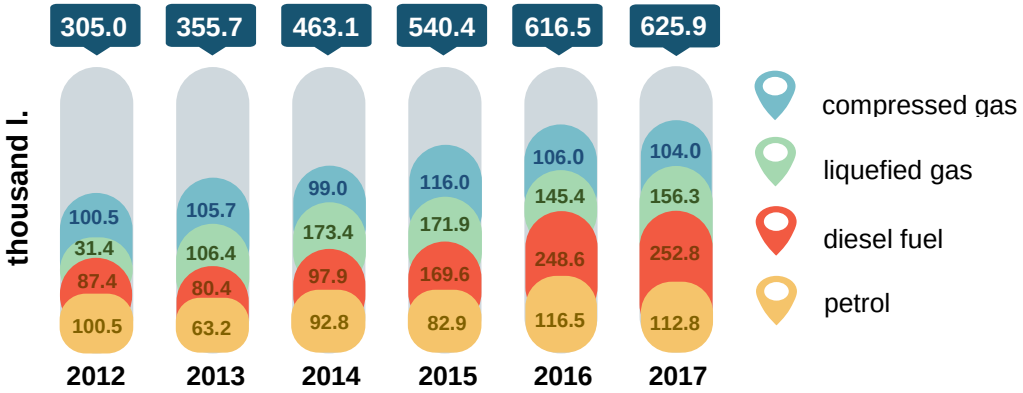


Figure 2.2.3.2 Consumption of other fuels by urban electric transport enterprises (trolley buses and trams) in Kharkiv in 2012 – 2017

Evaluation of the current state of the Kharkiv trolleybus and tram fleets and promising directions for their further development:

Current situation

- In recent years, there is a tendency in the city to increase passenger traffic.
- Introduction of a single electronic ticket “E-ticket” in the city transport system
- Significant physical deterioration of electric transport rolling stock (trams – more than 90%, trolleybuses – more than 40%).
- Lack of the necessary volume of capital repairs for rolling stock in accordance with the mileage.
- - Physical deterioration and the need for a gradual replacement and modernization of tram roads, cross-roads, turnouts, contact and cable networks, and traction substations.
- The material and technical base of electric transport enterprises of the city also needs modernization.
- The need for complex transport scheme adjustment for Kharkiv city to ensure sustainable functioning and dynamic development of urban electric transport.
- The problem of reimbursement for transportation of subsidy categories of passengers (reimbursement is not fully implemented).

Directions of development *

- Preservation and development of the electric transport infrastructure and its route network, as a key mode of transport for passenger traffic in the city,
- Correction of the integrated transport scheme maintained in Kharkiv city, taking into account the passenger traffic volume, available and promising routes of all types of passenger transport,
- Modernization, repair and provision of infrastructure maintenance of urban ground electric transport (tram roads, cross-sections, turnouts, tram and trolleybus lines, contact and cable networks, traction substations)
- Gradual renewal (by way of purchase) of rolling stock (trams and trolley buses).
- The introduction of electronic means of cashless payment of fares,.
- Construction of tram and trolleybus lines and other objects of urban electric transport according to the general plan of the city.
- Introduction of the use of renewable and alternative energy sources for energy systems of urban electric transport,
- Modernization of an automated traffic control system for urban electric transport, including passenger flow accounting, scheduling, and the like.
- Development and implementation of an automated system for monitoring and controlling the power consumption of urban electric transport (including remote control of traction substation equipment).

- ***Note:** The directions are based on the existing city programs and prospetive plans of public electric transport (trolleybuses and trams) development.

2.2.3.3 Kharkiv Metro

Services for the transportation of passengers by the Metro are provided by the municipal enterprise "Kharkivsky Metropoliten".

Passenger transportation is provided by two electric transport depots: the locomotive depots TCh-1 Moskovskoye and TCh-2 Saltivske.

Daily passenger traffic of Kharkiv Metro is more than **580,000** passengers (**213** mln passengers per year). The existing Metro system is designed to carry from **1.2** to **1.4** mln passengers per day.

Passenger travel in Kharkiv Metro is characterized by a high degree of cashless payment. About 80% of all Metro passengers use contactless smart cards.

Metro lines are equipped with automatic speed control of trains.

All stations are equipped with video surveillance systems for the movement of passengers from the vestibules to boarding train cars and vice versa.

Power supply devices, escalators, main ventilation, water supply system, heating of pedestrian exit steps are serviced through an automated dispatch control system integrated into a single dispatch center (SDC) of transportation technology management.

To ensure passenger transportation by the Metro, 326 passenger cars of rolling stock of the following types are operated: type 81-717, 81-714,81-718, 81-719, modernized cars Ezh3, Em508t, types 81-7036 and 81-7037.

A third of the rolling stock operated is re-equipped in accordance with the needs of people with disabilities.

General characteristics of the Metro (as of 01/01/2018):

- *Two depots provide passenger transportation in Kharkiv*
- *There are three Metro lines of the total length of 38.7 km*
- *30 stations are in operation and two are planned to be built.*
- *In operation are:*
  - *101.54 km of tunnels with 106.2 km of tracks*
  - *139 track switches*
  - *326 passenger cars*
  - *45 escalators*
  - *48 substations*
  - *More than 1,000 units of pumping and ventilation equipment*
  - *More than 120 km of water and sewer pipelines*

Table 2.2.3.1

General information about Kharkiv Metro line

Line name	End stations	Colour	Commissioned	Number of stations	Length
Kholodnohirsko-Zavodska	"Kholodna Hora" - "Industrialna"	red	23.08.1975	13	17.26
Saltivska	"Istorychnyi Muzei" - "Heroyiv Truda"	blue	11.08.1984	8	10.46
Oleksiivska	"Metrobudivnykiv" - "Peremoha"	green	06.05.1995	9	10.98
Total				**30**	**38.70**

Detailed information on consumption of fuel and energy resources by Kharkiv Metro is given in Figures 2.2.3.3-2.2.3.5 and in *Appendix 10.2.*

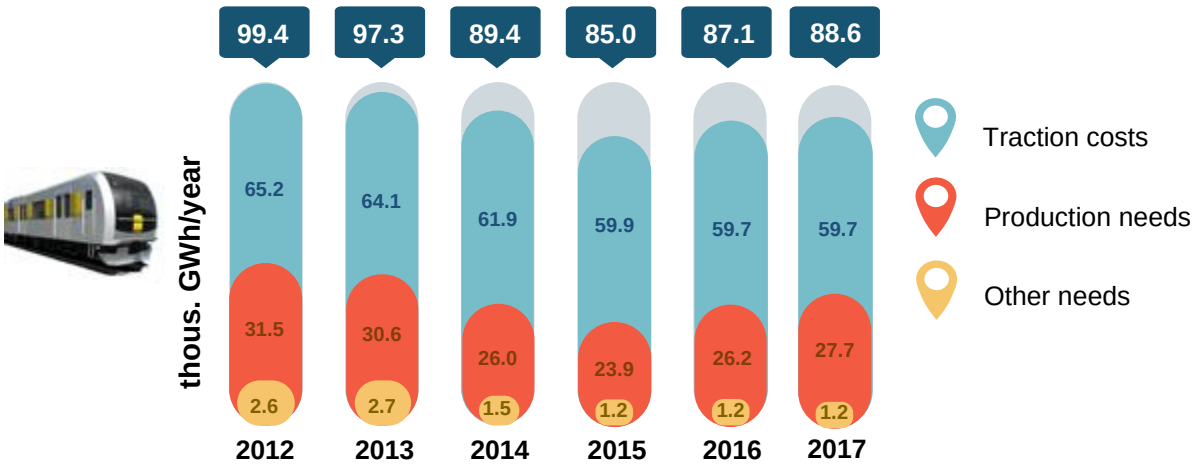


Figure 2.2.3.3 Electricity consumption by Kharkiv Metro in 2012 – 2017.

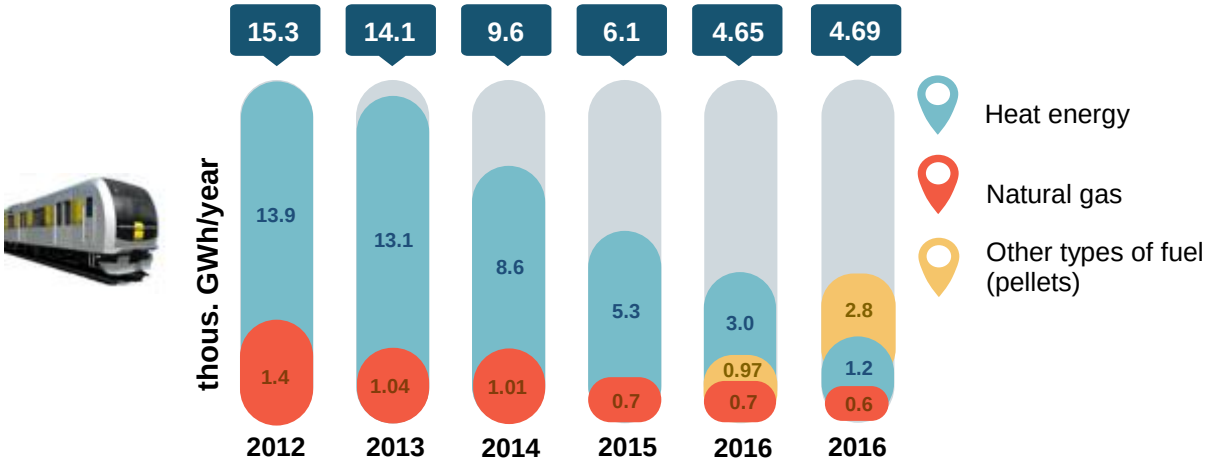


*Figure 2.2.3.4 Heat consumption by Kharkiv Metro in 2012 – 2017**

Note: Consumption of heat energy, natural gas, and pellets for heating are given in a single unit of measure – GW hour/year. The coefficients are used for the recalculation are given in the section 3.2.

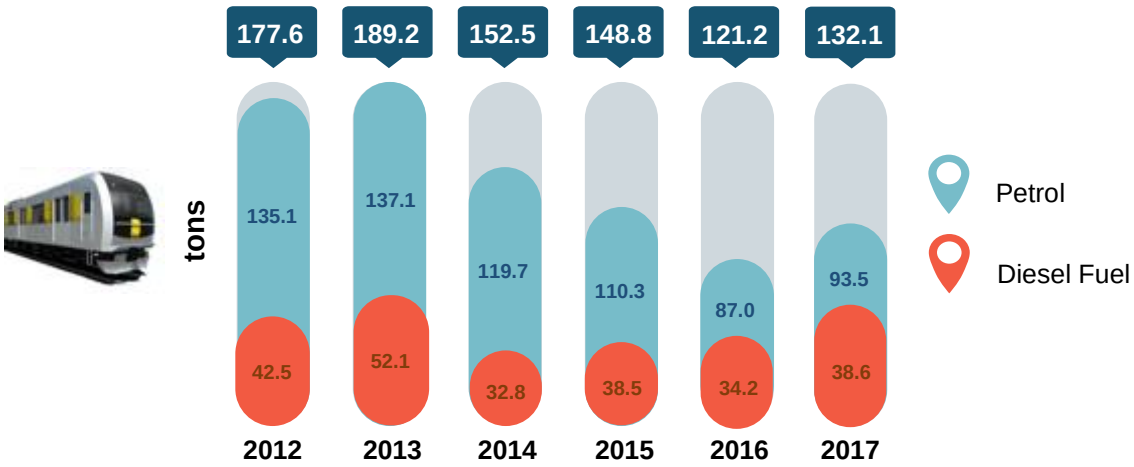


*Figure 2.2.3.5. Fuel consumption by Kharkiv Metro in 2012 – 2017**

Evaluation of the current state of Kharkiv Metro and promising directions for its further development:

Current situation

- Considerable physical deterioration of the rolling stock of electric transport (more than 90%), escalators (76%), technological transport (about 100%), and ventilation systems (86%).
- To reduce idle runs and improve the maintenance of rolling stock, it is necessary to construct the Oleksiivske locomotive depot on the third Metro line.
- The need to improve the existing automated dispatch control for transportation technology system.
- The need to adjust the integrated transport scheme in Kharkiv city to ensure maximum filling of the Metro with passengers, ensure its stable functioning and dynamic development.
- The urgent need to introduce energy-efficient technologies, given the significant infrastructure of the Metro and the amount of energy-intensive equipment.

Directions of development*

- Working out of feasibility studies and further designing of promising directions for the development of Kharkiv Metro.
- Continuation of the third Metro line (Alekseevskaya) through the construction of two new stations “Derzhavins’ka” and “Odes’ka”, as well as the “Alekseevske” locomotive depot.
- Renovation of the rolling stock and the implementation of the overhaul of existing cars with their modernization.
- Modernization, repair and maintenance of the Metro infrastructure facilities (escalator, pumping, ventilation equipment, traction substations, railways, contact rails, etc.).
- Adjustment of integrated transport scheme of Kharkiv city, taking into account the volume of passenger traffic, available and promising routes of all types of passenger transport.
- Further development of the automated dispatch control system and the Unified Dispatch Center.
- Implementation of energy efficient technologies, the use of renewable and alternative energy sources for the Metro energy systems.

*** Note:** The directions are based on the existing programs in the city and prospective plans for development of ME “Kharkiv Metropoliten”.

2.2.3.4 Public bus and route taxis

Passenger transportation by city bus and by route taxi about the city is mainly carried out by private carriers. They service **147** routes. The total length of bus routes is **1,458** km. The longest route is No. 304e: “Rogan” – Serhiivskyi Square (23km). The shortest route is No. 29: Permohy Avenue – Children’s Sanatorium (1.9km).

To ensure passenger transportation of by route taxis, the following main makes of buses are used: Bogdan, I-VAN, ATAMAN, Ruta, LAZ, MAN, Volvo, Setra.

Fuel consumption by city buses and route taxis is given in Figure 2.2.3.6 and in Appendix *10.3.*

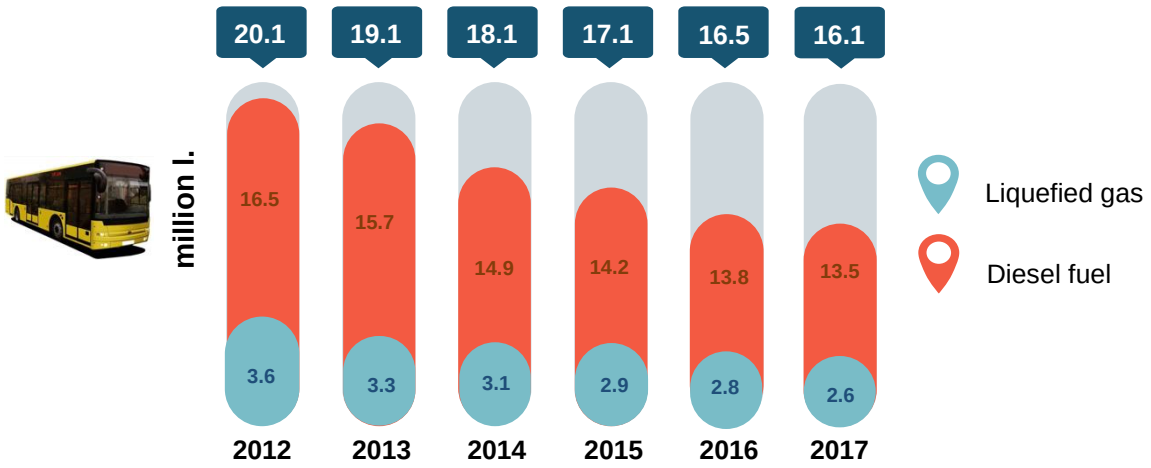


Figure 2.2.3.5 Fuel consumption by city buses and route taxis in Kharkiv in 2012 – 2017.

2.2.4 Public lighting

Public lighting network maintenance in Kharkiv is performed by the external electric lighting network municipal enterprise “Mis’ksvitlo”. The municipal enterprise “Mis’ksvitlo” operates the outdoor air cable lighting networks with a total length of **2498.0 km**.

To provide outdoor public lighting in Kharkiv used 79994 effective lighting points (Figure 2.2.4.1) with lamps of different types (Figure 2.2.4.2). As of 01/01/2018 the city provided a **98.97%** lighting level of the lighting points.

The outdoor lighting control and monitoring of its operation is carried out by an automated outdoor lighting control system through 849 control cabinets in which switching devices and electricity metering devices are located.

In order to ensure safe and uninterrupted work, as well as management of outdoor lighting networks for city streets, the municipal enterprise KP Mis’ksvitlo includes an emergency dispatch service, 8 operational and technical sections located in all administrative districts of the city (with the exception of Novobavarskyi District), and maintenance areas for decorative lights and installation of illumination. The duties of these departments include: the provision of outdoor lighting networks operation in the city, turning on and off the outdoor lighting at the streets of the city, daily checking that there are broken lighting points, and prompt response to emergency shutdowns in case of unforeseen situations on the streets of the city.

Detailed information about the characteristics of the city's public lighting system is given in *Appendix 11*. Trends of electric energy consumption for the needs of outdoor lighting is presented in Figure 2.2.4.3. and in *Appendix 11*.

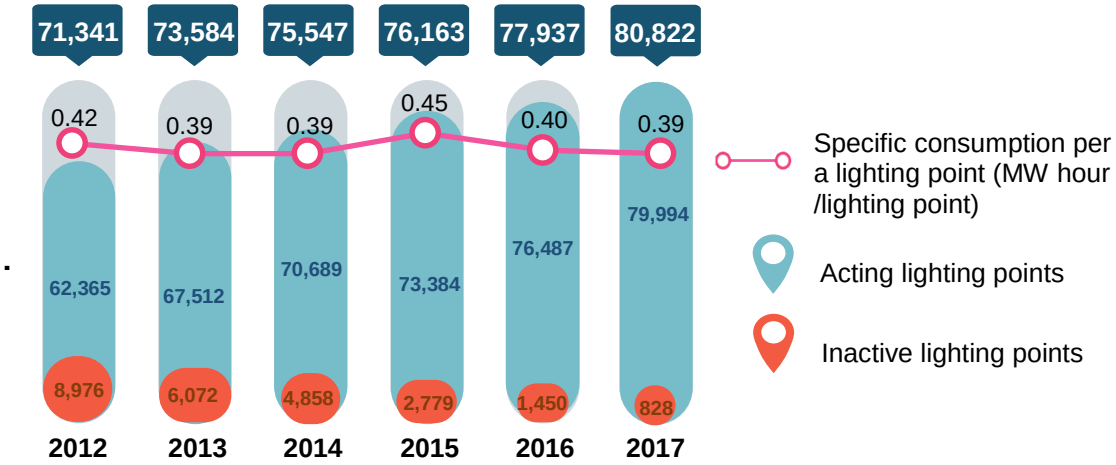


Figure 2.2.4.1 Development of outdoor lighting systems in Kharkiv in 2012- 2017 (trends of lighting point quantity and specific consumption per lighting point)

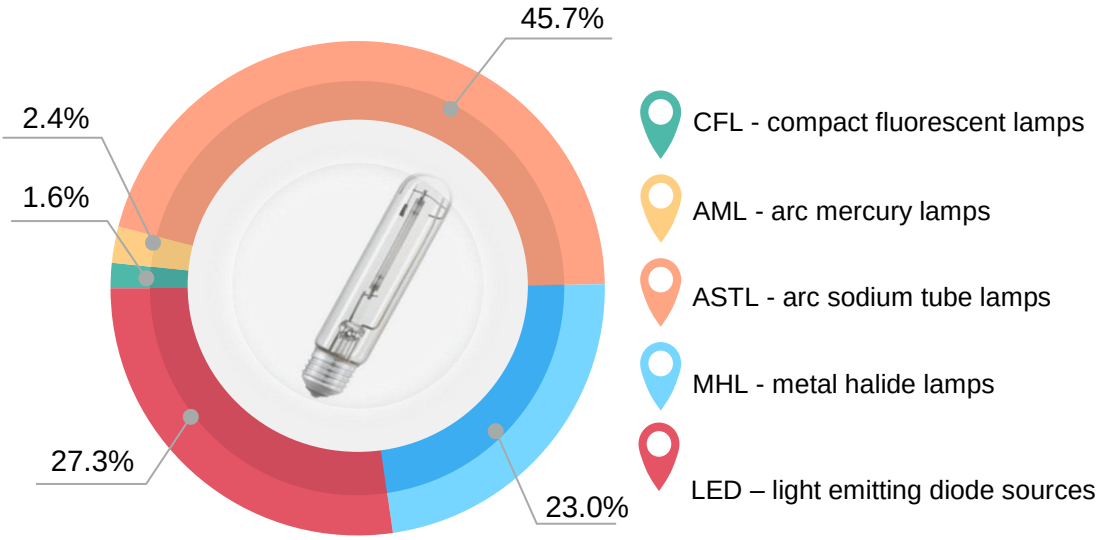


Figure 2.2.4.2 Proportion of light sources in the outdoor lighting system in Kharkiv,%

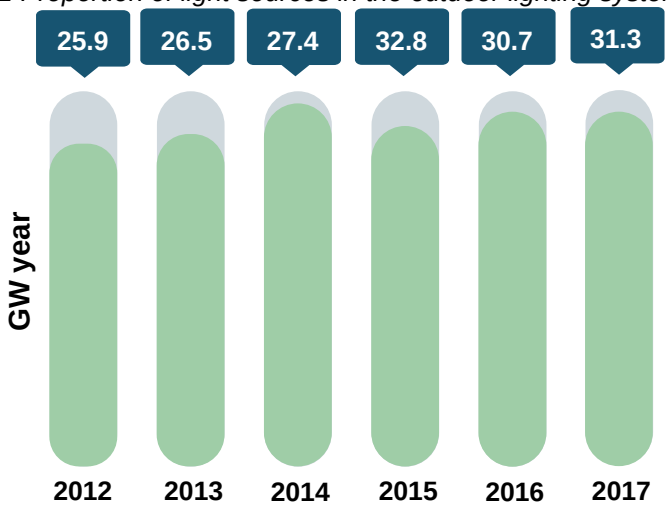


Figure 2.2.4.3 Trends of electric energy consumption for the public lighting needs in Kharkiv in 2012-2017.

Current situation

- The city is undergoing gradual modernization of the public lighting system. Lighting of 98.97% of light points is ensured.
- The external lighting networks, as well as special vehicles and the material and technical resources of ME “Misksvitlo” are significantly worn out.
- The level of illumination in residential buildings is insufficient; there is a need to build external lighting networks in residential buildings where they were not provided for.
- It is necessary to reconstruct public lighting networks using modern energy efficient technologies.
- The automated control system for external lighting in the city needs further development and improvement, iIncluding automatic data collection from meters on electricity consumption.

Directions of development *

- Gradual modernization of the outdoor lighting system of the city (transition to LED lighting, repair of overhead power lines using self-supporting insulated wires, and replacement of supports).
- Intellectualization of public lighting systems (introduction of electronic controls with dimers, ensuring automation control of the outdoor lighting system in the city, introduction of smart city elements).
- Ensuring the proper level of illumination in parks, squares and recreation areas for city residents.
- Ensuring an increase in the illumination of the city (in the middle of neighborhoods, pedestrian crossings, playgrounds, etc. including with the installation of supports for independent lighting on photovoltaic modules).
- Development of an electronic map of the outdoor city lighting system
- Reducing energy consumption and maintenance of public lighting systems.

*** Note:** The directions are based on the existing programs in the city and future development plans ME “Misksvitlo”.

2.2.5 Municipal solid waste

In recent years, in Kharkiv, there is a gradual increase in the formation and accumulation of production and consumption waste. It is one of the main factors of polluting environment and forming negative effects on all its components, as well as on public health.

Every year in Kharkiv, there is formed on average **3.0 mln m³** of municipal solid waste (in 2017 the amount of waste generated by Kharkiv was 2.89 mln m³), of which from the population – **2.63 mln m³,** from budget consumers – **0.08 mln m³,** other consumers – **0.18 mln m³.**

So, more **90%** of the total solid waste volume in the city is produced by the population; the share of other consumers does not exceed **10%.**

Today, the municipal solid waste management system which operates in Kharkiv includes the collection, transportation and disposal of solid waste from residential buildings, industrial enterprises, and non-production enterprises.

General characteristics of the municipal solid waste management system in Kharkiv:

- *Average annual solid waste volume:*
  - *3.0 mln m³ of municipal solid waste per year*
- *The number of containers for the collection of municipal solid waste is 8,051 units, incl.:*
  - *0.75 m³ capacty – 1,126 units*
  - *0.9 m³ capacty – 5,217 units*
  - *1.1 m³ capacty – 1,534 units*
  - *8 m³ capacty – 174 units*
- *The number of garbage trucks*
  - *144 units*

The main provider of services for the treatment and removal of household and bulky waste from enterprises and

individuals in the city is the unility company “Complex for the removal of household waste” which was established and belongs to Kharkiv City Council.

The disposal and burial of solid waste of hazard class IV (low hazard that can be used as an insulating layer) generated in Kharkiv are carried out in the Dergachy Solid Waste Landfill (Kharkiv region, Dergachevsky district), which is the communal property of Kharkiv City Council.

Dergachevsky municipal solid waste landfill has been in operation since 2005 and occupies now an area of 13.2 ha. The municipal enterprise “Municipal waste management company” of Kharkiv City Council is responsible for the operation of the landfill.

Information about the solid waste recycling volume in Kharkiv is given in *Appendix 12.*

The approximate morphological composition of municipal waste transported to the landfill is shown in Figure 2.2.5.1.

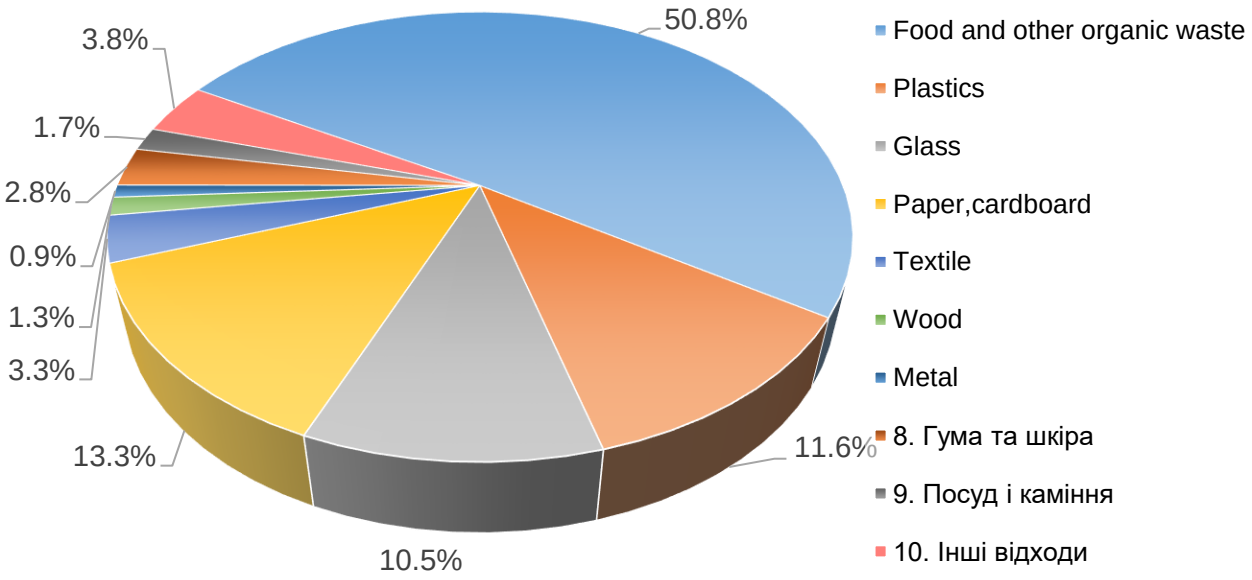
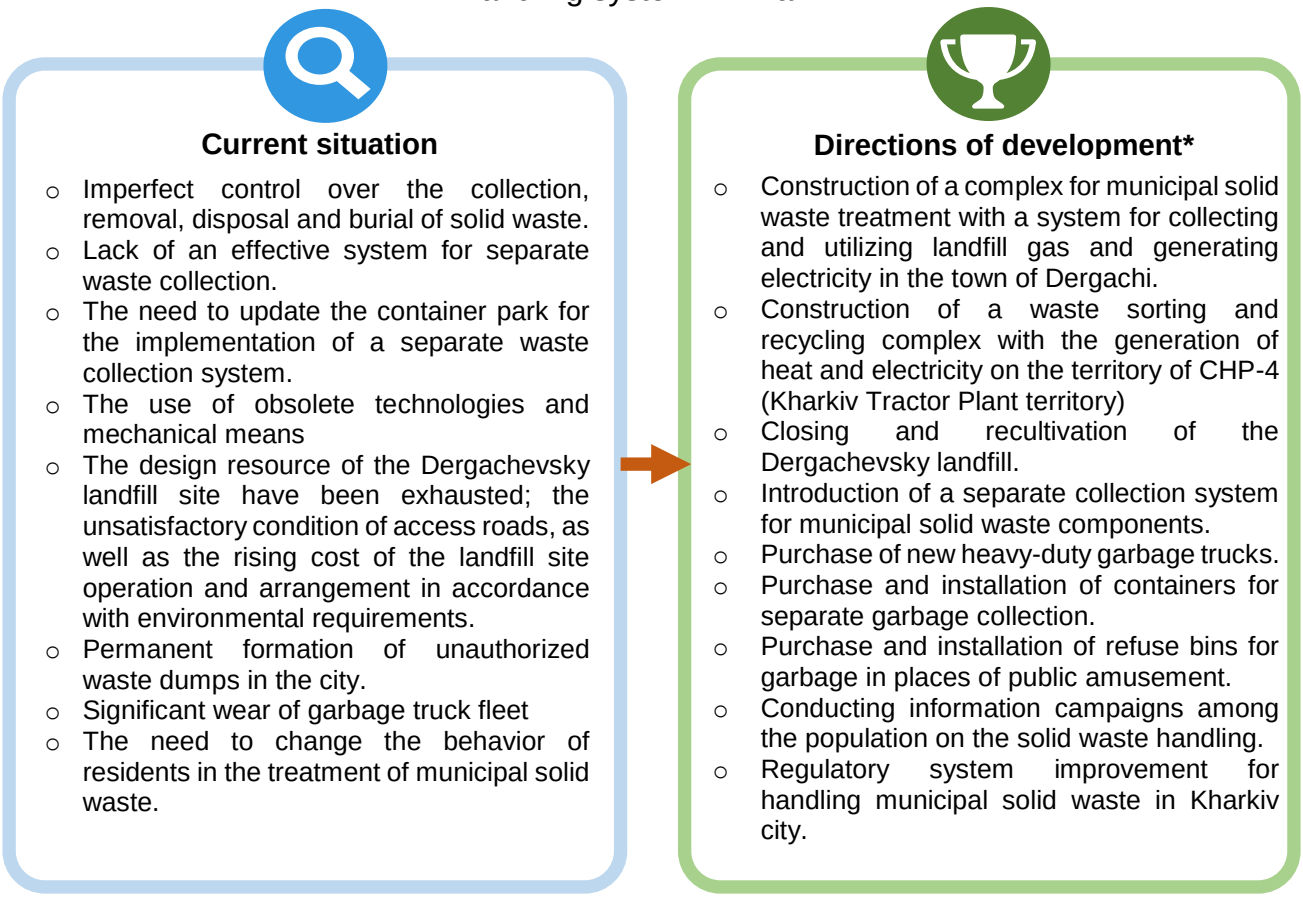


Figure 2.2.5.1. Average morphological composition of household waste in Kharkiv taken to the landfill (% of volume)

Evaluation of the current state and perspective directions of development of the solid waste handling system in Kharkiv:



* The directions are based on the existing programs in the city and prospective plans for development of ME “Complex for removal of municipal solid waste” and Derhachi Landfill”.

KHARKIV

BASELINE EMISSION INVENTORY

CHAPTER 3. Baseline Emission Inventory

3.1 Identification and rationale of key sectors

The baseline emission inventory determines the amount of CO_2, which is emitted due to energy consumption of the city in the baseline year. It allows us to identify the main anthropogenic sources of CO_2 emissions and, accordingly, to identify the main measures to reduce emissions. The baseline inventory is a tool that allows city authorities to measure the impact of proposed measures aimed at improving the situation with CO_2 emissions in the city.

In order to determine priority actions and measures aimed at reducing CO_2 emissions, it is necessary to take into account local conditions and future development prospects of Kharkiv. The methodology for calculating the baseline emission inventory (BEI) provides for the mandatory inclusion of at least three of the four key sectors in the BEI and the maximum possible inclusion of non-key sectors.

In order to prioritize the sectors for their inclusion in the BEI, it is proposed to assess their compliance with several basic criteria:

- *Social* – the social importance of the sector to the urban community.

- *Financial* – availability and amount of expenditures on the city budget funds sector.

- *Project availability* – availability or planning of implementation of projects on energy saving and energy efficiency in the sector.

- *Regulatory impact* – availability of regulatory influence of the city authorities on the sector.

- *Control over energy costs* – opportunity of controlling energy consumption in the sector by the city authorities.

The analysis of sectors is given in Table 3.1.1.

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Table 3.1.1

Sector Prioritization Evaluation for MF Kharkiv

Sector name	Key Sector with regard to methodology	Social criterion	Financial component	Availability of projects	Regulatory influence	Energy cost control
	(Yes, No)	**(1 is the lowest score, 6 is the highest score)**				
			Public buildings			
Public buildings that are funded from the city budget	Yes	6	6	3	6	6
Public buildings that are funded from the state and district budget	Yes	6	1	2	1	1
			Residential sector			
Residential buildings	***Yes***	6	5	4	4	3
			Municipial public lighting			
Public lighting	Yes	5	6	4	5	4

Sector name	Key Sector with regard to methodology	Social criterion	Financial component	Availability of projects	Regulatory influence	Energy cost control
	(Yes, No)	**(1 is the lowest score, 6 is the highest score)**				
Tertiary sector (service sector, private business)						
Tertiary sector	Yes	3	1	4	3	1
Local transport						
Municipal transport (transport owned by local authorities or municipal enterprises)	Yes	5	6	2	4	4
Passenger transport	Yes	6	4	4	5	3
Private transport	Yes	2	1	1	3	1
Energy Supply Companies						
Heat supply	No	6	4	6	5	4
Water supply	No	6	4	6	5	4
Power supply	No	6	1	n/a	2	1
Gas supply	No	6	1	n/a	2	1
Industrial enterprises	No	2	1	n/a	1	1

Based on the results of the analysis, it is recommended that the following sectors should be included in the SECAP:

- public buildings that are funded from the city budget;
- residential sector;
- passenger (public transportation in Kharkiv) and municipal transport;
- public lighting;
- tertiary sector;
- heat supplying enterprises (municipal enterprise “Kharkiv Heating Networks”);
- water supplying enterprise (municipal enterprise “Kharkivvodokanal”).

3.2 Energy consumption in key sectors

To calculate the baseline emission inventory, a consumption base for the main types of energy resources was created, which includes the main sources of CO_2 emissions from various types of activity in Kharkiv in 2012-2017. The energy consumption database includes:

- the sector of municipal buildings, equipment/facilities (public sector) includes emissions from the burning of natural gas, the use of electricity and heat energy from the centralized heat supply system in buildings (institutions and establishments) financed from the city budget;

- the sector of municipal buildings, equipment/facilities (municipal enterprises for heat and water supply) includes emissions from the heat energy consumption, from the municipal

enterprise “Kharkiv Heating Networks” (for own needs and from heat energy losses) and electricity from the municipal enterprise “Kharkivvodokanal” (electricity for water supply and disposal for all consumers of the city);

- in the residential sector, it includes emissions from the natural gas combustion in multi-storey and private houses, the use of electricity in apartment buildings and private houses and heat energy from the centralized heat supply system in apartment buildings;

- in public lighting it includes emissions from electricity consumption in public lighting;

- in the transport sector it includes emissions from fuel consumption by urban transport (passenger buses and route taxis), electricity and other types of energy resources by urban electric transport, as well as fuel by public transport;

- in the tertiary sector, it includes emissions from the use of heat energy, the burning of natural gas, the use of electricity in buildings and to ensure technological processes.

Energy consumption in 2012-2017 in the selected sectors in physical units of measurement are given in Table 3.2.1.

Table 3.2.1

Energy consumption in 2012-2017

Item No.	Sectors included in BEI	unit	Years					
			2012	2013	2014	2015	2016	2017
1. Municipal buildings, equipment/facilities								
1.1. Municipal Buildings								
1.1.1	Natural gas	thous. m^3	985.74	759.51	713.84	740.87	677.66	644.13
1.1.2	Electricity	MWh	38,005.25	38,842.21	38,341.10	36,050.52	42,056.10	39,085.36
1.1.3	Water supply	thous. m^3	1,872.00	1,819.20	1,640.10	1,536.60	1,544.20	1,560.80
1.1.4	Water disposal	thous. m^3	2,296.40	2,309.80	2,003.90	1,923.50	2,133.20	1,899.80
1.1.5	Heat energy	Gcal	270,309.95	264,196.99	242,249.07	233,028.89	255,115.67	252,772.00
1.1.6	Coal	ton	89.67	96.06	88.58	109.54	69.32	81.27
1.2. Municipal equipment/facilities								
Heat supply								
1.2.1	Heat energy	Gcal	1,248,976.00	1,237,399.00	1,105,259.00	1,047,552.00	1,106,760.00	1,074,220.00
Water supply								
1.2.2	Water supply	thous. m^3	104,555.20	103,382.50	95,277.20	93,636.50	96,538.40	106,921.60
1.2.2	Water disposal	thous. m^3	83,975.90	80,566.40	76,431.90	81,339.90	88,620.70	98,594.10
2. Residential buildings								
2.1	Natural gas	thous. m^3	301,038.35	296,838.77	279,361.15	225,609.67	219,025.88	218,053.01
2.2	Electricity	MWh	1,042,272.00	1,048,706.00	1,096,835.00	1,057,238.00	1,094,828.00	1,093,341.00
2.3.1	Water supply	thous. m^3	103,354.10	101,762.20	90,978.40	73,642.20	69,826.40	58,361.10

Item No.	Sectors included in BEI	unit	Years					
			2012	2013	2014	2015	2016	2017
2.3.2	Water disposal	thous. m^3	99,928.10	99,105.80	98,322.40	90,529.60	84,542.90	72,780.10
2.4	Heat energy	Gcal	5,292,830.71	5,173,908.36	4,757,256.94	4,605,908.13	4,884,301.69	4,646,569.00
3. Municipal public lighting								
3.1	Electricity	MWh	25,909.00	26,473.00	27,417.00	32,778.00	30,674.00	31,288.1
4. Transport								
4.1 Public Transport								
Electric transport (trolleybuses, trams)								
4.1.1	Compressed gas	thous. l	100.50	105.70	99.00	116.00	106.00	104.00
4.1.2	Liquefied gas	thous. l	31.40	106.40	173.40	171.90	145.40	156.30
4.1.3	Petrol	thous. l	85.71	63.20	92.80	82.90	116.50	112.80
4.1.4	Diesel fuel	thous. l	87.43	80.40	97.90	169.60	248.60	252.80
4.1.5	Electricity	MWh	76,823.00	77,696.00	82,031.00	82,952.00	82,603.00	82,002.00
Metro								
4.1.6	Electricity	MWh	99,401.50	97,318.40	89,360.60	84,970.00	87,086.50	88,559.40
4.1.7	Heat energy	Gcal	11,970.00	11,230.00	7,400.00	4,600.00	2,550.00	990.00
4.1.8	Natural gas	thous. m^3	147.80	111.80	106.10	78.70	75.30	67.49
4.1.9	Diesel fuel	ton	42.50	52.10	32.80	38.50	34.20	38.60
4.1.10	Petrol	ton	135.10	137.10	119.70	110.30	87.00	93.50
4.1.11	Pellets	ton	0.00	0.00	0.00	0.00	195.40	584.40

Item No.	Sectors included in BEI	unit	Years					
			2012	2013	2014	2015	2016	2017
Bus transport								
4.1.11	Liquefied gas	thous. l	3,555.83	3,342.48	3,141.93	2,953.42	2,776.21	2,609.64
4.1.12	Diesel fuel	thous. l	16,541.58	15,714.51	14,928.78	14,182.34	13,756.87	13,481.73
4.2 Municipal transport								
4.2.1	Liquefied gas	thous. l	968.49	822.82	739.33	705.93	535.49	488.51
4.2.2	Petrol	thous. l	935.10	920.13	934.52	885.58	682.90	661.20
4.2.3	Diesel fuel	thous. l	1,459.08	1,112.45	1,199.39	1,140.08	1,004.77	984.48
5. Tertiary sector (service sector, private business)								
5.1	Natural gas	thous. m3	77,870.66	69,050.32	64,133.38	57,391.76	31,222.62	30,015.30
5.2	Electricity	MWh	1,044,920.71	1,072,938.69	1,064,934.34	1,029,239.12	1,118,262.33	1,119,343.12
5.3.1	Water supply	thous. m^3	14,270.70	13,418.60	22,350.00	32,278.50	31,031.80	30,197.50
5.3.2	Water disposal	thous. m^3	15,627.80	14,844.70	13,576.70	13,253.50	14,901.60	13,793.80
5.4	Heat energy	Gcal	208,610.89	213,281.40	198,767.66	125,941.14	153,718.33	187,360.00

In order to further calculate CO_2 emissions for the consumed energy resources given in table 3.2.1 in natural terms, they were recalculated into single unit measurement, i.e. MWh.

The following factors were used for conversion:

Type of energy	Conversion rate	
Heat energy	1.163	MWh/1 Ggal
Liquefied gas	6.765	MWh/1000 l
Coal	7.2	MWh/t
Firewood	3.484	MWh/t
Diesel fuel	10.00	MWh/1000 l
Petrol	9.20	MWh/1000 l
Pellets	4.7	MWh/t

To determine the cost of electrical energy for water supply and disposal, the calculation of the corresponding specific indicators was performed. The results of the calculation are given in 3.2.2.

Table 3.2.2

Specific electric power consumption for water supply and disposal

No	Specific power consumption	Measurement unit	Years					
			2012	2013	2014	2015	2016	2017
1	Specific energy consumption for water supply	kW/m^3	2.222	2.191	2.162	2.235	2.332	2.627
2	Specific power consumption for water disposal	kW/m^3	0.54	0.52	0.54	0.55	0.57	0.65

In order to convert the volume of gas consumed from natural indicators to MWh, the corresponding coefficients are calculated depending on the parameters of the gas combustion heat. Information on natural gas conversion factors is given in table 3.2.3.

Table 3.2.3

Conversion rate for the natural gas from units of volume to units of energy

Parameter	Unit of measurement	Years					
		2012	2013	2014	2015	2016	2017
Natural gas	MWh/thous. m3	**9.37**	9.34	9.51	9.51	9.51	9.51

Consumption of all types of energy resources in 2012–2017 in the selected sectors for aggregate units of measurement, MWh/year, are given in table 3.2.4

Table 3.2.4

Energy consumption in 2012-2017 in the selected sectors in aggregate units, MWh/year

No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
1. Municipal buildings, equipment/facilities							
1.2. Municipal buildings							
1.1.1	Natural gas	9,236.42	7,093.80	6,788.58	7,045.64	6,444.55	6,125.68
1.1.2	Electricity	38,005.25	38,842.21	38,341.10	36,050.52	42,056.10	39,085.36
1.1.3	Water supply	4,159.13	3,985.97	3,546.71	3,433.70	3,600.69	4,100.03
1.1.4	Water disposal	1,247.82	1,208.71	1,081.76	1,052.75	1,213.66	1,239.20
1.1.5	Heat energy	314,370.47	307,261.10	281,735.67	271,012.59	296,699.52	293,973.84
1.1.6	Coal	645.59	691.62	637.80	788.71	499.08	585.14
	Total for municipal buildings	*367,664.67*	*359,083.41*	*332,131.61*	*319,383.91*	*350,513.60*	*345,109.25*
1.2. Municipal equipment/facilities							
Heat supply							
1.2.1	Heat energy	1,452,559.09	1,439,095.04	1,285,416.22	1,218,302.98	1,287,161.88	1,249,317.86
Water supply							
1.2.2	Water supply	232,296.11	226,516.88	206,036.34	209,241.14	225,103.81	280,869.80
1.2.3	Water disposal	45,630.89	42,160.06	41,259.86	44,517.90	50,419.55	64,310.94
	Total municipal equipment/facilities	*1,730,486.09*	*1,707,771.97*	*1,532,712.41*	*1,472,062.01*	*1,562,685.25*	*1,594,498.60*
	Total municipal buildings, equipment/facilities	***2,098,150.75***	***2,066,855.38***	***1,864,844.02***	***1,791,445.93***	***1,913,198.84***	***1,939,607.85***

No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
	2. Residential buildings						
2.1	Natural gas	2,820,729.30	2,772,474.10	2,656,724.56	2,145,547.92	2,082,936.16	2,073,684.13
2.2	Electricity	1,042,272.00	1,048,706.00	1,096,835.00	1,057,238.00	1,094,828.00	1,093,341.00
2.3.1	Water supply	229,627.56	222,966.71	196,740.21	164,561.66	162,818.00	153,307.38
2.3.2	Water disposal	54,299.00	51,861.65	53,076.90	49,547.49	48,099.54	47,472.99
2.4	Heat energy	6,155,562.12	6,017,255.42	5,532,689.83	5,356,671.15	5,680,442.87	5,403,959.75
	Total residential buildings	***10,302,489.99***	***10,113,263.88***	***9,536,066.49***	***8,773,566.22***	***9,069,124.57***	***8,771,765.24***
	3. Municipal public lighting						
3.1	Electricity	25,909.00	26,473.00	27,417.00	32,778.00	30,674.00	31,288.1
	Total for Public Lighting	***25,909.00***	***26,473.00***	***27,417.00***	***32,778.00***	***30,674.00***	***31,288.1***
	4. Transport						
	4.1. Public transport						
Electric transport (trolleybuses, trams)							
4.1.1	Compressed gas	679.88	715.06	669.74	784.74	717.09	703.56
4.1.2	Liquefied gas	212.42	719.80	1,173.05	1,162.90	983.63	1,057.37
4.1.3	Petrol	788.50	581.42	853.73	762.65	1,071.76	1,037.72
4.1.4	Diesel fuel	874.30	804.00	979.00	1,696.00	2,486.00	2,528.00
4.1.5	Electricity	76,823.00	77,696.00	82,031.00	82,952.00	82,603.00	82,002.00
	Total for electric transport	*79,378.11*	*80,516.28*	*85,706.52*	*87,358.30*	*87,861.48*	*87,328.65*

No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
Metro							
4.1.6	Electricity	99,401.50	97,318.40	89,360.60	84,970.00	87,086.50	88,559.40
4.1.7	Heat energy	13,921.11	13,060.49	8,606.20	5,349.80	2,965.65	1,151.37
4.1.8	Natural gas	1,384.89	1,044.21	1,009.01	748.44	716.10	641.83
4.1.9	Diesel fuel	500.01	612.96	385.89	452.95	402.36	454.13
4.1.10	Petrol	1,679.56	1,704.43	1,488.11	1,371.25	1,081.58	1,162.39
4.1.11	Pellets	0.00	0.00	0.00	0.00	918.38	2,746.68
	Total for Metro	*116,887.07*	*113,740.49*	*100,849.81*	*92,892.44*	*93,170.58*	*94,715.80*
Bus transport							
4.1.12	Liquefied gas	24,055.20	22,611.89	21,255.18	19,979.87	18,781.07	17,654.21
4.1.13	Diesel fuel	165,415.84	157,145.05	149,287.80	141,823.41	137,568.71	134,817.33
	Total for bus transport	*189,471.05*	*179,756.94*	*170,542.98*	*161,803.28*	*156,349.78*	*152,471.54*
		4.2. Municipal transport					
4.2.1	Liquefied gas	2,275.75	1,933.44	1,737.25	1,658.78	1,258.29	1,201.45
4.2.2	Petrol	2,988.06	2,940.22	2,986.22	2,829.82	2,182.16	2,302.76
4.2.3	Diesel fuel	5,068.00	3,864.00	4,166.00	3,960.00	3,490.00	3,317.43
	Total public transport	*10,331.80*	*8,737.65*	*8,889.47*	*8,448.60*	*6,930.45*	*6,821.64*
	Total transportation	***396,068.03***	***382,751.36***	***365,988.77***	***350,502.61***	***344,312.30***	***341,337.64***

No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
	5. Tertiary sector (service sector, private business)						
5.1	Natural gas	729,648.08	644,929.96	609,908.40	545,795.64	296,927.10	285,445.50
5.2	Electricity	1,044,920.71	1,072,938.69	1,064,934.34	1,029,239.12	1,118,262.33	1,119,343.12
5.3.1	Water supply	31,706.01	29,400.91	48,331.73	72,129.89	72,358.53	79,325.09
5.3.2	Water disposal	8,491.85	7,768.17	7,329.04	7,253.73	8,478.06	8,997.42
5.4	Heat energy	242,614.47	248,046.27	231,166.79	146,469.55	178,774.42	217,899.68
	Total for tertiary sector	***2,057,381.11***	***2,003,083.99***	***1,961,670.30***	***1,800,887.92***	***1,674,800.45***	***1,711,010.81***
	Total	***14,879,998.88***	***14,592,427.61***	***13,755,986.59***	***12,749,180.68***	***13,032,110.16***	***12,795,009.64***

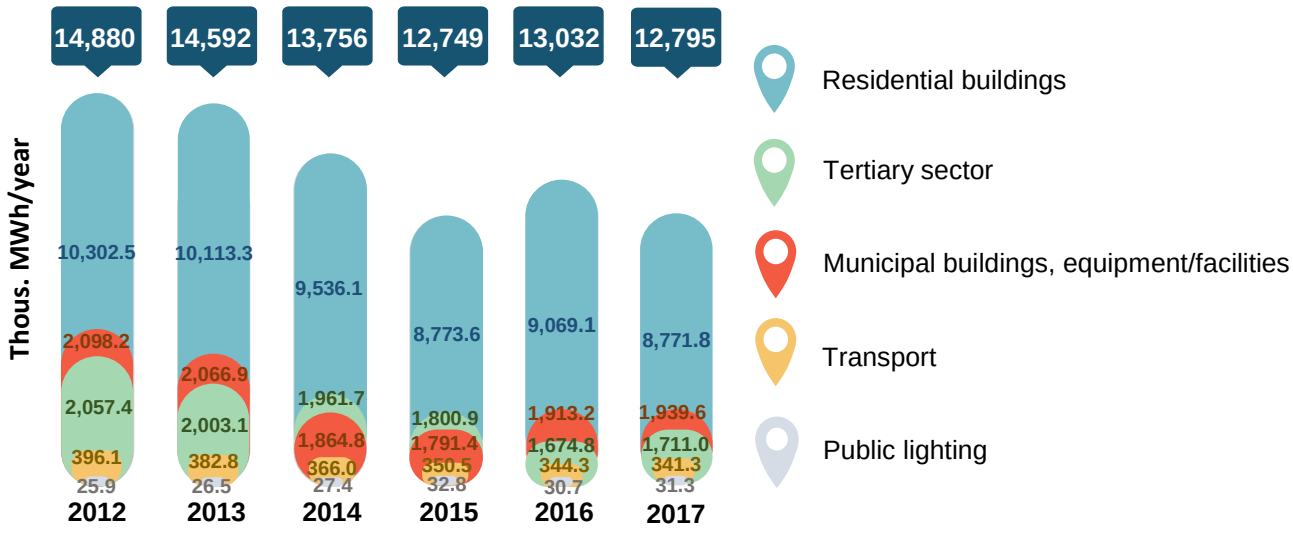


Figure 3.2.1 Energy consumption trends in 2012-2017 in selected sectors in aggregate units

3.3 CO_2 emissions analysis for Kharkiv in selected sectors in specified years

Based on the obtained consumption figures of the main types of energy resources, CO_2 emissions in 2012-2017 were calculated. When choosing factors for calculating CO_2 emissions, two approaches from the proposed within the framework of the European Union's "Covenant of Mayors" initiative have been considered. The first approach is based on the coefficients determined by the heads of the Intergovernmental Panel on Climate change (IPCC 2006) on the basis of the averaged data on fuel composition and national greenhouse gas inventory data. The IPCC Guidelines contain principles for calculating anthropogenic emissions and removals of greenhouse gases, which all countries should follow and a number of emission factors that are determined as a result of detailed studies.

Another approach is based on the use of emission factors derived from life cycle evaluation (LCA), which take into account the total life cycle of an energy carrier from its receipt to use, including transportation and operation, as well as emissions of greenhouse gases generated outside the area of use of energy (fuel).

Based on the analysis of the data obtained and possible methods for calculating CO_2 emissions, we accept for our further calculations the standard coefficients methodology (IPCC 2006).

In accordance with the recommendations given in the methodology for calculating the baseline emission inventory, we take into account only CO_2 emissions .

The values of the coefficients that were used in calculating the baseline emission inventory are as follows:

Type of energy source	CO_2 emission factor	
Natural gas	0.202	t/MWh
Coal	0.341	t/MWh
Liquefied gas	0.231	t/MWh
Diesel fuel	0.267	t/MWh
Petrol	0.249	t/MWh
Fuel oil	0.267	t/MWh
Firewood	0.00	t/MWh
Pellets	0.00	t/MWh

To calculate CO_2 emissions for electric energy, the values of emission factors were applied for each of 2012–2017 in accordance with Table 5 of the manual “How to develop a plan for sustainable energy development”, part II. Information on national emission factors for electricity is provided in table 3.3.1.

Table 3.3.1

National IPCC emission factors for electricity

Name	unit	Years					
		2012	2013	2014	2015	2016	2017
CO_2 emission factor for electricity	t/MWh	0.912	0.912	0.912	0.912	0.912	0.912

For the purpose of calculating emissions from heat energy production, additional calculations were made to determine the specific consumption of energy carriers. Calculation of unit costs for emissions from the heat energy production is given in Table 3.3.2.

CO_2 emissions calculation results in selected sectors are given in table.3.3.3.

Table 3.3.2

Calculation of unit costs of emissions from the production of heat energy by years (2012-2017)

indicator	unit	Years					
		2012	2013	2014	2015	2016	2017
Heat production	Gcal	5,708,565.00	5,386,930.00	4,829,378.00	4,632,309.00	4,924,207.00	4,848,343.00
Heat production	MWh/year	6,639,061.10	6,264,999.59	5,616,566.61	5,387,375.37	5,726,852.74	5,638,622.91
Spent energy carriers							
Gas consumption	thous. m^3	744,438.60	699,796.60	622,789.00	595,619.20	639,147.90	628,836.10
Electric energy consumption	thous. kW * h/year	203,828.40	206,403.30	190,814.30	189,479.70	182,038.10	130,766.30
Coal consumption	thous. tons	121.20	107.80	118.60	98.20	93.20	92.00
Water consumption for networks make-up	thous. m^3	6,819.40	6,853.00	6,779.90	7,106.90	7,823.50	4,183.50
Recalculation of energy carriers in MWh/year							
Gas consumption	MWh/year	6,975,389.68	6,536,100.24	5,922,723.39	5,664,338.59	6,078,296.53	5,980,231.31
Consumption Electricity	MWh/year	203,828.40	206,403.30	190,814.30	189,479.70	182,038.10	130,766.30
Coal consumption	MWh/year	872.64	776.16	853.92	707.04	671.04	662.40
Water consumption for networks make-up	MWh/year	15,151.04	15,015.31	14,661.49	15,881.16	18,242.48	10,989.54
Emissions from heat production							
Gas consumption	*tons of CO_2/year*	1,409,028.72	1,320,292.25	1,196,390.12	1,144,196.40	1,227,815.90	1,208,006.72
Electricity consumption	*tons of CO_2/year*	185,891.50	188,239.81	174,022.64	172,805.49	166,018.75	119,258.87
Coal consumption	*tons of CO_2/year*	297.57	264.67	291.19	241.10	228.82	225.88

indicator	unit	Years					
		2012	**2013**	**2014**	**2015**	**2016**	**2017**
Water consumption for networks make-up	*tons of CO_2/year*	13,817.75	13,693.96	13,371.28	14,483.61	16,637.14	10,022.46
Total emissions	*tons of CO_2/year*	***1,609,035.54***	***1,522,490.69***	***1,384,075.23***	***1,331,726.60***	***1,410,700.61***	***1,337,513.93***
Emissions per 1 MW		***0.242***	***0.243***	***0.246***	***0.247***	***0.246***	***0.237***
Emissions per 1 Gcal		***0.282***	***0.283***	***0.287***	***0.287***	***0.286***	***0.276***

*** Note:** The calculation of specific costs of emissions from thermal energy production is given only for KP “Kharkiv Heat Networks” without taking into account PJSC “Kharkiv CHP-5” due to lack of relevant information.

Table 3.3.3

CO_2 emissions calculation results in selected sectors by years (2012-2017)

Item No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
1. Municipal buildings, equipment/facilities							
1.1. Municipal buildings							
1.1.1	Natural gas	1,865.76	1,432.95	1,371.29	1,423.22	1,301.80	1,237.39
1.1.2	Electricity	34,660.78	35,424.09	34,967.08	32,878.08	38,355.16	35,645.85
1.1.3	Water supply	3,793.12	3,635.20	3,234.60	3,131.54	3,283.83	3,739.23
1.1.4	Water disposal	1,138.01	1,102.34	986.56	960.10	1,106.85	1,130.15
1.1.5	Heat energy	76,190.48	74,669.15	69,427.35	66,992.67	73,086.25	69,732.29
1.1.6	Coal	220.15	235.84	217.49	268.95	170.19	199.53
	Total for municipal buildings	*117,868.30*	*116,499.58*	*110,204.38*	*105,654.56*	*117,304.08*	*111,684.44*
1.2. Municipal equipment/facilities							
Heat supply							
1.2.1	Heat energy	352,040.62	349,722.10	316,761.62	301,157.12	317,067.70	296,345.41
Water supply							
1.2.2	Water supply	211,854.05	206,583.39	187,905.14	190,827.92	205,294.68	256,153.26
1.2.3	Water disposal	41,615.37	38,449.97	37,628.99	40,600.33	45,982.63	58,651.58
	Total for municipal equipment/facilities	*605,510.04*	*594,755.46*	*542,295.75*	*532,585.37*	*568,345.01*	*611,150.25*

Item No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
	Total for municipal buildings, equipment/facilities	***723,378.34***	***711,255.04***	***652,500.13***	***638,239.93***	***685,649.10***	***722,834.69***
	2. Residential buildings						
2.1	Natural gas	569,787.32	560,039.77	536,658.36	433,400.68	420,753.10	418,884.19
2.2	Electricity	950,552.06	956,419.87	1,000,313.52	964,201.06	998,483.14	997,126.99
2.3.1	Water supply	209,420.34	203,345.64	179,427.07	150,080.23	148,490.01	139,816.33
2.3.2	Water disposal	49,520.69	47,297.82	48,406.13	45,187.31	43,866.78	43,295.37
2.4	Heat energy	1,491,855.26	1,462,285.07	1,363,405.70	1,324,136.70	1,399,268.43	1,281,850.47
	Total for residential buildings	***3,271,135.67***	***3,229,388.17***	***3,128,210.79***	***2,917,005.98***	***3,010,861.46***	***2,880,973.35***
	3. Municipal public lighting						
3.1	Electricity	23,629.01	24,143.38	25,004.30	29,893.54	27,974.69	28,534.75
	Total for Public lighting	***23,629.01***	***24,143.38***	***25,004.30***	***29,893.54***	***27,974.69***	***28,534.75***
	4. Transport						
	4.1. Public transport						
Electric transport (trolleybuses, trams)							
4.1.1	Compressed gas	157.05	165.18	154.71	181.27	165.65	162.52
4.1.2	Liquefied gas	49.07	166.27	270.97	268.63	227.22	244.25
4.1.3	Petrol	196.34	144.77	212.58	189.90	266.87	258.39
4.1.4	Diesel fuel	233.44	214.67	261.39	452.83	663.76	674.98
4.1.5	Electricity	70,062.58	70,858.75	74,812.27	75,652.22	75,333.94	74,785.82

Item No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
	Total for electric transport	*70,698.47*	*71,549.65*	*75,711.93*	*76,744.86*	*76,657.43*	*76,125.97*
Underground railroad							
4.2.1	Electricity	90,654.17	88,754.38	81,496.87	77,492.64	79,422.89	80,766.17
4.2.2	Heat energy	3,373.90	3,173.90	2,120.80	1,322.44	730.53	273.11
4.2.3	Natural gas	279.75	210.93	203.82	151.18	144.65	129.65
4.2.4	Diesel fuel	133.50	163.66	103.03	120.94	107.43	121.25
4.2.5	Petrol	418.21	424.40	370.54	341.44	269.31	289.44
4.2.6	Pellets	0.00	0.00	0.00	0.00	0.00	0.00
	Total for Metro	*94,859.53*	*92,727.27*	*84,295.06*	*79,428.64*	*80,674.82*	*81,579.62*
Bus transport							
4.1.11	Liquefied gas	5,556.75	5,223.35	4,909.95	4,615.35	4,338.43	4,078.12
4.1.12	Diesel fuel	44,166.03	41,957.73	39,859.84	37,866.85	36,730.84	35,996.23
	Total for bus transport	*49,722.78*	*47,181.08*	*44,769.79*	*42,482.20*	*41,069.27*	*40,074.35*
	4.2. Municipal transport						
4.2.1	Liquefied gas	525.70	446.62	401.31	383.18	290.66	277.54
4.2.2	Petrol	744.03	732.11	743.57	704.63	543.36	573.39
4.2.3	Diesel fuel	1,353.16	1,031.69	1,112.32	1,057.32	931.83	885.75
	Total for public transport	*2,622.88*	*2,210.43*	*2,257.20*	*2,145.12*	*1,765.85*	*1,736.68*

Item No.	Sectors included in BEI	Years					
		2012	2013	2014	2015	2016	2017
	Total for transportation	***217,903.67***	***213,668.42***	***207,033.97***	***200,800.83***	***200,167.38***	***199,516.62***
	5. Tertiary sector (service sector, private business)						
5.1	Natural gas	147,388.91	130,275.85	123,201.50	110,250.72	59,979.27	57,659.99
5.2	Electricity	952,967.68	978,520.09	971,220.12	938,666.07	1,019,855.25	1,020,840.93
5.3.1	Water supply	28,915.88	26,813.63	44,078.54	65,782.46	65,990.98	72,344.48
5.3.2	Water disposal	7,744.56	7,084.57	6,684.09	6,615.41	7,731.99	8,205.64
5.4	Heat energy	58,799.78	60,279.04	56,965.80	36,206.39	44,037.66	51,687.06
	Total tertiary sector	***1,195,816.81***	***1,202,973.17***	***1,202,150.04***	***1,157,521.04***	***1,197,595.15***	***1,210,738.11***
	Total	***5,431,863.50***	***5,381,428.17***	***5,214,899.24***	***4,943,461.31***	***5,122,247.78***	***5,042,597.51***

3.4 Substantiation of baseline year selection

The baseline year is the year with which the reduction of CO_2 emissions will be compared in the year 2030. The year 2012 was choosed as a baseline year for estimating the current level of CO_2 emissions for Kharkiv.

The use of 2012 as a baseline is explained by the availability of complete and reliable information for the period on the consumption of all types of energy carriers and the most representative and stable functioning of the city's economy.

The calculation of the baseline emission inventory is taken as an absolute target indicator. In the baseline year for the selected economy sectors in Kharkiv, the baseline emission inventory in absolute terms is **5,431.9 tCO_2/ year.** To compare emissions in the selected sectors, per capita emissions are calculated. For the baseline year 2012 it is **3.7** tons CO_2/year per 1 inhabitant.

CO_2 emissions trends of in 2012-2017 in selected sectors is shown in Figure 3.4.1.

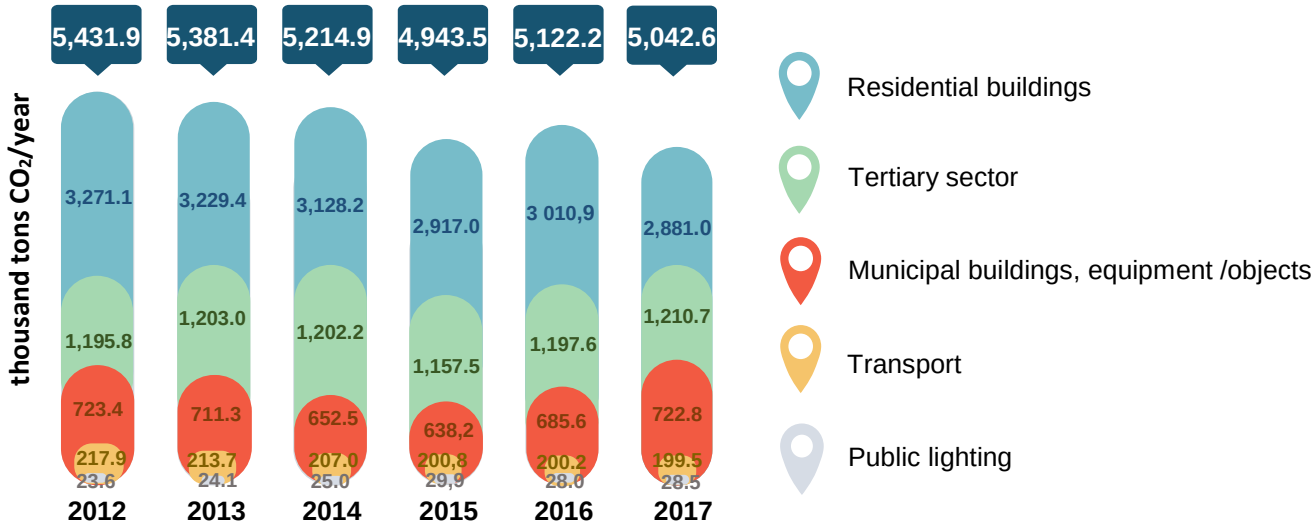


Figure 3.4.1 Trend of CO_2 emissions in 2012–2017 in the selected sectors

Distribution of CO_2 emissions with breakdown to emission sources in the baseline year 2012 looks as follows (Figure 3.4.2):

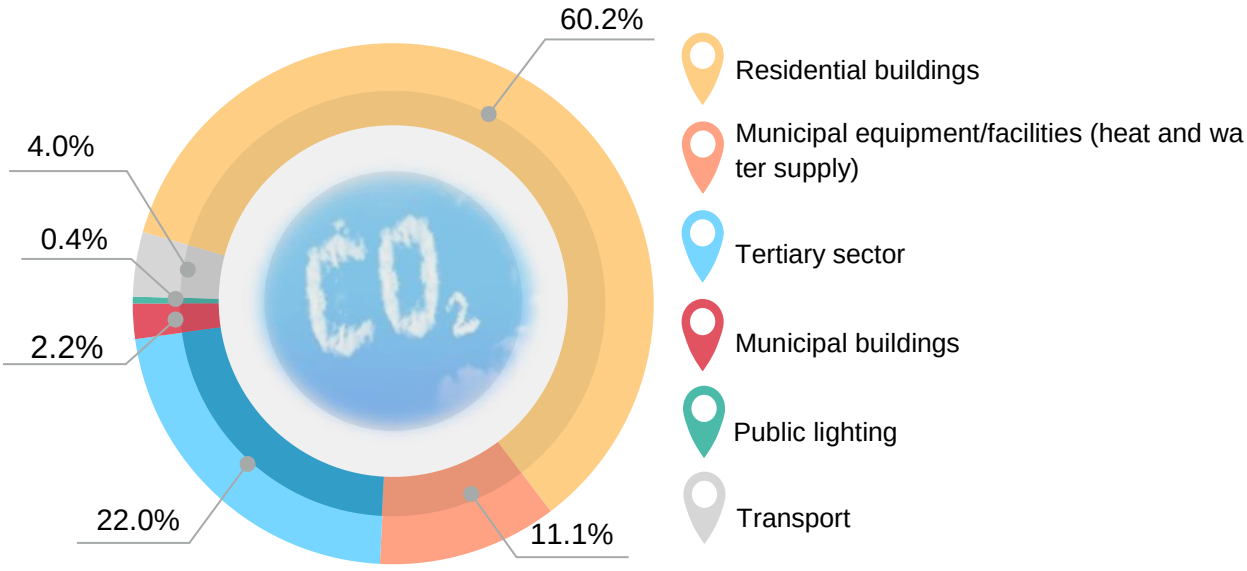


Figure 3.4.2 Distribution of CO_2 emissions with breakdown to emission sources in the baseline year 2012

Analysis of CO_2 specific emissions with breakdown to the sectors selected for the calculation of the baseline inventory indicates that the largest share of harmful substance emissions into the air, in particular, carbon dioxide, is accounted for residential buildings. The reason for this trend is significant energy consumption of the housing stock, as well as further gradual development of residential areas of the city.

Analyzing the distribution of CO_2 emissions with breakdown to the energy resource in the baseline year 2012 (Figure 3.4.1), it is clear that the greatest CO_2 emissions refer to manufacturing, heat production, electrical power and natural gas use (Figure 3.4.3).

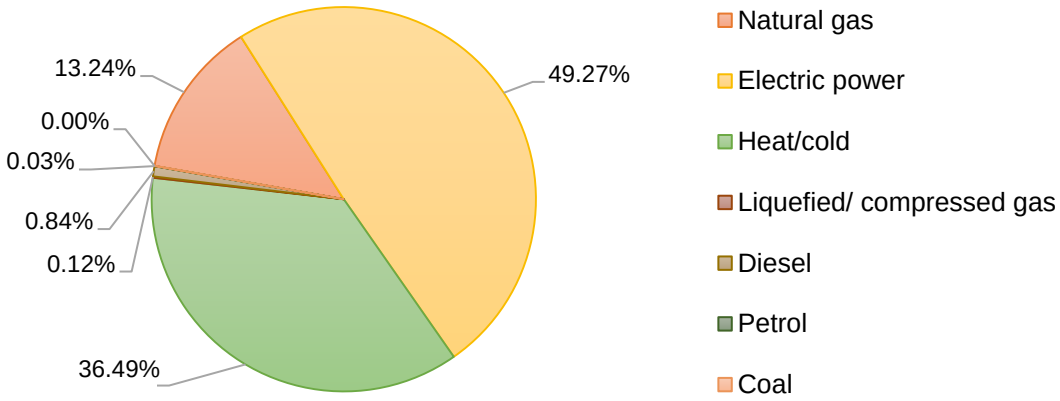


Figure 3.4.3 Distribution of CO_2 emissions depending on the energy source in the baseline year 2012

3.5 Baseline emission inventory creation

Information on the baseline emission inventory in accordance with the rules provided by the european commission methodology is given in Tables 3.5.1-3.5.7.

Table 3.5.1

Key parameters of the baseline emission inventory

Year	Type	Template	Filing year	Residents	CO_2 emissions	Updated	Edited
2012	BEI	SEAP	2019	1,451,000	5,431,863.50		

Table 3.5.2

Baseline parameters of BEI

Baseline year	2012
Number of inhabitants in the baseline year	1,451.000
Emission factor	IPCC
Reporting section	CO_2
Methodological notes	-

Table 3.5.3

Total energy consumption (baseline year 2012)

Sector	Total energy consumption [MWh/year]							
	Electricity	Heat power / Cold	Fossil fuel					Total
			Natural gas	Liquefied gas	Diesel	Petrol	Coal	
BUILDINGS, EQUIPMENT								
Municipal buildings, equipment/facilities	321,339.19	1,766,929.56	9,236.42	-	-	-	645.59	**2,098,150.75**
Residential buildings	1,326,198.57	6,155,562.12	2,820,729.30	-	-	-	-,	**10,302,489.99**
Municipal public lighting	25,909.00	,-	,-	-	-	-	-,	**25,909.00**
Tertiary sector	1,085,118.56	242,614.47	729,648.08	-	-	-	,-	**2,057,381.11**
Total	**2,758,565.31**	**8,165,106.14**	**3,559,613.80**	**-**	**-**	**-**	**645.59**	**14,483,930.85**
Transport								
Public transport	176,224.50	13,921.11	1,384.89	24,947.51	166,790.16	2,468.07	,-	**385,736.23**
Municipal transport	-,	,-	,-	2,275.75	5,068.00	2,988.06	,-	**10,331.80**
Total	**176,224.50**	**13,921.11**	**1,384.89**	**27,223.26**	**171,858.16**	**5,456.13**	**0.00**	**396,068.03**
Total	**2,934,789.81**	**8,179,027.25**	**3,560,998.69**	**27,223.26**	**171,858.16**	**5,456.13**	**645.59**	**14,879,998.88**

Table 3.5.4

Baseline emission inventory

Sector	Total energy consumption [tCO2/year]							
	Electric power	Heat/cold generation	Fossil fuel					Total
			Natural gas	Liquefied gas	Diesel	Petrol	Coal	
BUILDINGS, EQUIPMENT								
Municipal buildings, equipment/facilities	293,061.34	428,231.10	1,865.76	-	-	-	220.15	**723,378.34**
Residential buildings	1,209,493.09	1,491,855.26	569,787.32	-	-	-	-	**3,271,135.67**
Municipal public lighting	23,629.01	-	-	-	-	-	-	**23,629.01**
Tertiary sector	989,628.13	58,799.78	147,388.91	-	-	-	-	**1,195,816.81**
Total	2,515,811.57	1,978,886.13	719,041.99	0.00	0.00	0.00	220.15	**5,213,959.83**
Transport								
Public transport	160,716.74	3,373.90	279.75	5,762.87	44,532.97	614.55	-	**215,280.79**
Municipal transport	-	-	-	525.70	1,353.16	744.03	-	**2,622.88**
Total	**160,716.74**	**3,373.90**	**279.75**	**6,288.57**	**45,886.13**	**1,358.57**	-	**217,903.67**
Total	**2,676,528.31**	**1,982,260.04**	**719,321.74**	**6,288.57**	**45,886.13**	**1,358.57**	**220.15**	**5,431,863.50**

Table 3.5.5

Energy costs for heat generation

Local heat/cold generation	The amount of heat/cooling produced [MWh/year]		Energy costs [MWh/year]		CO_2 emissions
	Heat/cold from renewable sources	Heat/cold from non-renewable sources	Fossil fuel		Fossil fuel
			Natural gas	Coal consumption(fuel oil)	
District boiler rooms	0.00	6,639,061.10	6,975,389.68	872.64	1,409,028.72
Total	**0.00**	**6,639,061.10**	**6,975,389.68**	**872.64**	**1,409,028.72**

Table 3.5.6

Energy costs for thermal energy production

Heat/cold of local production	The amount of heat/cooling produced [MWh/year]		Energy costs [MWh/year]	CO_2 emissions
	Heat/cold with renewable sources	Heat/cold with non-renewable sources	Electricity	
District boiler rooms	0.00	6,639,061.10	203,828.40	185,891.50
Total	**0.00**	**6,639,061.10**	**203,828.40**	**185,891.50**

Table 3.5.7

Calculation of emission factors

National electric power	Local electric power	Heat/cold generaton	Fossil fuel			
			Natural gas	Liquefied gas	Diesel	Petrol
			Natural gas	Liquefied/natural gases	Diesel fuel	Motor gasoline
0.912	0.912	0.242	0.202	0.231	0.267	0.249

KHARKIV

GENERAL EVALUATION OF CITY'S SUSCEPTIBILITY AND MEASURES FOR KHARKIV'S ADAPTATION TO CLIMATE CHANGE

Chapter 4. SUSCEPTIBILITY EVALUATION AND MEASURES TO ADAPT KHARKIV TO CLIMATE CHANGE

4.1 Global climate change in Ukraine and susceptibility of cities to climate change

Studies show that the climate of Ukraine has been changing over the past decades, which is evidenced by its deviation from a number of climatological normals. Over the next century, the territory of Ukraine is forecast to maintain a gradual rise in temperature and a general tendency towards warming, with a possibility of a significant increase in temperature in summer months, which will lead to drought and heat oll over the country. Morever, the winter peiod is forecast to have fewer days with snow and frost, with shorter duration of the seasonal snow cover. Changes will occur in the amount of precipitation during the year, including the ratio between rainfall and solid precipitation. The climatic seasons are likely to shift, too, with an increase in recurrence and intensity of heat waves. Changes are expected in the duration of the vegetation period, water resources of local runoff and relative air humidity. An increase is forecast in the number and intensity of natural hydrometeorological phenomena. Natural hydrometeorological phenomena (NHP) are the most dangerous manifestation of climate instability. NHP include very heavy rain, snow, heavy hail, strong winds, squalls, tornadoes, strong dust storms, heavy blizzards, heavy fogs, heavy glaze, heavy snow slush build-up, etc. In many cases, they are characterized by significant intensity, hurt the economy and cause casualties.

Thus, for Ukraine, the main consequences of climate change may affect the following areas:

⇒ **Water resources**.

Rise in air temperature and uneven distribution of rainfall and local precipitation. Such precipitations do not provide effective accumulation of moisture in the soil and, combined with the rise in the air temperature, may lead to increased recurrence and intensity of drought.

Increased frequency and intensity of floodsing. For most rivers in Ukraine, flooding lasts from March to June and is caused by melting of snow and prolonged heavy rainfalls in spring and early summer. Due to abnormal weather conditions, they may shift to other seasons (winter, late summer, autumn).

Change in the amount of precipitation over the year. Reduced amount of rainfall in summer. This can lead to water shortage and a significant increase in severe droughts.

In general, rising temperatures and changes in moisture regimes are a prerequisite for changes in the river aqueous runoffs, which will affect the water supply of some regions of Ukraine.

⇒ **Sectors of economy and infrastructural branches of municipal economy**

Agriculture. Flooding, droughts, NHP, reduced duration of the seasonal snow cover may cause a decrease in the level or loss of yields. Droughts and an increased frequency and intensity of heat waves also increase the need for intensive irrigation in summer, which is closely related to the problem of changes in the water resources of local runoff.

It should be noted that the increase in the annual air temperature will have certain positive consequences. First of all, the probability of critical soil temperatures for wintering of winter crops and perennials will decrease in winter. At the same time, full vernalization of winter crops will not be ensured. Soil moisture will deteriorate, and the hibernation conditions for pests, plant pathogens and weeds will become more favorable.

A shift in climatic seasons and changes in the duration of the vegetation period will also bring about a number of positive consequences, namely: terms of plantig of spring crops will become earlier, terms of works as a whole will be

prolonged, it will be possible to grow later varieties, practise afterharvesting and stubble planting. However, despite a number of positive consequences, the expected climate changes will largely have a negative impact on agriculture in Ukraine.

Other sectors of economy. The negative effects of urbanization and climate change are creating a significant threat to the economic and social stability in all sectors of the country's economy. Climate changes will affect a wide range of economic activity: industry, trade, tourism, insurance services, etc. This will reflect on the financial situation of the general population.

Energy.

An increase in temperature will result in the decreased need for heating at the expense of a constantly increasing need for cooling and air conditioning, which will lead to increased electricity consumption and, consequently, a significant load on the electrical grid.

City infrastructure. Climate changes affect the physical infrastructure of the city: buildings, roads, sewerage and energy systems, which in its turn affects the comfort of living of its residents.

Significant deterioration of the housing and administrative stock of buildings is expected in the event of an increase in the number of natural disasters and catastrophes related to the climate change. From this point of view, flooding is considered to be the most destructive and costly.

High temperatures can also affect both the citizens and the transport infrastructure by contributing to destruction of the road surface, causing frequent road repairs, and thus disrupting the normal operation of the public transport.

⇒ **Public health.**

An increase in the number of fatalities caused by excessive heat and a cutdown in cases of hypothermia and freezing. Growth of negative tendencies in the incidence and spread of diseases among the population with changes in their typical distribution. An increase in the number of infectious diseases and allergic manifestations. Occurrence and spread of diseases, which are not typical for the country.

Given the above, intensification of climate change manifestations makes the city much more susceptible to them compared to other territories.

The concentration of significant population in cities and the specific microclimate contribute to this and may amplify some negative effects of climate change: high-rises, an urban transport network and a developed infrastructure (which can be exposed to climate change and cause significant discomfort for the city population).

The main potential negative effects of climate change that can affect Kharkiv can include: heat stress; flooding; reduction and disturbance of urban green areas; natural hydrometeorological phenomena; a decrease in quantity and deterioration of quality of potable water; an increase in the number of infectious diseases and allergic manifestations; disruption of the normal operation of the energy systems of the city.

In an effort to address these issues and prepare for the future, Kharkiv is planning to implement measures and procedures related to adaptation to climate change. Evaluation of susceptibility to climate change effects is a necessary and important stage in development of an effective adaptation plan of the city.

4.2 Climate change susceptibility evaluation methodology

To prepare this section, the existing methodologies for climate change susceptibility evaluation were evaluated and the integrated approach based on the Methodology proposed by the Covenant of Mayors on Climate and Energy set out in the SECAP Guidebook 2018 (Part 2) was used taking into account the study onducted with the support of the European Union "Climate Change Susceptibility

Evaluation: Ukraine", as well as practical experience in conducting susceptibility evaluations when developing a strategy for adaptation to climate change in a number of EU cities.

The chosen approach provides for 6 stages of the climate change adaptation cycle (Figure 4.2.1).

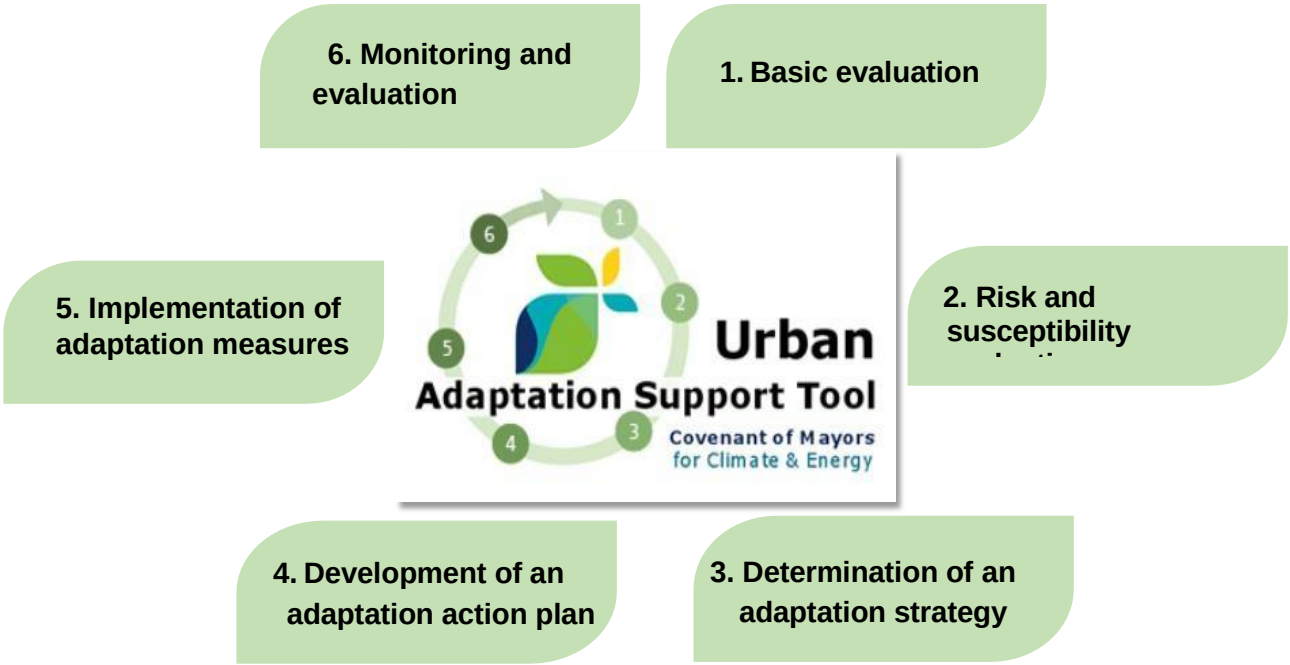


Figure 4.2.1 Stages of the cycle of adaptation to climate change

At the first stage, the basic evaluation is carried out, which includes:

- evaluation of high-level political support for adaptation actions.

- collection of information on adaptation risks and benefits.

- definition of adaptation obligations.

- identification of necessary resources (human, technical and financial).

- creation of an adaptation team with definition of clear responsibilities of each team member.

- involvement of relevant stakeholders (universities, research institutes, civil protection and emergency services, potential investors and others).

At the second stage, risks and susceptibility are evaluated:

- possible evaluation methods and data sources are determined.

- climate risks and susceptibility faced by the local authorities are evaluated.

- the most susceptible sectors are detertmined and prioritized.

- the main approaches to overcoming risks and susceptibility are developed.

At the third stage, all possible options for adaptation are determined. First of all, the collected data are organized and documented, and the adaptation options are evaluated. The possibilities of including adaptation matters in the existing local policies and programs is evaluated in order to identify opportunities for synergies and/or conflict situations. These stages are completed by selection, development and adoption of priority measures for adaptation and mitigation of climate change.

The fourth stage begins with development of an implementation action plan, determination of clear deadlines,

agreement of the roles and those responsible for implementation of adaptation measures. Agreement and synergy of mitigation and adaptation measures are ensured.

At the fifth stage, the planned adaptation measures are implemented.

The sixth stage is based on creation of a monitoring and evaluation system. This system needs to provide a set of indicators with control points. The evaluation monitoring system is communicated to the stakeholders. Regular monitoring of the progress and reporting to those responsible are carried out, as well as adaptation of the strategy to the new challenges and conclusions.

The topic of adaptation to climate change being completely new to most cities around the world, one of the main obstacles to developing adaptation measures is lack of uniform approach to evaluation of climate-related effects, susceptibility and risks in the territory of individual cities.

Use of different techniques for the same cities can lead to different results and, consequently, to different planning of adaptation measures. In order to reduce the likelihood of data inaccuracy and to promote comparability between different cities, standardization of indicators and evaluation methods for susceptibility and climate change risks is proposed.

The following sections (4.3 and 4.4) present an evaluation of Kharkiv's susceptibility to climate change by the list of values comprising a group of indicators as well as recommendations for development of measures to adapt Kharkiv to them.

To evaluate Kharkiv's susceptibility to climate change, the standardized groups of indicators proposed in the study "Climate change susceptibility evaluation: Ukraine" were used:

I. Groups of indicators for heat stress susceptibility evaluation.

II. Groups of indicators for flooding susceptibility evaluation.

III. Groups of indicators for evaluation of susceptibility of urban green zones.

IV. Groups of indicators for evaluation of susceptibility to natural hydrometeorological phenomena.

V. Groups of indicators for evaluation of susceptibility of potable water quality deterioration and quantity reduction.

VI. Groups of indicators for evaluation of susceptibility to an increase in cases of infectious diseases and allergic manifestations.

VII. Groups of indicators for evaluation of susceptibility of the city's energy systems.

4.3 Evaluation of Kharkiv's susceptibility to climate change

The evaluation of Kharkiv's susceptibility to climate change was carried out using the data from Kharkiv City Council, municipal enterprises and the data from open sources, in particular the Ukrainian Hydrometeorological Center.

The results of a comprehensive susceptibility evaluation for the city by sectors and all groups of indicators, which are indicated in the study "Evaluation of susceptibility to climate change: Ukraine" are shown in table. 4.3.1.

By the results of the evaluation, Kharkiv is most susceptible to heat stress (group I) and to potable water quality deterioration and quantity reduction (group V). Moderately high susceptibility was determined to the increase in the number of infectious diseases and allergic manifestations in the city (group VI), and also urban green zones (group III) and energy systems (group VII). Moderate susceptibility is to flooding (group II) and natural hydrometeorological phenomena (group IV).

Evaluation of the city's susceptibility to heat stress

Evaluation of Kharkiv's susceptibility to heat stress is very high (15 points).

According to the data of the Ukrainian Hydrometeorological Center, the city witnesses an increase in average daily and monthly air temperatures over the last decade compared to the climatic norm both in winter and in summer. The average annual temperature in the city increased by approximately 0.5°C compared to the period of 1970-2000. The increase happened unevenly (the average temperatures in April and May practically did not increase, and the average temperature in December even somewhat decreased). January and February warmed up the most, but the summer months were especially affected. A special place belongs to 2010 when one of the most powerful heat waves was recorded: July and August became the warmest in the history of meteorological observations, and June 2010 was 0.1°C behind. The autumn months warmed up less significantly.

In general, summers became significantly hotter, and winters – milder. Thus, September and May in most years became additional summer months. Thus, the duration of climatic summer in the city continues to grow and is approaching 5 months.

This situation indicates that the climate in Kharkiv, like that of the entire south-eastern Ukraine, is becoming more continental; the amount of the air coming from North Africa and Central Asia is increasing, while the west winds' activity is decreasing, and winters are often becoming less snowy. Summers are becoming drier, and precipitations are becoming fewer resulting in insufficient humidity in the city, with evaporation exceeding humidity. Therefore, the city is beginning to face the problem of insufficient soil moisture (soil drought). An atmospheric drought is a common occurrence, too.

All these factors are one of the reasons behind Kharkiv's high susceptibility to thermal stress.

In the general structure of the population, prevailing are the elderly people and people with chronic diseases (the high level of air pollution in the industrial region is one of the main causes of occurence and development of chronic diseases). The population of the city in general has access to information about weather and climate, about the rules of conduct during periods of excessive heat, but there is a need for additional measures to inform the population, increase their awareness of health care and disease prevention, and improve the notification system.

The developed industry of the city represented mainly by energy-intensive industries is a source of additional heat that enters the urban atmosphere, increasing the risk of heat stress. It should

be noted that the number of green plantings is insufficient in the northeast, east and southeast of the city housing most of the industrial zones.

At the same time, Kharkiv lies on a water-dividing elevation in the valley of the rivers Kharkiv, Lopan, Udy, Nemyshlia converging in the territory of the city, and there are quite large areas of green plantings (15,400 ha), which increases the city's resistance to heat stress.

Evaluation of Kharkiv's susceptibility to flooding

Evaluation of Kharkiv's susceptibility to flooding is estimated as moderate (7 points).

The potential risk of flooding in the city increased by the rise in the frequency of rainfalls in combination with the need to improve the operation of drain sewerage in some districts of the city (in needs of restoration and reconstruction).

The possibility of flooding is also conditioned by the location of the rivers in the city. At the same time, the rivers of Kharkiv are shallow, with a insignificant current velocity. Besides rivers, Kharkiv has about 20 water basins of both artificial (ponds, pits) and natural origin.

Another reason for flooding of territories in Kharkiv can be termination of operation of the marl-chalk aquifer in the artesian water supply system of the city.

Susceptibility evaluation of green areas of Kharkiv

The approximate area of all green plantings in Kharkiv is 15,400 ha.

The green zone of the city is represented by:

- forests of suburban area and the urban forest.
- parks in the place of forests.
- newly created parks.
- bank protection plantings along river beds;
- plantings of sanitary protection zones of industrial enterprises;
- field protection plantings on agricultural lands on the outskirts of the city.
- gardens.

Th specialized municipal enterprise "Kharkivzelenbud" of Kharkiv City Council has on its balance 94 squares coveing the area of 116 ha, 25 parks coveing the area of 2.5 ha, 2 hydroparks (Zhuravlivskyi and Udianskyi) coveing the area of 148.6 ha, 2 meadow parks (*Osnova* station and Oleksivskyi) coveing the area of 89.9 ha, 2 gardens (Karpivskyi and Taras Shevchenko Gardens) coveing the area of 36.7 ha, as well as 84 other land improvement facilities coveing the area of 709.8 ha, including an oakery on Derevianka Street coveing the area of 9 ha, the Memorial of Glory coveing the area of 7 ha, Netichenska, Himnasiina and Lopanska embankments coveing the area of 16.1 ha – the total of 203 environmentally protected sites.

The Department of Municipal Sevices and the Department of Culture of Kharkiv City Council perform the functions of management of municipal enterprises: parks of culture and recreation in Kharkiv, namely:

- Municipal Enterprise "Maxim Gorkiy Central Park for Culture and Leisure", park area – 83.75 ha;
- Municipal Enterprise "Park of Culture and Leisure "Green Grove" and V. Mayakovsky Park of Culture and Leisure", total area – 65.06 ha.

Municipal Enterprise "Association of Parks of Culture and Leisure of Kharkiv", which includes:

- Park of Mechanical Engineers, park area – 60.8 ha;
- Park of Culture and Leisure "Zustrch", park area – 19.7 ha;
- Park of Culture and Leisure "Yunist", park area – 7.2 ha.

The total area of parks is 236.5 ha.

The susceptibility of green areas of Kharkiv (group III) to climate change is estimated on the level of 11 points.

The largest areas occupied by green plantings are located along the western and northern borders of the city. Insufficient are green plantings in the northeast, east and southeast of the city mostly housing industrial zones. This

negatively affects the sanitary and environmental condition of Industrialnyii, Nemyshlianskyi, Slobidskyii, and Osnovianskyi administrative districts.

Urban green areas are negatively affected by changes in the usual for plants climatic conditions: rising temperatures and redistribution of precipitations by seasons, increasing durations of the vegetation period. As a result, some plant species are getting extinct and the condition of green plantings in general is deteriorating. This creates favorable conditions for emergence of invasive species of plants and insects that are adapted to higher temperatures, some of which are allergens. The factor that amplifies the climate change impact on the green areas of Kharkiv is inadequate air quality in this industrial city, which inhibits the normal growth and development of green plantings and causes plant diseases.

Plant diseases are also associated with the expansion of the habitat of certain species of pests and pathogens of plant diseases caused by the rising temperatures (including the winter ones). Emergence of new diseases and pests can pose a significant threat to the city's vegetation.

Evaluation of the city's susceptibility to natural hydrometeorological phenomena (NHP)

Kharkiv's susceptibility to natural hydrometeorological phenomena is estimated on the level of 7 points.

Manifestation of NHP can lead to disruptions in the normal operation of the city's infrastructure, ruin and other negative consequences. For example, heavy rainfalls or squalls can destruct or damage industrial facilities, which can lead to an accidental emission or discharge of pollutants into the environment, human casualties, disruption of the urban infrastructure operation.

Susceptibility to natural disasters is related to the fact that the city has of a significnat number of industrial enterprises that can be damaged by natural disasters. The closer the enterprises are to densely populated districts of the city, the more potentially dangerous the consequences of their ruin or damage by natural hydrometeorological phenomena can be.

In the recent years, Kharkiv recorded cases of heavy rainfalls and extreme winds casing to negative consequences.

The potential risk of the city's susceptibility to NHP is also related to the need to modernize and reconstruct storm drain sewerage in some districts of the city.

Evaluation of the city's susceptibility to potable water quality deterioration and quantity reducation

Kharkiv's susceptibility to potable water quality deterioration and quantity reducation is evaluated as high (13 points).

The rising temperatures, declining rainfalls in summer and increasing droughts predictably caused the run-off of the rivers to decrease, the evaporation from the basins to increase and their level to decrease respectively. The unsatisfactory environmental condition is observed in the surface waters in the Seversky Donets River and the Krasnopavlivsk Basin which ensure Kharkiv's water supply.

The inadequate condition of the water supply network increases the city's susceptibility to potable water quality deterioration and quantity reduction. Thus, there is a significant percentage of wear of the water supply network (55%) and the sewerage network (80%). The pumping equipment has served its standard life cycle and needs renewal. The current technological processes at ME "Kharkivvodokanal" are characterized by high energy consumption and use of obsolete equipment. The wastewater and sludge treatment system needs to be retrofited. The artesian water supply system in the city needs to be restored and further developed.

Enterprises of various industries represented in Kharkiv consume a

significant quantity of water resources for their activity and discharge a large quantity of unnertreated wastewater into water bodies. An important factor that also increases the city's susceptibility to water quantity reduction and quality deterioration is lack of effective water management on the level of the city authorities and of appropriate culture of water consumption among the population. Solving these two problems would save a significant quantity of water citywide.

Evaluation of the city's susceptibility to an increase in the number of infectious diseases and allergic reactions

The city's susceptibility to an increase in the number of diseases quite clearly reveals the tendencies in the sanitary and epidemiological situation of Kharkiv, which can be traced in the recent years, especially in the hot period.

The meteorological factors (primarily the rising temperatures) are a "catalyst" for intensification and spread of centers of infectious and allergic diseases in the presence of a number of dangerous factors of natural and man-made nature.

The urban heat island further raises the temperature and, accordingly, creates favorable conditions for overwintering of pathogens.

The susceptibility of the population of Kharkiv to the increase in the number of infectious diseases and allergic manifestations can be evaluated as moderately high (10 points).

The high susceptibility is conditioned by a fairly large number of the population who are older and younger than the working age and at risk by these types of diseases; the increasing frequency of natural hydrometeorological phenomena that can contribute to spread of infectious diseases (heavy rainfalls, abnormal heat); a forecast increase in the average air temperature. Moreover, the water bodies in the city, which have a rather high level of pollution due to the discharge of undertreated wastewater, contribute to the risk of spreading of the disease. The most polluted are the rivers Lopan, Nemyshlia and Udy.

Due to lack of treatment facilities in the drain network, the volumes of sand removal cones to the river beds are quite significant, and in some places the bed is almost blocked. As a result, the shallow waters increase in numbers, overgrown with moisture-loving vegetation, create favorable conditions for reproduction of the malaria mosquito larvae and pathogenic bacteria and deteriorate the hydrological regime.

The sources of surface water pollution also include violations of the land use regime in the bank water protection strips and presence of natural landfills in these areas.

Evaluation of susceptibility of the city's energy systems

The susceptibility of urban energy systems is evaluated as moderately high (10 points).

As mentioned above, the city observes an increase in the average daily and monthly air temperatures as compared to the climatic norm. This, in turn, increases the load on the city's electric systems and electricity consumption by the population, businesses and the tertiary sector in summer at the expense of the increasing number of air conditioners, refrigeration equipment and the increasing intensity of their operation.

In general, the city saw an increase in electricity consumption per capita in 2012-2017.

The increasing number of days with strong winds and recurrence of natural meteorological phenomena increase the risk of emergencies, damage to power lines, etc.

The technical condition of the city's electric energy system equipment is evaluated as satisfactory, but in need of modernization.

Table 4.3.1

Evaluation of Kharkiv's susceptibility to climate change

Indicator No.	I. Heat stress	II. Flooding	III. Urban green areas	IV. Natural hydrometeorological phenomena	V. Potable water quality deterioration and quantity reduction	VI. Increasing number of infectious diseases and allergic manifestations	VII. Energy systems of the city
1	2	2	2	1	0	2	4
2	2	0	2	2	1	2	2
3	1	1	1	2	1	4	0
4	2	1	0	2	1	2	0
5	1	1	0	0	2	0	2
6	0	0	0	0	2	0	2
7	1	0	1	-	2	-	-
8	1	1	1	-	1	-	-
9	2	0	0	-	1	-	-
10	2	0	1	-	1	-	-
11	0	1	1	-	1	-	-
12	1	0	2	-	0	-	-
Total	**15**	**7**	**11**	**7**	**13**	**10**	**10**

4.4 Recommendations for development of climate change adaptation measures for Kharkiv

The next stage after completion of the evaluation of the city's susceptibility to climate change and determination of the consequences that can most negatively affect the city and its inhabitants, is to develop a comprehensive city-wide plan for the city's adaptation to climate change.

The methodology offers a number of measures to be considered during the development of such a plan, namely: organizational, engineering, construction-architectural and economic measures.

Among the organizational measures, an important role belongs to informational and educational campaigns aimed at a specific target audience.

Engineering measures can be used to minimize the risks associated with almost all the negative effects of climate change in the city and are therefore very diverse. Of those, it is expedient to point out periodic and one-time.

Construction-architectural measures will also differ significantly from one another depending on the problem manifestation to be minimized. Construction-architectural measures are dominated by those that take a long time to implement, but the positive impact of their implementation will also last a long time.

Economic measures play an important role in reducing the susceptibility of the urban environment to certain negative effects of climate change.

For some of the negative effects of climate change, it is expedient to develop a monitoring system (early population warning) of risk management. This will minimize the damage caused by meteorological factors.

The recommendations for possible measures to be included in the citywide adaptation plan are as follows:

Recommendations aimed at reducing the city's susceptibility to heat stress

Organizational measures

1. To establish and implement a hot weather alert system in cooperation with the city authorities with the subdivision od the Hydrometeorology Office, the State Service emergency for response and with the participation of non-governmental organizations (whose role is very important in disseminating information among the public) on how to act during heat waves, how protect onself and help the most vulnerable categories of the population, etc.
2. To develop a plan to bring ambulances, hospitals and fire brigades on high alert during periods of extreme heat.
3. To ensrure constant reminders during hot periods in all media of the basic rules of conduct in the heat and the fire prevention rules, as well as to conduct large-scale information campaigns on heat waves, their manifestations and consequences, as well as ways to minimize their negative impact.
4. To ensure creation of a comfortable temperature regime during heat waves in public places where large numbers of people vulnerable categories of the population (children's preschool institutions, hospitals, homes for the elderly) congregate.
5. To develop maps of cool areas (parks, squares, lakes) in the territory of the city for people to spend time on hot days and disseminate this information.
6. To organize distribution of potable water in crowded places during hot days.
7. To monitor vulnerable categories of the population (identification of their number, distribution in the city, by districts, etc.) to coordinate actions and direct help to them in hot weather. To organize groups of residents to visit the elderly during the heat and help them, as appropriate.

Engineering measures

1. To ensure purchase of special equipment and irrigate the air, cover road surfaces and sidewalks during the high heat.

2. To arrange drinking fountains and pump rooms in different parts of the city.
3. To arrange places in the city with installed fog-forming systems of adiabatic cooling. To arrange additional shaded areas for people in parks, squares, near water basins during high temperatures.

Construction-architectural measures

1. To ensure construction of fountains and creation of additional ponds, to ensure proper care for natural water basins: rivers, lakes located in the city.
2. To use materials that are less heated to build sidewalks and parking lots.
3. To create as many green areas in the city as possible.
4. To carry out thermal modernization (insulation) of residential and public buildings. This will help reduce heating of premises in summer and heat loss in winter. To provide installation of ventilation and cooling systems in buildings.
5. To reduce excessive insolation of the premises, to design additional protection like blinds (rafters) during thermal modernization (insulation) or construction of new buildings.

Recommendations aimed at reducing the city's susceptibility to flooding

Organizational measures

1. To identify potential causes of flooding in the city (significant precipitations in a short time, rapid melting of large amounts of snow, rising water levels in water basins of the city, etc.) and its possible scale and to develop a map of potential flood zones.
2. To carry out planning of development of new areas of the city taking into account possible flooding of particular territories.
3. To control the regularity of cleaning and maintenance of storm sewerage to increase the capacity of water supply.
4. To carry out work in the city to ensure technogenic and environmental safety, development of emergency response and management plans at enterprises and public institutions in the event of flooding threat.
5. To provide adequate dissemination of information on the rules of behavior during flooding to the public of the city and especially those living in the zone of possible flooding.

Engineering measures

1. To constantly take measures to restore and maintain a favorable hydrological regime and sanitary condition of the rivers flowing through the city.
2. To conduct systematic cleaning of riverbeds from sludge and sediment.
3. To modernize the storm sewerage network. To ensure efficient operation of the storm sewerage system in all districts of the city.
4. To prevent possible flooding of the territories (pollution of waters, soils, waterlogging, deformation and ruin of foundations of buildings, structures, communications, development of landslides) by terminating operation of the marl-chalk aquifer in the system of artesian water supply of the city, it is expedient to encourage use of shallow water intakes for technical water supply for enterprises.
5. To take measures, if necessary, to strengthen the banks of the rivers Kharkiv, Lopan, Udy, Nemyshlia, which converge in the city, as well as other large bodies of water in the city.
6. To increase the surface through which water can infiltrate the soil and reduce the pressure on drainage systems during heavy rainfalls, to reduce watertight surfaces and maintain/increase the number of green plantings in cities.

Construction-architectural measures

1. To provide recommendations to construction professionals on the need to take the climate change into account and to reduce flood risks by development of the large-scale infrastructure, especially in areas of potential flooding.
2. To recommend to use preventive measures (raising the level of floors, electrical fittings and electrical equipment) during construction in flood-hazard areas.

Economic measures

1. To encourage flood insurance.

2. To provide funds in the city budget to eliminate consequences of natural hydrometeorological phenomena, including those that may cause flooding.

Recommendations aimed at reducing susceptibility to climate change of urban green areas

Organizational measures

1. To carry out a step-by-step technical inventory and passportization of green plantings. To create a list of tree species that are better adaptable to the expected climate change in the region and to use these species when creating new green areas.

2. To develop a system for monitoring of green areas of the city to identify “dangerous places” where fires may occur and a system for monitoring of plant diseases and pests.

3. To conduct information campaigns for the public on attitude of care towards green plantings in the city.

4. To ensure development of dendrological centers near the city for better supply of local reproductive material.

5. To control implementation of rapid felling and cleaning of trees damaged by the wind or due to manifestation of natural hydrometeorological phenomena.

6. To organize preservation of green plantings of the city, recreational zones, and their complex improvement. According to the Master Plan, to ensure expansion of the area and to increase the number of green zones in the city.

Engineering measures

1. To increase stability and durability of green plantings, it is recommended to perform the following set of measures:

- biological – selection of a sustainable under urban conditions range of wood and shrub species, creation of complex stable phytocenoses.

- agrotechnical – soil preparation, handling of plants and soil, application of fertilizers, liming, etc.

- physiological and biochemical – washing toxic compounds off the leaves by sprinkler irrigation of crowns of plants.

2. To ensure proper disposal of trees or branches affected by pests or diseases to prevent their further spread in the trees of the city.

3. To ensure an increase in the level of urban greening by planting trees, shrubs, creating new flower beds and lawns. Removal of emergency trees, as well as trees to have reached their age limit.

4. To carry out overhauls of green facilities, including planting of new trees with large planting material, to ensure laying of irrigation water supply, etc.

5. To carry out modernization and technical re-equipment of specialized municipal enterprise “Kharkivzelenbud”, renewal of the fleet of special machines, mechanisms, labor saving tools.

Recommendations aimed at reducing the city’s susceptibility to natural hydrometeorological phenomena

Organizational measures

1. To make a list of natural hydrometeorological phenomena with a high probability of occurrence in the city.
2. To prepare maps of areas and lists of important public buildings (hospitals, communications offices) and enterprises of the city that may be affected by flooding due to natural hydrometeorological phenomena and to develop an action plan to minimize the negative consequences.
3. To carry out information work with residents of the city on NHP that can happen in the city, as well as the consequences they may cause and the behavior of the population in case of their occurence.
4. To improve and control the work of the system of population notification about possible NHP, their scale and forecast consequences, including the use of modern information technologies for notification of NHP (for example: Google Maps with the natural disaster notification function).

Economic measures

1. To stimulate insurance against losses from natural hydro-meteorological phenomena.
2. To provide means in the city budget for liquidation of the consequences of natural hydrometeorological phenomena.

Recommendations aimed at reducing the city's susceptibility to potable water quality deterioration and quantity reduction:

Organizational measures

1. To evaluate the environmental condition and develop measures for sustainable use and protection of waters and restoration of water resources, to conduct an inventory and passportization of water bodies and artesian wells located in the city.
2. To carry out informational and educational measures to improve the culture of water consumption among the population of the city. To develop and implement educational and training programs on sustainable use of water. To organize thematic seminars on sustainable use of water and possible ways to save it for representatives of business, industry and other stakeholders operating in the city.
3. To develop an action plan for droughts or other unforeseen situations that will affect the city's water supply, which will provide for distribution of water among the city's consumers under the conditions of its limited quantity.
4. To develop an action plan to improve water resources management in the city. To stimulate the water resources management system of the city and the region to prevent waterlogging, erosion and washout.
5. To ensure reduction in discharges of pollutants by municipal enterprises by establishing stricter standards for the content of pollutants in industrial discharges.

Engineering measures

1. To introduce measures to reduce water consumption (economical flushing systems in toilets, nozzles for taps and showers to save water, etc.) at the place of production, at home, in public places
2. To increase water use efficiency through water reuse. To introduce water treatment facilities for reverse cycle water supply.
3. To maintain the water supply and sewerage network of the city in a proper condition to avoid accidents and to reduce water losses on the way to the consumer. To carry out periodic technical inspections and scheduled repairs/overhauls.
4. To ensure proper maintenance and operation of artesian wells located in the city, as well as modernization and development of artesian water supply.
5. To introduce new technologies for treatment of water supplied to consumers and wastewater.
6. When planting trees, to use those species that are adapted to arid conditions. For plants that need additional watering, to change irrigation methods taking into account the number, terms or technology.

Economic measures

1. to strengthen controls and increase fines for discharge of pollutants into water basins.

Recommendations aimed at reducing the city's susceptibility to an increase in cases of infectious diseases and allergic manifestations

Organizational measures

1. To ensure implementation of preventive and anti-epidemic measures (provision of urban amenities, water supply and sewerage, cleaning and sanitary treatment, control of living carriers of infectious diseases) in the territory of the city, including in places of mass recreation of people and recreational spaces.
2. To conduct objective monitoring of the state of natural water bodies within the city (which can become centers of an unsatisfactory sanitary and

epidemiological situation) in order to determine deterioration of their condition and to develop a set of appropriate measures to improve the sanitary and epidemiological situation around them.

3. To carry out urban greening planning taking into account the allergenic properties of plants and the effect of synergism in relation to the rising air temperatures. To ensure control of plant allergens by using modern methods.

Engineering and technical measures

1. In urban greening, to take into account the allergenic properties of plants and their adaptability to the urban environment.

2. To introduce separate collection, sorting and recycling of municipal solid waste (MSW) (this issue is not directly taken into account in the evaluation form, but MSW is a significant man-made factor that affects the sanitary condition of the city, especially in the warm season with temperatures rising).

Under this recommendation, to execute:

- proper arrangement of container sites (with surface runoff drainage from their territory into the storm sewerage system).
- elimination of unsanctioned landfills in the city, including in riparian water protection zones.
- explanatory work among the population concerning the pathogenic danger of places of accumulation of waste, especially in the warm period.
- disinfection of containers in accordance with the current standards.
- modernization of the city's container fleet and garbage collection fleet.

Economic measures

1. Ensure adequate funding for the city's healthcare institutions.

Recommendations aimed at reducing the city's energy systems susceptibility to climate change

Organizational measures

1. To evaluate the impact of climate change on the energy sector, to determine its most susceptible components in the city.

2. To develop the city's targeted energy efficiency programs for budget institutions and establishments of the city.

3. To ensure implementation of the city target "Program on improvement of energy efficiency of the housing stock in Kharkiv in 2018–2022" and other city programs aimed at encouraging the population to save fuel and energy resources.

4. To encourage measures that enable temperature reduction in buildings without use of air conditioners (blinds/rafters, additional shading with trees, etc.).

5. To encourage and promote development of alternative energy sources in the city, as well as use of highly efficient cogeneration.

6. To conduct information and educational campaigns in the city among the city's residents and to introduce educational courses/programs in the city's educational institutions on energy saving and energy efficiency.

7. To encourage introduction of energy-saving technologies in industry and in the tertiary and private sectors.

8. To ensure implementation of measures for development and improvement of the energy management system in budget institutions and establishments of the city.

Engineering measures

1. To ensure effective technical operation of budget institutions and establishments, residential buildings.
2. To ensure implementation of measures aimed at maintaining, restoring and improving the service characteristics of buildings and engineering systems, as well as prevention of their premature deterioration.
3. To implement measures to modernize the city's electric energy system. To ensure a proper condition (constant technical inspections and repairs) maintained on the power supply lines, as they are more likely to be adversely

affected by an increase in the frequency of natural hydrometeorological events.

Construction-architectural measures

1. To ensure implementation of measures aimed at comprehensive energy-efficient modernization of the housing stock and budget institutions and establishments of the city.

Economic measures

1. To provide funds in the city budget for the city's target programs for energy conservation and energy efficiency.

KHARKIV

SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN

Chapter 5 SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN

5.1. Strategy, objectives and commitments until 2030

Kharkiv joining the European initiative “Covenant of Mayors”, and its voluntary commitment to reduce CO_2 emissions by at least 30% compared to the baseline year 2012 determined the main goal of the sustainable energy and climate action plan of Kharkiv till 2030.

The strategic goal of Kharkiv’s SECAP is to ensure comfort of living for its residents by mitigation of and adaptation to the negative effects of climate change, improvement of the quality of services provided while reducing the energy consumption of the urban infrastructure and CO_2 emissions.

The specific objectives of the SECAP are:

- reducing CO_2 emissions by 2030 in certain sectors by at least **31.3 %**, or **1,700,200** tons/year (*Figure 5.1.1*).
- reducing the consumption of all main types of energy resources by **5,001,500** MWh/year.
- increasing the share of electric and heat energy generation at the expense of renewable sources and use of highly efficient cogeneration by **395,300** MWh/year (**2.65%**) in the selected districts, as well as additional **22,100** MWh/year at the expense of utilization of landfill gas to gerenate electricity after the construction of a waste recycling plant.
- raising awareness of the residents’ responsibility for sustainable use of FER
- attracting investments in energy saving and energy efficiency projects.

The strategic goal and the specific objectives set forth in the Action Plan are implemented by introducing energy-saving measures and conducting information and educational campaigns on energy saving topics.

This Chapter contains projects and measures aimed at reducing CO_2 emissions in the selected sectors, namely:

- *in the sector of municipal buildings, equipment/facilities (municipal buildings) district* – increasing energy efficiency of budget institutions of the city by developing and improving the energy management system, implementing measures aimed at ensuring efficient technical operation, maintenance, restoration and improvement of performance characteristics of buildings, their comprehensive thermal modernization. It is also proposed to implement educational courses/programs in educational institutions and other informational and educational measures.

- *in the sector of municipal buildings, equipment/facilities* (heat supply) - increasing the reliability of the heat supply system of Kharkiv by modernizing it: reconstruction of boiler houses, liquidation of uneconomical boiler houses, replacement of pipelines of the heat networks with pre-insulated ones, transition from four-pipe heat supply system to a two-pipe one and to local hot water preparation using the consumer's IHP, construction of cogeneration stations, introduction of systems of automation, dispatching and commercial electricity metering (SCADA) systems, installation of heat metering devices at the consumers’.

- *in the sector of municipal buildings, equipment/facilities (water supply)* – increasing the reliability of the water supply system of Kharkiv by its modernization: reconstruction of the existing water supply and distribution pumping stations of Kharkiv with replacement of the technically worn out sections of the water supply and distribution networks, introduction of technology and equipment for water disinfection, an increase in the reliability and durability of the sewerage networks.

- *in the sector of residential buildings* – conducting energy audits and producing energy efficiency certificates for residential

buildings, ensuring their proper technical performance, conducting current and major repairs, comprehensive thermal modernization of residential buildings. Carrying out informational and explanatory work among the population of the city on energy efficiency issues.

- *in the sector of municipal public lighting* – reconstructing the external lighting system, increasing its energy efficiency and automation, provision of an appropriate level of lighting on the entire territory of the city.

- *in the transport sector* – developing the city's electric transport network is identified as a priority to ensure the quality and efficiency of the passenger transportation. To achieve this goal, it is necessary to adjust the complex transport scheme of Kharkiv, to ensure renewal of the rolling stock of the electric transport of the city (trolleybuses, trams and metro cars), development of the metro lines. To modernize the power supply management system of the city electric transport. Along with the development of the electric transport in the city, it is provided for popularization of bicycle transport and construction of bicycle lanes. For the city bus, it is necessary to optimize the quantitative and qualitative composition of the city buses, as well as to provide incentives for carriers to renew their rolling stock.

- *in the tertiary sector* – ensuring energy efficient operation of buildings and equipment, modernizing the lighting systems, conducting thermal rehabilitation of building envelopes, installing equipment for metering and regulation of thermal energy, modernizing the technological equipment.

One of the significant factors in the deterioration of the environmental condition of the city is environment pollution with waste generated in the process of economic and social activity. Within the SECAP framework, it is planned to implement a number of measures for solid waste management, ensuring of their full and timely collection, removal and recycling. Thus, Kharkiv is implementing a project on construction of a complex for municipal solid waste treatment with a system of landfill gas collection, utilization and electric energy generation in Derhachi. To solve the problem of municipal solid waste management in the city, as well as to ensure effective operation of the complex for municipal solid waste treatment under construction in Derhachi, it is proposed to additionally carry out a number of organizational, informational, educational, regulatory and methodological measures.

The summary of the main measures under the SECAP is given in Appendix 17.

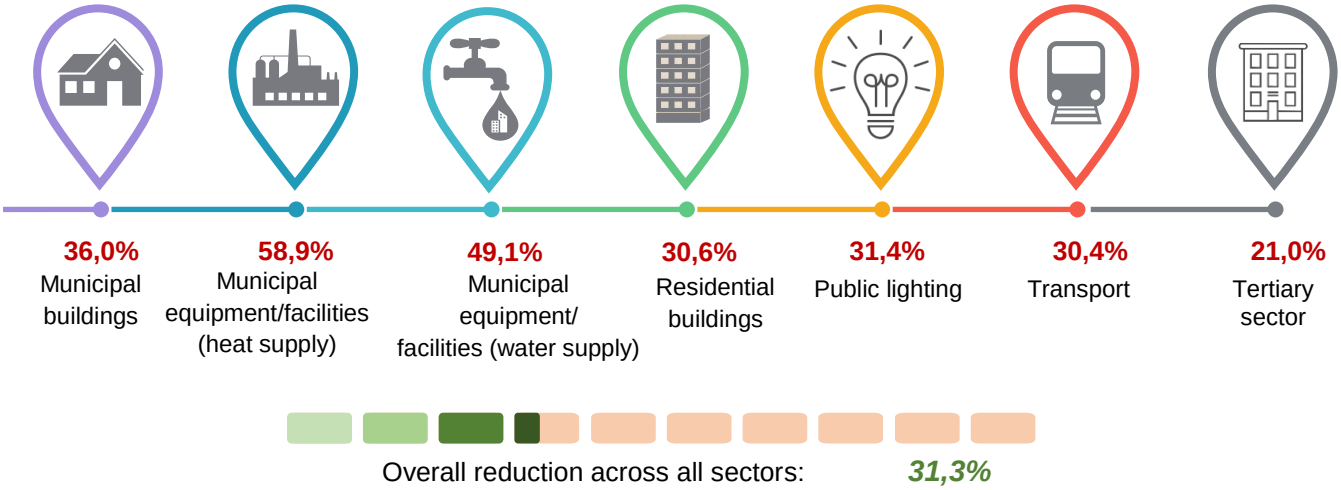


Figure 5.1.1. Expected reduction in CO_2 emissions by selected sectors

The summary calculation of CO_2 emissions by sectors is given in Table 5.1.1.

Table 5.1.1

Summary calculation of CO_2 emissions reduction by 2030 by sectors

No.	Sectors included in BEI	Total emissions in baseline 2012, tons/year	Emission reduction, t/year	Reduction of CO_2 emissions,%
1.	Municipal buildings, equipment/facilities	**723,378.34**	374,437.79	51.8
1.1.	*Municipal buildings*	**117,868.30**	42,461.17	36.0
1.2.	*Municipal equipment/ facilities*	**605,510.04**	331,976.62	54.8
2.	Residential buildings	**3,271,135.67**	1,000,553.48	30.6
3.	Public lighting	**23,629.01**	7,411.30	31.4
4.	Transport	**217,903.67**	66,153.99	30.4
5.	Tertiary sector	**1,195,816.81**	251,659.24	21.0
	Total	**5,431,863.50**	**1,700,215.81**	**31.3**

5.2. Description of planned energy efficiency projects and measures

5.2.1. Municipal buildings, equipment/facilities

5.2.1.1. Municipal buildings

To increase the energy efficiency of budget institutions and establishments in Kharkiv, as well as to reduce CO_2 emissions, it is proposed to carry out a number of measures, namely:

1. Measures for development and improvement of the energy management system in educational, cultural and healthcare institutions.

- To improve the existing energy management system in educational, cultural, and healthcare institutions, it is proposed to implement the following list of measures:
- To conduct a detailed analysis of the existing stock of buildings in order to determine the estimated energy consumption baseliner.
- To conduct a detailed analysis of the existing stock of buildings in order to determine the estimated energy consumption baseliner.
- To clarify the technical and operational characteristics of buildings.
- To conduct a comprehensive analysis of the energy performance of buildings.
- To perform a building ranking in terms of energy consumption, including taking into account typical development projects, as well as in accordance with the operational characteristics of the facilities (the purpose of the building, opening hours, number of visitors person regularly occupying the premises etc.).
- To assess energy efficiency and energy saving potential with distribution by types of energy resources; to determine the minimum required energy consumption.
- To start energy consumption monitoring in buildings of establishments, including daily operational monitoring. For this purpose, it is proposed to consider either the possibility to purchase of specialized monitoring software choosing it among the products that are on the market today or developing own software in view of the Kharkiv's needs
- To track changes in energy consumption trends (in terms of a week, month, quarter, half-year, year) and plan energy costs.
- To assess unreasonable changes in the energy consumption of buildings

- To examine the state of building envelopes and their engineering systems by conducting energy audits and producing energy certificates.

- To develop recommendations for the implementation of energy-efficient measures in buildings.

- To create a basis for economical energy consumption by developing and introducing mechanisms for motivating personnel who are working in buildings of those establishments.

- To ensure the preparation of appropriate targeted energy efficiency programs for their budget financing.

- To ensure the preparation of investment projects, as well as the search for additional financial resources for their implementation: loan and grant funds from international financial organizations and international technical assistance projects operating in Ukraine, funds using the mechanism of ESCOs, and other sources prohibited by current legislation.

- To assess the effectiveness of energy-saving projects and proposals for their further implementation according to the results of their implementation.

2. Measures to ensure effective technical performance of buildings housing educational, cultural and healthcare institutions.

- To ensure the effective technical maintenance of the buildings occupied by educational, cultural and healthcare institutions, it is proposed to implement the following list of measures:

- To proceed with the maintenance of operation and repair documentation on the list in accordance with the current regulatory and legal acts.

- To provide for conducting technical inspections of buildings and their engineering systems with a corresponding frequency determined in current regulatory legal acts, namely: general scheduled inspections, preventive examinations with registering the existing damages, and unscheduled inspections after natural phenomena.

- To provide the organization of maintenance of structural elements of buildings occupied by institutions and establishments and their engineering systems with the development of annual plans - schedules of work.

- To carry out the organization of emergency repair work and the prevention of emergency situations.

- To organize:

A) sanitary maintenance of buildings (disinfection, disinfestation, disinsection, etc.).

B) cleaning of premises and common areas.

C) cleaning the structural elements of buildings.

D) external improvement of buildings and the maintenance of local territories, including proper disposal of rainwater.s

- To ensure the implementation of measures to comply with fire safety regulations.

- To continue the annual preparation of buildings and engineering systems for the autumn-winter period.

- To organize the installation, control, calibration, maintenance and repair of energy and water accounting tools. Maintain an appropriate registry for installed meters.

3. Measures to maintain, restore and improve performance characteristics of buildings housing educational, cultural and healthcare institutions and their engineering systems, as well as preventing their premature deterioratiom.

In order to maintain, restore and improve the operation qualities of buildings occupied by educational, cultural, and public health institutions and their engineering systems, as well as prevent their premature wear, it is proposed to implement the following list of measures:

- To ensure the development of plans-schedules on current and capital repairs.

- To carry out the implementation of the current planned (preventive) repairs in accordance with the approved plans -

schedules and unpredicted current repairs in case of a need for their immediate implementation.

- To implement comprehensive capital repairs in accordance with the approved plans – schedules and selective capital repairs in case of situations requiring immediate implementation.

As part of comprehensive capital repairs, it is provided for:

- To repair, restoration, underpinning, and shoring of foundations, basements, walls, ceilings, floors, roofs, porches and other structural elements of buildings.
- To repair (modernization) of electricity, heat and water supply and sanitation engineering systems.
- To restore the damaged thermal insulation of the heating and hot water pipelines.
- To install automated coolant control units activated depending on the ambient air temperature (IHP).
- To install automated supply units for hot water supply (hot water supply module based on a plate heat exchanger connected in parallel to heat networks).
- To modernize interior lighting systems with the replacement of LED lamps.
- To take other measures that need to be performed for normal performance of the building and engineering networks.

4. Measures to conduct comprehensive energy efficient modernization of buildings housing educational, cultural and healthcare institutions.

To ensure maximum energy resources and cold water saving, it is proposed to implement a list of energy-efficient measures in a number of buildings of educational, cultural and health institutions aimed at their comprehensive modernization, namely:

- Thermal insulation of the building envelopes (walls, roofs, overlappings of cellars and basements).
- Replacement of windows and doors with energy efficient ones.
- Modernization of the existing ventilation systems through installation of central heat exchangers.
- Installation of local ventilation systems with heat recovery.
- Installation and replacement of commercial metering stations for energy resources and cold water, if necessary.
- Installation, if necessary, of technological metering stations for energy resources and cold water.
- Installation of automated coolant control units activated depending on the ambient air temperature (IHP).
- Installation of automated supply units for hot water supply (hot water supply module based on a plate heat exchanger connected in parallel to heat networks).
- Reconstruction of heating systems with installation of temperature controllers.
- Restoration and replacement of insulation on main pipelines.
- Modernization of indoor and outdoor lighting systems with their replacement with LED lamps.
- Modernization of the plumbing equipment.
- It is proposed to consider the possibility of installing solar collectors or heat pumps to heat hot water in the institutions and establishments where there are pools, as well as significant consumption of hot water.
- When insulating facades, restoration of the water sewerage system where necessary, to prevent deterioration of the facades of buildings with rainwaters and subsidence of the foundations of buildings due to flooding.

Before starting the design works, to conduct an inspection of the technical condition of the buildings to determine the degree of their physical deterioration. According to the results of the surveys, perform the necessary measures to improve the technical condition of buildings along with the proposed energy efficient measures.

The proposed measures should be implemented in compliance with the existing state building norms and standards of Ukraine.

The Program “Energy efficiency improvement of educational institutions”

Within the framework of the program “Energy efficiency improvement of educational institutions”, it is planned to implement a number of measures aimed at developing and improving the energy management system, ensuring the efficient operation of buildings, including through current and capital repairs, introduction of a comprehensive approach to the inclusion in the educational process of secondary and preschool educational courses and programs aimed to environmental education and the formation of children and youth frugal attitude to energy consumption, holding annual Sustainable Energy Days, etc. (see section 5.2.7. and organizational measures of the SECAP).

- Also, it is proposed to implement projects for complex thermal modernization of 199 educational institutions.

- The main criteria for selecting buildings for complex modernization projects were the following:

- Location of educational institutions. It is planned to cover all 9 districts of the city (a district-wise list of institutions is given in appendix 13).

- Selection of buildings by their intended purpose to achieve a more significant social effect. With the modernization of 199 buildings, it is proposed, first of all, to make a focus on pre-school institutions. **125 pre-school institutions** and **77 schools** are considered for a comprehensive modernization.

- the typical building, which is characteristic of the stock of public buildings in Kharkiv.

- high potential to save energy to achieve a significant economic effect.

The list of measures that are proposed to be implemented within the framework of the program “Energy efficiency improvement of educational institutions” is given in table 5.2.1.1.

Estimation of the required amount of investment and performance indicators for projects on complex thermal modernization in the context of areas of the city are given in table 5.2.1.2; detailed information in the context of buildings is given in appendix 13.

Table 5.2.1.1.1

List of measures under “Energy efficiency improvement of educational institutions” program

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementa-tion dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Development and improvement of the energy management system	15,470.0	4,838.3	8,032.4	1,291.8	2019-2021
2.	Introduction of educational courses/programs in educational institutions and holding annual Sustainable Energy Days	1,795.2	4,917.3	0.0	1,630.3	2020-2030
3.	Ensuring effective technical maintenance of buildings	32,340.0	6,983.8	5,614.2	1,864.7	2019-2030
4.	Conduction of current and capital reparation	614,350.0	27,209.6	46,722.2	7,265.0	2019-2030
5.	Comprehensive energy efficient upgrades for **199** buildings	3,172,097.5	72,916.7	126,501.5	19,517.5	2020-2030
6.	Installation of solar collectors/heat pumps	26,330.4	,	2,777.2	809.6	2020-2030
	Total	**3,862,383.1**	**116,865.7**	**189,647.5**	**32,378.8**	**-**

*** Note:** Saving energy consumption and reducing CO_2 emissions is achieved through the production of hot water from renewable (alternative energy sources).

Table 5.2.1.1.2

Performance indicators for projects on complex thermal modernization with breakdown by city districts

Institution location	No. of buildings	Investment	FER saved	Expenditure reduction	Emission reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	t CO_2	years
Industrialnyii	24	381,466.0	8,546.8	18,110.2	2,273.3	2020-2030
Kyivskyi	18	250,379.5	7,411.5	15,791.3	2,009.2	2020-2030
Moskovskyi	59	993,554.3	20,105.8	42,691.0	5,386.1	2020-2030
Nemyshlianskyi	20	279,103.9	7,389.5	15,605.1	1,942.4	2020-2030
Novobavarskyi	5	82,804.2	2,094.4	4,437.3	556.8	2020-2030
Osnovianskyi	9	151,607.5	3,583.4	7,544.8	932.1	2020-2030
Slobidskyi	23	404,427.0	8,409.4	17,930.3	2,285.3	2020-2030
Kholodnohirskyi	11	141,301.5	3,197.8	6,811.5	866.1	2020-2030
Shevchenkivskyi	30	487,453.7	12,178.1	25,866.9	3,266.3	2020-2030
Total	**199**	**3,172,097.5**	**72,916.7**	**154,788.3**	**19,517.4**	**-**

The program “Energy efficiency improvment in healthcare institutions”

When implementing energy efficient measures in medical institutions of the city, first of all, it is necessary to take into account their specificity associated with the modes of operation, this includes, namely: the presence of around the clock patients in hospitals, the relevant requirements for the microclimate parameters (temperature, humidity, air exchange rate)

Moreover, medical institutions in Kharkiv are mainly represented by complexes of buildings located on single land plots. Such complexes usually include hospital buildings, clinics, and kitchens, administrative, economic and other ancillary buildings. Due to that accounting for the consumption of energy resources with breakdown to each building is mostly absent and is usually conducted throughout the complex, or by groups of several buildings.

Given the above, in order to achieve a reduction in the energy consumption, it is necessary to consider the phased implementation of energy efficiency projects throughout the medical facility.

A set of measures aimed at the development and improvement of the energy management system in hospitals, especially regarding the organization of an effective monitoring system, is one of the most important measures to ensure further evaluation of the energy saving effect received. For the effective functioning of the energy monitoring system, it is proposed, first of all, to install technical accounting devices in buildings (or at main consumers) for all types of energy resources.

Implementation of energy efficient measures in a number of clinics at medical institutions in the city may be significantly limited due to their location on the first floors of residential buildings. In such cases, it is necessary to conduct their detailed examination in order to determine the list of perspectives for the implementation of energy efficiency measures.

So, within the framework of program the “Energy efficiency improvement of healthcare institutions”, it is planned to implement measures aimed at developing and improving the energy management system in the city’s hospitals, ensuring efficient operation of both individual hospital buildings and hospital complexes.

It is proposed to provide current and capital repairs, as well as to consider projects for the comprehensive modernization of polyclinics and hospitals, which will not only reduce energy consumption and CO_2 emissions but also provide a significant social effect.

The list of measures that are proposed to be implemented within the framework of the program "Energy efficiency improvement of healthcare institutions" is given in table 5.2.1.3.

Table 5.2.1.1.3

The list of measures within the framework of the program "Energy efficiency improvment in healthcare institutions"*

No.	Measure name	Investment	FER saved	Expenditure reduction	Emissions reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Development and improvement of the energy management system	5,628.9	3,135.90	3,214.80	837.2	2019-2021
2.	Ensuring effective technical maintenance of buildings	11,767.8	2794.1	2,247.20	746.0	2019-2030
3.	Conduction of current and capital repairment	223,548.6	6,608.20	18,701.30	1,764.40	2019-2030
4.	Integrated energy efficient modernization of buildings in 20 city hospitals	1,016,150.6	19,631.60	43,782.40	5,241.40	2020-2030
	Total	**1,257,095.9**	**32,169.8**	**67,945.7**	**8,589.0**	**-**

***Note:** When assessing the cost of implementing the proposed measures, as well as reducing energy consumption and CO_2 emissions, the fact is taken into account that the medical institutions of the city are separate managers of funds and the measures specified are allocated by each hospital. Estimations of the required size of investments and indicators for the effectiveness of the above-mentioned measure implementation with breakdown to the city's medical institutions are given in Appendix 14.

Program "Energy efficiency improvement in cultural institutions"

When implementing energy efficient measures in the city, cultural institutions need to take into account their specific characteristics, namely: a significant number of buildings of cultural institutions (especially for the library system of the city) located in residential buildings. Moreover, a number of buildings are treated as architectural monuments.

In these cases, it is recommended to conduct a detailed inspection of such buildings before implementing any energy efficient measures to determine the optimal list of EE measures.

Within the framework of the "Energy efficiency improvment in cultural institutions" program, it is planned to implement measures aimed at development and improvement of the energy management system, ensuring of efficient operation of buildings, their current repairs and overhauls.

It is proposed to implement projects on complex thermal modernization in **9** cultural institutions. The list of the cultural institutions for complex thermal modernization projects, evaluation of the required amount of investments and efficiency indicators are given in Appendix 15.

The list of measures proposed for implementation under the "Energy efficiency improvment in cultural institutions" Program is given in Table 5.2.1.1.4.

Table 5.2.1.1.4

List of measures under “Energy efficiency improvment in cultural institutions” program

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementa-tion dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Development and improvement of the energy management system	1,693.9	150.8	426.9	40.3	2019-2030
2.	Ensuring effective technical maintenance of buildings	3,541.0	1,015.8	610.8	271.2	2019-2030
3.	Conduction of current and capital repairment	67,267.6	2,895.3	3,552.6	773.0	2019-2030
4.	Comprehensive energy efficient upgrades for **9** buildings	119,802.0	1,531.0	4,831.0	408.8	2020-2022
	Total	**192,304.5**	**5,592.9**	**9,421.3**	**1,493.3**	**-**

5.2.1.2. Municipal equipment/facilities

Heat supply

To increase the reliability of the heat supply system of Kharkiv by carrying out its modernization, it is proposed to implement the following measures:

1. Measures under the “Energy efficiency improvment in the centralized heat supply sector” project implemented in Kharkiv from the loan funds of the International Bank for Reconstruction and Development and the Clean Technology Fund.

2. Since 2016, the municipal enterprise “Kharkiv Heating Networks” began to implement the “Energy efficiency improvment in the centralized heat supply sector” project in Kharkiv.

The aim of the project is to reduce the consumption of fuel and energy resources, reduce costs and improve the quality of services provided, modernize and upgrade fixed assets, improve energy efficiency and reliability of the centralized heat supply system in Kharkiv.

As part of the project, it is planned to perform the following measures:

1. Construction of cogeneration stations.

As a result of the construction of two cogeneration stations with an electrical capacity of 4 MW and 4.3 MW, the city’s own need for electricity and reduction of costs for purchased electricity will be partially met, as well as additional generation of heat energy will be achieved.

2. Elimination of 12 boiler houses.

3. Reconstruction of 58 boiler houses.

The obsolete boilers (with the efficiency of not more than 80%) will be replaced with boilers having an efficiency of about 95% and installation of new pumping equipment.

4. Installation of IHP and heat meters in residential buildings.

Detailed information on this measure and the calculation of reduction of the fuel and energy consumption and CO_2 emissions are shown in section 5.2.2 “Residential buildings”.

5. Reconstruction of the turbogenerator at combined heat and power plant CHP-3.

It is planned to introduce a 20 MW electric turbine generator at CHP-3, as a result of which the main production equipment should be partially restored and electric power is needed before the electric load required for the execution of the schedule, as well as the use of heat energy produced in the cogeneration cycle increases.

6. The introduction of frequency converters with the replacement of pumping units at 8 centralized heat supply system facilities.

It is proided for modernization of pumping stations and boiler houses with reconstruction of 6 kW switchgears, replacement of pumping units and installation of frequency converters on electric motors of pumping units in Kharkiv.

7. Replacement of about 30 km of the existing heat pipelines with new pre-insulated pipelines in polyurethane foam insulation

8. Introduction of automation, dispatching and commercial electricity metering (SCADA) systems.

Strategies for further modernization of the heat supply system of the city:

1. Replacement of high power boilers (50 MW and higher).

2. Transition from the four-pipe heat supply system to the two-pipe one. Local preparation of hot water using IHPs. Calculations of reduction of thermal energy consumption and CO_2 emissions are given in section 5.2.2 Residential buildings.

3. Installation of heat metering devices at consumers' (section 5.2.1.1 Municipal buildings, 5.2.2 Residential buildings, and 5.2.5 Tertiary sector).

4. Replacement of heat pipelines with new pre-insulated ones.

5. Waste recycling with heat and electric energy generation by building in the territory of the combined heat and power plant CHPP-4 (the territory of Kharkiv Tractor-Building Plant) a modern sorting complex for waste treatment and recycling.

The proposed measures to modernize the heating networks of the city and the boiler industry are recommended to be implemented in coordination with the measures for thermal rehabilitation of residential, municipal buildings and tertiary sector construction. In particular, the possibility to apply the concept of modernization of thermal districts, as appropriate, shouls be consired.

The list of measures proposed for implementation to increase the reliability of the heat supply system of Kharkiv is given in Table 5.2.1.2.1.

Table 5.2.1.2.1

Summary of the performance of projects in heating

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementa-tion dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	***Measures under "Energy efficiency improvment in the heating supply sector" project***	***2,364,087.4***	***644,741.1***	***301,200.0***	***183,644.0***	**-**
1.1.	Construction of 2 cogeneration stations	211,226.4	48,760.0	29,400.0	15,493.6	2019-2025
	Electic power generation	-	23,000.0	-	9,259.7	-
	Heat generation	-	25,760.0	-	6,233.9	-
1.2.	Demolition of 12 boiler rooms	66,406.5	521.8	6,400.0	108.3	2019-2025
1.3.	Reconstruction of 58 boiler rooms	526,489.2	10,002.8	39,700.0	2,695.1	2019-2025
1.4.	Reconstruction of the turbogenerator at CHP-3	208,756.5	342,857.1	117,500.0	108,666.9	2019-2025
	Electic power generation	,-	160,000.0	,-	64,415.4	-
	Heat generation	,-	182,857.1	,-	44,251.4	-
1.5.	The introduction of frequency converters with the replacement of pumping units at 8 facilities of the centralized heat supply system	227,606.5	6,250.0	46,000.0	5,700.0	2019-2025
1.6.	Replacement of about 30 km of existing heat pipelines	494,100.0	3,843.4	7,400.0	961.0	2019-2025
1.7.	The introduction of automation, dispatching and electricity commercial accounting systems(SCADA)	629,502.3	232,506.0	54,800.0	50,019.2	2019-2025
2.	***Strategies for further modernization of the heat supply system of the city***	***2,540,780.1***	***74,408.2***	***138,340.2***	***23,839.3***	**-**
2.1.	Replacement of high power boilers	466,780.0	35,567.0	18,480.9	8,607.2	2025-2030
2.2.	Replacement of heat pipelines with new pre-insulated pipelines	949,000.0	15,641.2	20,787.9	1,845.7	2025-2030
2.3	Construction of a modern waste sorting and recycling complex in the territory of CHP-4	1,125,000.10	23,200.00	99,071.40	13,386.40	2025-2030
	Total	**4,904,867.5**	**719,149.3**	**439,540.2**	**207,483.3**	**-**

Water supply

Kharkiv plans to implement the following projects in its water supply system:

1. "Reconstruction of existing pumping stations for water supply and distribution in Kharkiv".

The project provides for complete replacement of the process and electrical equipment at the existing pumping stations. It assumes the maximum level of introduction of energy-saving equipment at 21 water pumping stations (rotational speed converters, soft start systems, etc.), technology and equipment for water disinfection using sodium hypochlorite, which will reduce the potential danger of objects and significantly reduce the formation of organochlorine compounds in potable water

The project plans are:

- *Donets water treatment complex* – reconstructing and replacing the main technological and electrical equipment on rises 1 and 2 of Water Supply Shops No.1, 2, 3 and at Rohanska pumping station (replacing the pumping equipment, cable lines, switchgears, chlorination equipment, installing devices for smooth start of electric motors).

- *Dnipro water treatment complex* – reconstructing and replacing the main technological and electrical equipment on rises 1 and 2 (replacing the pumping equipment, cable lines, switchgears, chlorinator equipment, installation of frequency converters of electric motors).

- *city water pumping stations* – reconstructing and replacing the main technological and electrical equipment at pumping stations No. 1, 8, 10, 14, 25, 25-a, 26, 27-a, 27-b, 28, 28-a, 29, pumping stations of rises 2-3 of Piatyhatky and Kulinichi, implementing equipment for water disinfection, replacing the pumping equipment, cable lines, switchgears, transition from chlorine use to sodium hypochlorite, installation of frequency converters for electric motors.

2. Reconstruction of technically worn-out sections of the water mains and distribution networks of the centralized water supply system of Kharkiv

The project provides for:

- replacement or rehabilitation of the water mains and water supply networks by years of their construction and their length;
- excess pressure reduction in areas of the pumping stations at the expense of the equipment of control points;
- installation of technological water meters at inlets of heat distribution stations and individual heating points;
- introduction of pressure regulators;
- installation of automatic air valves (plungers) and pressure regulators;
- introduction of a citywide system of teleinspection and monitoring of the water mains and networks with the purchase of modern diagnostic equipment;
- other measures to ensure reliable operation of the water supply system.

Kharkiv plans to implement the following project in its sewerage system:

3. "Sewerage networks reliability and durability improvement by rehabilitation using modern materials and technologies".

The project plans to*:*

- rehabilite and relocate the existing sewerage networks made of reinforced concrete of different diameters;

- rehabilite the existing tunnel collectors operated without major repairs for a long time;

- increase the reliability of electricity supply for sewerage pumping stations and efficiency of their performance;

- construction of a duplicate collector;

- introduction of dispatching management of the pipeline system for sewerage transportation with creation of an automated system to account for and control of the quantity of the arriving sewerage, the fill rate of the networks and pumping volumes;

- other measures to improve the city's sewerage system physical condition and hydraulic performance.

The measures to be implemented in the city's water supply/sewerage system is given in Table 5.2.1.2.2.

Table 5.2.1.2.2

Summary of performance indicators in supply water project

No.	Measurement name	Investment	FER saved	Expenditure reduction	Emission reduction	Implement ation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Reconstruction of the existing pumping stations of the water supply and distribution system of Kharkiv with replacement of technically worn out sections of water pipelins and distribution networks	1,113,600.0	74,200.0	237,169.6	67,670.4	2020-2026
2.	Reconstruction of technically worn out sections of water pipelins and distribution networks of the centralized water supply system of Kharkiv	2,027,480.0	39,490.3	107,169.6	36,015.2	2020-2026
3.	Improvement of reliability and durability of sewerage networks through rehabilitation using modern materials and technologies	406,000.0	22,815.4	75,169.6	20,807.7	2022-2026
	Total	**3,547,080.0**	**136,505.8**	**419,508.8**	**124,493.3**	**-**

5.2.2. Residential buildings

According to the results of the BEI calculation, it is determined that the housing sector is the largest consumer of energy resources in the city and produces the main share of CO_2 emissions. To improve the situation in the housing sector, it is proposed to implement the program “Energy efficiency improvement of the housing stock”.

The main objective of the program “Energy efficiency improvement of the housing stock” is to ensure the reduction of the fuel and energy resources consumption, CO_2 emissions, improving the technical condition and extending the life of residential buildings. To this end, it is proposed to organize the implementation of a number of measures, namely:

1. Energy audits and certification of energy efficiency of residential buildings.

Ensuring that energy audits of residential buildings be conducted to determine the list of EE measures for their further implementation, as well as energy certification of buildings in accordance with article 7 of the Law of Ukraine “On Energy Efficiency of Buildings”.

2. Information and educational campaign among the population of the city on energy efficiency issues and annual Sustainable Energy Days.

The detailed list of measures is given in section 5.2.7.2. Information, educational and organizational measures under SECAP

3. Incentives for city residents to implement energy saving measures in households and use of energy-efficient appliances

- Encouraging residents to use modern energy-efficient lighting and household appliances of A, A +, A ++ class in their households.

Incentives for co-owners of apartment buildings to implement energy-saving and energy-efficient measures in buildings (replacement of windows with energy-saving ones in their own homes, reconstruction of the heating system, measures to reduce hot and cold water consumption: economical flushing systems in toilets, nozzles on taps and in showers to save water, etc.).

- Encouraging installation of apartment and building heat, electricity, gas and cold water meters, as well as heat distributors, where appropriate.

To encourage the residents of the city, it is proposed to obligatorily implement measures on informational and educational work, as well as implementation of the city's targeted programs on co-funding measures relating to the housing stock, interest refund on energy saving loans, etc.

3. Measures to ensure efficient technical maintenance of residential buildings.

- To continue maintenance of operation and repair documentation as per the list in accordance with the current regulatory and legal acts.
- To provide technical inspections of buildings and their engineering systems with a corresponding frequency defined in the existing regulatory and legal acts, namely: general scheduled inspections, preventive examinations with recording the existing damages, and carrying unscheduled inspections after natural phenomena.
- To organize the maintenance of structural elements in residential buildings and their engineering systems in accordance with the developed annual plans - schedules of work.
- To organize the organization of emergency repair work and the prevention of emergency situations.
- To organize:

a) Sanitary maintenance of buildings (disinfection, disinfestation, deratization, etc.).

b) Cleaning of premises and common areas.

c) Cleaning the structural elements of buildings.

d) External improvement of buildings and the maintenance of local territories, including proper disposal of rainwater.

- To ensure the implementation of measures to comply with fire safety regulations.
- To continue the annual preparation of buildings and engineering systems for the autumn-winter period.
- To organize installation, control, calibration, maintenance and repair of energy and water accounting tools; maintain an appropriate registry for installed meters.

4. Measures to maintain, restore and improve performance characteristics of residential buildings and their engineering systems, as well as prevent their premature deterioration.

In order to maintain, restore and improve the functional performance of residential buildings, as well as preventing their premature wear, it is proposed to implement the following measures:

- To ensure the development of plans-schedules of current repairs and overhauls.
- To carry out the current planned (preventive) repairs in accordance with the approved plans-schedules and unscheduled current repairs in case of a need for their immediate implementation.
- To carry out complex capital repairs in accordance with the approved plans – schedules, and also selective capital repairs in case of situations requiring their immediate implementation.

As part of comprehensive and selective overhauls, it should be provided for repair, restoration, strengthening and underpinning of the foundations, basements, walls, ceilings, floors, roofs, porches, and other structural elements of buildings. Restoration of waterproofing of a socle and paving on perimeter of buildings.

- Repair (modernization) of engineering systems of electricity, heat and water supply and drainage.
- Restoration of damaged thermal insulation of heating and hot water supply pipelines.
- Equipping buildings with public lighting control systems and replacing lamps with energy-saving ones.
- Replacement of luminaires with incandescent lamps in the elevator cabins

of residential buildings with energy-saving luminaires with LEDs.

- Replacement of windows on stairwells with energy-efficient and entrance groups of doors, restoration of vestibules.

- Equipping about 4,500 residential buildings with automated coolant control units depending on the ambient air temperature (IHP) and automated hot water supply units.

- It is proposed to annually implement measures aimed at extending the service life of elevators, as well as the replacement of elevators that have exhausted their service life.

- Other measures that need to be taken for the proper functioning of the building and utilities.

5 Measures under "Energy efficiency improvment in the centralized heat supply sector" project implemented in Kharkiv from the loan funds the International Bank for Reconstruction and Development, and the Clean technology fund:

- Installation of 250 IHPs, 1,000 heat meters and pumps at heating points of residential buildings

4. Measures to conduct complex energy efficient modernization of residential buildings.

In order to ensure maximum energy resource savings, it is proposed to implement a number of energy efficient measures in **2,350** apartment buildings to their integrated thermal modernization, namely:

- Heat insulation of the building envelopes (walls, roofs, covers of cellars and basements).

- Thermal modernization of public spaces with installation of energy-efficient windows and doors in entrance halls, entrance doors to basements and access to attics, and restoration of wind porch.

- Installation of commercial metering stations for energy resources and cold water, if necessary

- Installation of automated heat carrier control units depending on the ambient air temperature (IHP) and automated hot water supply units.

- Restoration and replacement of trunk pipeline insulation.

Restoration and replacement of insulation of main pipelines.

- Installation in buildings of lighting control systems for common areas and replacement of lamps with energy-saving ones.

To prevent rainwater from ruining the facades of buildings and to prevent subsidence of the foundation due to flooding by restoring the water disposal system when insulating the facades, where necessary.

Before you start works on a facility, it is necessary to conduct a structural survey to determine the degree of the deterioration of the building. According to the results of the survey, perform the necessary measures to improve the technical condition of the buildings along with the proposed energy efficient measures.

The proposed measures need to be implemented with the involvement of funds from co-owners of apartment buildings and the attraction of appropriate information and educational component to encourage residents to save fuel and energy resources.

To ensure proper quality of work and achieve the planned economy of fuel and energy resources, measures should be implemented in compliance with the current State Building Codes and Standards of Ukraine.

Thermal improvement measures proposed for the rehabilitation of residential buildings are recommended to be carried out in accordance with the strategy for upgrading the city's heat supply system. In particular, it is recommended to consider the possibility of applying the thermal areas modernization concept, where possible.

The list of measures proposed for implementation in the housing sector is given in Table 5.2.2.1.

Table 5.2.2.1

List of measures under “Energy efficiency improvement of the housing stock” program

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implement ation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Energy audits and energy efficiency certification of residential buildings	20,540.0	13,380.5	2,430.0	3,572.6	2020-2025
2.	Carrying out of informational and explanatory work among the population of the city concerning energy efficiency and annual Days of Sustainable Energy	7,990.0	178,201.6	0.0	59,079.8	2020-2030
3.	Encouraging city residents to implement energy efficiency measures and use energy-saving lighting and household appliances in households	1,834,000.0	920,417.6	145,500.0	245,751.5	2019-2030
4.	Ensuring effective technical maintenance of buildings	1,112,345.0	399,742.2	201,430.0	106,731.2	2019-2030
5.	Current and capital repairs	6,785,345.0	1,159,904.1	475,700.0	309,694.4	2019-2030
6.	Installation of heat points, pumps and heat meters within the Project “Energy efficiency improvment in the centralized heat supply sector”	364,840.2	67,764.0	21,256.0	13,901.3	2019-2020
7.	Comprehensive energy efficient modernization of 2,350 residential buildings	5,143,179.0	980,609.3	298,176.5	261,822.7	2021-2030
	Total	**15,268,239.2**	**3,720,019.3**	**1,144,492.5**	**1,000,553.5**	**-**

5.2.3. Municipal public lighting

Public lighting occupies an insignificant share in the baseline emission inventory: only 0.1%. At the same time, the development of this sector is the basis for the safety of residents and ensuring comfortable living conditions in the city.

Among the main measures for the modernization of public lighting are the following:

- development and improvement of the energy management system at the municipal enterprise “Mis’ksvitlo”.
- development of an electronic map of the city’s outdoor lighting system.
- reconstruction of the city’s outdoor lighting system (transition to LED lighting, repair of overhead power lines using self-supporting insulated wires, replacement of supports, if necessary). Ensuring an adequate level of lighting coverage in the city (in the middle of neighbourhoods, pedestrian crossings, playgrounds, recreational areas for residents, etc., including the installation of supports with independent lighting on photovoltaic modules).
- modernization of the automatic control system for outdoor lighting (installation of electronic control gear with dimers, development and improvement of the automation system for controlling the outdoor lighting of the city).

Table 5.2.3.1

List of measures under “Modernization of the outdoor lighting system” program

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Development and improvement of the energy management system	2,350	313	1,439.4	285.4	2020-2022
2.	Development of an electronic map of the city's outdoor lighting system	4,300	156.5	719.7	142.7	2020-2022
3.	Reconstruction of the city's outdoor lighting system	733,900	5,000.1	2,4844	4,926.7	2019-2030
4.	Modernization of the automatic control system for outdoor lighting	79,140	1953	8,981.8	1781.1	2020-2022
5.	Installation of poles with autonomous lighting based on photovoltaic modules	3200	302	1,497.9	275.4	2021-2022
	Total	**822,890.0**	**7,724.6**	**37,482.8**	**7,411.3**	**-**

5.2.4. Transport

Since the bulk of passenger traffic in Kharkiv is carried out by electric transport, it is proposed to make development of the city's electric transport network a priority to ensure the quality and efficiency of passenger transportation and take a number of measures to modernize the city's electric transport network, increase its energy efficiency and reduce CO_2 emissions:

1. Adjustment of Kharkiv's complex transport scheme.

It is necessary to carry out an adjustment of the integrated transport scheme taking into account the increase in passenger traffic, the emergence of new and promising routes of all types of passenger transport. Exclusion of duplication of tram and trolleybus routes by other types of urban passenger transport.

2. Modernization of the power supply system of urban electric transport in Kharkiv.

Electrical energy supply for the tram and trolley lines in Kharkiv is provided by 59 traction substations, which needs to operate without constant personnel duty in the centralized dispatch control and telecontrol mode. Moreover, the operated traction substations are not fit to ensure efficient use of electricity from the process of regenerative braking of thr rolling stock, both that which is currently on the routes and that planned for purchase from IFI loans.

This project will be implemented in several stages and includes the following measures:

- conducting an energy audit of the traction electric network of Kharkiv;
- replacement of the worn-out cable networks that ensure operation of the traction substations and power supply of the urban electric transport;
- modernization and reconstruction of the traction substations with installation of modern equipment that ensures the recovery process;
- installation and adjustment of modern tele-mechanics devices;
- consolidation of district dispatching points, organization of communication channels based on fiber-optic communication of Ethernet or GPRS architecture;
- modernization and reconstruction of the existing DDPs to ensure their operation on modern communication channels;
- creation of AEMS on the basis of DDP with the central control point (CDO).

3. Modernization of Kharkiv trolley-bus fleet.

The project provides for the purchase of new rolling stock for the municipal enterprise “Trolleybus depot no. 2” from the EBRD loan funds.

Implementation of the project provides for ensuring efficient overland transportation in Kharkiv by using **57** new modern trolleybuses.

4. Acquisition of rolling stock for urban electric transport (trolley buses).

The project provides for the purchase of new rolling stock for the municipal enterprise “Trolleybus depot no. 3” from the EBRD loan funds in the number of 61 units.

5. Extension of the third Metro Line in Kharkiv.

The investment project provides for the construction of two Metro stations “Derzhavinska” and “Odeska”, as well as the depot “Oleksiivske”, and also the purchase of new rolling stock.

Expansion of the Metro modernization of rolling stock (***85*** carriages will lead to a reduction in the number of less energy-efficient ground transportation means and will avoid the associated CO_2 emissions. The project is planned to be implemented with loan funds from the EBRD, EIB, as well as the city budget.

6. Renewal of Kharkiv Metro rolling stock.

Provision is made for the purchase of new **35** Metro cars from the EBRD loan funds.

7. Modernization, repair and maintenance of Metro infrastructure facilities

To ensure effective work of Kharkiv Metro in the following years, it is necessary to carry out modernization and repair of the escalator, pumping and ventilation equipment, traction substations, railways, and contact rail.

8. Road safety in Kharkiv

Implementation of a number of measures provided by the approved city programs to improve road safety and to develop electric transport of the city:

- modernization and maintenance of public transport stops, parking lots for vehicles.
- creation of a network of charging stations for electric vehicles in places of temporary parking or parking vehicles, as well as other ancillary infrastructure for development of this mode of transport.
- reconstruction of the existing automated traffic control system in the city with creation of a dispatching center for overand passenger transport.
- development and implementation of complex and local schemes of traffic organization on the street and road network of the city to prevent occurrence of places of concentration of traffic accidents and delays.
- keeping, maintenance and repair of the infrastructure facilities of the city overland electric transport (tram and trolleybus lines, contact and cable networks, traction substations, etc.).
- reconstruction, overhaul of tram tracks, crossings, switches, including with the use of the latest technologies.
- other measures provided by the specified programs.

Transportation of passengers by city bus and route taxis in the city is mainly carried out by private carriers, so for these types of public transport, the following measure is proposed for implementation:

9. Optimization of the quantitative and qualitative composition of the city bus fleet, encouraging carriers to renew the rolling stock.

Evaluating the potential benefits of “green” modes of transport and active mobility, it is also proposed to implement:

10. Popularization of cycling transport and construction of bicycle tracks

The list of measures proposed for implementation in the transport sector is given in Table 5.2.4.1.

Table 5.2.4.1

List of measures for their implementation in the transport sector of Kharkiv

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Adjustment of complex transport scheme of in Kharkiv.	10,000.0	2,271.5	4,242.9	1,282.2	2020-2021
2.	Modernization of the power supply system for urban electric transport in Kharkiv	1,402,150.0	7,049.0	10,607.3	6,428.7	2020-2025
3.	Modernization of the trolley fleet in Kharkiv.	333,499.9	7,835.9	18,821.7	7,146.4	2019-2020
4.	Acquisition of rolling stock of urban electric vehicles	270,000.0	7,835.9	18,821.7	7,146.4	2019-2020
5.	Extension of the third Metro line in Kharkiv	10,230,000.0	18,929.1	33,943.2	10,684.9	2019-2024
6.	Modernization of the rolling stock for Kharkiv Metro	1,305,000.0	7,952.1	36,064.7	7,252.3	2019-2022
7.	Modernization, repair and maintenance of Metro infrastructure facilities	349,879.0	13,826.0	21,850.2	3,871.3	2019-2025
8.	Road safety in Kharkiv	640,000.0	17,689.1	47,578.9	10,395.8	2019-2030
9.	Optimization of the quantitative and qualitative composition of city buses, stimulation of carriers to upgrade their rolling stock	120,000.0	28,420.7	14,214.5	7,458.4	2020-2025
10.	The popularization of cycling transport and construction of bicycle tracks	83,000.0	7,950.2	8,485.8	4,487.7	2020-2030
	Total	**14,743,528.9**	**119,759.6**	**214,630.9**	**66,154.0**	**-**

5.2.5. Tertiary sector

To increase energy efficiency and reduce CO_2 emissions in the tertiary sector of Kharkiv, it is proposed to implement the following measures:

- to introduce measures for energy efficient operation of buildings and equipment.
- to replace lamps with energy-saving ones and install automatic lighting control systems in the tertiary sector buildings.
- to carry out thermal insulation of external walls, to replace window structures in houses of the tertiary sector.
- to use energy efficient process equipment.
- to use energy efficient technological equipment.
- to increase efficiency of water use through water reuse (to introduce water recirculation).

The list of measures proposed to improve energy efficiency in buildings of the tertiary sector is given in Table 5.2.5.1.

Table 5.2.5.1

List of measures for implementation in the tertiary sector of Kharkiv

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	Introduction of measures for energy efficient performance of buildings and equipment	320,437.2	40,573.8	33,786.6	10,833.2	2019-2030
2.	Annual Sustainable Energy Days	250.0	8,290.6	0.0	2,748.6	2020-2030
3.	Introduction of energy efficient lighting	179,464.9	103,401.0	33,143.9	94,301.7	2019-2030
4.	Thermal insulation of exterior walls, replacement of window constructions	1,065,182.6	99,119.0	55,905.8	23,986.8	2020-2030
5.	Installation of heat points and heat meters	565,378.0	53,445.0	75,345.2	12,933.7	2020-2030
6.	Use of energy efficient process equipment	1,236,688.1	230,773.3	91,911.5	106,855.2	2020-2030
	Total	**3,367,400.8**	**535,602.7**	**290,093.0**	**251,659.2**	-

5.2.6. Municipal solid waste treatment

One of the significant factors leading to the deterioration of the ecological state of the city is pollution of its environment with waste generated in the process of economic, social, and household activity. Addressing issues related to the elimination or limitation of the negative impact of waste (and especially hazardous) on human health and the environment requires special attention.

The purpose of the measures planned to be implemented within the framework of SECAP is to ensure full and timely collection, removal, disposal, treatment and burial of solid waste and a significant reduction of their harmful effects on the environment and human health, improvement and alignment with the current environmental requirements of the entire municipal solid waste.

The main results of the implementation of the proposed measures will be:

1. New construction of a complex for solid waste treatment with a system of landfill gas collection, utilization and generation in Derhachi

- arrangement of a new landfill;
- construction of a modern waste sorting plant;
- a power plant with a network of biogas collection from the landfill.

The main results of the implementation of the proposed measures will be:

Environmental:

- reduction of the harmful effects caused by household waste on the environment and the health of city residents through the introduction of new, modern, highly efficient methods for collecting, storing, transporting, treatment and disposing of municipal solid waste in accordance with modern environmental protection requirements;
- cleaning of territories from their pollution by household waste, liquidation and prevention of unauthorized landfills;
- - gradual reduction of household waste accumulation through the introduction of separate collecting of resource-valuable components of municipal solid waste.

Economic:

- the transformation of the sanitary cleaning and waste management sphere into a self-sustaining and profitable sector of housing and communal services.

Social:

- the creation of additional jobs in the field of household waste management;
- improving the environmental culture in all segments of the population

2. Ensuring of effective municipal solid waste management

To solve the problem of municipal solid waste management in the city, as well as to ensure effective operation of the complex for municipal solid waste treatment, which is now being built in Derhachi to the North of Kharkiv, it is necessary to carry out a number of measures of organizational, informational, educational, regulatory and methodological nature.

1. Organizational measures.

- studies to determine the morphological composition of municipal solid waste, as well as to assess the system and methods for municipal solid waste management in the city to introduce an effective scheme for separate collection, sorting, transportation and industrial treatment of municipal solid waste.
- optimization of the existing scheme of sanitary cleaning of the city, including improvement of the system of park and garden waste collection, treatment and use.
- development and implementation of a MSW monitoring system.
- creation and maintenance of the urban information database on MSW management.

2. Regulatory and methodological measures.

- revision and approval of standards on the provision of services for waste disposal in Kharkiv. Bringing them to an economically viable level to ensure uninterrupted functioning of a complex of municipal solid waste.
- development of other legal acts to ensure the introduction of an effective system for the treatment of solid waste in Kharkiv.

3. *Information and educational measures.*

- beginning and conducting of a constant cycle of television and radio programs, preparation and dissemination of video products (social advertising) on issues of culture of solid waste management.
- conducting of information and educational work with civilized municipal solid waste management, measures for environmental education of the population. Development, printing and distribution of information materials targeting various groups of the city's population (for children, youth, the elderly, and others).
- organization and conducting of thematic lectures, trainings on solid waste management, training on the fundamentals of separate waste collection, as well as municipal sanitation to eliminate illegal dumping sites.
- organization and conducting at institutions of secndary and preschool education of of competitions, exhibitions, children's festivities on sutainable waste management.

Table 5.2.6.1

List of measures for municipal solid waste treatment in Kharkiv

No.	Measure name	Investment	FER saved	Expenditure reduction	Emission reduction	Implementation dates
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years
1.	New construction of a complex for municipal solid waste treatment with a system for collecting and utilizing landfill gas and generating electricity	1,125,472.1	22,140.0	123,567.0	51,000	2017-2020
2.	Ensuring efficient solid waste management	10,678.8	-	-	6,245.2	2020-2030
	Total	**1,136,150.9**	**22,140.0**	**123,567.0**	**57,245.2**	-

5.2.7. Informational, educational and organizational measures within SECAP

To achieve the planned reduction in the level of consumption of energy resources, and therefore to reduce CO_2 emissions in the city, it is necessary to develop a set of measures aimed at changing the public awareness on the rational use of energy resources in all the studied sectors for which the baseline emission inventory was calculated. At the same time, it is seen that for the introduction of information and educational measures, the municipal and residential buildings sector should be a priority.

A significant amount of research shows that only by changing the consumer's behaviour, their careful attitude to the use of energy resources, a reduction of resource consumption by at least 10% can be achieved.

In addition to reducing the consumption of fuel and energy resources, a complex of informational and educational measures should also be aimed at solving other problematic issues of the city's measures Namely, they are: improving the discipline of payments for municipal enterprises, attracting co-owners of apartment buildings to co-financing capital repairs, introducing energy efficiency measures in their homes, providing a culture of treatment of solid waste (separate garbage collection), and so on. Particular attention should be paid to appropriate work with children and young people in educational institutions of the city.

Regarding the possible tools to ensure those information and educational measures, first of all, we should pay attention to the mandatory tool, the use of which is expressly provided for in the Covenant of Mayors, namely the Sustainable Energy Days. The Sustainable Energy Days in a city are proposed by the Covenant of Mayors as a means of a kind of "mobilization" for several days of city residents, politicians, and representatives of business, public organizations, and other interested parties to think together about the prospects of production and consumption of energy, both in the city and in the world. The purpose of the days is, above all, to raise the information awareness level of the urban community about modern ways of more efficient energy consumption, the use of renewable energy sources and countering global climate change in line with common European policies. At the same time, the Sustainable Energy Days provide cities with a unique opportunity to bring the main key ideas and measures of the sustainable energy development and climate plan to almost all interested parties, from executive authorities to ordinary citizens.

The indicative list of measures of the Sustainable Energy Days is wide enough

and may include, but is not limited to the following areas:

1. Demonstration measures:

- Doors Open Days in the municipal and industrial enterprises of the city, in public establishments and private houses, where modern energy efficient technologies, equipment and materials are applied.

- exhibitions, trade fairs and technology festivals (best performance reviews) with the participation of manufacturers of energy-efficient equipment and materials, enterprises engaged in the design or construction of buildings with low energy consumption.

- festival of films on the subject of environmental issues, global climate change, as well as on economic energy use. Displaying of thematic videos in crowded places on promotional video sites.

2. Educational measures:

- conferences, seminars, discussion forums and round tables.

- organization of educational games and training for various target groups on the economical use of energy resources and climate change.

- presentation of school curricula for energy saving and climate protection, relevant teaching materials.

- conducting school buildings together with students of energy audits (collecting data on energy, identifying places and ways of unproductive energy losses, working out recommendations for their reduction and use, practical implementation of low-cost or organizational energy saving measures).

- student performances with presentations of the results of their own research on energy efficiency, the use of renewable and alternative energy sources, and the like.

3. Cultural mearures:

- concerts of famous singers, musical groups and orchestras under the appropriate slogans, thematic press conferences with musicians and artists.

- competitions for the best drawing, photography, literary work, handicraft, dance, related to the subject of energy efficiency and climate protection in schools and kindergartens.

- organizing quizzes for children and adults with questions on energy efficiency and climate protection.

4. Sports measures

- family sports competitions with the participation of famous athletes in the role of judges and fans.

- Bicycles and roller skating racings, called “Clean air”.

5. Formal measures:

- solemn opening and closing ceremonies of the Sustainable Energy Days.

- solemn awarding of winners of contests and competitions.

A mandatory element of the Sustainable Energy Days is the preparation and wide dissemination of information materials on energy-saving topics.

Informational materials should be aimed at the shaping of a careful attitude to energy consumption among city residents, promoting awareness to make rational decisions when introducing energy-saving measures in everyday life or buying household appliances of the appropriate energy efficiency class.

Corresponding informational materials can be both of individual use (intended to students, distributed among residents of multi-family and private houses), and also in the form of external social advertising

Annual Sustainable Energy Days will allow to reduce CO_2 emissions

– *by 5,919.4 tons/year in the residential sector.*

– *by 2,748,6 tons/year in the tertiary sector*

– *by 340.0 t/year in the municipal buildings sector.*

In total, reduction in CO_2 emissions is expected to be 9,008 tons/year.

5.2.7.1. Introduction of educational courses/programs in educational institutions

In the Ukrainian cities, there is already gained experience in implementing educational projects for environmental and energy efficient subject. Such projects were supported as international - both donors (USAID, GIZ), and business. Kharkiv also has a positive experience in this direction within the framework of cooperation with projects GIZ. The measure proposes the introduction of an integrated approach to the inclusion in the educational process of general education and pre-school educational institutions of courses and programs aimed at environmental education and the formation in children and young people of a careful attitude to the consumption of energy resources.

In general education institutions, such courses and programs can be introduced in the form of elective classes, extra-curricular lessons, and the like. In addition, it is proposed to conduct a discussion of the problems of energy and resource efficiency in the lessons of physics, chemistry, geography, natural science, and others.

It is possible to organize research and analysis by students of the consumption of energy resources at school in order to involve them in the recording of energy consumption indicators shown by meters. An acquaintance of students with the basic engineering systems of the school building to which it receives various types of energy. Conducting various competitions on economical energy use (for example, “prepare your class for the winter”), other competitive activities between students on topics related to energy efficiency: contests, quests, brain-rings, etc. Organization of study tours about facilities and enterprises producing various types of energy.

The introduction of educational courses/programs in educational institutions will reduce CO_2 emissions:

by 1,290.3 t/year in the sector of municipal buildings

5.2.7.2. Conducting information and educational work among the city’s population on energy efficiency issues

An important factor in reducing the amount of energy consumption in the city and ensuring the further rational use of energy resources is a change in the consciousness of city residents.

Among the main problems hindering the introduction of energy-efficient measures in the residential sector are the following:

- insufficient awareness of city residents about the state of the energy sector and dangerous trends in its development for the near term.
- insufficient level of self-organization of residents at the level of their own homes.
- significant investments are needed to conduct a comprehensive thermal modernization of residential buildings.

The proposed measures to implement them in the residential sector are:

- conducting awareness campaigns among residents of the city, dissemination of information through the local media (television, radio, print media), printed manuals, and popular social networks
- assistance to the formation of an effective owner institution with regard to apartment buildings in the city, including by creating condominiums.
- providing incentives for co-owners of apartment buildings to introduce energy-saving and energy-efficient measures in buildings. Training of members of the co-owners initiative groups on the implementation of energy-efficient measures in apartment buildings.

- ensuring attraction for financing the measures on the energy efficiency of own funds belonging to co-owners of multi-apartment buildings, loans, including from the energy efficiency fund and other sources of financing.

- introduction in the city of measures carried out by energy efficiency consulting centers, which can provide advice on the use in the home of energy-saving household appliances. Conducting explanatory work among city residents on current regulatory and legal acts, state building norms and standards aimed at Energy efficiency improvment buildings. Provide information on best practices in the field of energy saving for the residential sector, helping in general to increase the technical awareness of city residents.

- support of residents from the city authorities in the implementation of energy efficiency projects.

Conducting awareness-raising work among the city's population on energy efficiency issues will reduce CO_2 emissions:

At 53,160.4 tons/year in the residential sector.

5.2.7.3. Effectiveness evaluation for the implementation of information-educational and organizational measures for SECAP

Table 5.2.7.4.1

Summary information on the evaluation of the effectiveness of awareness-raising and organizational measures for SECAP

No.	Measure name	Investment	FER saved	Emission reduction	Implementation dates
		thous. UAH	MWh/year	tons of CO_2 /year	years
1.	Annual Sustainable Energy Days, *including reduction of CO_2 emission by sectors:*	2,290.0	23,656.30	8,667.00	2020-2030
1.1.	*Residential buildings*	1,590.0	*17854.6*	*5919.4*	-
1.2.	*Tretiary sector*	250.0	*8290.6*	*2748.6*	-
1.3.	*Municipal buildings*	450.0	*1025.5*	*340.0*	-
2.	Introduction of educational courses/programs in educational institutions, *including reduction of CO_2 emission by sectors:*	1,345.2	3,891.80	1,290.3	2020-2030
3.	Conducting information and educational work among the city's population on energy efficiency issues	6,400.0	160,347.0	53,160.4	2020-2030
	Total	**10,035.2**	**187,895.1**	**63,117.7**	**-**

5.3. Prospects and directions for the use of unconventional and renewable energy sources

Apart from the comprehensive development and application of energy-saving technologies, equipment, materials and energy-efficient production, another important issue in the complex of energy saving measures should be an increase in the share of renewable and non-traditional (alternative) energy sources for modern energy in the city's fuel and energy balance.

Despite the considerable potential of many types of renewable energy sources (unconventional and renewable energy sources) in Ukraine, as well as a significant number of adopted legal acts, the share of renewable energy sources in the country's energy balance in 2017 was only 4.4% according to the state statistics service of Ukraine.

The perspectives of using renewable and alternative energy in Kharkiv are considered within the framework of the sustainable energy and climate plan of actions.

One of these promising sources of energy is the energy of the sun.

The potential for the development of solar energy primarily depends on the level of solar insolation and the number of sunny days in the region.

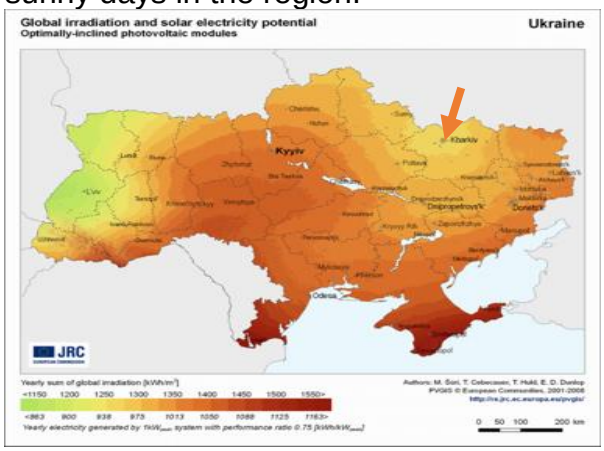


Figure 5.4.1. Solar activity map in Ukraine

As seen from fig 5.3.1 and table 5.3.1 Kharkiv region and Kharkiv is on the 10th place among the regions of Ukraine in terms of insolation. It means that it has a sufficient level of solar radiation, it allows considering the possibility of implementing projects using solar energy as a source.

Table 5.3.1

Insolation in cities of Ukraine, kWh/m^2/day

City	Month												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Simferopol	1.27	2.06	3.05	4.30	5.44	5.84	6.20	5.34	4.07	2.67	1.55	1.07	3.58
Mykolaiv	1.25	2.10	3.07	4.38	5.65	5.85	6.03	5.34	3.93	2.52	1.36	1.04	3.55
Odesa	1.25	2.11	3.08	4.38	5.65	5.85	6.04	5.33	3.93	2.52	1.36	1.04	3.55
Kherson	1.30	2.13	3.08	4.36	5.68	5.76	6.00	5.29	4.00	2.57	1.36	1.04	3.55
Zaporizhzhia	1.21	2.00	2.91	4.20	5.62	5.72	5.88	5.18	3.87	2.44	1.25	0.95	3.44
Dnipro	1.21	1.99	2.98	4.05	5.55	5.57	5.70	5.08	3.66	2.27	1.20	0.96	3.36
Donetsk	1.21	1.99	2.94	4.04	5.48	5.55	5.66	5.09	3.67	2.24	1.23	0.96	3.34
Luhansk	1.23	2.06	3.05	4.05	5.46	5.57	5.65	4.99	3.62	2.23	1.26	0.93	3.34
Kirovohrad	1.20	1.95	2.96	4.07	5.47	5.49	5.57	4.92	3.57	2.24	1.14	0.96	3.30
Kharkiv	**1.19**	**2.02**	**3.05**	**3.92**	**5.38**	**5.46**	**5.56**	**4.88**	**3.49**	**2.10**	**1.19**	**0.90**	**3.26**
Poltava	1.18	1.96	3.05	4.00	5.40	5.44	5.51	4.87	3.42	2.11	1.15	0.91	3.25
Cherkasy	1.15	1.91	2.94	3.99	5.44	5.46	5.54	4.87	3.40	2.13	1.09	0.91	3.24

Uzhhorod	1.13	1.91	3.01	4.03	5.01	5.31	5.25	4.82	3.33	2.02	1.19	0.88	3.16
Sumy	1.13	1.93	3.05	3.98	5.27	5.32	5.38	4.67	3.19	1.98	1.10	0.86	3.16
Vinnytsia	1.07	1.89	2.94	3.92	5.19	5.30	5.16	4.68	3.21	1.97	1.10	0.90	3.11
Kyiv	1.07	1.87	2.95	3.96	5.25	5.22	5.25	4.67	3.12	1.94	1.02	0.86	3.10
Khmelnytskyi	1.09	1.86	2.87	3.85	5.08	5.21	5.04	4.58	3.14	1.98	1.10	0.87	3.06
Zhytomyr	1.01	1.82	2.87	3.88	5.16	5.19	5.04	4.66	3.06	1.87	1.04	0.83	3.04
Chernihiv	0.99	1.80	2.92	3.96	5.17	5.19	5.12	4.54	3.00	1.86	0.98	0.75	3.03
Rivne	1.01	1.81	2.83	3.87	5.08	5.17	4.98	4.58	3.02	1.87	1.04	0.81	3.01
Lutsk	1.02	1.77	2.83	3.91	5.05	5.08	4.94	4.55	3.01	1.83	1.05	0.79	2.99
Ternopil	1.09	1.86	2.85	3.85	4.84	5.00	4.93	4.51	3.08	1.91	1.09	0.85	2.99
Ivano-Frankivsk	1.19	1.93	2.84	3.68	4.54	4.75	4.76	4.40	3.06	2.00	1.20	0.94	2.94
Chernivtsi	1.19	1.93	2.84	3.68	4.54	4.75	4.76	4.40	3.06	2.00	1.20	0.94	2.94
Lviv	1.08	1.83	2.82	3.78	4.67	4.83	4.83	4.45	3.00	1.85	1.06	0.83	2.92

Wind power has considerable potential among existing non-conventional and renewable energy sources. An important factor when choosing the location of wind turbines is to take into account the wind characteristics of terrain. Wind installations application for the production of electricity on an industrial scale is most effective in the regions of Ukraine, where the average annual wind speed reaches> 3 m/s, *(Figure 5.3.2).*

The average and maximum wind speed in the Kharkiv region is given in figure*. 5.3.3*.

Figure 5.3.2 Average wind speed map in Ukraine

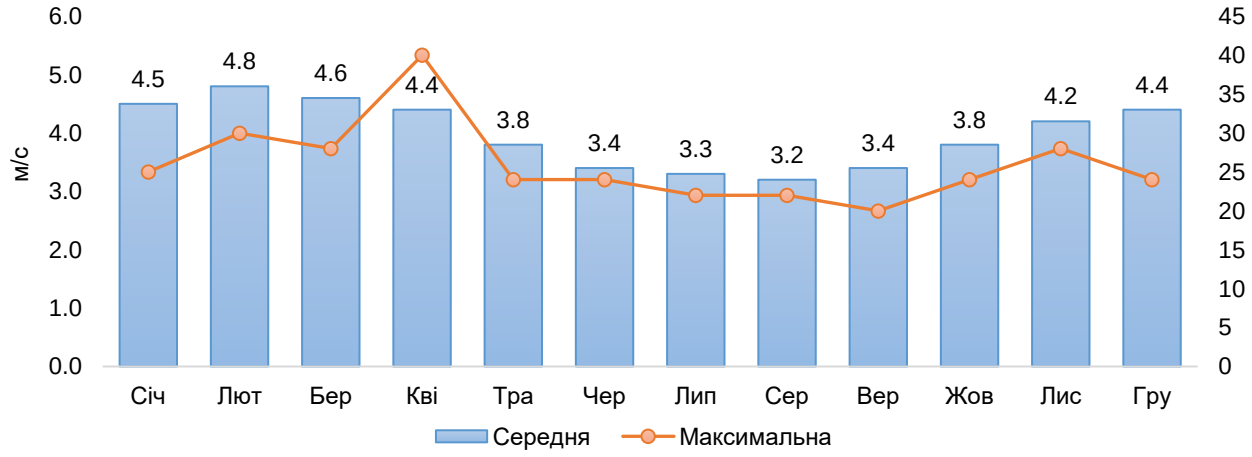


Figure 5.3.3 Wind speed map in Kharkiv region m/s

Analysis of world experience in the energy industry, including recommendations included in the provisions of Directive 2012/27/CE of the European Parliament and the Council dated October 25, 2012, on energy

efficiency indicate that for modern conditions, one of the priorities is the development and implementation of highly efficient cogeneration, i.e. joint combined heat and power generation. This approach allows saving primary energy in comparison with the separate heat and electricity generation, as well as reducing greenhouse gas emissions, and contributing to the sustainable energy development of the city.

Given the prospects of this trend in the city, it is planned to implement projects for the construction of cogeneration plants.

One of the solutions to the problem of stable heat and hot water supply in Kharkiv can also be the used by low-potential energy of natural and man-made origin through the introduction of energy-saving technologies based on heat pumps, which “taking” low potential heat from the soil, air, or water, convert it into energy able to heat water for space heating and hot water.

In addition to natural sources, it is possible to use low potential waste heat of anthropogenic origin, namely, ventilation emissions, the cooling water of technological and energy equipment of enterprises, industrial and municipal wastewater, etc.

Taking into account the factors of the negative impact caused by landfill gas on the environment and its energy value, it becomes an urgent task to collect and utilize biogas at the city landfill. The construction of a complex for municipal solid waste treatment with a system for collecting and utilizing landfill gas and generating electricity was launched in Derhachi, Kharkiv region, where the urban landfill is geographically located, to solve this problematic issue.

Urban municipal enterprises have begun the process of using biomass (pellets, etc.) for the production of heat energy, which must be further developed.

Among the measures aimed at the use of solar energy are proposed to introduce a solar system to replace the heat load of the hot water system in educational institutions and health institutions of the city where there is a significant analysis of hot water during the year.

Also, the use of photovoltaics by installing autonomous lighting poles on photovoltaic modules is envisioned.

In the future, it is possible to use the roofs of buildings occupied by municipal companies for the placement of solar panels and the production of electrical energy.

As a promising direction, we can consider the construction of solar stations to supply the urban electric transport network with electric energy.

Construction of solar stations to provide the electric transport network of the city with electric power can be considered a prospective direction.

Since Kharkiv is just beginning to gradually introduce the use of renewable and alternative energy sources, the main tasks in this direction for the near future are:

- determination of reserves and resources, development and testing of efficient schemes, technologies and equipment, implementation of pilot projects.
- creation of specialized enterprises for the production of equipment, its certification, installation and service, the provision of research and design work, training of specialists;
- instructing research and development institutions and higher education institutions to develop alternative energy projects and hold competitions for financing these projects.
- use of loan funds from the EBRD, NEFCO, KfW, the World Bank, and other international financial organizations for the implementation of measures to introduce renewable and alternative energy sources.
- the attraction of private investment in the development of renewable energy.

5.4. Organizational structure

One of the basic conditions for fulfilling the obligations stipulated in the Covenant of Mayors is the adaptation and optimization of internal management structures, the provision them with qualified personnel, and the determination of key units that must be involved in both the SECAP preparation and implementation processes. The plan of actions defines only the main directions for achieving the strategic goals of reducing energy consumption, reducing CO_2 emissions, and increasing the use of renewable and non-conventional energy sources. The implementation of measures and projects provides for the coordinated work of all departments of Kharkiv City Council, municipal enterprises of the city, public organizations of the city, and other interested persons and entities.

For the successful solving of tasks within the framework of the SECAP implementation, it is necessary to ensure:

1. Formation of a permanent working group on the implementation of sustainable energy (and climate) action plan in Kharkiv until 2030 in order to coordinate the actions of all stakeholders.

The working group should include the heads of structural divisions of the city council, key persons from heat and water supply enterprises, urban public transport enterprises and other municipal municipal enterprises of the city involved in the implementation of SECAP. An individual at the level of a deputy mayor should be appointed to be responsible for the implementation of SECAP; it has authority and influence on all participants in the process.

Within its competence, the working group:

- forms the concept of municipal energy policy.
- develops and submits proposals for improving the energy management system in the city.
- submits requests and receives the necessary information on the functioning of the energy sector of the city from enterprises, organizations and institutions of all forms of ownership.
- provides for the organization of appropriate monitoring and reporting on the status of SECAP implementation.
- monitors the implementation of the necessary measures within the framework of the Plan of actions.
- informs the city public about its measures and other issues related to ensuring the plan of actions, reducing energy consumption and CO_2 emissions in the city.

2. Definition of the unit coordinating and ensuring the monitoring of the implementation of projects in accordance with the SECAP, as well as projects that may emerge in the future and ensure the reduction of energy consumption and CO_2 emissions.

Within the context of SECAP implementation, this division should ensure the following tasks:

- development and implementation of a reporting system for the energy resources consumption.
- development and implementation of a reporting system for energy efficient and environmentally friendly projects in the city.
- data monitoring on project implementation and trends in energy consumption, emissions, etc.
- coordination and tracking of the “soft measures” (advertising campaigns, exercises and the like) implementation.
- making proposals on financing projects from the city budget, as well as from extrabudgetary funds; participation in the preparation of business plans and feasibility studies.

3. Create a structure for the preparation of investment applications, feasibility studies for attracting additional financial resources and ensuring the implementation of projects within the SECAP framework.

This structure can be created in the form of a municipal company, energy or investment agency.

4. To establish close cooperation with public organizations and unions. This will allow the city to attract additional resources subject to limitations budgetary and extrabudgetary funds.

General organizational structure for SECAP implementation is shown in figure. 5.4.1.

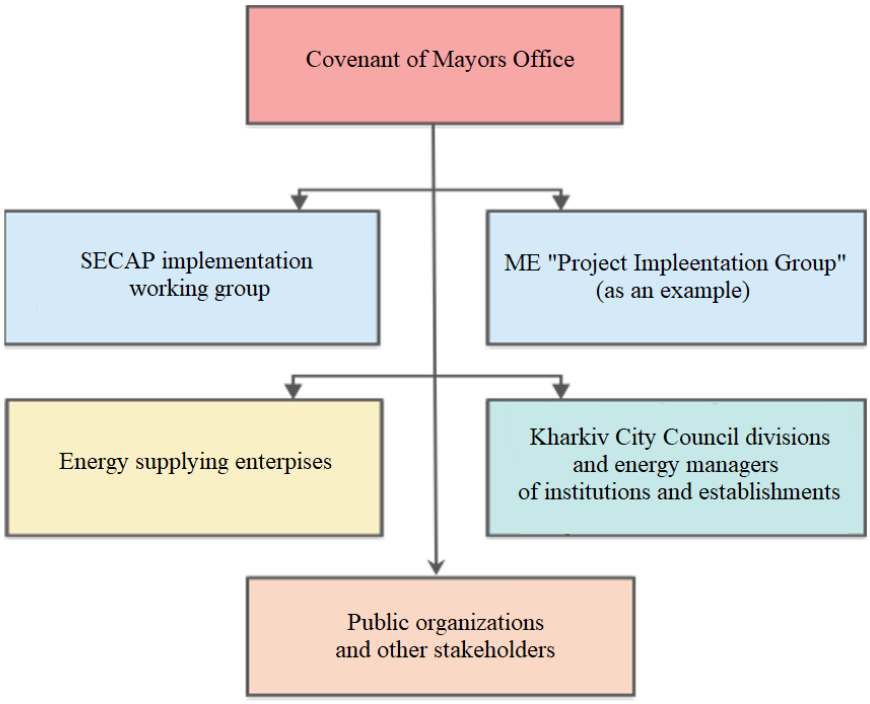


Figure 5.4.1. Organizational structure for SECAP implementation in Kharkiv

5.5. Monitoring and reporting

The organization of the SECAP implementation monitoring process is an important part of the process on fulfilling the obligations of a signatory to the Covenant of Mayors, and it allows assessing the current status of the achievement of the planned goals to perform and to take corrective measures, if necessary.

In accordance with the “Guidelines for Reporting on the Implementation of the Sustainable Energy and Climate Action Plan and Monitoring”, the following monitoring steps are envisaged:

⇒ Activity report

⇒ Full report

The activity report is submitted every two years after the adoption of the SECAP and is primarily aimed at tracking the implementation results of the measures included in the SECAP, namely, the amount of savings achieved and the reduction of CO_2 emissions;

The planned measures implementation monitoring describes the state and the problematic issues of measures implementation (obstacles and risks), as well as their impact on the achievement of the SECAP objectives.

Monitoring energy consumption and CO_2 emissions allows understanding how the city is progressing towards the achievement of the goals set in the SECAP and to determine the factors influencing the results obtained.

The full report, which is submitted 4 years after the date of SECAP adoption, provides for the preparation of a Monitoring emission inventory, in addition to the above-mentioned actions.

The deadlines for submitting reports on the implementation of the SECAP to the Office of the Covenant of Mayors are shown in Figure 5.7.1.

In order to obtain the necessary analytical information for the preparation of reports, it is necessary to set up in the

city a system of constant fuel and energy resources consumption monitoring. In general, the presence in the city of a system for constant fuel and energy resources consumption monitoring meets the tasks defined by the Covenant of Mayors and is also an important component of the energy management system.

In particular, fuel and energy resources consumption monitoring in the public sector, public lighting and by municipal enterprises should be carried out on a monthly basis. Monitoring the fuel and energy resources consumption in the transport sector must be carried out annually.

In general, the introduction of the fuel and energy monitoring system together with the energy management system will allow:

- The energy efficiency measures effectiveness to determine;
- The effective analysis of energy consumption data and the development of appropriate measures to conduct;
- Improve the system of communications and information exchange with municipal and other municipal enterprises of the city to achieve a coordinated energy policy in the city;
- Form a unified city register of projects related to energy efficiency, to conduct continuous monitoring of their implementation;
- Monitor the costs of purchasing fuel and energy resources from the city budget;
- Provide a basis for conducting awareness-raising measures aimed at changing the public's awareness on the use of fuel and energy resources, as well as explanatory work on the effectiveness of certain measures aimed at reducing the use of energy resources;
- Introduce an annual CO_2 monitoring system.

Figure 5.5.1. Deadlines for submission of reports on the implementation of the SECAP of Kharkiv

5.6. SECAP funding sources

The financial component of SECAP is crucial in the implementation of energy-efficient projects, and it is the factor in the implementation process that determines the realism of SECAP.

Therefore, in order to ensure the implementation of the SECAP in Kharkiv, the following sources of funding for the efficient use of energy resources are considered:

1. Own funds of enterprises.

Own funds of enterprises operating in the production and transportation of heat energy, water supply, urban public transport, public lighting, the tertiary sector (small and medium-sized business and the service sector) and others.

2. State target programs (state budget).

3 . City target programs (city budget).

4. Donor grants.

Usually, grants for the implementation of infrastructure investment projects are provided to cities and enterprises participating in international technical assistance projects. Since a grant is an irrevocable target financing. however, by the allocation of grant funds to finance investment projects is extremely limited and mainly aimed at financing small demonstration projects and/or conducting pre-project studies.

5. Bank loans.

Bank loans for financing both short-term projects and medium-term projects, as well as loans from international financial institutions and foreign government agencies, such as the World Bank, IFC, EBRD, EIB, KfW, NEFCO, and others (for medium-term and long-term investment projects).

6. Borrowing (bonds).

To finance their medium-term investment projects, enterprises and local authorities can attract additional financial resources in the domestic or foreign financial markets by issuing bonds.

Kharkiv already has experience in borrowing by issuing bonds to finance the development budget deficit, including for the construction and reconstruction of social and cultural facilities, objects of transport infrastructure, roads and engineering facilities on them. So, the indicated source of funding can be used to finance infrastructure projects and programs under SECAP.

7. Own funds of co-owners of apartment buildings

One of the important tasks that need to be accomplished within the framework of the SECAP implementation is to encourage co-owners of apartment buildings to finance and co-finance energy efficiency measures in their own homes.

8. *Financial Leasing.*

Financial leasing is one of the most reliable legally regulated instruments that can be used to attract funding for medium-term investment projects in the production,which are discussed within the framework of the SECAP.

9. Attracting private capital.

Attracting private capital to finance short-term, medium-term and long-term investment projects can be carried out as follows:

- by providing a deferment of payment for work performed.
- by applying the ESCO mechanism.
- through the use of public-private partnerships.

In recent years, state and local budgets have been a key and guaranteed source of financing infrastructure projects in Kharkiv.

It is obvious that the amount of funds allocated from the city budget, or which have already been attracted by the city from international financial institutions, is not enough, especially for the implementation of projects on deep thermal modernization of buildings.

Thus the focus on energy projects funding sources must be significantly biased in favour of engaging loans, grants and other sources of funding mentioned above. Municipal budget funds should be directed mainly to ensure the necessary share of co-financing energy efficiency projects.

Possible options for cooperation for the implementation of future energy efficiency projects include the following international financial institutions: NEFCO (Northern Environment Finance Corporation), UNDP (United Nations Development Program in Ukraine), IFC (International Finance Corporation), EBRD (European Bank for Reconstruction and Development), EIB (European Investment Bank, E5P - Eastern Europe Energy Efficiency and Environmental Partnership), WB (World Bank), KfW (German development bank), GIZ, USAID and others.

In the public sector, the main source of financing is loan and grant funds with the provision of co-financing from the city budget, and also the use of the ESCO mechanism.

As to residential buildings, residents' funds were added to the structure of financing sources (about 30-50% of co-financing depending on the complexity of energy-efficient measures), In addition, it is possible to attract bank loans for the implementation of measures (under the warm credit program, as well as the energy efficiency fund). For other sectors, the determining source of financing, except for credit and grant funds, is own funds.

5.6.1. Budget review of Kharkiv

Budget revenues of Kharkiv in 2017 amounted to **13,535.1 mln UAH** of these, revenues of the general fund were 7,505.6 mln UAH (55.5%), special fund – 605,0 mln UAH (3.9%), %), transfers from the state budget – 5 499,6 mln UAH (40.6%).

Compared to 2016, budget revenues increased by 3,287.4 mln UAH or by 32.1 %.

Budget expenditures of Kharkiv in 2017 amounted to **14,178.0** mln UAH (of them from the general fund – 10,412.4 mln UAH, from the special fund – 3,765.6 mln UAH.) Compared to 2016, it has increased by 4,080.4 mln UAH.

The main priority areas for spending funds from the city budget during the entire budget period were the timely financing of protected budget items: wages, energy carriers, medicines, nourishment, etc. In general, the structure of the budget expenditures of Kharkiv indicates its social orientation.

Thus, in 2017 in the socio-cultural sphere of the city, more than 60.9% of the total budget expenditures or 8,636.4 mln UAH, which is 40.6 higher than the corresponding figure in 2016 (6,141.8 mln UAH), of which 2,630.2 mln UAH (18,6%) was spent on education, 1,690.8 mln UAH (11.9%) was spent for health care, spent on social protection and social security – 3,478.1 mln UAH (24.5%), was spent on culture and art – 552.8 mln UAH (3.9%), %) was spent on physical education and sports – 284.5 mln UAH. (2.0%).

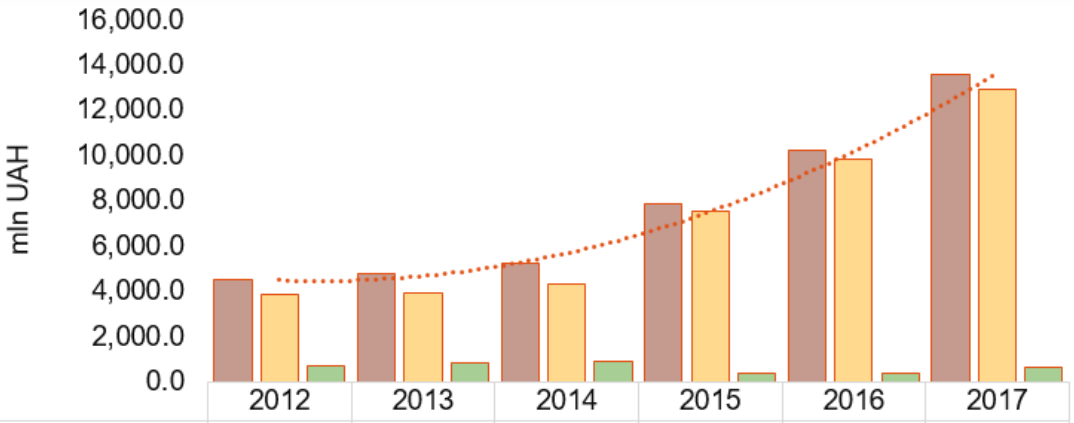
At the same time, the analysis of the revenue and expenditure parts of the Kharkiv budget shows that the city has certain financial resources for the implementation of infrastructural projects in the field of energy efficiency and energy saving.

The information on revenues and expenditures of Kharkiv in 2012-2017 is given in Table 5.6.1.1 and in Figure 5.6.1.1-5.6.1.2.

Table 5.6.1.1.

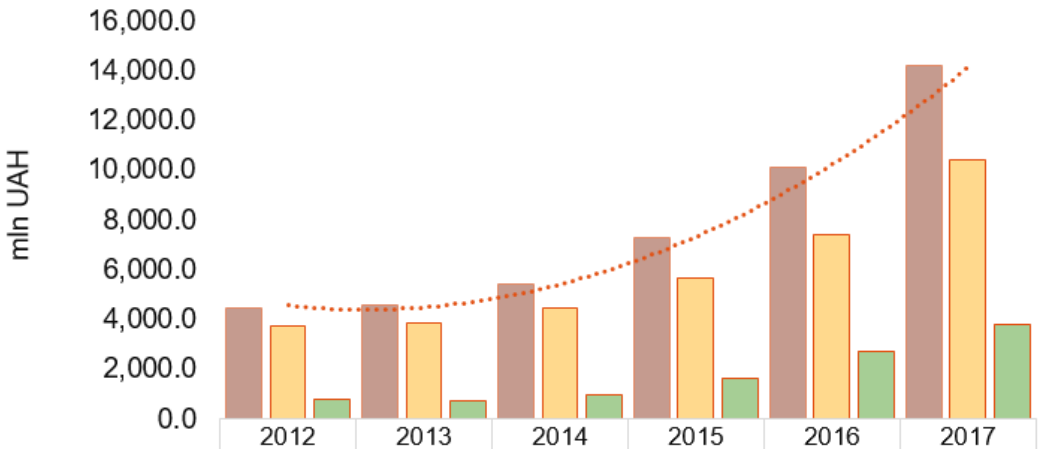
Budget revenues and expenditures of Kharkiv in 2012-2017, mln UAH

Indicator	**Years**					
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
			Budget revenues			
General fund	3,842.0	3,940.4	4,314.1	7,516.6	9,856.9	12,930.1
Special fund	689.2	824.1	883.7	346.7	390.8	605.0
Total revenues	**4,531.2**	**4,764.5**	**5,197.8**	**,7,863.3**	**10,247.7**	**13,535.1**
			Budget expenditures			
General fund	3,723.1	3,864.5	4,465.8	5,652.9	7,396.1	10,412.4
Special fund	751.6	723.5	,960.8,	,1,626.4,	2,701.5	3,765.6
Total expenditures	**4,474.7**	**4,588.0**	**5,426.6**	**,7,279.3**	**10,097.6**	**14,178.0**



	2012	2013	2014	2015	2016	2017
Total city budget revenues	4,531.2	4,764.5	5,197.8	7,863.3	10,247.7	13,535.1
General fund revenues in the city budget	3,842.0	3,940.4	4,314.1	7,516.6	9,856.9	12,930.1
Special fund revenues in the city budget	689.2	824.1	883.7	346.7	390.8	605.0

Figure 5.6.1.1 Trends in Kharkiv budget revenues in 2012-2017

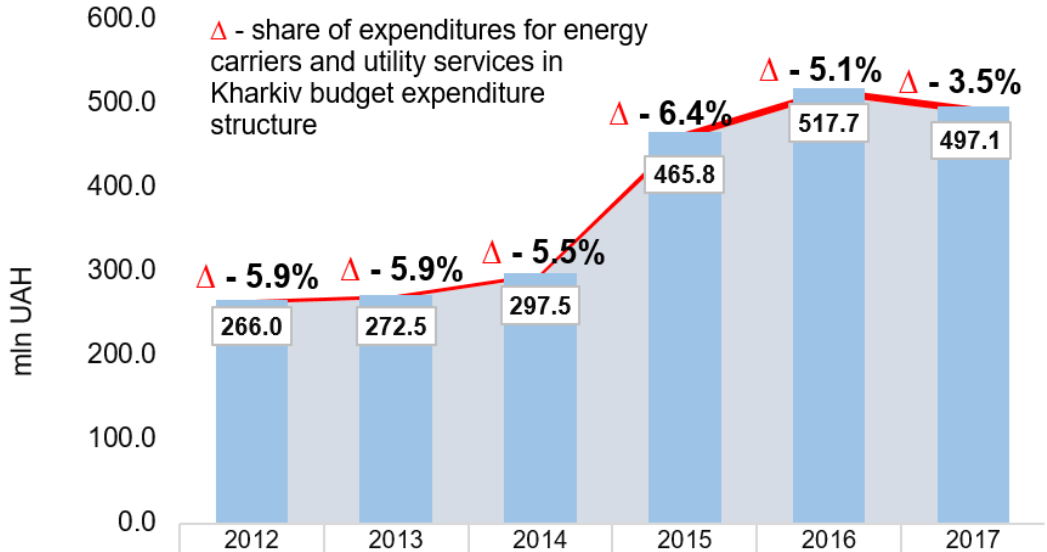


	2012	2013	2014	2015	2016	2017
Total city budget expenditures	4,474.7	4,588.0	5,426.6	7,279.3	10,097.6	14,178.0
General fund expenditures in the city budget	3,723.1	3,864.5	4,465.8	5,652.9	7,396.1	10,412.4
Special fund expenditures in the city budget	751.6	723.5	960.8	1,626.4	2,701.5	3,765.6

Figure 5.6.1.2 Trends in Kharkiv budget expenditures in 2012-2017

It should be noted that the share of energy and utility costs in the expenditure pattern of the Kharkiv municipal budget during 2012-2017 did not exceed 7%.

Since 2015, paying for energy resources has been significantly increased. This situation is mainly due to the increase in energy tariffs. The trends in the amounts of paying for energy and the share of energy and utility expenditure in the Kharkiv municipal budget pattern in 2012-2017 are shown in Figure 5.6.1.3.



	2012	2013	2014	2015	2016	2017
Обсяг видатків по спеціальному фонду міського бюджету	3.9	4.3	4.0	7.7	8.2	9.9
Обсяг видатків по загальному фонду міського бюджету	262.1	268.2	293.6	458.2	509.5	487.2
Загальний обсяг видатків	266.0	272.5	297.5	465.8	517.7	497.1

Figure 5.6.1.3. Trends in expenditures on energy carriers from Kharkiv budget in 2012-2016.

The detailed information on expenditures on energy carriers and utility services from the city budget is given in appendix 16.

5.6.2. Calculation of investment for Kharkiv SECAP implementation

The planned amount of funds to be directed to implementation of energy-efficient projects in the selected SEAP sectors is **49.1 billion UAH.**

The detailed information on the amount of the investments needed with a breakdown by sectors is given in Table 5.6.2.1. The schedule of financing measures by sectors for the period from 2019 till 2030 is given in Table 5.6.2.2.

Table 5.6.2.1

Investment needed for implementation of energy saving measures in Kharkiv to fulfil SEAP obligations till 2030

	Sector	Investment, thous. UAH	% Total
1.	Municipal buildings, equipment/facilities, including:		
1.1.	*Municipal buildings*	5,311,783.5	*10.8*
1.2.	*Municipal equipment/facilities*	8,451,947.5	*17.2*
2.	Residential buildings	15,268,239.3	*31.1*
3.	Municipal public lighting	822,890.0	*1.7*
4.	Transport	14,743,528.9	*30.0*
5.	Tertiary sector (small and medium business, service sector)	3,367,400.8	*6.9*
6.	Municipal Solid Waste managment	1,136,150.9	*2.3*
	Total	**49,101,940.8**	

Table 5.6.2.2

Financing schedule for SECAP measures by sectors for the period from 2018 till 2030 **(thous. UAH)**

	Sectors	2019	2020	2021	2022	2023	2024
1.	**Municipal buildings, equipment/facilities, including:**	748.233.5	1.303.856.4	1.295.144.1	1.220.726.1	1.205.647.1	1.144.525.1
1.1.	*Municipal buildings*	21.825.8	300.151.5	430.255.7	420.092.1	536.635.4	475.513.3
1.1.1.	Programs “Energy efficiency improvement of educational institutions”	10.083.4	142.865.3	270.362.3	290.012.9	423.418.6	359.300.0
1.1.2.	Energy efficiency improvement of healthcare facilities	8.865.4	103.569.9	105.742.8	106.039.9	108.213.1	110.536.9
1.1.3.	Programs “Energy efficiency improvment in cultural institutions”	2.877.0	53.716.3	54.150.6	24.039.3	5.003.7	5.676.4
1.2.	*Municipal equipment/facilities*	726.407.7	1.003.704.8	864.888.4	800.634.1	669.011.8	669.011.8
1.2.1.	Modernization of heat system	576.407.7	576.407.7	437.591.2	292.136.9	160.514.6	160.514.6
1.2.2.	Modernization of water supply/water disposal	150.000.0	427.297.1	427.297.1	508.497.1	508.497.1	508.497.1
2.	**Residential buildings**	529.357.0	672.347.1	1.164.371.0	1.222.224.5	1.300.532.5	1.317.476.9
3.	**Municipal public lighting**	16.457.8	49.373.4	65.831.2	65.831.2	65.831.2	82.289.0
4.	**Transport**	400.499.8	4.027.293.5	3.351.573.5	2.992.773.5	1.712.423.5	1.536.973.5
5.	**Tertiary sector (small and medium business, service sector)**	120.000.0	295.218.3	295.218.3	295.218.3	295.218.3	295.218.3
6.	**Municipal solid waste managment**	562.736.1	564.515.9	1.779.8	1.779.8	1.779.8	508.5
	Total	**2.377.284.1**	**6.912.604.5**	**6.173.917.8**	**5.798.553.4**	**4.581.432.4**	**4.376.991.2**

Table 5.6.2.2 (continuation)

	Sectors	2025	2026	2027	2028	2029	2030	Всього
1.	**Municipal buildings, equipment/facilities, including:**	1,529,143.3	1,409,969.1	936,982.0	1,066,698.0	993,950.4	908,855.9	13,763,731.0
1.1.	*Municipal buildings*	436,668.1	478,008.6	513,518.7	643,234.7	570,487.1	485,392.6	5,311,783.5
1.1.1.	Programs “Energy efficiency improvement of educational institutions”	317,759.6	355,254.1	387,918.4	514,786.6	437,694.6	352,927.4	3,862,383.1
1.1.2.	Energy efficiency improvement of healthcare facilities	112,559.5	115,732.7	117,905.8	120,079.0	124,425.4	123,425.4	1,257,095.9
1.1.3.	Programs “Energy efficiency improvment in cultural institutions”	6,349.1	7,021.8	7,694.4	8,369.0	8,367.1	9,039.8	192,304.5
1.2.	*Municipal equipment/facilities*	1,092,475.1	931,960.5	423,463.4	423,463.4	423,463.4	423,463.4	8,451,947.5
1.2.1.	Modernization of heat system	583,978.0	423,463.4	423,463.4	423,463.4	423,463.4	423,463.4	4,904,867.5
1.2.2.	Modernization of water supply/water disposal	508,497.1	508,497.1	0.0	0.0	0.0	0.0	3,547,080.0
2.	**Residential buildings**	1,375,330.3	1,433,183.8	1,491,037.2	1,548,890.8	1,606,744.1	1,606,744.1	15,268,239.3
3.	**Municipal public lighting**	82,289.0	82,289.0	82,289.0	82,289.0	74,060.1	74,060.1	822,890.0
4.	**Transport**	413,173.5	66,363.7	61,363.7	60,363.7	60,363.7	60,363.2	14,743,528.9
5.	**Tertiary sector (small and medium business, service sector)**	295,218.3	295,218.3	295,218.3	295,218.3	295,218.3	295,218.3	3,367,400.8
6.	**Municipal solid waste managment**	508.5	508.5	508.5	508.5	508.5	508.5	1,136,150.9
	Total	**3,695,662.9**	**3,287,532.3**	**2,867,398.7**	**3,053,968.3**	**3,030,845.1**	**2,945,750.1**	**49,101,940.8**

KHARKIV

APPENDICES

Appendix 1. Geographical location and climatic conditions

Table 1

Average monthly air temperature in Kharkiv 2012-2017 (°C)

Months	Years					
	2012	2013	2014	2015	2016	2017
January	-4.7	-3.5	-6.9	-2.9	-7.2	-5.8
February	-10.2	-1.2	-2.0	-2.5	+1.0	-4.0
March	-0.5	-0.8	+5.2	+3.3	+3.5	+5.0
April	+13.8	+11.4	+9.4	+9.1	+12.1	+8.9
May	+19.8	+20.4	+18.9	+16.1	+15.6	+14.6
June	+21.8	+22.2	+18.4	+21.4	+20.2	+19.6
July	+24.7	+21.2	+22.5	+21.4	+22.7	+21.5
August	+21.9	+21.0	+22.1	+21.6	+22.2	+23.5
September	+16.7	+12.2	+15.4	+18.7	+14.0	+17.1
October	+10.9	+8.0	+6.2	+5.8	+6.2	+8.1
November	+3.7	+5.2	+0.5	+4.0	+0.4	+2.2
December	-4.8	-1.8	-2.7	+0.3	-4.6	+2.9

Table 2

Main climatic indicators of Kharkiv

Indicator	January	February	March	April	May	June	July	August	September	October	November	December	Year
Air temperature													
Absolute maximum, °C	11.2	14.6	21.8	30.5	34.5	36.8	38.8	39.8	34.5	29.3	20.3	13.4	39.8
Absolute minimum, °C	−35.6	−35.0	−32.2	−13.1	−6	−1.1	5.7	1.2	−4.8	−18.1	−22.6	−31.4	−35.6
Average temperature, °C	−4.6	−4.5	0.7	9.2	15.6	19.3	21.3	20.3	14.4	7.9	0.9	−3.5	8.1
Warmest and coldest months													
Absolute maximum, °C	0.6	2.0	5.3	13.7	20.4	23.7	25.8	26.1	19.0	12.0	7.9	2.9	13.2
Absolute maximum	-16.2	-16.6	-7.9	1.6	10.1	14.7	16.6	15.9	10.0	1.0	-7.6	-11.1	0.9
Air humidity													
Air humidity, %	86	83	77	66	61	65	65	63	70	78	86	87	74
Precipitation													
Precipitation rate, mm	36	33	33	34	50	61	61	43	45	45	40	36	516
Daily maximum, mm	35	27	37	46	57	68	83	77	56	67	41	34	83
Monthly minimum, mm	1.0	0.0	2.0	0.0	1.0	1.0	3.0	0.0	0.0	0.0	1.0	3.0	279
Monthly maximum, mm	127	101	152	113	148	144	239	203	151	134	165	132	898
Number of rainy days	15	12	11	10	10	10	10	7	9	8	13	17	132
Wind speed													
The average wind speed, m/s	4.3	4.5	4.6	4.2	3.7	3.5	3.3	3.2	3.5	3.8	4.1	4.3	3.9

Appendix 2. Population of Kharkiv

Table 1

Distribution of resident population by gender and age as of January 1, 2018, people

Indicator name	Gender		
	Men	Women	Total
Younger than working age (0-15 years old)	98,957	93,614	192,571
Working age (16-59 years old)	451,522	467,983	919,505
Older than working age (60 and older)	111,006	207,433	318,439
Total	**661,485**	**769,030**	**1,430,515**

Appendix 3. Economic Potential Evaluation of Kharkiv

Table 1

Main indicators of Kharkiv socio-economic development in 2012 - 2017

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Industry and business							
Volume of industrial products sold (goods, services)	Billion UAH	34.1	34.9	40.0	52.8	61.0	73.1
Volume of products sold by small and medium enterprises	Billion UAH	-	-	87.5	127.8	157.8	196.2
Number of small enterprises per 10,000 people	Unit	131	137	129	129	132	115
Number of employees in small enterprises	Thousand people	100.7	99.1	88.5	82.8	83.0	86.6
Employment, unemployment and incomes							
Average monthly salary per employee, nominal	UAH	2,753	3,096	3,270	3,840	4,605	6,427
Number of registered unemployed at the end of the period (according to the state employment service)	Persons	3,548	-	-	-	5,581	4,878
The need of employers (enterprises, institutions, organizations and individual entrepreneurs) for employees to fill vacancies at the end of the period	Persons	-	-	-	1,822	2,502	3,072
Transport							
Freight turnover	Million tkm	-	-	-	-	1,958.2	2,862.0
Passenger traffic	Million pass. km	-	-	-	-	819.6	823.9
Construction and reconstruction of the roads	Million UAH	-	78.4	34.4	127.7	142.0	185.9
Building							
Completed construction of housing	Thousand sq. m		241.1	195.4	245.5	366.6	373.1
Foreign economic activity							
Export of goods	Million US dollars	2,022.1	1,699.6	1,409	907.7	669.2	760.7
Import of goods	Million US dollars	2,741	1,585.1	1,128.6	807.9	889.9	978.6
Investment measures							
The volume of foreign direct investment (equity) at the beginning of the year	Million US dollars	2,444.9	1,730.3	1,654.2	1,426.3	1,310.4	407.8

Appendix 4. Characteristics of Kharkiv municipal heat supply system

Table 1

Heating season duration (2012-2017)

Heating season, years	Start	End	Duration, days	Average air temperature during the heating period, °C
2011–2012	15.10.2011	09.04.2012	177	-1.5
2012–2013	15.10.2012	15.04.2013	182	-0.4
2013–2014	04.10.2013	14.04.2014	192	1.5
2014–2015	23.10.2014	14.04.2015	173	-0.2
2015–2016	12.10.2011	05.04.2012	176	0.9
2016–2017	15.10.2016	02.04.2017	170	-1.3

Table 2

Heat generation, losses and useful output in Kharkiv in 2012-2017, Gcal

Parameter name	Years					
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Heat production	7,414,905	7,225,382	6,608,490	6,319,376	6,710,156	6,456,691
- including CHP-5	1,706,340	1,838,452	1,779,112	1,687,067	1,785,949	1,608,348
Expenditures for own process needs	72,742	68,408	58,173	47,742	55,722	49,762
Annual heat output	7,342,163	7,156,974	6,550,317	6,271,634	6,654,434	6,406,929
Expenses for own economic and domestic needs of the enterprise	21,297	19,858	18,902	18,547	20,625	17,995
Network losses	1,154,937	1,149,133	1,028,184	981,263	1,030,413	1,006,463
Useful heat output, including:	6,165,929	5,987,983	5,503,231	5,271,824	5,603,396	5,382,470
- for heating	4,244,716	3,993,841	3,893,826	3,538,685	3,710,314	3,433,739
- for hot water supply	1,921,213	1,994,142	1,609,406	1,733,139	1,893,082	1,948,731

Table 3

Distribution of heat energy consumption by consumer categoriesin Kharkiv in 2012 – 2017, gcal

Parameter name	Years					
	2012	2013	2014	2015	2016	2017
Useful heat output, total, including:	6,165,929	5,987,983	5,503,231	5,271,824	5,603,396	5,382,470
For heating, TOTAL, including:	**4,244,716**	**3,993,840**	**3,893,826**	**3,538,685**	**3,710,314**	**3,433,739**
Population	3,441,239	3,249,844	3,209,488	2,931,686	3,064,075	2,815,970
State-financed organisations, including:	531,198	508,647	464,390	428,032	455,112	438,038
- *state budget*	218,180	200,944	182,949	159,592	172,648	164,832
- *regional budget*	68,232	69,986	63,551	59,417	50,654	45,521
- *district budget*	182,230	178,455	163,635	155,997	178,267	173,560
- *local budget*	62,556	59,262	54,255	53,027	53,543	54,125
Industry	68,451	27,297	24,918	55,288	53,661	23,949
Other consumers	203,829	208,052	195,030	123,679	137,466	155,782
HWS, total, including:	**1,921,213**	**1,994,142**	**1,609,406**	**1,733,139**	**1,893,082**	**1,948,731**
Population	1,851,592	1,924,064	1,547,769	1,674,222	1,820,226	1,830,599
State-financed organisations, including:	59,644	60,115	53,746	52,378	50,075	52,132
- *state budget*	17,930	16,242	13,974	12,716	12,798	12,797
- *regional budget*	16,189	17,393	15,412	15,656	13,971	14,248
- *district budget*	13,640	13,297	12,966	12,528	12,766	13,765
- *local budget*	11,885	13,183	11,394	11,477	10,540	11,322
Industry	5,195	4,734	4,153	4,277	6,528	34,422
Other consumers	4,782	5,229	3,737	2,262	16,252	31,578

Appendix 5. Characteristics of Kharkiv gas supply system

Table 1

Main technical and operational parameters of the gas supply system in Kharkiv

Indicator	Measurement unit	Years					
		2012	**2013**	**2014**	**2015**	**2016**	**2017**
		226	227	225	225	225	225
Length of high pressure gas pipelines	km	751	761	767	778	782	791
Length of medium pressure gas pipelines	km	4,195	4,220	4,242	4,266	4,279	4,285
Length of low pressure gas pipelines	km	2,055	2,005	1,999	1,891	1,728	1,685
Average number of employees	Persons	303	303	300	299	315	315
GDS number	Unit	1,512	1,550	1,603	1,687	1,920	2,015
Number of cabinet-type GDSs	Unit	524	548	538	546	546	546
Number of cathodic protection stations on gas pipeline networks	Unit	35	36	36	36	37	37
Number of ground protection units	Unit	486,101	487,847	488,826	489,912	491,286	493,001
Number of residential consumers with natural piped gas supply.	Unit	3,402	3,349	3,364	3,362	**0*,**	**0***
Number of utility enterprises with piped gas supply	Unit	831	853	866	874	4,221	4,351
Number of gasified industrial enterprises	Unit	506,027	507,665	509,086	509,883	510,587	511,112

*** Note:** Chanmged over to the group of industrial enterprises.

Table 2

Technical expenitures in networks and expenitures on technological issues, thous. m^3

Indicator	**Years**					
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Technical expenitures in networks	14,000.4	12,362.6	23,324.4	20,511.5	20,685.4*	20,237.2*
Expenitures on technological issues	229.1	398.2	606.8	158.1		

Note: Information in 2016-2017 is only available in a summary form.

Table 3

Information on natural gas consumption by major consumer groups in Kharkiv in 2012–2017, thous. m^3

Gas consumers	Years					
	2012	2013	2014	2015	2016	2017
Total for heat supply enterprises of all, incl.:	***974,192***	***943,298***	***860,531***	***817,084***	***952,284***	***936,267***
Municipal heat and power supply enterprises	946,512	915,034	832,572	790,966	932,001	916,157
Other heat supply enterprises	27,680	28,264	27,959	26,118	20,283	20,110
All budget sphere, including:	***10,745***	***10,421***	***9,032***	***6,979***	***6,988***	***6,881***
- state	*9,136*	*9,077*	*7,734*	*5,626*	*5,860*	*5,816*
- regional	*623*	*584*	*584*	*612*	*450*	*421*
- local	*680*	*453*	*471*	*513*	*436*	*412*
- district	*306*	*306*	*243*	*228*	*242*	*232*
Population, total, incl.:	***301,038***	***296,839***	***279,361***	***225,610***	***219,026***	***218,053***
Consumption for cooking (gas stoves)	90,441	102,999	87,308	61,905	61,927	61,850
Gas consumption for cooking and hot water heating	21,166	20,486	20,584	20,530	20,521	20,525
Integrated gas consumption, incl. for heating	189,432	173,354	171,470	143,174	136,578	135,678
Industrial enterprises and other consumers	***519,138***	***460,335***	***427,556***	***382,612***	***208,151***	***200,102***
Total gas consumption by the city	***1,805,113***	***1,710,894***	***1,576,480***	***1,432,284***	***1,386,448***	***1,361,303***

Appendix 6. Characteristics of Kharkiv power supply system

Table 1

Main technical and operational parameters of the Kharkiv power supply system

Indicator	Years					
	2012	2013	2014	2015	2016	2017
Number of transformer substations:						
- 110 kV	30	30	30	30	30	30
- 35 kV	1	1	1	1	1	1
- 6-10 kV	2,165	2,210	2,231	2,248	2,241	2,243
Number of distribution points						
- 6-10 kV	208	213	217	220	222	228
Length of power lines:						
- 10 kV, km	892.78	903.98	926.26	940.07	930.38	934.43
- 6 kV, km	3,176.82	3,127.39	3,180.42	3,204.03	3,212.88	3,223.12

Table 2

Expenitures in electricity consumption in Kharkiv in 2012-2016, MWh

Indicator	Years					
	2012	2013	2014	2015	2016	2017
Actual expenitures in electricity transmission and distribution	507.58	465.11	419.53	408.12	415.39	410.12
Fact of additional calculation on revealed violations of Rules on Electric Power Usage	10,981.73	10,587.06	10,512.06	10,629.51	10,295.80	10,314.20

Table 3

Number of consumers supplied with electric energy in Kharkiv in 2012-2017, service receivers.

Indicator	Years					
	2012	2013	2014	2015	2016	2017
Number of consumers supplied with electric energy, incl.:	583,907	587,859	593,111	597,792	601,880	606,459
- individuals	*567,000*	*570,740*	*575,659*	*580,080*	*583,749*	*588190*
- legal entities	*16,907*	*17,119*	*17,452*	*17,712*	*18,131*	*18,269*

Table 4

Electricity consumption by consumers of all categories in Kharkiv in 2012-2017, MW

Electricity consumers	Years					
	2012	2013	2014	2015	2016	2017
Municipal enterprises, including:	***785,759***	***789,342***	***792,002***	***767,171***	***775,599***	***671,445***
- Municipal enterprise Misksvitlo	25,909	26,473	27,417	32,778	30,702	31,288
- Municipal enterprise “Kharkivvodokanal”	339,011	326,997	318,200	305,548	304,261	292,263
- Municipal enterprise “Kharkiv heating networks”	139035	146,964	146,102	143,097	142,294	138,386
- Municipal enterprise “Miskelektrotransservis”	78428	78,840	83,307	84,472	84,357	83,462
- Municipal enterprise “Kharkivsky Metropoliten”	99,401	97,318	89,361	84,970	87,086	88,559
- Municipal enterprise “Zhylkomservis”	80,691	87,017	98,617	87,044	92,820	93,533
- Institutions that provide housing and utilities services and are subordinate to the housing and utilities services management of Kharkiv	23,284	25,733	28,998	29,262	34,079	37,487
Population	***1,042,272***	***1,048,706***	***1,096,835***	***1,057,238***	***1,094,828***	***1,093,341***
Public sector institutions, including:	***181,621***	***183,064***	***183,093***	***174,743***	***180,388***	***174,650***
- state budget	143,616	144,222	144,752	138,692	138,332	135,565
- district budgets in Kharkiv (local budget)	18,014	18,727	18,710	18,047	23,271	21,627
- local budget	19,991	20,115	19,631	18,004	18,785	17,458
Industrial enterprises	***586,340***	***612,172***	***521,421***	***450,698***	***432,816***	***415,503***
Other consumers	***945,520***	***975,621***	***975,573***	***944,268***	***1,031,176***	***1,119,343***
Total electricity consumption in the city	***3,541,512***	***3,608,905***	***3,568,924***	***3,394,118***	***3,514,807***	***3,474,282***

Appendix 7. Characteristics of Kharkiv water supply and sewerage system

Table 1

General characteristics of centralized water supply and sewerage system of the municipal enterprise “Kharkivvodokanal”

Indicators	Unit	Years					
		2012	2013	2014	2015	2016	2017
Total design capacity of water pumping stations	Thous. m^3/day	4,476.4	4,476.4	4,476.4	4,476.4	4,459.3	4,435.5
Installed capacity of water treatment facilities	Thous. m^3/day	1,205.0	1,205.0	1,205.0	1,205.0	1,205.0	1,205.0
Installed capacity of wastewater treatment plants	Thous. m^3/day	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0
The total installed capacity of the municipal sewerage system	Thous. m^3/day	1,100.0	1,100.0	1,100.0	1,100.0	1,100.0	1,100.0
Installed production capacity of the municipal waterworks	Thous. m^3/day	960.9	962.3	969.4	968.4	1,081.8	1,055.7

Table 2

Information on deterioration of water and sewerage networks of municipal enterprise “Kharkivvodokanal” in 2012-2017

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Length of water supply networks	km	2,631.4	2,657.9	2,669.7	2,672.3	2,679.0	2,680.2
Length of water supply networks that need to be replaced	km	1,080.4	1,401.3	1,425.2	1,468.0	1,479.4	1,491.3
	%	*39.1*	*51.5*	*52.2*	*54.9*	*55.2*	*55.6*
Number of network leaks per year	Pc.	4,692	4,423	4,299	4,039	4,013	4,472
Length of sewer networks	km	1,620.3	1,638.9	1,646.8	1,653.1	1,656.3	1,659.4
Length of sewer networks that need to be replaced	km	1,309.2	1,312.0	1,316.3	1,322.5	1,325.1	1,327.5
	%	*80.8*	*80.1*	*79.9*	*80.1*	*80.0*	*80.0*

Table 3

Information on total water supply and sewerage volumes by the municipal enterprise "Kharkivvodokanal" in 2012-2017

Indicators	Measure-ment unit	Years					
		2012	2013	2014	2015	2016	2017
Total amount of water released	Thousand m^3	130,405.1	127,526.8	124,551.4	116,418.4	110,932.8	98,453.8
Total potable water produced	Thousand m^3	227,452.6	223,609.9	213,344.6	203,970.7	201,613.8	199,565.1
Total amount of wastewater	Thousand m^3	205,789.2	200,712.6	193,921.8	190,450.5	193,525.2	189,950.6

Table 4

Information on the number of consumers receiving centralized water supply and sewerage services in 2012-2017

Indicators	Measure-ment unit	Years					
		2012	2013	2014	2015	2016	2017
Number of water consumers	pc.	561,901	566,713	572,356	580,181	587,894	589,572
Number of sewerage consumers	pc.	536,442	540,385	547,652	550,724	561,869	564,173
Number of population serviced by the enterprise (water supply)	People	1,257,032	1,256,433	123,9759	1,244,992	1,242,644	1,237,261
Number of population serviced by the enterprise (water disposal)	People	1,205,823	1,203,327	1,189,808	1,185,299	1,180,509	1,176,146
Percentage of consumers who have water metering devices	%	39.0	39.8	42.0	46.9	51.0	54.6

Table 5

Water consumption by all categories of consumers in Kharkiv in 2012-2017

No.	Categories of consumers	Volume of water supply by year. thous. m^3					
		2012	2013	2014	2015	2016	2017
1	Population	103,354.1	101,762.2	90,978.4	73,642.2	69,826.4	58,361.1
2	Public sector institutions. including:	5,272.6	5,046.6	4,739.0	4,413.5	4,217.2	4,084.9
2.1	*State budget*	*2,461.4*	*2,326.6*	*2,201.6*	*2,021.5*	*1,840.1*	*1,763.3*
2.2	*Regional budget*	*939.2*	*900.8*	*897.3*	*855.4*	*832.9*	*760.8*
2.3	*City budget*	*1,872.0*	*1,819.2*	*1,640.1*	*1,536.6*	*1,544.2*	*1,560.8*

No.	Categories of consumers	Volume of water supply by year. thous. m^3					
		2012	2013	2014	2015	2016	2017
3	*Other consumers*	14,270.7	13,418.6	22,350.0	32,278.5	31,031.8	30 197.5
Total for the city		**122 897.4**	**120,227.4**	**118,067.4**	**110,334.2**	**105,075.4**	**92,643.5**

Table 6

Water discharge volumes with distribution by categories of consumers in Kharkiv in 2012-2017

No.	Consumer categories	Water discharge volumes by year, thous. m^3					
		2012	2013	2014	2015	2016	2017
1	Population	99,928.1	99,105.8	98,322.4	90,529.6	84,542.9	72 780.1
2	Public sector institutions	6,257.4	6,195.7	5,590.8	5,327.5	5,460.0	4 782.6
2.1	*- state budget*	*2,914.4*	*2,861.8*	*2,592.0*	*2,449.0*	*2,362.1*	*2 032.3*
2.2	*- regional budget*	*1,046.6*	*1024.1*	*994.9*	*955.0*	*964.7*	*850.5*
2.3	*- city budget*	*2,296.4*	*2,309.8*	*2,003.9*	*1,923.5*	*2,133.2*	*1 899.8*
3	Other consumers	15,627.8	14,844.7	13,576.7	13,253.5	14,901.6	13 793.8
Total for the city		**121 813.3**	**120,146.2**	**117,489.9**	**109,110.6**	**104,904.5**	**91,356.5**

Appendix 8. Characteristics of state-financed organisations in Kharkiv

Table 1

General characteristics of public sector buildings funded from the municipal budget in Kharkiv

Name	Number of institutions	Number of buildings	Total area	Heated area
	Pc.	Pc.	Thousand m ^{2}	Thousand m ^{2}
Labor and social policy	13	15	10.0	9.1
Culture	47	133	67.4	55.7
Health care	67	181	463.8	429.5
Education	421	455	1,518.3	1,087.2
Total	**548**	**784**	**2,059.5**	**1,581.5**

Table 2

Energy and water consumption by state-financed organisations in Kharkiv in 2012-2017

Name	Measure-ment unit	Years					
		2012	2013	2014	2015	2016	2017
Natural gas	Thousand m^3	985.74	759.51	713.84	740.87	677.66	644.13
Electric energy	MWh	38,005.25	3,8842.21	38,341.10	36,050.52	42,056.10	39,085.36
Water supply	Thousand m^3	1,872.00	1,819.20	1,640.10	1,536.60	1,544.20	1,560.80
Water disposal		2,296.40	2,309.80	2,003.90	1,923.50	2,133.20	1,899.80
Heat energy	Gcal	270,310.95	264,196.99	242,249.07	233,028.89	255,115.67	252,772.00
Coal	Ton	89.67	96.06	88.58	109.54	69.32	81.27

Appendix 9. Characteristics of Kharkiv housing stock

Table 1

Information on residential buildings serviced by municipal enterprise “Zhylkomservis” by year of their construction

Number of floors	Years/units					
	1900-1960	**1961-1980**	**1981-1990**	**1991-2000**	**2001-2016**	**Total**
1 floor	1,844	27	4	-	-	**1,875**
2-4 floors	2,592	180	10	8	-	**2,790**
5 and more	525	1,879	666	212	99	**3,381**
Total	**4,961**	**2,086**	**680**	**220**	**99**	**8,046**

Table 2

Information on trends of the creation of condominiums in Kharkiv

Years	Amount.units.
До 2000	–
2000-2009	218
2010	44
2011	11
2012	13
2013	17
2014	21
2015	12
2016	187
2017	26
Total	**549**

Table 3

Energy and water consumption by residential areas in Kharkiv in 2012 -2017

Name	Measurement unit	Years					
		2012	**2013**	**2014**	**2015**	**2016**	**2017**
Natural gas	Thousand m^3	301,038.35	296,838.77	279,361.15	225,609.67	219,025.88	218,053.01
Electric energy	GWh	1,042.27	1,048.71	1,096.84	1,057.24	1,094.83	1,093.34
Water supply	Thousand m^3	103,354.10	101,762.20	90,978.40	73,642.20	69,826.40	58,361.1
Water disposal		99,928.10	99,105.80	98,322.40	90,529.60	84,542.90	72,780.1
Heat energy	Thousand gcal	5,292.83	5,173.91	4,757.26	4,605.91	4,884.30	4,646.57

Appendix 10. Characteristics of Kharkiv public transport

10.1. Kharkiv trolleybus and tram

Table 1

Characteristics of passenger transportation carried out by electric transport in Kharkiv

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Total number of trolleybus routes	un.	24	23	23	23	23	23
Total number of tram routes	un.	13	13	13	13	13	13
Total length of the trolleybus routes	km.	394.1	366.1	366.1	366.1	372.7	372.8
Total length of tram routes	km.	342.7	342.7	342.7	342.7	342.7	342.7
Total density of trolley routes	km/sq.km	1.31	1.05	1.05	1.05	1.06	1.07
Total density of tram routes	km/sq.km	1.14	0.98	0.98	0.98	0.98	0.98
Total number of trolleybus routes	un.	168	170	178	178	177	184
Total number of trams on routes	un.	194	187	188	187	169	211
Total passenger capacity of trolleybuses on routes	un.	23,378	23,660	23,674	23,674	23,541	24,472
Total passenger capacity of trams on routes	un.	23,989	22,142	22,864	22,466	20,202	25,223
Average age of rolling stock engaged in urban passenger transportation	years						
- *trolleybus*		8.5	8.8	9.5	10.2	11.2	11.3
- *tram*		27.0	29.0	29.1	29.6	29.6	30.5
Number of passengers transported	Million pass.						
- *trolleybus*		98.5	112.6	123.8	142.3	144.8	141.7
- *tram*		97.9	91.0	99.7	112.3	103.8	104.3

Table 2

Passengers transported in municipal passenger electric transport, mln. pass.

Indicators	Years					
	2012	2013	2014	2015	2016	2017
Municipal enterprise “Trolleybus depot No. 2	47.9	52.8	62.3	74.1	75.9	76.4
Municipal enterprise “Trolleybus depot No. 3”	50.6	59.8	61.5	68.2	68.9	65.3
Municipal enterprise “Zhovtneve tram depot”	42.6	34.6	41.7	49.7	48.5	46.4
Municipal enterprise “Saltivske tram depot”	55.3	56.4	58.0	62.6	55.3	57.9

Table 3

Electricity consumption by public electric transport (trolleybuses and trams) in Kharkiv

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Annual electricity consumption by trolley buses.	MW	29,500	32,814	35,226	36,522	38,045	38,425
Annual electricity consumption by trams	MW	47,323	44,882	46,805	46,430	44,558	43,577

Table 4

Fuel consumption by other types of municipal electric transport enterprises

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Annual gasoline consumption	Thous. l	85.7	63.2	92.8	82.9	116.5	112.8
Annual consumption of diesel fuel	Thous. l	87.4	80.4	97.9	169.6	248.6	252.8
Annual consumption of liquefied gas	Thous. l	31.4	106.4	173.4	171.9	145.4	156.3
Annual consumption of compressed gas	Thous. l	100.5	105.7	99.0	116.0	106.0	104.0
Total	**Thous. l**	**305.0**	**355.7**	**463.1**	**540.4**	**616.5**	**625.9**

10.2. Kharkiv Metro

Table 5

Information on consumption of energy resources by Kharkivsky Metropoliten in 2012-2017

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Electricity							
Total received	MWh	99,401.5	97,318.4	89,360.6	84,970.0	87,086.5	88,559.4
Total consumption. including:	MWh	99,401.5	97,318.4	89,360.6	84,970.0	87,086.5	88,559.4
Traction costs	MWh	65,237.2	64,060.3	61,868.6	59,889.0	59,707.0	59,695.7
Production needs (including: engines of pumps. fans. escalators. lighting. etc.).	MWh	31,521.0	30,600.0	25,968.0	23,865.0	26,198.0	27,684.8
Other needs	MWh	2,643.3	2,658.1	1,524.0	1,216.0	1,181.5	1,178.9
Heat energy							
Total heat consumption	Thousand gcal	11.97	11.23	7.40	4.60	2.55	0.99
Total natural gas consumption	Thousand m3	147.84	111.80	106.10	78.70	75.30	67.49
Total consumption other fuels. (pilet)	t	-	-	-	-	195.40	584.40

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
		Fuel					
Diesel fuel	t	42.5	52.1	32.8	38.5	34.2	38.6
Petrol	t	135.1	137.1	119.7	110.3	87.0	93.5
Total	**t**	**177.6**	**189.2**	**152.5**	**148.8**	**121.2**	**132.1**

10.3. City bus and route taxis

Table 6

Information on fuel consumption by city buses and route taxis in 2012-2017

Indicators	Measurement unit	Years					
		2012	2013	2014	2015	2016	2017
Liquefied gas	thous. l.	3,555.83	3,342.48	3,141.93	2,953.42	2,776.21	2,609.64
Diesel fuel	thous. l.	16,541.58	15,714.51	14,928.78	14,182.34	13,756.87	13,481.73

Appendix 11. Characteristics of Kharkiv public lighting

Table 1

General characteristics of public lighting in Kharkiv

Indicators	Unit	Years					
		2012	2013	2014	2015	2016	2017
Total length of outdoor lighting networks	km	2,387.0	2,488.4	2,465.9	2,403.2	2,442.8	2,498.0
Total number of light points	Pc.	71,341	73,584	75,547	76,163	77,937	8,0822
Acting	Pc.	62,365	67,512	70,689	73,384	76,487	79,994
Inactive	Pc.	8,976	6,072	4,858	2,779	1,450	828
Necessary	Pc.	8,976	6,072	4,858	2,779	1,450	828
Specific energy consumption per operating light point	MWh/light point	0.42	0.39	0.39	0.45	0.40	0.39
Svetotochek burning level	%	87.4	91.7	93.6	96.4	98.1	98.97
Total number of control cabinets	Pc.	758	770	782	805	825	849
Control system	type	Central	Central	Central	Central	Central	Central
Total number of electricity meters	Pc.	617	650	653	706	732	752
Including differential accounting	Pc.	388	602	647	702	730	750
Number of damages to lighting networks of the city	Accidents/ year	3203	3169	3127	3116	3079	2986
Expenditures on repairs (current repair and maintenance)	Thousand UAH	19,722.0	19,363.0	20,138.0	24,918.0	28,622.0	34,429.6

Table 2

Distribution of light sources by main types (operating light points), pcs.

Type of light source	Years					
	2012	2013	2014	2015	2016	2017
CFL – compact fluorescent lamps	-	-	-	-	1,723	1,318
AML – arc mercury lamps	8,227	7,702	6,987	6,609	2,664	1,894
ASTL – arc sodium tube lamps	53,493	58,779	62,671	65,744	70,704	36,575
MHL – metal halide lamps	-	386	386	386	386	18,386
LED – light-emitting-diode sources	645	645	645	645	1,010	21821
Total	**62,365**	**67,512**	**70,689**	**73,384**	**76,487**	**79,994**

Table 3

Information on electricity consumption for public lighting in 2012-2017

Indicator	Unit	Years					
		2012	2013	2014	2015	2016	2017
Electric energy	MWh	25,909.00	26,473.00	27,417.00	32,778.00	30,702.00	31,288.1

Appendix 12. Solid waste management

Table 1

Volumes of municipal solid waste recycling in Kharkiv in 2012-2017

Indicators	Years					
	2012	2013	2014	2015	2016	2017
Collection of municipal solid waste, thous. m^3	2,949.51	2,782.88	3,240.55	3,310.66	3,020.22	2,891.22
Disposal of municipal solid waste, thous. m^3	2,949.51	2,782.88	3,240.55	3,310.66	3,020.22	2,891.22
Cost of 1 m^3 waste disposal, UAH:						
Population	41.92	41.92	55.56	55.56	55.56	55.56
Budgetary institutions	45.37	45.37	60.84	60.84	60.84	60.84
Other consumers	58.70	58.70	79.32	79.32	79.32	79.32
Number of units of vehicles for municipal solid waste removal, units	N/A	N/A	N/A	N/A	107	144

Table 2

Information on characteristics of Derhachi landfill

Indicators	Years					
	2012	2013	2014	2015	2016	2017
Area. ha	13.2	13.2	13.2	13.2	13.2	13.2
Cost of 1 m^3 waste burial, UAH:						
Population			7.24			
Budgetary institutions			7.93			
Other consumers			10.34			

Table 3

Approximate morphological composition of municipal waste transported to the landfill

No.	Type of municipal solid waste	% of the volume
1.	Food and other organic waste	41.38
2.	Plastic	7.67
3.	Glass	7.74
4.	Paper. cardboard	13.45
5.	Textile	3.81
6.	Wood	1.67
7.	Metal (ferrous metal)	2.32
8.	Metal (nonferrous metal)	0.55
9.	Hazardous waste	0.51
10.	Other waste	20.9

Appendix 13. “Energy efficiency improvement in educational institutions” program

Table 1

Summary on number of objects for Kharkiv integrated thermal modernization projects with breakdown by districts

Area of the institution	Number of objects	Total
	Buildings	Buildings
Industrialnyi	7 secondary schools/ 17 pre-school	24
Kyivsky	7 secondary schools/ 11 pre-schools	18
Moskovskyi	25 secondary schools/ 34 pre-schools	59
Nemyshlianskyi	7 secondary schools/ 13 pre-schools	20
Novobavarskyi	3 secondary schools/ 2 pre-schools	5
Osnovianskyi	2 secondary schools/ 7 pre-schools	9
Slobidskyi	10 secondary schools / 13 pre-schools	23
Kholodnohorskyi	2 secondary school/ 9 pre-schools	11
Shevchenkivskyi	11 secondary schools/ 19 pre-schools	30
Total	**77 secondary schools/ 125 pre-schools**	**199**

Table 2

Performance indicators for complex thermal modernization projects with breakdown by buildings in districts of Kharkiv

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
	Industrialnyi district						
1	Kharkiv specialized school, levels I-III, No. 75 of Kharkiv City Council of Kharkiv oblast	33,505.00	393.52	1,045.38	174.91	32.1	2022-2026
2	Kharkiv comprehensive school, levels I-III, No. 168 of Kharkiv City Council of Kharkiv oblast	47,415.00	533.37	1,467.88	237.28	32.3	2022-2026
3	Kharkiv comprehensive school, levels I-III, No. 157 of Kharkiv City Council of Kharkiv oblast	40,303.50	426.62	1,166.33	189.76	34.6	2022-2026
4	Kharkiv comprehensive school, levels I-III, No. 118 of Kharkiv City Council of Kharkiv oblast	20,250.00	207.42	600.10	92.39	33.7	2022-2026
5	Kharkiv specialized school, levels I-III, No. 155 of Kharkiv City Council of Kharkiv oblast	29,213.50	237.43	652.09	105.62	44.8	2022-2026
6	Kharkiv comprehensive school, levels I-III, No. 70 of Kharkiv City Council of Kharkiv oblast	16,000.00	194.34	571.54	86.61	28.0	2022-2026
7	Kharkiv comprehensive school, levels I-III, No. 26 of Kharkiv City Council of Kharkiv oblast	16,050.00	192.02	547.24	85.50	29.3	2022-2026
8	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 232, combined type, of Kharkiv City Council“	5,279.50	121.09	346.25	53.92	15.2	2020-2021
9	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 272 of Kharkiv City Council”	9,900.00	211.49	593.00	94.13	16.7	2020-2021
10	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 268, combined type, of Kharkiv City Council”	9,275.00	193.65	555.83	86.24	16.7	2020-2021
11	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 322 of Kharkiv City Council”	5,240.00	106.83	328.78	47.67	15.9	2020-2021
12	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 240, combined type, of Kharkiv City Council”	10,320.00	189.67	514.32	84.35	20.1	2022-2026

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
13	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 439, combined type, of Kharkiv City Council”	11,110.00	206.48	577.97	91.89	19.2	2022-2026
14	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 280 of Kharkiv City Council”	10,118.50	178.07	503.02	79.27	20.1	2022-2026
15	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 193 of Kharkiv City Council”	10,134.00	173.84	496.03	77.41	20.4	2022-2026
16	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 438 of Kharkiv City Council”	12,290.00	198.34	568.25	88.33	21.6	2022-2026
17	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 378 of Kharkiv City Council”	11,140.00	168.53	502.51	75.13	22.2	2022-2026
18	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 463 of Kharkiv City Council”	12,340.00	179.78	500.47	80.00	24.7	2027-2030
19	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 400 of Kharkiv City Council”	12,340.00	179.09	508.56	79.73	24.3	2027-2030
20	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 376 of Kharkiv City Council”	10,600.00	154.00	438.43	68.57	24.2	2027-2030
21	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 457 of Kharkiv City Council”	11,622.00	167.00	489.56	74.41	23.7	2027-2030
22	Municipal company ‘Pre-school educational institution (kindergarten and nursery) No. 453 of Kharkiv City Council”	12,340.00	173.43	493.44	77.22	25.0	2027-2030
23	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 407 of Kharkiv City Council”	12,340.00	172.67	495.38	76.90	24.9	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
24	Municipal institution “Pre-school educational institution (kindergarten and nursery) No. 150 of Kharkiv City Council”	12,340.00	148.16	438.59	66.04	28.1	2027-2030
	Total for Industrialnyi district	***381,466.00***	***5,106.85***	***14,400.93***	***2,273.28***	***26.5***	**-**
	Kyivskyi district						
1	Kharkiv comprehensive school, levels I-III, No. 164 of Kharkiv City Council of Kharkiv oblast	19,433.00	372.18	996.84	163.43	19.5	2022-2026
2	Kharkiv gymnasium No. 172 of Kharkiv City Council of Kharkiv oblast	43,326.60	817.90	2,340.15	355.39	18.5	2022-2026
3	Municipal institution “Kharkiv comprehensive school, levels I-III, No. 158 of Kharkiv City Council of Kharkiv oblast”	19,412.85	352.18	1,049.33	155.37	18.5	2022-2026
4	Municipal institution “Kharkiv specialized school, levels I-III, No.166 “Vertycal” of Kharkiv City Council of Kharkiv oblast”	21,758.50	326.07	932.59	144.48	23.3	2022-2026
5	Municipal institution “V.G. Serhieiev Kharkiv specialized school, levels I-III, with in-depth study of certain subjects No.16 Kharkiv City Council of Kharkiv oblast”	19,213.00	275.09	752.16	121.93	25.5	2022-2026
6	Kharkiv comprehensive school, levels I-III, No.165 of Kharkiv City Council of Kharkiv oblast.	22,169.00	316.74	871.24	140.24	25.4	2022-2026
7	Municipal institution “Kharkiv comprehensive school, levels I-III, No. 96 of Kharkiv City Council of Kharkiv oblast”	17,914.00	226.50	651.79	100.88	27.5	2022-2026
8	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 109 of Kharkiv City Council»	5,695.00	189.59	539.61	81.47	10.6	2020-2021
9	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 370 of Kharkiv City Council”	6,410.00	179.14	534.42	77.91	12.0	2020-2021
10	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 180 of Kharkiv City Council”	7,800.00	213.24	640.49	92.61	12.2	2022-2026

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
11	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 136 of Kharkiv City Council”	8,125.00	212.07	614.47	90.92	13.2	2022-2026
12	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 374, combined type, of Kharkiv City Council”	7,252.50	189.80	587.68	81.55	12.3	2022-2026
13	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 248 of Kharkiv City Council”	9,110.00	201.07	582.86	85.64	15.6	2022-2026
14	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 264 of Kharkiv City Council”	7,595.00	160.04	464.85	70.16	16.3	2022-2026
15	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 410 “Sonechko”, combined type, of Kharkiv City Council”	9,040.00	165.51	488.69	71.37	18.5	2027-2030
16	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 382 “Dzhereltse” of Kharkiv City Council”	6,625.00	102.27	329.74	42.74	20.1	2027-2030
17	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 373 “Parostok” of Kharkiv City Council”	10,430.00	164.02	470.67	71.08	22.2	2027-2030
18	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 464, combined type, of Kharkiv City Council”	9,070.00	141.69	412.57	62.01	22.0	2027-2030
	Total for Kyivskyi district	***250,379.45***	***4,605.11***	***13,260.18***	***2,009.16***	***18.9***	
	Moskovskyi district						
1	Kharkiv comprehensive school, levels I-III, No. 103 of Kharkiv City Council of Kharkiv oblast	23,564.50	330.56	880.68	145.92	26.8	2022-2026
2	Kharkiv comprehensive school, levels I-III, No. 56 of Kharkiv City Council of Kharkiv oblast	24,009.00	268.24	726.33	118.29	33.1	2022-2026
3	Kharkiv high-school No. 141 of Kharkiv City Council of Kharkiv oblast	24,875.00	278.21	771.59	123.79	32.2	2022-2026

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
4	Kharkiv comprehensive school, levels I-III, No. 42 of Kharkiv City Council of Kharkiv oblast	27,184.00	297.56	813.61	132.35	33.4	2022-2026
5	Kharkiv comprehensive school, levels I-III, No. 167 of Kharkiv City Council of Kharkiv oblast	28,247.00	300.82	818.90	132.55	34.5	2022-2026
6	Municipal institution “Kharkiv educational complex” school, levels I-III, and preschool educational institution (kindergarten and nursery) No. 8 Kharkiv City Council of Kharkiv oblast” (school subdivision)	23,015.00	247.33	682.69	110.04	33.7	2022-2026
7	Kharkiv comprehensive school, levels I-III, No. 58 of Kharkiv City Council of Kharkiv oblast	33,651.50	358.06	1,014.28	159.41	33.2	2022-2026
8	Kharkiv comprehensive school, levels I-III, No. 111 of Kharkiv City Council of Kharkiv oblast	28,678.00	284.62	764.07	125.15	37.5	2027-2030
9	Kharkiv specialized school, levels I-III, No. 156 of Kharkiv City Council of Kharkiv oblast	28,308.00	279.55	790.03	123.49	35.8	2027-2030
10	Kharkiv comprehensive school, levels I-III, No. 97 of Kharkiv City Council of Kharkiv oblast	28,569.00	286.37	806.53	127.47	35.4	2027-2030
11	Kharkiv comprehensive school, levels I-III, No. 143 of Kharkiv City Council of Kharkiv oblast	28,678.00	290.02	832.99	129.16	34.4	2027-2030
12	Municipal institution “Kharkiv specialized school, levels I-III, No. 3 of Kharkiv City Council of Kharkiv oblast”	19,490.00	185.89	511.59	82.70	38.1	2027-2030
13	Kharkiv comprehensive school, levels I-III, No. 122 of Kharkiv City Council of Kharkiv oblast	27,184.00	251.51	705.75	110.65	38.5	2027-2030
14	Kharkiv comprehensive school, levels I-III, No. 138 of Kharkiv City Council of Kharkiv oblast	24,009.00	223.78	637.05	99.64	37.7	2027-2030
15	Kharkiv comprehensive school, levels I-III, No. 128 of Kharkiv City Council of Kharkiv oblast	24,009.00	221.12	617.16	98.41	38.9	2027-2030
16	Kharkiv comprehensive school, levels I-III, No. 140 of Kharkiv City Council of Kharkiv oblast	24,009.00	218.39	621.89	97.24	38.6	2027-2030
17	Kharkiv comprehensive school, levels I-III, No. 124 of Kharkiv City Council of Kharkiv oblast	24,009.00	218.58	643.25	97.41	37.3	2027-2030
18	Kharkiv comprehensive school, levels I-III, No. 31 of Kharkiv City Council of Kharkiv oblast	27,184.00	234.67	645.59	104.40	42.1	2027-2030
19	Kharkiv comprehensive school, levels I-III, No. 142 of Kharkiv City Council of Kharkiv oblast	28,678.00	256.95	760.53	114.53	37.7	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
20	Kharkiv comprehensive school, levels I-III, No. 123 of Kharkiv City Council of Kharkiv oblast	25,534.00	219.21	600.23	97.50	42.5	2027-2030
21	Kharkiv comprehensive school, levels I-III, No. 139 of Kharkiv City Council of Kharkiv oblast	23,584.00	207.20	597.79	92.29	39.5	2027-2030
22	Kharkiv comprehensive school, levels I-III, No. 98 of Kharkiv City Council of Kharkiv oblast	13,675.00	180.52	518.13	79.92	26.4	2027-2030
23	Kharkiv comprehensive school, levels I-III, No. 64 of Kharkiv City Council of Kharkiv oblast	29,102.00	239.35	669.37	106.52	43.5	2027-2030
24	Kharkiv comprehensive school, levels I-III, No. 84 of Kharkiv City Council of Kharkiv oblast	23,347.25	196.35	581.29	87.52	40.2	2027-2030
25	Kharkiv comprehensive school, levels I-III, No. 25 of Kharkiv City Council of Kharkiv oblast	27,184.00	217.29	591.64	96.64	45.9	2027-2030
26	Municipal institution “Preschool educational institution (kindergarten and nursery) No.112, combined type, of Kharkiv City Council”	9,725.00	215.50	644.77	93.81	15.1	2020-2021
27	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 85 of Kharkiv City Council”	9,725.00	204.66	565.82	88.61	17.2	2020-2021
28	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 55 of Kharkiv City Council”	9,725.00	195.69	580.58	85.09	16.8	2020-2021
29	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 336 of Kharkiv City Council”	9,725.00	185.04	524.90	79.71	18.5	2020-2021
30	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 454 of Kharkiv City Council”	9,725.00	187.00	529.17	81.10	18.4	2022-2026
31	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 168 of Kharkiv City Council”	9,725.00	183.99	506.31	79.85	19.2	2022-2026
32	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 317 of Kharkiv City Council”	10,905.00	204.61	585.77	88.37	18.6	2022-2026
33	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 148 of Kharkiv City Council”	9,725.00	187.75	547.29	81.88	17.8	2022-2026

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
34	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 33, combined type, of Kharkiv City Council”	10,905.00	199.68	559.37	86.22	19.5	2022-2026
35	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 366, combined type, of Kharkiv City Council”	9,725.00	176.15	509.98	76.27	19.1	2022-2026
36	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 270 of Kharkiv City Council”	10,905.00	195.61	558.74	84.68	19.5	2022-2026
37	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 292 of Kharkiv City Council”	9,125.00	179.32	547.11	80.00	16.7	2022-2026
38	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 28 of Kharkiv City Council”	9,725.00	176.13	519.27	76.56	18.7	2022-2026
39	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 97 of Kharkiv City Council”	9,730.00	177.09	526.12	77.32	18.5	2022-2026
40	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 198 of Kharkiv City Council”	10,905.00	191.79	562.97	82.72	19.4	2022-2026
41	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 79 of Kharkiv City Council”	10,905.00	187.10	521.32	80.93	20.9	2022-2026
42	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 182, combined type, of Kharkiv City Council”	10,905.00	189.78	538.82	82.39	20.2	2027-2030
43	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 70 of Kharkiv City Council”	9,725.00	170.48	498.68	73.88	19.5	2027-2030
44	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 375 of Kharkiv City Council”	10,840.00	180.94	497.54	78.11	21.8	2027-2030
45	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 12, combined type, of Kharkiv City Council”	10,905.00	184.95	537.68	80.48	20.3	2027-2030
46	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 80 of Kharkiv City Council”	10,905.00	181.12	521.18	78.91	20.9	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
47	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 367 of Kharkiv City Council”	10,905.00	172.90	482.88	74.77	22.6	2027-2030
48	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 363 of Kharkiv City Council”	12,340.00	198.37	576.28	86.05	21.4	2027-2030
49	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 137 of Kharkiv City Council”	10,905.00	176.99	523.13	77.35	20.8	2027-2030
50	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 125 of Kharkiv City Council”	6,175.00	96.28	262.50	42.09	23.5	2027-2030
51	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 199 of Kharkiv City Council”	10,905.00	163.61	467.00	71.01	23.4	2027-2030
52	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 117 of Kharkiv City Council”	12,340.00	181.66	515.17	78.42	24.0	2027-2030
53	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 39 of Kharkiv City Council”	10,905.00	161.90	455.99	70.28	23.9	2027-2030
54	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 174 of Kharkiv City Council”	10,905.00	158.48	468.81	69.01	23.3	2027-2030
55	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 124, combined type, of Kharkiv City Council”	12,340.00	186.45	558.08	83.07	22.1	2027-2030
56	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 58 of Kharkiv City Council”	12,340.00	160.55	465.02	69.91	26.5	2027-2030
57	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 440 of Kharkiv City Council”	11,110.00	139.74	430.93	60.18	25.8	2027-2030
58	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 115 o Kharkiv City Council”	10,201.00	113.75	349.98	50.76	29.1	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
59	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 100 of Kharkiv City Council”	8,221.00	98.67	273.56	43.33	30.1	2027-2030
	Total for Moskovskyi district	***993,554.25***	***12,255.92***	***34,815.68***	***5,386.09***	***28.5***	**-**
	Nemyshlianskyi district						
1	Kharkiv educational complex No. 180 of Kharkiv City Council of Kharkiv oblast	11,893.00	257.16	719.21	108.10	16.5	2027-2030
2	Municipal institution “Kharkiv comprehensive school, levels I-III, No 74 of Kharkiv City Council of Kharkiv oblast”	21,480.00	273.20	764.60	120.13	28.1	2027-2030
3	Kharkiv comprehensive school, levels I-III, No. 160 of Kharkiv City Council of Kharkiv oblast	27,300.00	324.84	859.68	144.37	31.8	2027-2030
4	Municipal institution “Complex children's and youth sports school No. 16 of Kharkiv City Council”	11,108.50	127.83	336.94	56.81	33.0	2027-2030
5	Municipal institution “Center for Children and Youth Creativity No. 6 of Kharkiv City Council“	11,020.50	108.31	282.80	48.12	39.0	2027-2030
6	Kharkiv specialized school, levels I-III, No. 73 of Kharkiv City Council of Kharkiv oblast	29,180.00	275.69	779.92	120.54	37.4	2027-2030
7	Kharkiv comprehensive school, levels I-III, No. 38 of Kharkiv City Council of Kharkiv oblast	18,119.00	292.13	806.22	128.78	22.5	2027-2030
8	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 294 of Kharkiv City Council”	10,180.50	231.69	637.76	100.04	16.0	2020-2021
9	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 429 of Kharkiv City Council”	10,978.00	246.05	704.00	105.33	15.6	2020-2021
10	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 377 of Kharkiv City Council”	11,087.00	229.58	626.68	97.61	17.7	2020-2021
11	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 428 of Kharkiv City Council”	11,061.00	220.79	607.48	93.69	18.2	2020-2021

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
12	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 309 of Kharkiv City Council”	8,426.90	176.86	513.61	76.23	16.4	2022-2026
13	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 361, combined type, of Kharkiv City Council”	11,785.50	227.93	622.62	98.74	18.9	2022-2026
14	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 138 of Kharkiv City Council”	11,968.50	226.13	637.77	97.21	18.8	2022-2026
15	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 265 of Kharkiv City Council”	13,680.00	248.92	689.27	106.39	19.8	2022-2026
16	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 383 of Kharkiv City Council”	11,108.50	204.70	562.13	88.58	19.8	2022-2026
17	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 288, combined type, of Kharkiv City Council”	10,505.00	195.69	555.06	84.96	18.9	2027-2030
18	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 237, combined type, of Kharkiv City Council”	13,175.00	228.39	626.96	98.70	21.0	2027-2030
19	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 384 of Kharkiv City Council”	11,061.00	178.38	496.09	77.05	22.3	2027-2030
20	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 267 of compensating type of Kharkiv City Council”	13,986.00	210.72	587.93	91.02	23.8	2027-2030
	Total for Nemyshlianskyi district	***279,103.90***	***4,484.98***	***12,416.74***	***1,942.40***	***22.5***	***-***
	Novobavarskyi district						
1	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 143 of the combined type of Kharkiv City Council	11,350.00	273.69	760.27	115.94	14.9	2020-2021

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
2	Municipal institution «Preschool educational institution (kindergarten and nursery) No. 82, combined type, of Kharkiv City Council“	9,725.00	201.86	540.51	87.80	18.0	2020-2021
3	Municipal institution «Preschool educational institution (kindergarten and nursery) No. 286, combined typeof Kharkiv City Council“	5,910.00	117.81	389.20	52.68	15.2	2022-2024
4	Kharkiv specialized school, levels I-III, No. 162 of Kharkiv City Council of the Kharkiv region	26,725.00	330.62	933.67	144.11	28.6	2022-2024
5	Kharkiv comprehensive school, levels I-III, No. 153 of Kharkiv City Council of Kharkiv oblast	29,094.20	351.32	961.46	156.26	30.3	2022-2024
	Total for Novobavarskyi district	***82,804.20***	***1,275.30***	***3,585.11***	***556.79***	***23.1***	**-**
	Osnovianskyi district						
1	Municipal institution “Center for Children's and Youth Creativity” No.7 of Kharkiv City Council”	17,518.00	233.86	608.41	98.57	28.8	2022-2023
2	Kharkiv comprehensive school, levels I-III, No. 53 of Kharkiv City Council of Kharkiv oblast	42,585.00	457.44	1,236.49	198.31	34.4	2022-2023
3	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 353, combined type, of Kharkiv City Council”	10,051.00	269.48	691.53	109.19	14.5	2020-2021
4	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 420 of Kharkiv City Council	17,217.00	284.72	761.43	116.33	22.6	2020-2021
5	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 441, combined type, of Kharkiv City Council”	11,268.50	194.28	574.41	82.73	19.6	2022-2023
6	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 349 of Kharkiv City Council”	9,692.00	161.47	468.00	71.93	20.7	2022-2023
7	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 24 of Kharkiv City Council”	17,315.50	243.18	678.03	101.67	25.5	2027-2030
8	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 50 of Kharkiv City Council”	15,129.00	204.73	562.83	86.00	26.9	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
9	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 345, combined type, of Kharkiv City Council”	10,831.50	153.26	419.84	67.32	25.8	2027-2030
	Total for Osnovianskyi district	***151,607.50***	***2,202.41***	***6,000.96***	***932.06***	***25.3***	**-**
	Slobidskyi district						
1	Municipal institution “Center for Children's and Youth Creativity” No.4 of Kharkiv City Council	4,485.00	93.26	247.45	41.45	18.1	2022-2026
2	Kharkiv Gymnasium No. 82 of Kharkiv City Council of Kharkiv oblast	35,325.00	399.26	1,086.12	176.46	32.5	2022-2026
3	Kharkiv comprehensive school, levels I-III, No. 91 of Kharkiv City Council of Kharkiv oblast	38,710.00	418.41	1,125.92	186.03	34.4	2022-2026
4	Kharkiv comprehensive school, levels I-III, No. 68 of Kharkiv City Council of Kharkiv oblast	37,095.00	373.21	1,050.65	166.12	35.3	2022-2026
5	M.V. Lomonosov Kharkiv Gymnasium No. 46 of Kharkiv City Council of Kharkiv oblast	39,480.00	428.47	1,382.46	191.45	28.6	2022-2026
6	Kharkiv Gymnasium No. 178 “Osvita” of Kharkiv City Council of Kharkiv oblast	5,588.50	123.12	405.14	55.04	13.8	2027-2030
7	Kharkiv comprehensive school, levels I-III, No. 78 of Kharkiv City Council of the Kharkiv region	26,172.50	225.06	642.41	100.22	40.7	2027-2030
8	299th Infantry Division Kharkiv comprehensive school, levels I-III, No. 95 of Kharkiv City Council of Kharkiv oblast	31,294.00	251.99	755.48	112.36	41.4	2027-2030
9	Kharkiv comprehensive school, levels I-III, No. 44 of Kharkiv City Council of Kharkiv oblast	21,923.00	245.39	689.98	109.23	31.8	2027-2030
10	Kharkiv comprehensive school, levels I-III, No. 151 of Kharkiv City Council of Kharkiv oblast	29,215.00	317.62	905.30	137.88	32.3	2027-2030
11	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 263 of Kharkiv City Council”	9,765.00	213.33	590.83	93.17	16.5	2020-2021
12	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 335 of Kharkiv City Council”	10,105.00	192.25	536.34	83.85	18.8	2020-2021

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
13	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 114 of Kharkiv City Council”	9,125.00	167.65	487.07	73.05	18.7	2020-2021
14	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 461 of Kharkiv City Council”	10,907.50	209.27	651.15	91.74	16.8	2020-2021
15	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 348 of Kharkiv City Council”	10,100.00	181.72	523.30	79.65	19.3	2022-2026
16	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 458, combined type, of Kharkiv City Council”	10,910.00	184.63	519.73	79.80	21.0	2022-2026
17	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 160, combined type, of Kharkiv City Council”	10,300.00	179.64	523.00	78.39	19.7	2022-2026
18	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 146 of Kharkiv City Council”	10,300.00	172.21	489.01	75.10	21.1	2022-2026
19	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 296 of Kharkiv City Council”	8,826.50	155.48	497.68	69.45	17.7	2022-2026
20	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 355 of Kharkiv City Council”	13,391.00	198.17	547.50	84.57	24.5	2027-2030
21	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 337 of Kharkiv City Council”	11,140.00	163.88	461.76	71.28	24.1	2027-2030
22	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 266, combined type, of Kharkiv City Council”	10,580.00	156.99	461.59	68.83	22.9	2027-2030
23	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 300 of Kharkiv City Council”	9,689.00	138.32	427.78	60.21	22.6	2027-2030
	Total for Slobidskyi district	***404,427.00***	***5,189.33***	***15,007.65***	***2,285.31***	***26.9***	-

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
	Kholodnohirskyi district						
1	Kharkiv gymnasium No.152 of Kharkiv City Council of Kharkiv oblast	29,644.50	283.61	864.31	126.51	34.3	2022-2023
2	Kharkiv gymnasium No.86 of Kharkiv City Council of Kharkiv oblast	21,532.50	201.57	594.81	89.84	36.2	2022-2023
3	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 302, combined type, of Kharkiv City Council”	5,687.00	125.25	359.83	55.78	15.8	2020-2021
4	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 9, combined type, of Kharkiv City Council”	10,136.50	202.62	537.06	88.81	18.9	2020-2021
5	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 142, combined type, of Kharkiv City Council”	11,808.00	218.60	606.00	92.80	19.5	2020-2021
6	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 78, combined type, of Kharkiv City Council”	10,105.00	172.70	520.47	77.01	19.4	2023-2024
7	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 414, combined type, of Kharkiv City Council”	11,105.00	170.33	471.16	73.65	23.6	2023-2024
8	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 425, combined type, of Kharkiv City Council”	11,105.00	171.41	468.23	74.95	23.7	2027-2030
9	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 447, combined type, of Kharkiv City Council”	11,128.50	157.85	460.47	67.79	24.2	2027-2030
10	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 29, combined type, of Kharkiv City Council”	8,575.00	137.29	441.08	61.34	19.4	2027-2030
11	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 325, combined type, of Kharkiv City Council”	10,474.50	129.45	350.62	57.57	29.9	2027-2030
	Total for Kholodnohirskyi district	***141,301.50***	***1,970.68***	***5,674.03***	***866.06***	***24.9***	-

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
	Shevchenkivskyi district						
1	Kharkiv teaching and educational complex No. 179 of Kharkiv City Council of Kharkiv oblast	6,850.00	184.38	555.97	81.08	12.3	2022-2026
2	Kharkiv comprehensive school, levels I-III, No. 176 of Kharkiv City Council of Kharkiv oblast	8,830.00	212.95	596.11	93.70	14.8	2022-2026
3	Kharkiv comprehensive school, levels I-III, No. 150 of Kharkiv City Council of Kharkiv oblast	29,213.00	402.86	1,132.93	176.42	25.8	2022-2026
4	Municipial institution “Kharkiv gymnasium No. 169 of Kharkiv City Council of Kharkiv oblast”	38,716.20	527.66	1,628.81	231.06	23.8	2022-2026
5	Kharkiv Lyceum No. 149 of Kharkiv City Council of Kharkiv oblast	29,210.00	368.69	1,022.24	162.18	28.6	2022-2026
6	Kharkiv comprehensive school, levels I-III, No. 147 of Kharkiv City Council of Kharkiv oblast	28,525.85	334.31	932.14	147.02	30.6	2027-2030
7	Kharkiv specialized school, levels I-III, No. 29 of Kharkiv City Council of Kharkiv oblast	25,450.00	304.30	849.77	135.42	29.9	2027-2030
8	Kharkiv comprehensive school, levels I-III, No. 146 of Kharkiv City Council of Kharkiv oblast	29,473.00	332.25	920.79	144.80	32.0	2027-2030
9	Kharkiv comprehensive school, levels I-III, No. 159 of Kharkiv City Council of Kharkiv oblast	29,963.00	334.48	931.92	147.22	32.2	2027-2030
10	Kharkiv comprehensive school, levels I-III, No. 154 of Kharkiv City Council of Kharkiv oblast	29,213.10	318.50	930.92	139.44	31.4	2027-2030
11	Kharkiv specialized school, levels I-III, No. 109 of Kharkiv City Council of Kharkiv oblast	43,444.40	466.02	1,259.18	205.99	34.5	2027-2030
12	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 446 of Kharkiv City Council”	10,272.10	275.70	789.98	115.26	13.0	2020-2021
13	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 354, combined type, of Kharkiv City Council”	9,065.00	237.35	674.84	102.30	13.4	2020-2021
14	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 290, combined type, of Kharkiv City Council”	9,265.00	237.88	671.14	102.78	13.8	2020-2021

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
15	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 411, combined type, of Kharkiv City Council”	10,272.10	228.80	643.92	97.10	16.0	2020-2021
16	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 323, combined type, of Kharkiv City Council”	10,982.10	242.84	703.84	103.18	15.6	2022-2026
17	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 437, combined type, of Kharkiv City Council”	10,272.10	205.01	573.10	86.03	17.9	2022-2026
18	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 430 of Kharkiv City Council”	10,188.60	207.84	586.64	89.40	17.4	2022-2026
19	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 445 of Kharkiv City Council”	10,270.00	208.02	606.04	89.54	16.9	2022-2026
20	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 303 of Kharkiv City Council”	10,228.25	188.41	545.63	81.75	18.7	2022-2026
21	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 158, combined type, of Kharkiv City Council”	10,270.00	188.27	544.51	81.54	18.9	2022-2026
22	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 27, combined type, of Kharkiv City Council”	10,270.00	187.49	549.88	80.97	18.7	2027-2030
23	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 399, combined type, of Kharkiv City Council”	10,272.10	179.29	510.97	76.92	20.1	2027-2030
24	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 418, combined type, of Kharkiv City Council”	10,992.10	191.61	558.25	82.31	19.7	2027-2030
25	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 51, combined type, of Kharkiv City Council”	10,729.00	188.22	518.74	82.06	20.7	2027-2030

No.	Institution name/district	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	t CO_2/year	years	years
26	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 416 of Kharkiv City Council”	10,272.10	167.27	484.16	71.44	21.2	2027-2030
27	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 450, combined type, of Kharkiv City Council”	10,270.00	170.42	509.57	73.94	20.2	2027-2030
28	Municipal institution “Comprehensive children and youth sport school” No.12 of Kharkiv City Council”	10,272.10	142.34	367.95	62.80	27.9	2027-2030
29	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 140 of Kharkiv City Council”	8,715.50	165.61	430.71	73.57	20.2	2027-2030
30	Municipal institution “Preschool educational institution (kindergarten and nursery) No. 279 of Kharkiv City Council”	5,687.00	112.88	309.57	49.07	18.4	2027-2030
	Total for Shevchenkivskyi district	***487,453.70***	***7,511.67***	***21,340.21***	***3,266.29***	***22.8***	-
	Total for educational institutions	***3,172,097.50***	***44,602.19***	***126,501.50***	***19,517.48***	***25.1***	-

Appendix 14. “Energy efficiency improvment in healthcare institutions” program

Table 1

Performance indicators for implementation of energy-efficient measures in medical institutions of Kharkiv

No.	Name of institution	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years	years
1.	Municipal healthcare institution “Prof. O.I. Meshchaninov Kharkiv Municipal Emergency Aid Hospital “	225,415.3	4,610.7	11,408.4	1,233.8	19.8	2021-2030
2.	Municipal healthcare institution “Kharkiv hospital No. 1”	11,808.0	520.6	1,225.6	139.3	9.6	2021-2030
3.	Municipal healthcare institution “Kharkiv clinical hospital No. 2”	77,840.6	2,216.3	5,227.4	593.1	14.9	2021-2030
4.	Municipal healthcare institution “Kharkiv hospital No. 3”	38,705.0	966.7	2,332.5	258.7	16.6	2021-2030
5.	Municipal healthcare institution “Kharkiv children's hospital No. 5”	32,333.5	702.3	1,570.2	187.9	20.6	2021-2030
6.	Municipal healthcare institution “Kharkiv clinical hospital No. 7”	77,241.8	1,089.0	2,830.4	291.4	27.3	2021-2030
7.	Municipal healthcare institution “Kharkiv clinical hospital No. 8”	74,117.2	1,024.0	2,646.7	274.0	28	2021-2030
8.	Municipal healthcare institution “Kharkiv clinical hospital No. 13”	54,508.5	1,927.0	4,386.4	515.7	12.4	2021-2030
9.	Municipal healthcare institution “Prof. I.I. Girshman Kharkiv clinical hospital No. 14”	37,383.0	989.8	2,402.0	264.9	15.6	2021-2030
10.	Municipal healthcare institution “Kharkiv clinical children's hospital No. 16	25,208.4	674.9	1,583.7	180.6	15.9	2021-2030
11.	Municipal healthcare institution “Kharkiv multidisciplinary hospital No. 17”	208,890.4	4,049.7	9,876.4	1,083.7	21.2	2021-2030
12.	Municipal healthcare institution “Kharkiv multidisciplinary hospital No. 18”	50,939.7	1,309.5	3,039.2	350.4	16.8	2021-2030
13.	Municipal healthcare institution “Kharkiv children's clinical hospital No. 19”	18,131.0	470.9	1,107.9	126.0	16.4	2021-2030
14.	Municipal healthcare institution “Kharkiv children's clinical hospital No. 24 “	31,377.5	870.1	2,078.4	232.8	15.1	2021-2030
15.	Municipal healthcare institution “Kharkiv multidisciplinary No. 25”	67,261.4	1,809.6	4,308.7	484.2	15.6	2021-2030

No.	Name of institution	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	tons of CO_2/year	years	years
16.	“Kharkiv clinical hospital No. 27”	39,045.1	1,088.1	2,706.4	291.2	14.4	2021-2030
17.	“Kharkiv hospital No. 28”	26,621.4	570.3	1,346.5	152.6	19.8	2021-2030
18.	Municipal healthcare institution “Kharkiv clinical hospital No. 30”	29,101.1	642.3	1,526.7	171.9	19.1	2021-2030
19.	Municipal healthcare institution “Kharkiv clinical hospital No. 31”	34,639.0	794.8	1,926.6	212.7	18	2021-2030
20.	Municipal healthcare institution “Kharkiv student hospital”	96,528.0	1,843.2	4,415.6	493.2	21.9	2021-2030
	Total	***1,257,095.9***	***28,169.8***	***67,945.7***	***7,538.2***	***18.5***	**-**

Appendix 15. “Energy efficiency improvment in cultural institutions” program

Table 1

Performance indicators for Kharkiv integrated thermo-modernization projects with breakdown by buildings in districts

No.	Name of institution/location area	Investment	FER saved	Expenditure reduction	Emission reduction	Simple payback period	Project implementation period
		thous. UAH	MWh/year	thous. UAH	T CO_2/year	years	years
	Geographical location: Shevchenkivskyi district						
1.	Municipal primary specialized art school “Kharkiv choreographic school”	21,276.00	258.6	698.2	69.0	30.5	2020
2.	Municipal primary specialized art school “I.Yu. Repin Kharkiv children's art school No.1.”	15,411.00	203.3	526.4	54.3	29.3	2020
3.	Municipal primary specialized art school “V.I. Sokolsky Children's music school No 9.”	13,479.60	244.6	617.8	65.3	21.8	2020
	Geographical location: Osnovianskyi district						
4.	Municipal cultural institution “Palace of culture of Chervonozavodskyi district of Kharkiv “	29,892.00	401.0	1,050.5	107.1	28.5	2021
5.	Municipal cultural institution “House of culture of Chervonozavodskyi district of Kharkiv “	2,635.20	52.3	131.2	14.0	20.1	2021
	Geographical location: Kiyvsky district						
6.	Municipal cultural institution “Center of Culture of Kyivsky district	17,400.00	52.3	995.7	14.0	17.5	2 021
	Geographical location: Kholodnohirskyi district						
7.	Central Municipal Library	4,182.00	42.3	106.2	11.3	39.4	2 022
	Territorial location: Novobavarskyi district						
8.	Municipal primary specialized art school “ M.D. Leontovych children's music school No. 4	7,110.00	112.5	285.9	30.0	24.9	2 022
	Territorial location: Nemyshlianskyi district						
9.	K.I. Shulzhenko children's music school No.12.	8,416.20	164.1	419.1	43.8	20.1	2 022
	Total	***119,802.00***	***1,531.0***	***4,831.0***	***408.8***	***24.8***	

Appendix 16. Kharkiv budget review

Table 1

Information on expenditures on energy carriers and utility services from Kharkiv budget in 2012-2017

No.	2012	General fund	Special fund	Total
		thous. UAH	thous. UAH	thous. UAH
1.	Payment for heat supply	188,105.7	2,093.8	190,199.5
2.	Payment for water supply and wasterwater disposal	29,413.0	541.8	29,954.8
3.	Electricity payment	40,054.9	1,122.7	41,177.6
4.	Payment for natural gas	4,342.5	178.0	4,520.5
5.	Payment for other types of energy	140.5	10.4	150.9
	Total	*262,056.6*	*3,946.7*	*266,003.3*
No.	**2013**	**General fund**	**Special fund**	**Total**
		thous. UAH	**thous. UAH**	**thous. UAH**
1	Payment for heat supply	192,664.5	2,292.3	194,956.8
2	Payment for water supply and wasterwater disposal	28,989.8	640.4	29,630.2
3	Electricity payment	43,243.9	1,309.1	44,553.0
4	Payment for natural gas	3,146.0	89.5	3,235.5
5	Payment for other types of energy	173.0	0.9	173.9
	Total	*268,217.2*	*4,332.2*	*272,549.4*
No.	**2014**	**General fund**	**Special fund**	**Total**
		thous. UAH	**thous. UAH**	**thous. UAH**
1	Payment for heat supply	220,871.2	1,985.5	222,856.7
2	Payment for water supply and wasterwater disposal	21,475.8	477.8	21,953.6
3	Electricity payment	48,584.6	1,385.4	49,970.0
4	Payment for natural gas	2,488.0	105.5	2,593.5
5	Payment for other types of energy	148.7	0.0	148.7
	Total	*293,568.3*	*3,954.2*	*297,522.5*
No.	**2015**	**General fund**	**Special fund**	**Total**
		thous. UAH	**thous. UAH**	**thous. UAH**

1	Payment for heat supply	380,049.9	5,155.4	385,205.3
2	Payment for water supply and wasterwater disposal	13,858.2	362.6	14,220.8
3	Electricity payment	60,142.5	1,946.9	62,089.4
4	Payment for natural gas	3,895.7	186.8	4,082.5
5	Payment for other types of energy	229.3	1.3	230.6
	Total	*458,175.6*	*7,653.0*	*465,828.6*

No.	**2016**	**General fund**	**Special fund**	**Total**
		thous. UAH	**thous. UAH**	**thous. UAH**
1	Payment for heat supply	407,533.5	4,015.8	411,549.3
2	Payment for water supply and wasterwater disposal	17,782.6	897.0	18,679.6
3	Electricity payment	79,074.5	3,044.8	82,119.3
4	Payment for natural gas	4,965.2	213.1	5,178.3
5	Payment for other types of energy	168.9	0.0	168.9
	Total	*509,524.7*	*8,170.7*	*517,695.4*

No.	**2017**	**General fund**	**Special fund**	**Total**
		thous. UAH	**thous. UAH**	**thous. UAH**
1	Payment for heat supply	375,920.6	5,647.0	381,567.6
2	Payment for water supply and wasterwater disposal	21,126.6	908.5	22,035.1
3	Electricity payment	84,630.4	3,131.4	87,761.8
4	Payment for natural gas	5,331.1	2,16.7	5,547.8
5	Payment for other types of energy	235.5	,0.0	235.5
	Total	*487,244.2*	*9,903.6*	*497,147.8*

Appendix 17. Summary list of main SECAP measures

Table 1

Summary list of main SECAP measures

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
1.	**Municipal buildings, equipment/facilities**	**-**	**-**	**-**	**13,763,731.0**	**618,666.3**	**394,962.6**	**374,437.9**
1.1.	*Municipal buildings*	-	-	-	*5,311,783.5*	*154,628.4*	*3,345.5*	*42,461.2*
1.1.1.	"Energy efficiency improvement in educational institutions" programs	-	-	-	3,862,383.1	116,865.7	3,345.5	32,378.9
	Development and improvement of the energy management system	City budget, international technical assistance, grants	2019	2021	15,470.0	4,838.3	0.0	1,291.8
	Introduction of educational courses/programs in educational institutions and holding annual Sustainable Energy Days	City budget, international technical assistance, grants	2020	2030	1,795.2	4,917.3	0.0	1,630.3
	Ensuring efficient technical operation of buildings	City budget	2019	2030	32,340.0	6,983.8	0.0	1,864.7
	Conduction of current and capital reparation	City budget	2019	2030	614,350.0	27,209.6	0.0	7,265.0
	Complex energy efficient modernization of **199** buildings	IFI loans (NEFCO, KFW, EIB), city budget, ESCO	2020	2030	3,172,097.5	72,916.7	0.0	19,517.5
	Installation of solar collectors/heat pumps	IFI loans (NEFCO, KFW, EIB), city budget, ESCO, grants	2020	2030	26,330.4	0.0	3,345.5	809.6
1.1.2.	"Energy efficiency improvement in healthcare institutions" programs	-	-	-	1,257,095.9	32,169.8	0.0	8,589.0

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	Development and improvement of the energy management system	City budget, international technical assistance, grants	2019	2021	5,628.9	3,135.90	0.0	837.2
	Ensuring efficient technical operation of buildings	City budget	2019	2030	11,767.8	2794.1	0.0	746.0
	Conduction of current and capital reparation	City budget	2019	2030	223,548.6	6,608.20	0.0	1,764.40
	Complex energy efficient modernization of buildings in **20** city's hospital	IFI loans (NEFCO, KFW, EIB), city budget, ESCO, grants	2020	2030	1,016,150.6	19,631.60	0.0	5,241.40
1.1.3.	"Energy efficiency improvement in culture institutions" programs	-	-	-	192,304.5	5,592.9	0.0	1,493.3
	Development and improvement of the energy management system	City budget, international technical assistance, grants	2019	2030	1,693.9	150.8	0.0	40.3
	Ensuring efficient technical operation of buildings	City budget funds	2019	2030	3,541.0	1,015.8	0.0	271.2
	Conduction of current and capital repairs	City budget funds	2019	2030	67,267.6	2,895.3	0.0	773.0
	Complex energy efficient modernization of **9** buildings	IFI loans (NEFCO, KFW, EIB), city budget, ESCO, grants	2020	2022	119,802.0	1,531.0	0.0	408.8
1.2.	Municipal buildings, equipment/facilities	-	-	-	8,451,947.5	464,037.9	391,617.1	331,976.7
1.2.1.	Heat supply system modernization	-	-	-	4,904,867.5	327,532.2	391,617.1	207,483.4
	Measures under "Energy efficiency improvment in centralized heat supply sector" project	-	-	-	2,364,087.4	253,124.0	391,617.1	183,644.0
	Construction of 2 cogeneration stations	International Bank for Reconstruction and Development and Clean Technology Fund	2019	2025	211,226.4	0.0	48,760.0	15,493.6

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	electricity generation	-	-	-	0.0	0.0	23,000.0	9,259.72
	heat generation	-	-	-	0.0	0.0	25,760.0	6,233.9
	Elimination of 12 boiler houses	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	66,406.5	521.8	0.0	108.3
	Reconstuction of 58 boiler-houses	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	526,489.2	10,002.8	0.0	2,695.1
	Turbogenerator reconstruction at CHP-3	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	208,756.5	0.0	342,857.1	108,666.9
	Generation of electric power	-	-	-	0.0	0.0	160,000.0	64,415.4
	heat generation	-	-	-	0.0	0.0	182,857.1	44,251.4
	Introduction of frequency converters with replacement of pump units at 8 objects of centralized heat supply system	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	227,606.5	6,250.0	0.0	5,700.0
	Replacement of about 30 km of existing heating pipelines	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	494,100.0	3,843.4	0.0	961.0
	Introduction of automation. dispatching and commercial electricity metering systems (SCADA)	International Bank of Reconstruction and Development and Clean Technology Fund	2019	2025	629,502.3	232,506.0	0.0	50,019.2

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	Strategies for further modernization of city's heating system	**-**	**-**	**-**	**2,540,780.1**	**74,408.2**	**0.0**	**23,839.3**
	Replacement of high power boiler-houses	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2025	2030	466,780.00	35,567.00	0.0	8,607.21
	Replacement of heating pipelines with new pre-insulated pipelines	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2025	2030	949,000.0	15,641.2	0.0	1,845.7
	Construction in the territory of CHP-4 of a modern complex of sorting. treatment and utilization of garbage	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2025	2030	1,125,000.1	23,200.0	0.0	13,386.4
1.2.2.	Modernization of water supply and wasterwater disposal system	-	-	-	3,547,080.0	136,505.7	0.0	124,493.3
	Reconstruction of existing pumping stations of water supply and distribution system of Kharkiv with replacement of technically worn-out sections of water mains and distribution networks	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2020	2026	1,113,600.0	74,200.0	0.0	67,670.4
	Reconstruction of technically worn-out sections of water mains and distribution networks of centralized water supply system of Kharkiv	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2020	2026	2,027,480.0	39,490.3	0.0	36,015.2
	Improvement of reliability and durability of drainage	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank),	2020	2026	406,000.0	22,815.4	0.0	20,807.7

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	networks through rehabilitation using modern materials and technologies	grants, own funds of enterprises						
2.	**Residential buildings**	-	-	-	**15,268,239.2**	**3,720,019.3**	**0.0**	**1,000,553.5**
	"Energy efficiency improvement of housing stock" program	-	-	-	15,268,239.2	3,720,019.3	0.0	1,000,553.5
	Energy audits and certification of energy efficiency of residential buildings	City budget fundsfunds of co-owners .credit funds. Energy Efficiency Fund.	2020	2025	20,540.0	13,380.5	0.0	3,572.6
	Informational and educational work among city population on energy efficiency, and annual Days of Sustainable Energy	City budget funds. funds of international technical assistance projects. grant funds	2020	2030	7,990.0	178,201.6	0.0	59,079.8
	Encouragement of city residents to implement energy-efficient measures and use energy-saving lighting devices and household appliances in their households	City budget fundsfunds of co-owners .credit funds	2019	2030	1,834,000.0	920,417.6	0.0	245,751.5
	Ensuring of efficient technical performance of buildings	City budget fundsfunds of co-owners	2019	2030	1,112,345.0	399,742.2	0.0	106,731.2
	current repairs and overhauls	City budget funds.funds of co-owners .credit funds	2019	2030	6,785,345.0	1,159,904.1	0.0	309,694.4
	Installation of heat points, pumps and heat meters under "Energy efficiency improvment in centralized heat supply sector" project	International Bank of Reconstruction and Development and the Clean Technology Fund	2019	2020	364,840.2	67,764.0	0.0	13,901.3

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	Complex energy-efficient modernization of **2,350** buildings	City budget fundsfunds of co-owners .credit funds. Energy Efficiency Fund.ESCO	2021	2030	5,143,179.0	980,609.3	0.0	261,822.7
3.	**Municipal public lighting**	-	-	-	**822,890.0**	**7,422.6**	**302.0**	**7,411.3**
	"Modernization of external lighting system" program	-	-	-	822,890.0	7,422.6	302.0	7,411.3
	Development and improvement of energy management system	Own funds of enterprises	2020	2022	2350.0	313.0	0.0	285.4
	Development of electronic map of city's external lighting system	Own funds of enterprises	2020	2022	4300.0	156.5	0.0	142.7
	Reconstruction of city's external lighting system	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2019	2030	733900.0	5000.1	0.0	4926.7
	Modernization of automatic control system for external lighting	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2020	2022	79140.0	1953.0	0.0	1781.1
	Installation of supports with autonomous lighting on photovoltaic modules	Own funds of enterprises, grants, IFI loans	2021	2022	3200.0	0.0	302.0	275.4
4.	**Transport**	**-**	**-**	**-**	**14,743,528.9**	**119,759.6**	**0.0**	**66,154.0**
	Adjustment of Kharkiv complex transport scheme	City budget	2020	2022	10,000.0	2,271.5	0.0	1,282.2
	Modernization of electric power supply management system of Kharkiv electric transport.	IFI loans (NEFCO, KFW, EIB, EBRD, World Bank), grants, own funds of enterprises	2020	2025	1,402,150.0	7,049.0	0.0	6,428.7
	Renewal of Kharkiv trolleybus fleet.	EBRD loans	2019	2020	333,499.9	7,835.9	0.0	7,146.4

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	Acquisition of city's electric transport rolling stock	EIB loans	2019	2020	270,000.0	7,835.9	0.0	7,146.4
	Extension of third metro line in Kharkiv	Loans from EBRD, EIB, City budget	2019	2024	10,230,000.0	18,929.1	0.0	10,684.9
	Renewal of Kharkiv metro rolling stock	EIB loans	2019	2022	1,305,000.0	7,952.1	0.0	7,252.3
	Modernization, repairs and maintenance of metro infrastructure infrastructure	Own funds of enterprises	2019	2025	349,879.0	13,826.0	0.0	3,871.3
	Road safety in Kharkiv	IFI loans, own funds of enterprises, grants	2019	2030	640,000.0	17,689.1	0.0	10,395.8
	Optimization of quantitative and qualitative structure of city buses, encouragement of carriers to renew their rolling stock	Own funds of enterprises	2020	2025	120,000.0	28,420.7	0.0	7,458.4
	Promotion of bicycle transport and construction of bicycle paths	City budget, grants	2020	2030	83,000.0	7,950.2	0.0	4,487.7
5.	**Tertiary sector (small and medium-sized business, service sector)**	**-**	**-**	**-**	**3,367,400.8**	**535,602.7**	**0.0**	**251,659.2**
	Ensuring of energy efficient performance of buildings and equipment	Funds of private enterprises	2019	2030	320,437.2	40,573.8	0.0	10,833.2
	Annual Sustainable Energy Days	Funds of private enterprises	2020	2030	250.0	8,290.6	0.0	2,748.6
	Introduction of energy efficient lighting	Funds of private enterprises	2019	2030	179,464.9	103,401.0	0.0	94,301.7
	Insulation of building envelopes and replacement of windows	Funds of private enterprises	2020	2030	1,065,182.6	99,119.0	0.0	23,986.8
	Installation of heat points and heat meters	Funds of private enterprises	2020	2030	565,378.0	53,445.0	0.0	12,933.7

No.	Project name	Sources of financing	Start date	Completion date	Investment	Expecting saving	Renewable energy production/cogeneration	Emission reduction
			year	year	thous. UAH	MWh/year	MWh/year	tons of CO_2/year
	Use of energy-efficient technological equipment	Funds of private enterprises	2020	2030	1,236,688.1	230,773.3	0.0	106,855.2
	Total by selected sectors	**-**	**-**		***47,965,789.9***	***5,001,470.4***	***395,264.6***	***1,700,216.0***
6.	**MSW management**	**-**	**-**	**-**	**1,136,150.9**	**-**	**22,140.0**	**57,245.2**
	New construction of a complex for municipal solid waste treatment with a system of landfill gas collection, utilization and generation	World Bank, Clean Technology Fund, city budget	2017	2020	1,125,472.1	0.0	22,140.0	51,000.0
	Ensuring of efficient solid waste management	City budget, international technical assistance projects, grants	2020	2030	10,678.8	0.0	0.0	6,245.2
	Total by measures	-	-	-	**49,101,940.8**	**5,001,470.4**	**417,404.6**	**1,757,461.2**