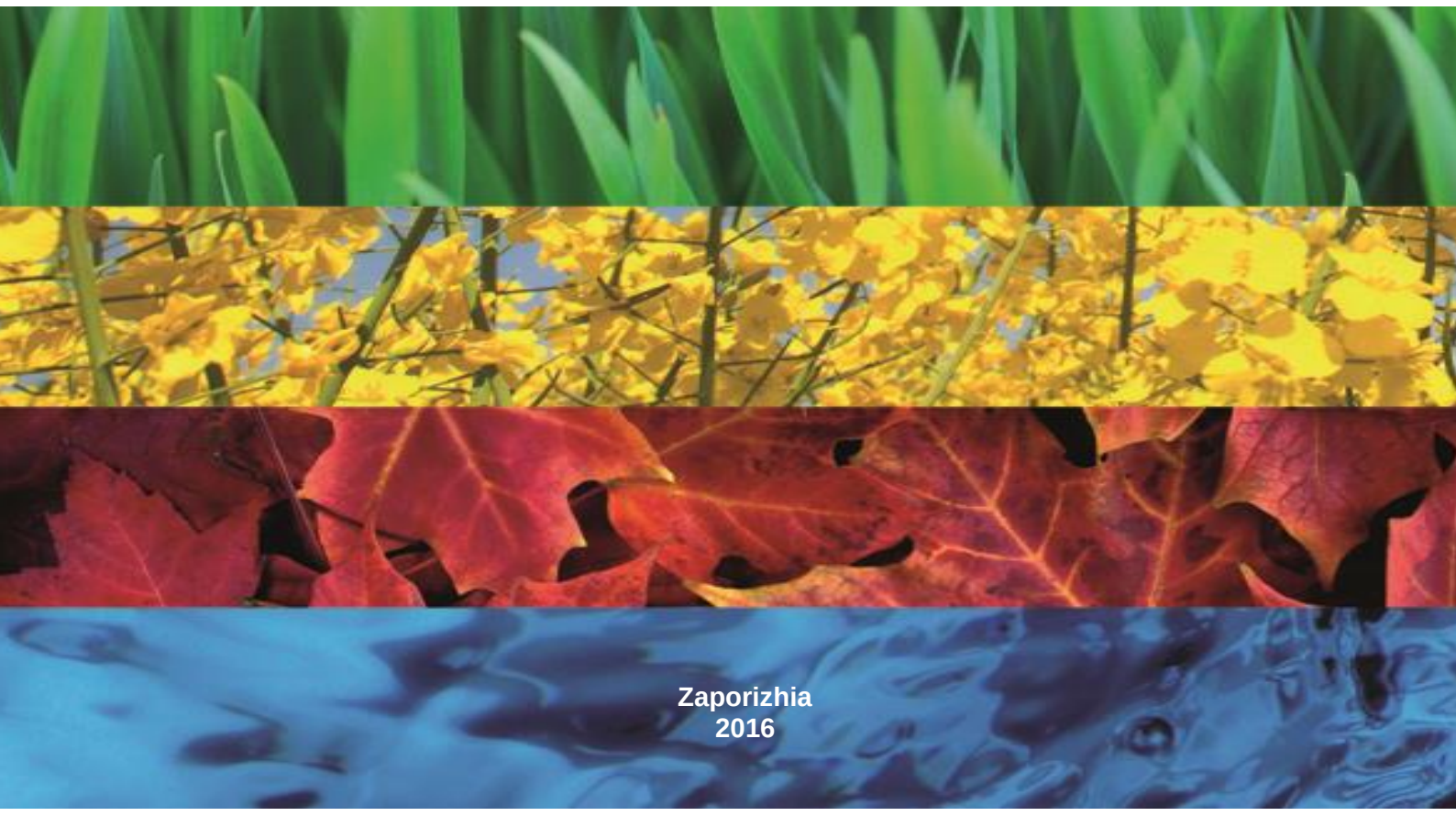
City Energy Efficient Transformation Initiative

City Energy Efficiency Assessment Report

City of Zaporizhia

(April 11, 2016)



Zaporizhia
2016

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List of abbreviations

CHP	Combined heat and power
CA	City Authority, City Administration
CEETI	City Energy Efficient Transformation Initiative
DH	District heating
DPP	Discounted payback period
EBRD	European Bank for Reconstruction and Development
EE	Energy efficiency
EIB	European Investment Bank
EnPC	Energy Performance Contracting
ESCO	Energy Service Company
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GWh	Giga Watt Hours = million kilo Watt Hours
IFI	International Finance Institution
IHS	Individual Heating Substations
KfW	Kreditanstalt für Wiederaufbau (German government-owned development bank)
KPI	Key Performance Indicator
LED	Light Emitting Diode
MEP	Municipal Energy Plan
mln	million
MSS	Motor Soft Starter
MTM	Miski teplovi merezhi (name of municipal DH utility)
MU	Municipal Utility
n/a	not available
PEC	Primary Energy Consumption
PV	Photovoltaic
RE	Renewable Energy
REI	Relative Energy Intensity
SEAP	Sustainable Energy Action Plan
TRACE	Tool for Rapid Assessment of City Energy
UAH	Ukrainian Hrivna (local currency)
USD	United States dollar
VAT	Value-added tax
VSD	Variable Speed Drive, Frequency Control
WB	The World Bank
WWTP	Waste Water Treatment Plant

1 Introduction

The purpose of this report is to present the summarized results from the urban energy efficiency assessment which was performed with the Tool for Rapid Assessment of City Energy (TRACE) by the Energy Sector Management Assistance Program (ESMAP) of the World Bank in the framework of the City Energy Efficiency Transformation Initiative (CEETI). CEETI is a technical assistance program and has been supporting the three Ukrainian cities Kiev, Ternopil and Kamianets-Podilsky in building local capacity for developing and implementing transformational energy efficiency investments in municipal services, public buildings and infrastructure since 2014.

Building upon those efforts the city of Zaporizhia as the fourth Ukrainian city has been selected to benefit from an urban energy efficiency assessment and preliminary identification of potential energy efficiency investment projects and development of an investment pipeline.

The city of Zaporizhia is an important industrial center of Ukraine has a strong commitment to sustainable development as reflected in the city's:

- Municipal Energy Plan for the period 2014-2030 (MEP);
- joining of the Covenant of Mayors in 2013 and elaboration of a Sustainable Energy Action Plan for the period of 2015-2030 (SEAP);
- engagement for IFI investments in sustainable energy, such as the planned EBRD, KfW and EIB projects.

The findings of the City Energy Efficiency Assessment Report enable the municipality to develop and inform a sound cross-sectoral municipal investment program until 2030 and mobilize finance and technical assistance to implement the identified energy efficiency investments.

The interrelation between the CEETI Project's EE assessment report and the SEAP is considered in two directions: a) the SEAP-2014 provide the justification for intervention and targets in prioritized sectors, and b) the TRACE analysis provides the conceptual background for an energy efficiency investment project catalogue and for the in-depth analysis for the SEAP up-date.

Process of the Energy Efficiency Assessment and Structure of the Report

The purpose of the EE assessment is to analyze the performance of sectors of municipal energy consumption to prioritize areas of intervention and develop a set of energy efficiency measures which will provide the framework for the follow-up energy efficiency Priority Investment Program of the city. The sectors of municipal infrastructure which have been analyzed in the light of their energy performance are:

- Municipal public buildings
- Street lighting
- District heat supply
- Residential buildings
- Urban public transportation
- Potable water supply and waste water treatment
- Solid waste management

And to a lower extend:

- Industry
- Commercial buildings
- Private transport
- Non-municipal public buildings
- Power supply

The process is accompanied by active communication with the city stakeholders (as **City Administration**, **municipal utilities** and **energy enterprises**) to confirm the results of the analysis and generate ownership.

The process of the Energy Efficiency Assessment commenced with the compilation of related data and information from the Zaporizhia City Authority as well as utilities of municipal services. Data collection and interviews with stakeholders took place in January – February 2016. The results have been documented in the City Background Report (please refer to Chapter 2 and Annex 1)

Out of that report the Key Performance Indicators for the City of Zaporizhia have been calculated (please refer to Annex 2) and aggregated in the TRACE model.

The benchmarking component of the TRACE enables the comparison of energy performance with Ukrainian and other peer cities with similar characteristics. From this "Relative Energy Intensity" a rough estimate of the theoretical energy efficiency potential in each sector has been derived. (please refer to Chapter 2 and Annex 4).

Additional factors for the prioritization of the target sectors are the spending for energy and the City authority level of control in terms of budget control, regulatory and enforcement power (please refer to Chapter 3 and Annex 3).

The report builds largely upon analysis and project proposals of the existing urban energy efficiency plans and initiatives, which are complemented by the findings from the deployment of the TRACE model and a set of further recommendations on EE investments and actions. Sources for the analysis and recommendations of the City Energy Efficiency Assessment Report are:

- Project proposals from **Municipal Energy Plan** and **Sustainable Energy Action Plan**;
- Investment projects out of those plans, which commenced the implementation
- Energy efficiency projects from short-term investment programs which were given by Zaporizhia municipal utilities and energy enterprises within CEETI Project in Zaporizhia: Concern «Miski teplovi merezhi» (district heating sector), MU «Vodokanal» (potable water and wastewater sector), MU «Zaporizhelectrotrans» (municipal electric transportation sector), MU «Zaporizhmisksvitlo» (street lighting sector);
- Project proposals defined during the work meetings with the representatives of municipality, utilities and energy enterprises within CEETI Project in Zaporizhia;
- A range of energy efficiency recommendations from **TRACE;**
- Project proposals based on international best practice developed by the Consultant.

The recommended EE projects are in line with the targets and approach of the key EU documents related to climate change mitigation such as:

- Directive 2010/31/EU on the energy performance of buildings (EPBD);
- Directive 2009/28/EU on the promotion of the use of energy from renewable sources;
- Directive 2012/27/EU on energy efficiency.

The preliminary evaluation leads to a set of energy efficiency recommendations by sector (please refer to Chapter 4 and Annex 4).

Key sector features and challenges together with the EE potential analysis have been presented and discussed at the Decision Workshop in March 2016.

The present energy efficiency assessment report reflects the decisions taken during the workshop with key energy stakeholders of the city.

It has been agreed with the World Bank team and the City Administration to aggregate data on energy consumption baseline for the year 2015 out of available and proven data of the year 2012 and up-date those according to recent deviations.

2 City energy background and benchmarking with other cities

2.1 City energy consumption

The city of Zaporizhia is one of the largest administrative, industrial and cultural center in the south of Ukraine and is located on the main waterway – the river of Dnipro.

The area of the city in the current administrative boundaries comprises 33 099 hectares. The population of Zaporizhia according to the last census in 01/2013 amounted to 768,900 inhabitants.

An overall amount of city wide consumed energy in 2012 is **17 622.7 GWh.**

Specific primary energy consumption (PEC) in 2012 was 22 866 kWh per capita per annum.

The energy intensity of Zaporizhia is twice as much as for less industrialized cities in Ukraine, such as Ternopil or Kamianets-Podilsky[1] and even 30% higher as in the capital Kyiv.

According to the energy balance of 2012 the industry sector constitutes the largest energy consumer with approx. 60% of the overall energy consumption.

The residential sector in the city is the second largest energy consumer, with a share of approximately 25 %, while the following sectors are: private vehicles – 8 %, the sector of commercial buildings (including other buildings) – 3 %.

The final energy consumption of all sectors which are under the control of the City Administration amounts to 538.7 GWh, representing 3.35 % of overall consumption. This includes sectors of district potable water and wastewater, public transportation, street lighting, municipal buildings.

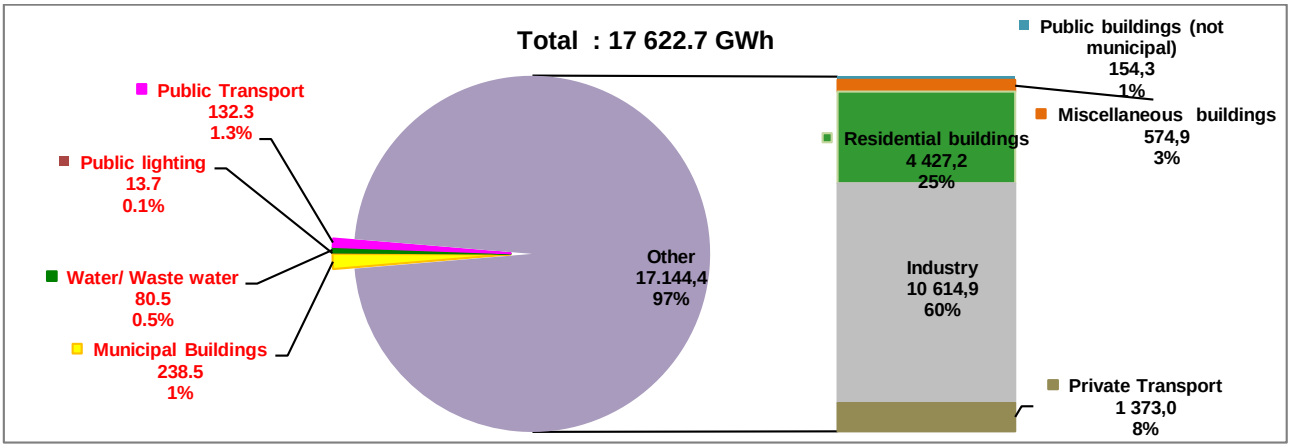


Figure 2.1. Final energy consumption by city consumers for 2012

Note: *the sectors, where the City Authority has high influence, are marked with* ***red color.***

[1] Primary Energy Consumption (PEC) benchmark with other analyzed cities in Ukraine

	Zaporizhia	Ternopil	Kamianets-P.	Kyiv
Population	768.900	218.600	102.300	2.868.700
PEC (GWh)	17.623	2.727	1.151	48.191
Energy Intensity (MWh/capita)	23	12	11	17

Annex 1 of the report provides the energy balance of Zaporizhia for the basic year of 2012, which enables to identify the energy flow from primary through energy transformation, distribution and losses to the end use sectors.

2.2 City energy spending

Energy expenditures for the sectors, which are controlled by the city authority (municipal public transportation, public buildings, street lighting, solid waste, potable water & wastewater), amounted to 30.2 mln USD in 2015, of which 50 % were spent on supplying energy to municipal public buildings. These 15.4 mln USD make a share of 8 % of the municipal budget of Zaporizhia which amounted to 153.5 mln USD in 2015.

Energy consumption of the sectors, which are directly controlled by the city authority, amounts to only 3 % of the total energy consumption in the city. But implementing energy efficiency measures in these sectors is very important for the city and the City Authority, in particular because energy savings in these sectors will directly lead to the decreasing energy costs and reducing expenditures from the city budget or governmental subsidies. This is mainly related to the expected increase of the energy cost, where investment in energy saving will oppose the growth of tariffs and risks of losing the accessible sources of energy or services for end-consumers.

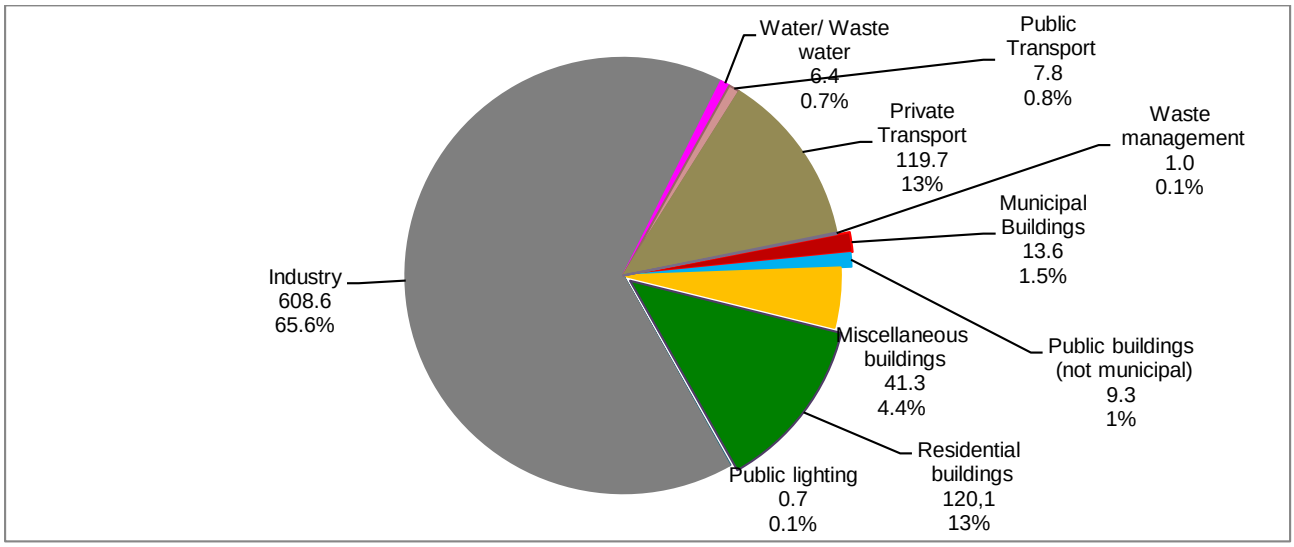


Figure 2.2. Energy expenditures for 2015, amounted at 928.4 mln USD[2]

The majority of municipal infrastructure of the city of Zaporizhia has been constructed in 1960-70th and is to a large extend outworn be reaching its lifetime. Additionally, the city is experiencing a number of economic challenges, due to recent political and economic developments in Ukraine.

The main challenges for the city of Zaporizhia are:

- Short to medium term increase of energy prices and elimination of the cross subsidization for the population will have negative effects on affordability of energy and maintenance of municipal services.
- The city's infrastructure is ageing. That has been due to 40 years for utility, energy and industrial assets without any retrofit. Zaporizhia is losing attractiveness compared to other cities.

[2] estimated on energy prices in December, 2015

- The energy intensive industry of Zaporizhia will without any large retrofit efforts lead to decreased competitiveness and tax incomes up to 2030, which will consequently decrease the supply to the city budget in the long-run period.
- High level of air pollution and GHG emissions due to high degree of industrialization.
- The most critical sectors of Zaporizhia are residential and public buildings, due to their high energy intensity. Growth of energy tariffs goes ahead of income growth. This reduces the ability of CA and residents to pay for energy consumption.

2.3 Energy efficiency benchmarking of the city of Zaporizhia

The benchmarking exercise allows to compare city energy efficiency indicators of Zaporizhia with other peer-cities, based on 12 selected key energy efficiency indicators (according to the TRACE model methodology).

Annex 4 describes the process and results of benchmarking of Zaporizhia in detail.

The following table provides a summary on the characteristics of the sectors.

Table 2.1. Summary benchmarking of Key Performance Indicators of Zaporizhia

Sector	Selected KPI		Comparison of Performance with better performing cities	Theoretical energy saving potential[3]
District heating	Heat losses from DH network	14 %	Medium performance: *Peer-cities: cities in Eastern Europe* *Ukrainian peer city Kyiv: 18%*	5-10%
Private vehicles	Specific energy consumption of private vehicles	1.54 MJ / passenger km	Medium performance	25 %
Public transportation	Specific energy consumption of Public transportation	0.81 MJ / passenger km	Low to Medium performance *Ukrainian peer city Kyiv: 0,4* MJ / passenger km *Peer-cities: Warsaw, Belgrade, Budapest*	35 - 50%
City wide energy consumption	Annual primary energy consumption per capita	88,9 GJ/capita	Low performance *Ukrainian peer city Kyiv: 56* 88,9 GJ/capita	50%
Solid waste	Percent of processed solid waste	0,3 %	Very low performance *Ukrainian peer city Kyiv: 17%* *Peer-cities: Barcelona, Vienna, Toronto.*	50-70%

[3] The theoretical primary energy saving potential combines measures reduction of energy consumption at the end consumer side and the use of renewable energy sources at the energy generation side to substitute primary energy carriers.

Sector	Selected KPI		Comparison of Performance with better performing cities	Theoretical energy saving potential[3]
Water supply and waste water	Energy density of potable water production	0.55 kWh_e/m^3	Medium performance *Ukrainian peer city Kyiv:* 0,66 kWh_e/m^3 *Peer-cities: Vienna, Cebu*	60%
	Energy density of wastewater treatment	0.52 kWh_e/m^3	Medium performance *Ukrainian peer city Kyiv:* 0,73 kWh_e/m^3 *Peer-cities: Vienna, Toronto*	50%
Municipal public buildings	Energy consumption for space heating of municipal buildings	161 kWh_e/m^2	Low performance *Ukrainian peer city Kyiv: 1*86 kWh_{th}/m^2 *Peer-cities: Budapest, Skopje*	70-80%
Residential buildings	Energy consumption for space heating of multi-storey residential buildings	161 kWh_{th}/m^2	Low performance *Peer-cities: Budapest, Skopje*	70-80%
Street lighting	Specific electricity consumption per 1 km of lit street	10 506 kWh_e/km	Medium performance *Ukrainian peer city Kyiv:* 38000 kWh_e/km *Peer-cities: Helsinki, Toronto*	40-60%

In comparison with peer-cities from the TRACE database and the Ukrainian Peer city of Kyiv, the majority of specific energy indicators of Zaporizhia are high low to medium.

This indicates the potential for energy saving, which are:

- Thermal energy consumption by municipal public buildings;
- Specific electricity consumption by potable water & wastewater;
- Specific energy consumption by street lighting;
- Specific energy consumption by urban transport;
- Specific energy consumption by public transportation;
- Specific losses in the system of thermal energy distribution.

The energy savings potential in the above mentioned municipal sectors is significant at a level of 60-70 % which can be achieved by the combination of investment measures at a) reduction of energy consumption at the end consumer side and b) the use of renewable energy sources at the energy generation side to substitute primary energy carriers, e.g. for district heating or hot water supply and use of waste heat.

The results of the comparative analysis deliver one component to define the prioritized sectors of the city with high energy saving potential. Moreover, the results define the performance of

Zaporizhia in comparison to Ukrainian and European cities in order to define the main direction for the city's energy policy for the next 10 years.

Figure 2.3. Specific thermal energy consumption by **residential buildings**

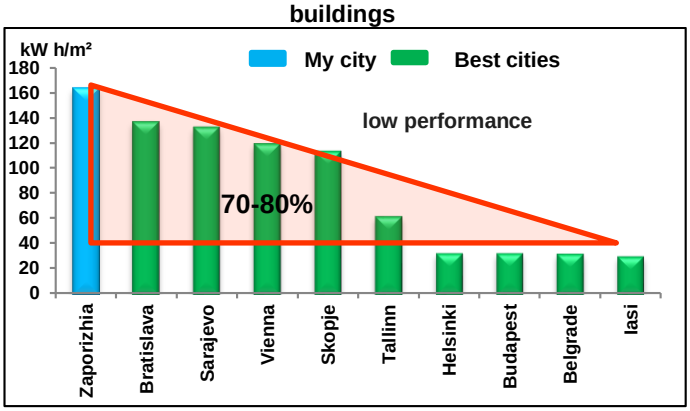


Figure 2.4. Specific thermal energy consumption by **municipal buildings**

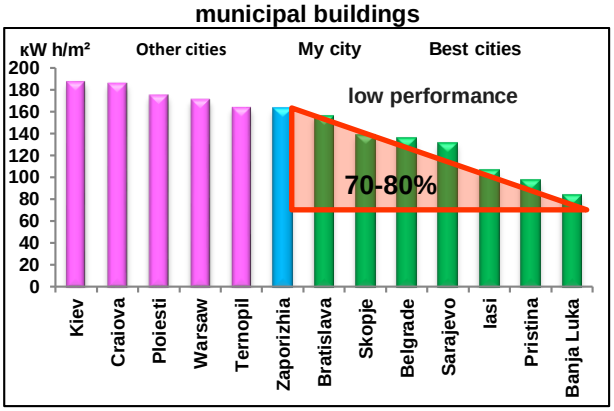


Figure 2.5. Specific electricity consumption for potable water

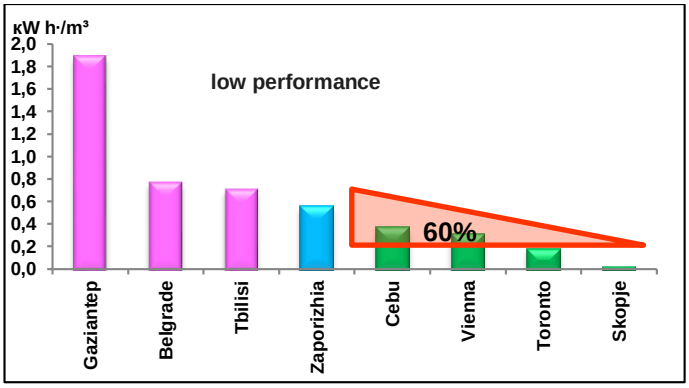
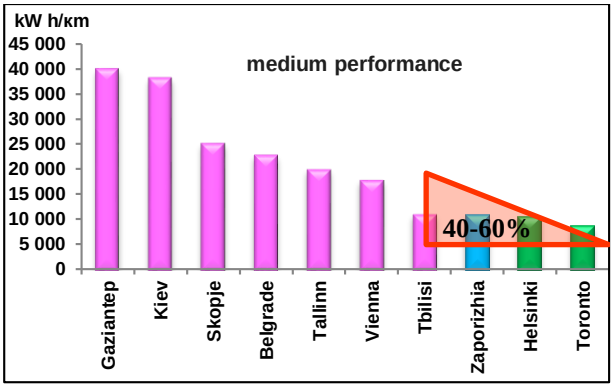


Figure 2.6. Specific electricity consumption of 1 km of illuminated street



2.4 Planned, ongoing and completed investment programs

The city's first long-term energy strategy was elaborated in 2012, as **Municipal Energy Plan for the period of 2014-2030** (MEP). In 2013 the city of Zaporizhia joined the European Covenant of Mayors initiative. A **Sustainable Energy Action Plan for the period of 2015-2030** (SEAP) was elaborated in 2014 and has been approved by Zaporizhia City Council's Decision № 68[4], dated March 25, 2015.

Following the recommendations given in MEP and SEAP, the Zaporizhia City Administration has established **Municipal Utility «Zaporizhia Energy Agency»** (Zaporizhia City Council's Decision № 18[5], dated June 30, 2015). The main objectives of the Agency are:

1. Development of EE investment projects, which have been considered and included in the list of energy efficiency recommendations for further elaboration of the city's priority investment program;
2. Implementation of EE investment projects by means of Energy Performance Contracting (EnPC) as a delivery mechanism;
3. Leveraging financing from central government sources, International Financing Institutions (IFI), donors and private parties.

Currently, the Agency is in the process of formation and staffing.

A number of investment projects have been recently implemented or committed for financing from municipal funding sources, as well as with funding and technical assistance of IFIs. The experience obtained and lessons learned from those EE interventions are necessary for the further

[4] Source: Official website of Zaporizhia City Council: http://meriazp.gov.ua/test/index.php?id=42&pid=14876
[5] Source: Official website of Zaporizhia City Council: http://meriazp.gov.ua/test/index.php?id=42&pid=16005

planning and implementation of EE investment projects in order to build local institutional capacities and apply financial delivery mechanisms.

Municipal buildings sector

- The pilot project for «Thermal renovation and reconstruction of the municipal health facility, called «Oleksandrivsky District Central Policlinic» in 88 Soborny avenue, Zaporizhia» was implemented in 2015;
- The project for «Thermal renovation of 361 municipal public buildings» is under consideration by KfW Development Bank and EBRD;
- The project for «Renewable heat generation with heat pumps and biomass boilers for 275 municipal public buildings» is under consideration by KfW and EBRD.

Residential buildings sector

- The «Installation of heat meters in multi-storey residential buildings program» was implemented by «Miski teplovi merezhi» (municipal DH utility). As a result, 76 % of all residential buildings are equipped with heat meters (as of March 01, 2016).
- State Program for financial support of thermal retrofit initiatives in residential sector (ongoing). The program enables municipalities to obtain up to 40% of targeted subsidies for purchasing of EE goods.
- Municipal program for reimbursement of interest paid on loans provided by local financial institutions for implementation of energy savings measures between 2015 and 2019. Beneficiaries are Homeowners Associations (HOAs) of multistorey buildings.

District heating sector

During the period 2012 and 2015 «Miski teplovi merezhi» completed a short-term investment program aimed at increasing energy efficiency of district heat facilities, including:

- Installation of condensing economizer units in flue gas channel of 7 large-scale boiler-houses;
- Replacement of water pumps and boiler fans with variable speed drives at boiler-houses;
- Renovation of district heating networks

As a result, the annual energy savings of 65.6 GWh are achieved.

Potable water and wastewater sector

The EBRD-supported Project «Investment in the Development of the Water Supply and Water Treatment System in Zaporizhia» was successfully completed in 2014. Interventions comprise:

- Replacement of energy-intensive pumps and motors to match duty requirements with peak efficiency on water pump stations (level 1-3) and sewage pump stations;
- Equipment of operating motors with VSD and MSS;
- Reconstruction of the Waste Water Treatment Plant-1 (WWTP-1);
- Renovation of potable water supply networks.

As a result, the annual energy savings of 29.1 GWh are achieved.

Street lighting sector

- Replacement of 28 600 energy intensive mercury-vapor lamps with sodium-vapor lamps until 2014;
- Pilot project on «Renovation of street lighting system and replacement by LED». More than 1 000 LED lamps have been installed during 2015-2016, financed from municipal budget of Zaporizhia.

Annexes 1 and 4 comprise more detailed information about the implemented EE projects.

2.5 City Energy Efficiency Objectives

Zaporizhia joined the European initiative Covenant of Mayors in 2013 and has prepared a Sustainable Energy Action Plan (SEAP) which defines three pillars of the city's long-term objectives until 2030:

1. Energy saving targets **«From energy imports to energy exports»**:

- 67% reduction of space heating demand in 2418 multi-storey residential and 361 public buildings;
- 67% reduction of natural gas consumption for district heating;
- 100 % replacement of natural gas with local renewables for heating of public buildings and hot water supply;
- Installation of renewable energy[6] generation capacity of 100 MWe.

2. Financial targets **«City money should remain in the city»**:

- 67% reduction of costs for space heating of residential buildings;
- 80% reduction of costs for space heating of municipal public buildings;
- 60% reduction of costs for hot water supply;
- 50% reduction of costs for power supply of residential and public buildings and municipal utilities.

3. Environmental targets **«Zaporizhia becomes a green city»**:

- Up to 2020: 6 % reduction of CO2 emissions compared to 2012;
- Up to 2030: 30 % reduction of CO2 emissions compared to 2012;
- Up to 2050: 50 % reduction of CO2 emissions compared to 2012.

Those ambitious targets can only be achieved by integrated planning and implementation of large scale investment projects in the frame of a city energy efficiency transformation program. On the basis of the TRACE assessment an investment project pipeline has been developed which paths the way towards to comprehensive improving energy efficiency and renewable energy use in the municipal energy sectors.

Dynamics of political and economic challenges drive the need to achieve financial benefits which are linked to reduced energy demand, such as result of public buildings retrofit, supporting the city authority to manage the expected impacts of energy price increases.

The expected main benefits of the program when the city implements those measures will be:

Direct benefits:	**Indirect benefits:**
✓ Reduction of energy and water losses ✓ Reduction of energy demand and consumption ✓ Reduction of energy costs ✓ Reduction of energy bills and budget spending ✓ Substitution of gas consumption ✓ Increase of efficiency of municipal facilities ✓ Reduction of costs for operation, repair and maintenance of facilities ✓ Partly covering own energy demand by renewable energy ✓ Reduction of consumption of environmental resources ✓ Reduction of environmental emissions	✓ Increase of working and living comfort (in particular in buildings by meeting the normative conditions) ✓ Increase of quality of municipal services and utilities ✓ Addressing the challenges of natural gas deficits ✓ Reduction of the risks of crisis events in urban infrastructure and facilities. ✓ Reduction of gas price state subsidies ✓ Reduction of state subsidies and budget transfer to municipality for municipal facility and service operation ✓ Increase of safety of urban infrastructures (e.g.

[6] This comprises solar photovoltaic installations, biomass CHPs, a biogas plant

Direct benefits:	**Indirect benefits:**
	environmental damages or at streets)

3 Identifying Priority Sectors of City Energy Efficiency Interventions

The purpose of sector prioritization is to identify those sectors of the urban infrastructure which have highest energy saving potential and highest impact on the energy efficiency transformation of the city. This will enable to address activities, efforts and investment programs in a priority order of importance.

Following the TRACE methodology, the exercises of prioritization of each sector considers three factors:

- City authority's level of control [%].
- Theoretical energy efficiency potential - "Relative Energy Intensity" [%];
- Level of spending for energy in the sector of municipal energy [USD/a];

The highest priority sector relates to the product of these factors, with

- the largest indicator of relative energy efficiency;
- the largest level of the City Authority's control in terms of expenditures and its influence on energy politics in the sector.

The analyzed sector prioritization according to the TRACE methodology for the city of Zaporizhia outlines as follow in priority order.

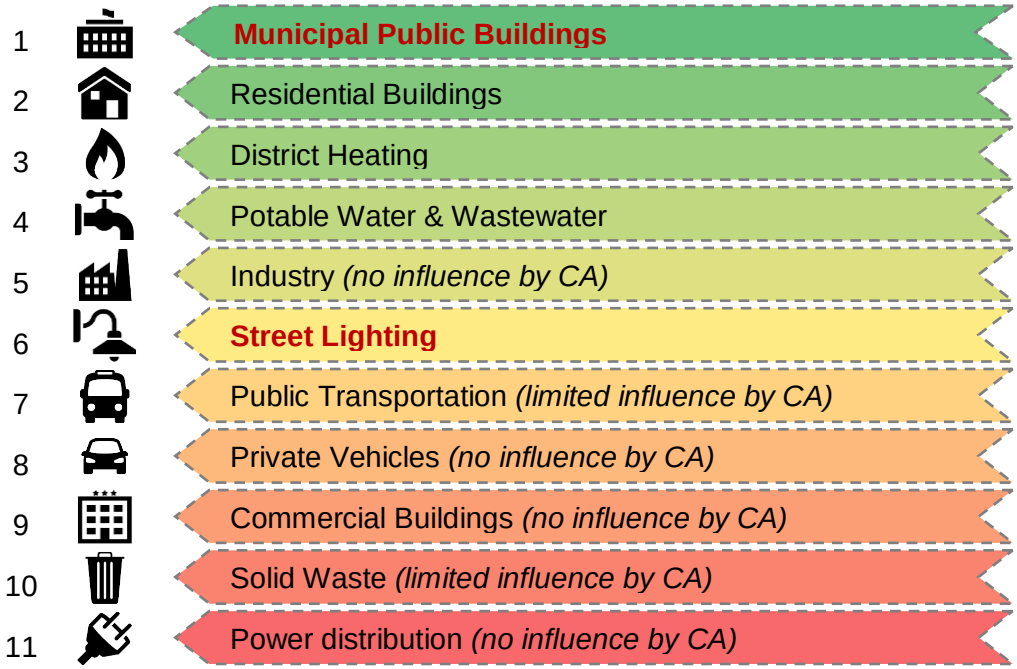


Figure 3.1. The results of the city sector prioritization (according to TRACE methodology)

***Note:** **Red color** marked are those sectors, on which energy efficiency interventions will lead to direct reduction of energy spending from the city budget.*

The following sectors are set aside and not pursued further, as the city has almost little leverage on them:

- Public, non-municipal buildings;
- Commercial buildings;

- Solid waste sector;
- Public, non-municipal owned transportation;
- Private transport;
- Power distribution;
- Industrial sector.

This does not necessarily mean that no energy efficiencies are to be developed in these sectors. It simply indicates that, when compared to other sectors, they are unlikely to produce as compelling energy efficiency savings potential or are unlikely to be achievable by the CA.

More detailed information on identifying priority sectors is provided in Annex 3.

4 Recommended Investment Pipeline for City Energy Efficiency Transformation

The implementation of energy efficiency transformation in Zaporizhia is planned in two stages:

1. During the short-term period 2017-2020: Implementation of prioritized EE investment projects which ensure the fulfilment of obligations by 2020 under Covenant of Mayors;
2. During the medium-term period 2021-2030: Implementation of perspective EE investment projects which ensure the achievement of goals by 2030 established in Sustainable Energy Action Plan and Municipal Energy Plan.

4.1 Priority energy efficiency investment plan for the period 2017-2020

Table 4.1 provides a summary of 15 recommended EE investment projects for the period of 2017-2020 for the priority sectors in terms of investment demand, energy efficiency potential and a preliminary indication of profitability.

Table 4.1. Preliminary key investment projects for the period 2017-2020

Code	Project name	Investment demand, including VAT	EE/RE Potential			Specific EE per investment	Discounted payback period (DPP)[7]
			Natural gas	Electricity	Total		
		mln USD	mln m³/a	GWh/a	GWh/a	kWh/USD	years
	Municipal buildings	**31.9**	**8.3**	**-**	**78.0**	**2.4**	**12.2**
PB-01-I	Thermal renovation of 361 municipal public buildings (1st stage: 121 buildings)	27.6	5.6	-	52.9	1.48	11.9
PB-02-I	Renewable heat generation with heat pumps and biomass boilers for 275 municipal public buildings (1st stage: 90 buildings)	4,3	2.7	-	25.1	5.83	14.8
	Residential buildings	**87.0**	**14.8**	**-**	**139.1**	**1.2**	**9.0**
RB-01	Partial thermal renovation of 214 multistorey residential buildings (windows, EE ventilation, individual heating substations)	87.0	14.8	-	139.1	1.2	9.0
	District heat supply	**35.1**	**25.0**	**40.0**	**307.4**	**8.8**	**5.6**

[7] Calculation of payback period is based on a) approximate evaluation of investment costs, b) forecasted growth of energy prices (please refer to Annex 5), c) discount rate r=5% (for the projects funded by KfW) and r=7% (for the projects funded by EBRD and other IFIs). Operation period is up to 2030. Assumed accuracy of calculation is in a range of ± 15%.

Code	Project name	Investment demand, including VAT	EE/RE Potential			Specific EE per investment	Discounted payback period (DPP)[7]
			Natural gas	Electricity	Total		
		mln USD	mln m³/a	GWh/a	GWh/a	kWh/USD	years
DH-01	Renewable energy hot water for Shevchenkivsky residential district (construction of biomass CHP with total installed capacity of 1.2 MWe and 5.0 MWth)	13.4	4.3	8.0	48.8	3.6	11.9
DH-02	Installation of 801 individual heating substations and remote metering system	7.8	3.0	1.1	29.2	3.8	5.7
DH-03	Replacement of circuit pumps and equipment with VSD in 2 large-size boiler-houses	1.7	-	5.9	5.9	3.5	2.5
DH-04	Replacement of burners on 6 boilers of type PTVM-30 on Artema boiler-house	1.5	0.6	-	5.5	3.8	6.0
DH-05	Construction of CHP (total installed capacity of 3.0 MWe and 3.0 MWth) on Tovaryska boiler-house	4.0	-3.1	24.0	24.0	6.1	4.3
DH-06	Reduction of Gas Consumption Program of Concern "MTM" for the period of 2016-2017 *(increasing efficiency of 12 medium-size boiler-houses and 3 central heating substations)*	1.2	1.7	0.1	16.5	13.5	1.6
DH-07	Replacement of 10 coal boilers with biomass boilers	0.7	-	-	3.2	4.4	3.4
DH-08	Reduction of Electricity Consumption Program of Concern "MTM" for the period of 2016-2017 *(equipment of pumps and fans with VSD on 7 medium-size boiler-houses)*	0.5	-	0.8	0.8	1.5	6.0
DH-09	Utilization of industrial waste heat for hot water supply in Zavodsky residential district	4.3	18.5	-	173.4	40.2	10.0
	Potable water and wastewater	**3.7**	**-**	**9.8**	**9.8**	**2.6**	**3.2**
WW-01	Reduction of Power Consumption Program of MU «Vodocanal» for the period of 2016-2017 *(equipment of pumps with VSD on Khortitsa Water Pump Station (level-3) and with MSS on Dnipro Water Pump Station (level-1) and 9 sewage pump stations)*	3.7	-	9.8	9.8	2.6	3.2
	Street lighting	**22.3**	**-**	**13.7**	**13.7**	**0.6**	**9.7**
SL-01	Renovation of street lighting system based on LED and PV power plant with 6.0 MWp capacity	22.3	-	13.7	13.7	0.6	9.7
	Municipal electric transportation	**1.6**	**-**	**0.6**	**0.6**	**0.4**	**-**
TM-01	Replacement of 10 outworn trolley-buses with new more efficient trolley-buses	1.6	-	0.6	0.6	0.4	-
	Total	**181.6**	**48.2**	**64.1**	**548.5**	**3.0**	**11.0**

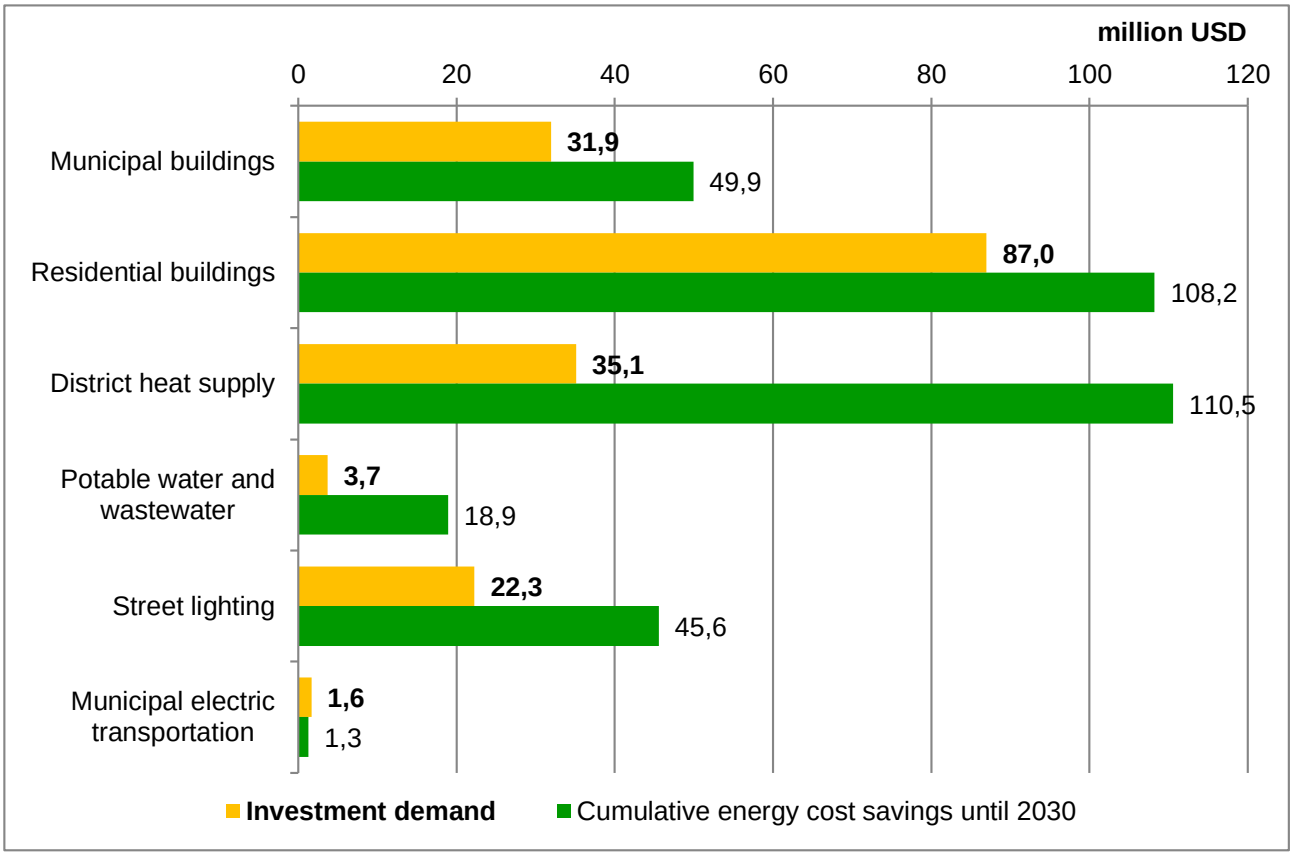


Figure 4.1 Preliminary investment demand and energy cost saving potential for key city energy sectors (including VAT) for the period 2017-2020

The overall investment demand for the above listed recommended investment measures for the period 2017-2020 amounts to approximately at **181.6** mln USD[8]. The cumulative energy cost savings (accumulated from time of implementation until including the year 2030) from implementation of investment projects are **334.4** mln USD, including VAT[9].

Moreover, the following benefits from implementation of recommended investment projects are expected:

- **Reduction of expenditures from the city budget** on energy supply of:
  - Municipal public buildings;
  - Street lighting system;
- Increase of the estate value of municipal public buildings;
- Reduction of building repair and maintenance costs;
- Extended operation time of the buildings for 25-50 years;
- Providing standard heating comfort conditions in the buildings;
- Increase of the value of municipal utility enterprises;
- **Creation of additional jobs** in the city;
- **Increased tax** revenues from local businesses;

[8] Sources for the investment amounts are a) information from the City Administration, b) municipal investment plans, c) existing feasibility and pre-feasibility studies in the frame of SEAP and MEP and d) energy sector expert estimates. This amount includes installation costs and VAT.

[9] The saved energy costs are calculated as cumulative annual energy savings with the assumption on the projection of energy prices and tariffs up to 2030 (please refer to Annex 5)

- **Development of capacities** and knowledge on EE project implementation;
- Increased city living quality and attractiveness;
- Reduction of CO_2 emissions.

More detailed information on the recommended EE investment projects for each city sectors is provided in Annex 4.

4.2 Energy efficiency investment plan for the period of 2021-2030

Table 4.2 provides a summary of 7 recommended investment projects for the priority sectors for the period 2021-2030 in terms of investment demand, energy efficiency potential and a preliminary indication of profitability.

Table 4.2. The preliminary key technical and economic indicators of investment projects for the period 2021-2030

Code	Project name	Investment demand, including VAT	EE/RE Potential			Specific EE per investment	Discounted payback period (DPP)[10]
			Natural gas	electricity	total		
		mln USD	mln m³/a	GWh/a	GWh/a	kWh/USD	years
	Municipal buildings	**120.6**	**19.7**	**26.7**	**211.6**	**1.8**	**8.8**
PB-01-II	Thermal renovation of 361 municipal public buildings (2nd stage: 240 buildings)	58.5	11.3	-	106.5	1.4	11.4
PB-02-II	Renewable heat generation with heat pumps and biomass boilers for 275 municipal public buildings (2nd stage: 185 buildings)	18.3	8.3	-	78.4	4.3	9.3
PB-03	Construction of PV power plant with 19.2 MWp capacity to cover municipal public buildings consumption	43.9	-	26.7	26.7	0.6	6.7
	Residential buildings	**1067.9**	**212.2**	**-**	**1 992.5**	**1.9**	**8.6**
RB-02	Thermal renovation of 2418 multistorey residential buildings	976.9	185.1	-	1 738.5	1.5	8.2
RB-03	Renewable hot water for 590 multistorey residential buildings (*installation solar thermal collectors and heat pumps for utilization of ventilation waste heat on rooftops*)	91.0	27.0	-	254.0	2.8	11.9
	District heat supply	**24.1**	**6.7**	**-**	**63.2**	**2.6**	**8.5**
DH-10	Utilization of waste heat on WWTP-1 for hot water supply in Komunarsky residential district (*Construction of Heat Pump Station on WWTP-1*)	24.1	6.7	-	63.2	2.6	8.5
	Potable water and wastewater	**16.84**	**-**	**35.0**	**35.0**	**2.1**	**4.2**
WW-02	Use of 40 000 t/a of sludge for power generation and activated carbon production on WWTP-1	16.8	-	35.0	35.0	2.1	4.2
	Total	**1 229.5**	**238.6**	**61.7**	**2 302.4**	**1.9**	**11.7**

[10] Calculation of payback period is based on a) approximate evaluation of investment costs, b) forecasted growth of energy prices (please refer to Annex 5), c) discount rate r=5% (for the projects funded by KfW) and r=7% (for the projects funded by EBRD and other IFIs). Operation period is up to 2030. Assumed accuracy of calculation is in a range of ± 15%.

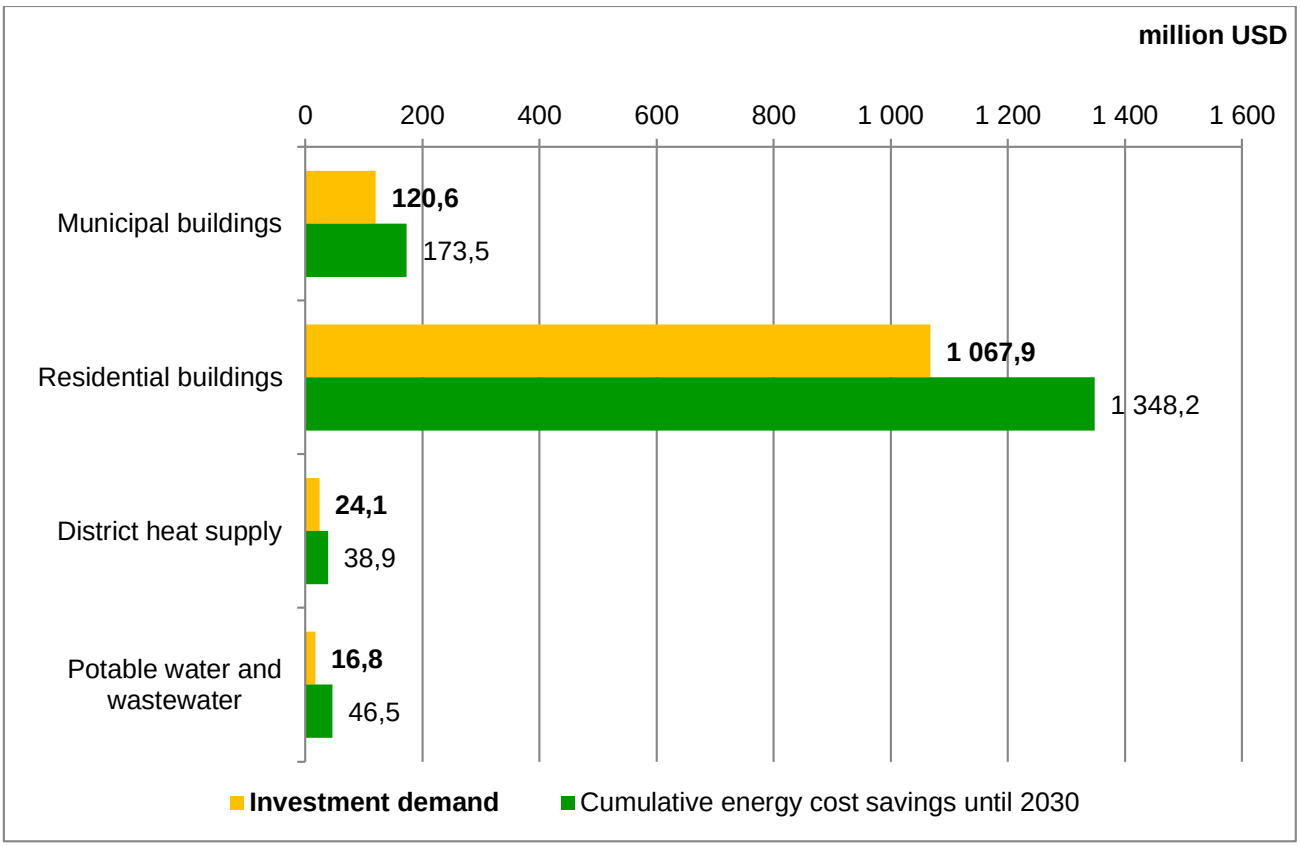


Figure 4.2. Preliminary investment demand and energy cost saving potential for key urban sectors (including VAT) for the period 2021-2030

The overall investment demand for the period 2021-2030 amounts to approximately **1 229.5** mln USD[11], including VAT. The cumulative energy cost savings (accumulated from time of implementation until, including the year 2030) from implementation of investment projects are **1 607.1** mln USD[12], including VAT.

More detailed information on the recommended EE investment projects for each city sectors is provided in Annex 4.

4.3 Summary of energy efficiency investment pipeline for the period 2017-2030

Starting with an analysis of all urban sectors by means of the TRACE a comprehensive investment pipeline of 22 EE options has been created in 6 selected sectors where the City Authority has high influence and interest as well as those which have large EE potential.

Table 4.3 provides a summary of EE investment pipeline in selected sectors for the period 2017-2030 in terms of investment demand, energy efficiency potential and profitability.

[11] Sources for the investment amounts are a) information from the City Administration, b) municipal investment plans, c) existing feasibility and pre-feasibility studies in the frame of SEAP and MEP and d) energy sector expert estimates. This amount includes installation costs and VAT.

[12] The saved energy costs are calculated as cumulative annual energy savings with the assumption on the projection of energy prices and tariffs up to 2030 (please refer to Annex 5)

Table 4.3. Summary of preliminary key technical and economic indicators for an EE investment pipeline for the period 2017-2030

Code	Sector	Investment demand, including VAT	EE/RE Potential			Specific EE per investment	Discounted payback period (DPP)[13]
			Natural gas	electricity	total		
		mln USD	mln m³/a	GWh/a	GWh/a	kWh/USD	years
1	Municipal buildings	152.6	28.0	26.7	289.6	1.9	9.4
2	Residential buildings	1 154.9	227.0	-	2 131.6	1.8	8.6
3	District heat supply	59.2	31.8	40.0	370.6	6.3	6.5
4	Potable water and wastewater	20.5	-	44.8	44.8	2.2	4.1
5	Street lighting	22.3	-	13.7	13.7	0.6	9.7
6	Municipal electric transportation	1.6	-	0.6	0.6	0.4	-
	Total	**1 411.1**	**286.8**	**125.8**	**2 850.9**	**2.0**	**11.4**

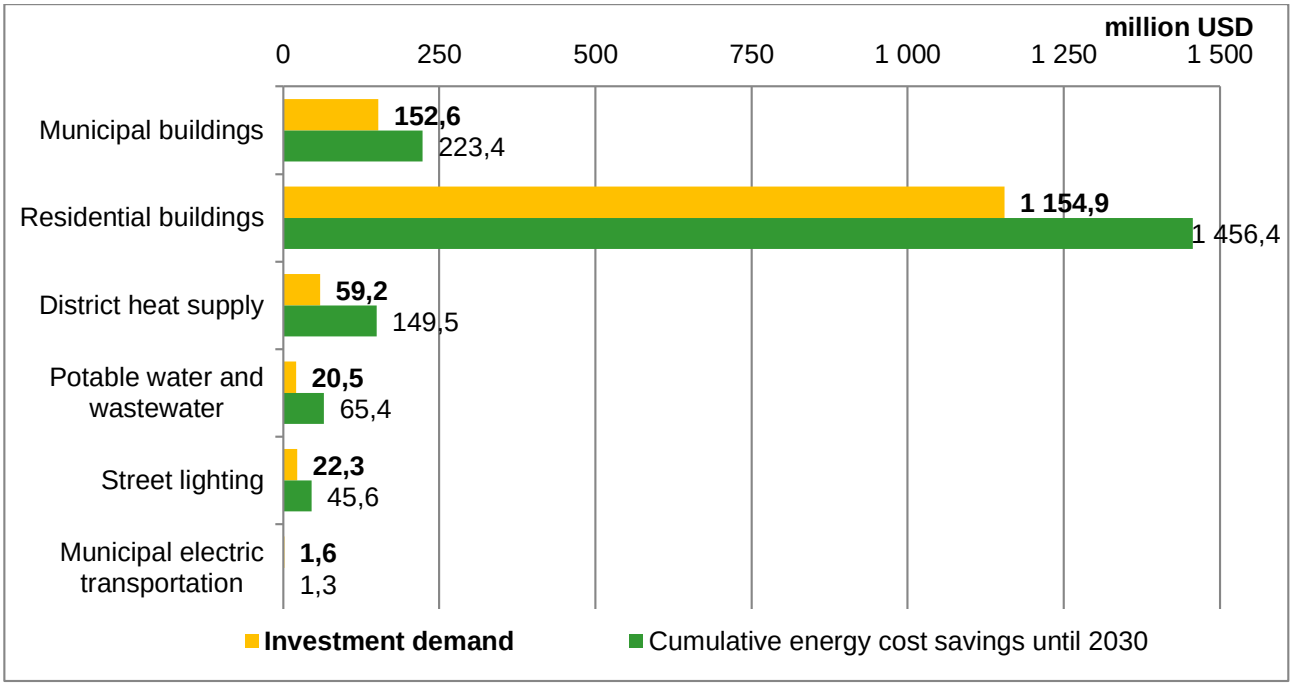


Figure 4.3 Preliminary investment demand and energy cost saving potential for key urban sectors (including VAT) for the period 2017-2030

The overall **investment demand** for the implementation of the above recommended 22 energy efficiency projects in the period of 2017-2030 amounts to approximately **1 411.1** mln USD[14], including VAT. The cumulative energy cost savings (until the year 2030) from implementation of investment projects for the period of 2017-2030 are **1 941.5** mln USD[15], including VAT.

[13] Calculation of payback period is based on a) approximate evaluation of investment costs, b) forecasted growth of energy prices (please refer to Annex 5), c) discount rate r=5% (for the projects funded by KfW) and r=7% (for the projects funded by EBRD and other IFIs). Operation period is up to 2030. Assumed accuracy of calculation is in a range of ± 15%.

[14] Sources for the investment amounts are a) information from the City Administration, b) municipal investment plans, c) existing feasibility and pre-feasibility studies in the frame of SEAP and MEP and d) energy sector expert estimates. This amount includes installation costs and VAT.

[15] The saved energy costs are calculated as cumulative annual energy savings with the assumption on the projection of energy prices and tariffs up to 2030 (please refer to Annex 5)

Evaluation of preliminary profitability of the sector investment programs[16]

The purpose of this rough evaluation is to identify those sectors of the urban infrastructure which have good profitability and highest potential to attract potential investors and financiers.

For the evaluation two key factors are used:

- I = investment demand for recommended EE projects, [mln USD];
- E = cumulative energy cost savings (until the year 2030) from implementation of recommended EE projects for the period of 2017-2030 [mln USD].

The ranking of sector relates to the ratio of E-factor to I-factor which will result in **Score**: as higher score, the higher sector priority.

Figure 4.4 illustrates the results of identifying priority sectors, taking into account overall investment demand and profitability of recommended EE projects in selected sectors[17]. As a result one can clearly recognize that the sectors of Municipal buildings, Residential buildings, District heat supply; Potable water and wastewater and Street lighting have a ratio above 1, which indicates profitability over the defined implementation period.

Energy Efficiency Recommendations Matrix

The Energy Efficiency Recommendations Matrix provided in table 4.4 gives an overview of the recommended EE projects according to their investment demand and their profitability.

Table 4.4. Matrix of recommended EE projects

		Investment demand	
		< 10 mln USD	**> 10 mln USD**
Discounted payback period (DPP)	**< 12 years**	1. DH-02. Installation of 801 individual heating substations and remote metering system 2. DH-03. Replacement of circuit pumps and equipment with VSD in 2 large-size boiler-houses 3. DH-04. Replacement of 6 burners on boiler type PTVM-30 on Artema boiler-house 4. DH-05. Construction of CHP on Tovaryska boiler-house 5. DH-06. Reduction of Gas Consumption Program of Concern "MTM" for the period of 2016-2017 6. DH-07. Replacement of 10 coal boilers with biomass boilers 7. DH-08. Reduction of Electricity Consumption Program of Concern "MTM" for the period of 2016-2017 8. DH-09. Utilization of industrial waste heat for hot water supply in Zavodsky residential district 9. WW-01. Reduction of Power Consumption Program of MU «Vodocanal» for the period of 2016-2017	**1. PB-01. Thermal renovation of 361 municipal public buildings** **2. PB-02. Renewable heat generation with heat pumps and biomass boilers for 275 municipal public buildings** 3. PB-03. Construction of PV power plant with 19.2 MWp capacity to cover municipal public buildings consumption 4. RB-01. Partial thermal renovation of 214 multi-storey residential buildings 5. RB-03. Renewable hot water for 590 multi-storey residential buildings (installation solar thermal panels and heat pumps for utilization of ventilation waste heat on rooftops) **6. DH-01. Renewable hot water for Shevchenkivsky residential district (construction of biomass CHP)** 7. DH-10. Utilization of waste heat on WWTP-1 for hot water supply in Komunarsky residential district (Construction of Heat Pump Station on WWTP-1) 8. WW-02. Use of 40,000 t/a of sludge for power generation and activated carbon production on WWTP-1 9. SL-01. Renovation of street lighting system based on LED and PV power plant with 6.0 MWp capacity
	> 12 years	1. TM-01. Replacement of outworn trolley-buses by 10 new more efficient ones	1. RB-02. Thermal renovation of 2418 multi-storey residential buildings

Note: *The projects, which are included into the Program of German financial cooperation with Ukraine «United Financial Loan – A component of municipal infrastructure in Eastern Ukraine» (financed by KfW Development Bank) are marked with red color*

Further analysis of recommended projects and detailed scrutiny in terms of their economic viability will lead to the set of investment project packages proposed for implementation under the targeted **City Priority Investment Program.**

[16] based on preliminary analysis of investment demand and profitability of recommended EE projects (please refer Chapter 4)

[17] following the TRACE methodology (please refer to Chapter 3)

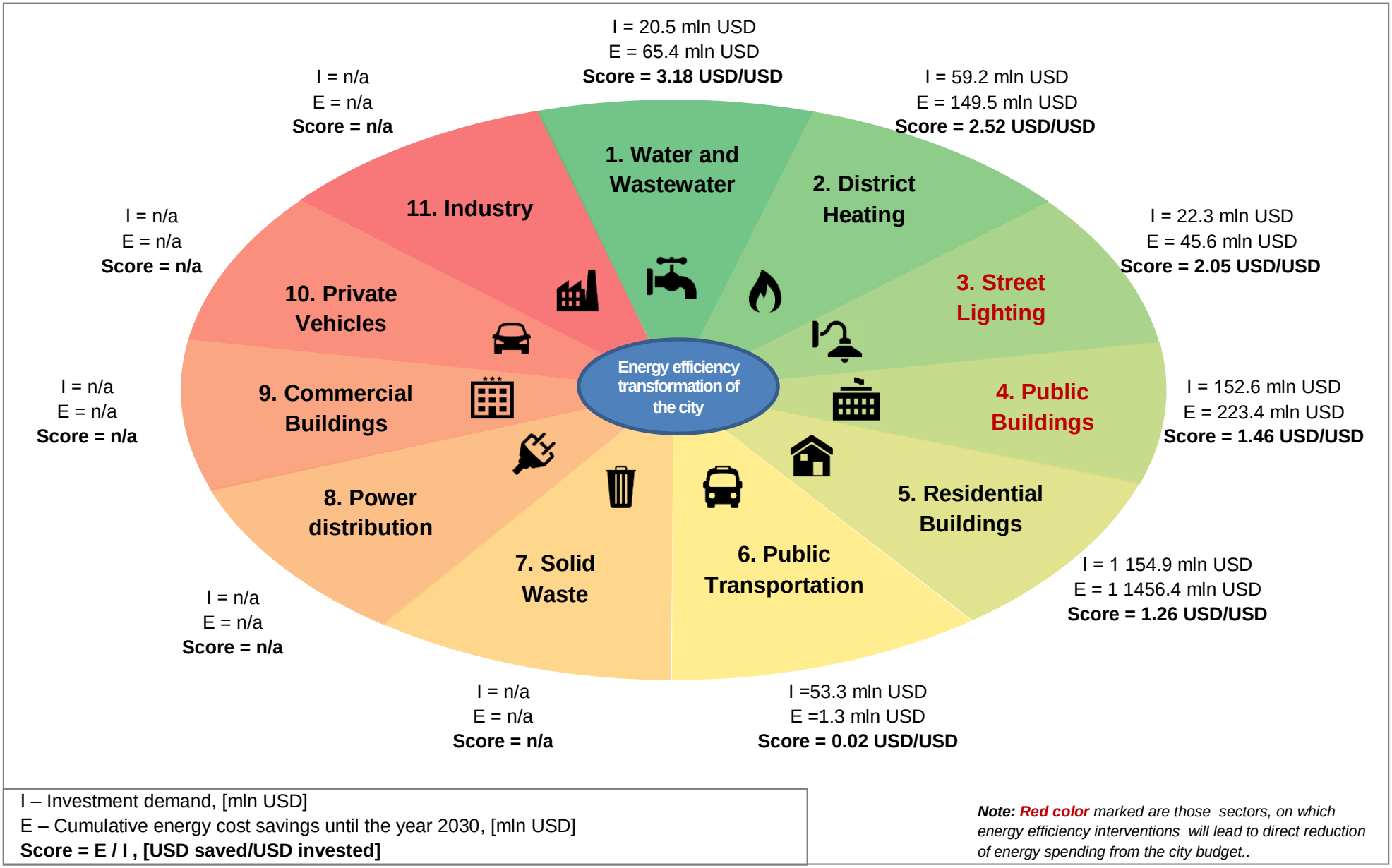


Figure 4.4. Evaluation of preliminary profitability of the sector investment programs

5 Energy Efficiency Potential in Key City Energy Sectors

An evaluation of reducing energy consumption has been performed for two planning periods of city energy efficiency transformation (as outlined in Chapter 4):

- **in 2020** – for a short-term period of planning from 2017-2020;
- **in 2030** – for a medium-term period of planning from 2017-2030.

5.1 Expected results of energy transformation of the city up to 2020

During the period 2017-2020 it is planned to implement 15 investment projects in 6 selected city sectors (as outlined in Chapter 4.1).

A potential of the reduction of natural gas consumption for the period 2017-2020 is **452.4 GWh/a** or **12.7%** can be achieved by means of:

- Energy savings: 386.5 GWh/a or 10.9%;
- Substitution by renewable energy use: 65.9 GWh/a or 1.9%

A potential of the reduction of electricity consumption and replacement for the period of 2017-2020 is **64.1 GWh/a** or **8.4%**

- Energy savings: 47.7 GWh/a or 6.2%;
- Substitution by renewable energy use: 16.4 GWh/a or 2.1%

Figures 5.1-5.3 contain expected results of energy transformation of the city by 2020.

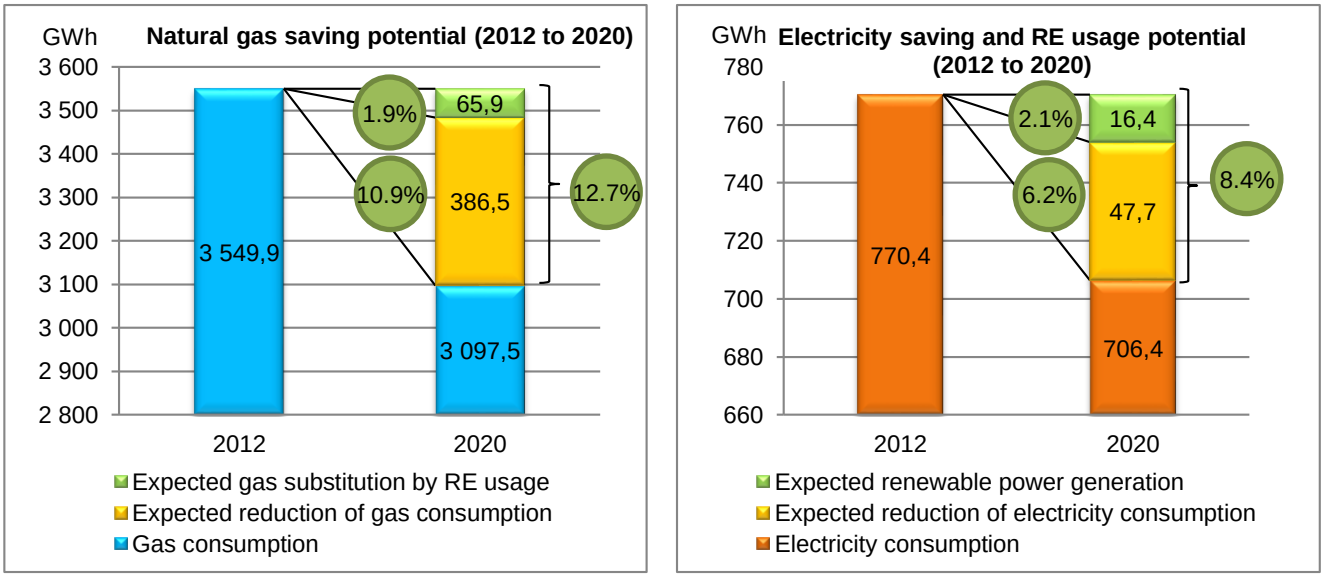


Figure 5.1. Preliminary energy savings and renewable energy usage potential (final energy gas and electricity) of a recommended EE Investment plan for 6 selected city sectors for the period 2017-2020

More detailed information on the evaluation of energy saving and renewable energy usage potential in city energy sectors is provided in Annex 4.

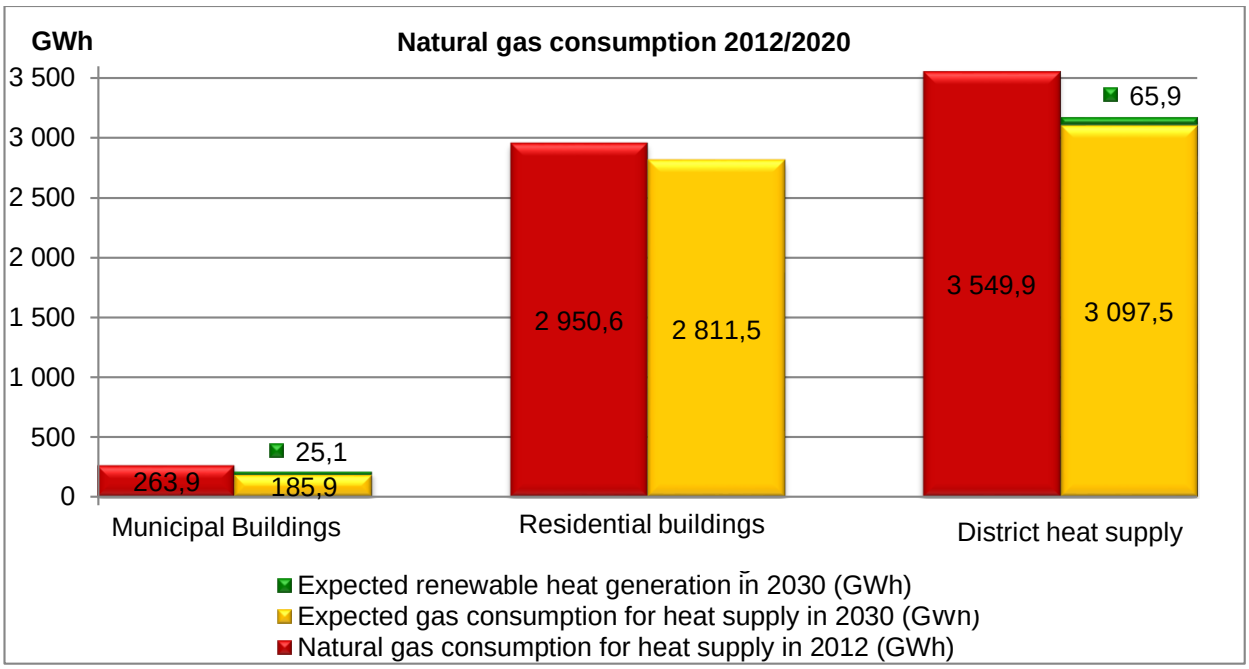


Figure 5.2. Preliminarily calculated potential of reduction of natural gas consumption for the period 2017-2020

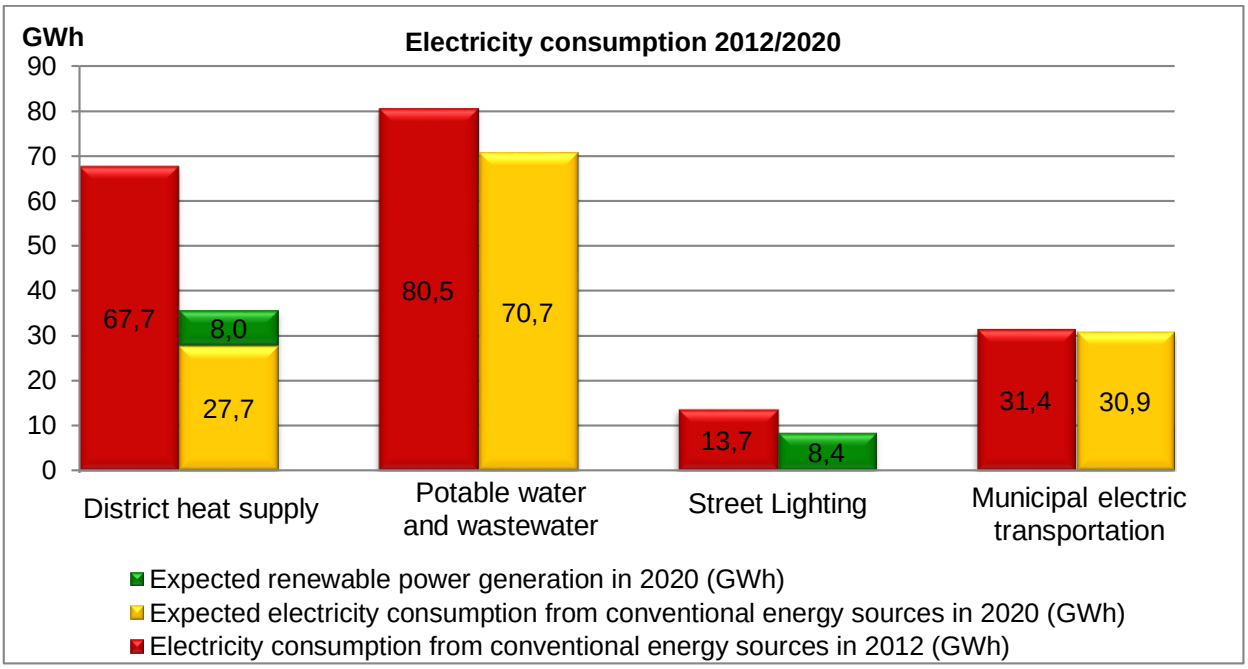


Figure 5.3. Preliminarily calculated potential of reduction of electricity consumption from conventional energy sources[18] for the period 2017-2020

[18] Nuclear Power Plants, Coal and Gas Power Plants etc. within Ukraine United Energy System

5.2 Expected results of energy transformation of the city up to 2030

During the period 2017-2030 it is planned to implement 22 investment projects in 6 selected city sectors (as outlined in Chapters 4.1-4.3) leading to:

A potential reduction of natural gas consumption for the period 2017-2030 amounting to **2 693.0 GWh/a** or **75.9%**, by means of:

- Energy savings: 2 231.6 GWh/a or 62.9%;
- Substitution by renewable energy use: 461.4 GWh/a or 13.0%

A potential reduction of electricity consumption and replacement for the period 2017-2030 amounting to **125.8 GWh/a** or **16.4%**

- Energy savings: 47.7 GWh/a or 6.2%;
- Substitution by renewable energy use: 78.1 GWh/a or 10.1%

Figures 5.4-5.6 contain expected results of city energy transformation by 2030. Figure 5.7 illustrates the targeted evolution of energy balance of Zaporizhia for the period 2002 to 2030 (excluding industry).

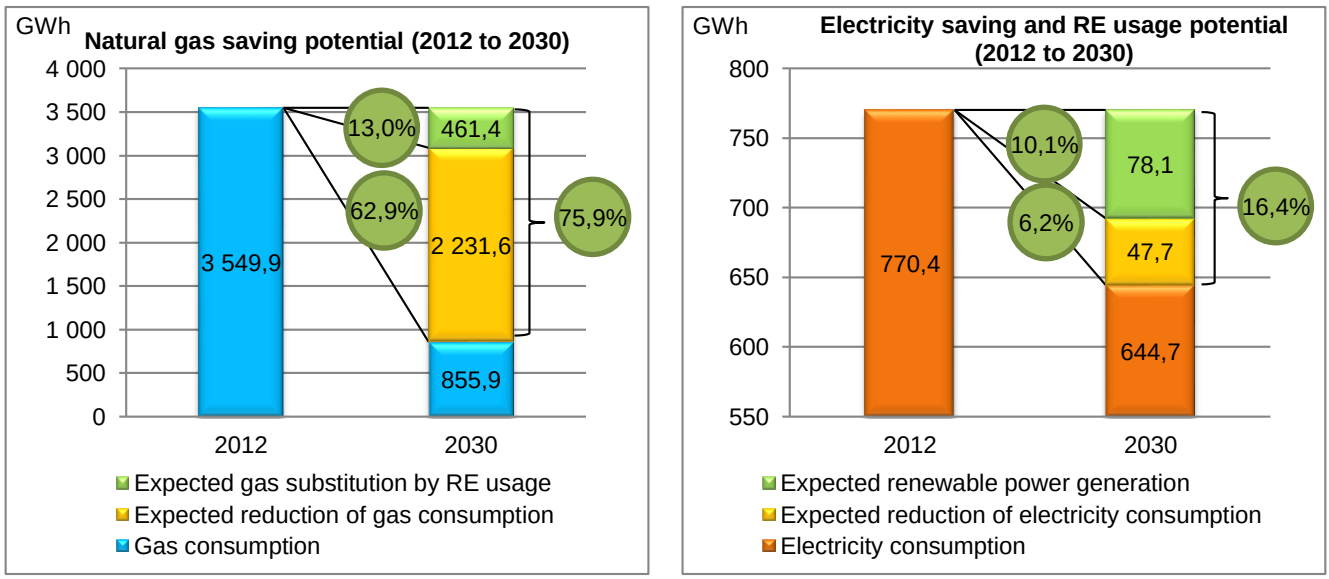


Figure 5.4. Preliminarily calculated energy savings and renewable energy usage potential (final energy gas and electricity) of recommended EE Investment plan in 6 selected city sectors for the period 2017-2030

More detailed information on the evaluation of energy saving and renewable energy usage potential in city energy sectors is provided in Annex 4.

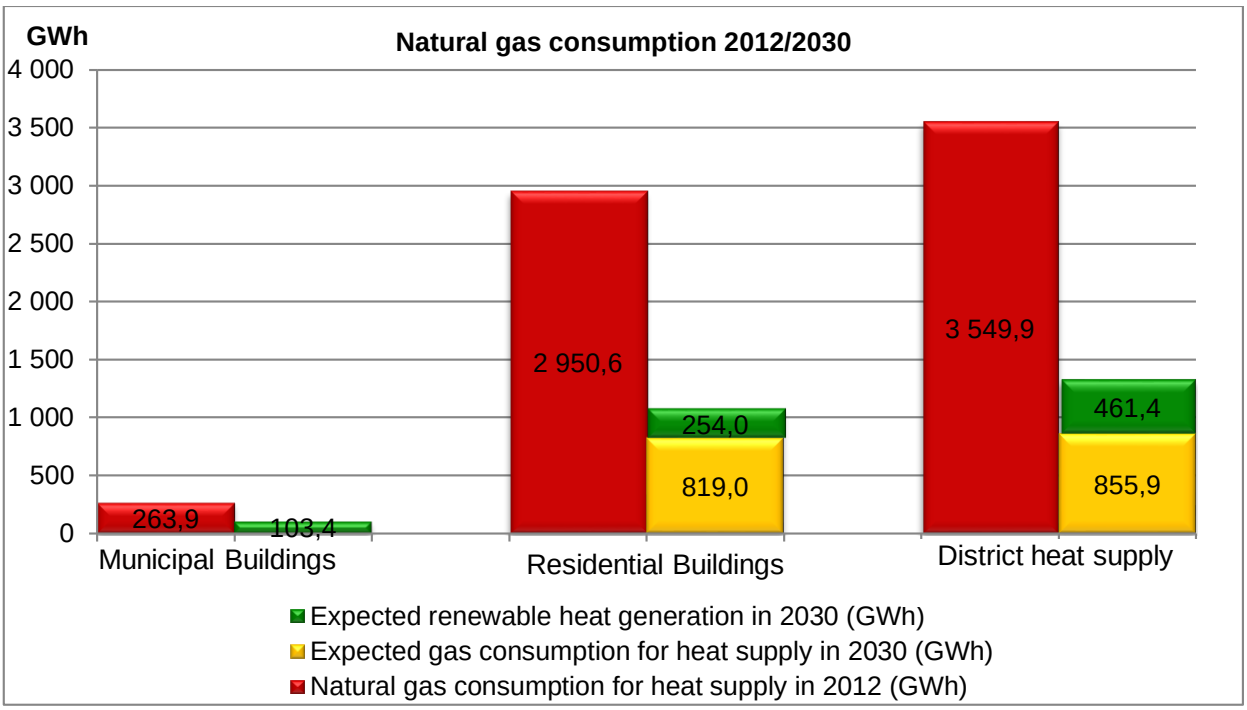


Figure 5.5. Preliminarily calculated reduction potential for natural gas consumption for the period 2017-2030

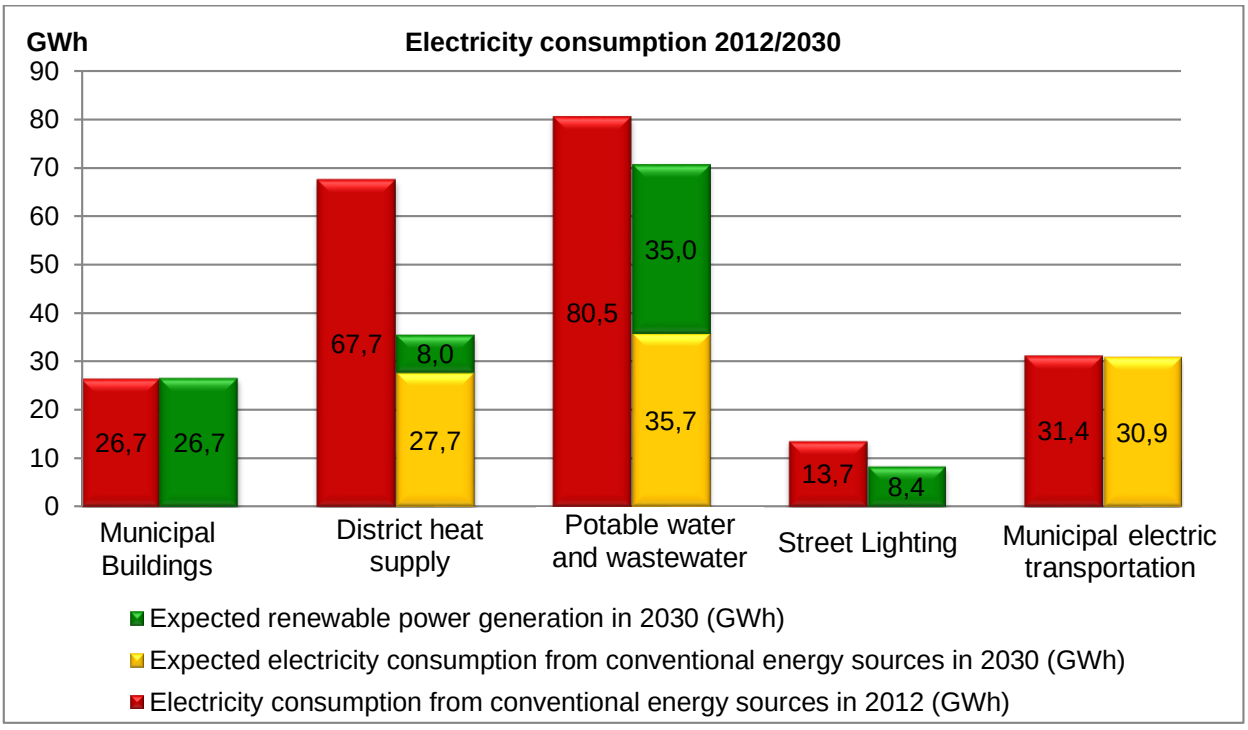


Figure 5.6. Preliminarily calculated reduction potential for electricity consumption from conventional energy sources[19] for the period 2017-2030

[19] Nuclear Power Plants, Coal and Gas Power Plants etc. within Ukraine United Energy System

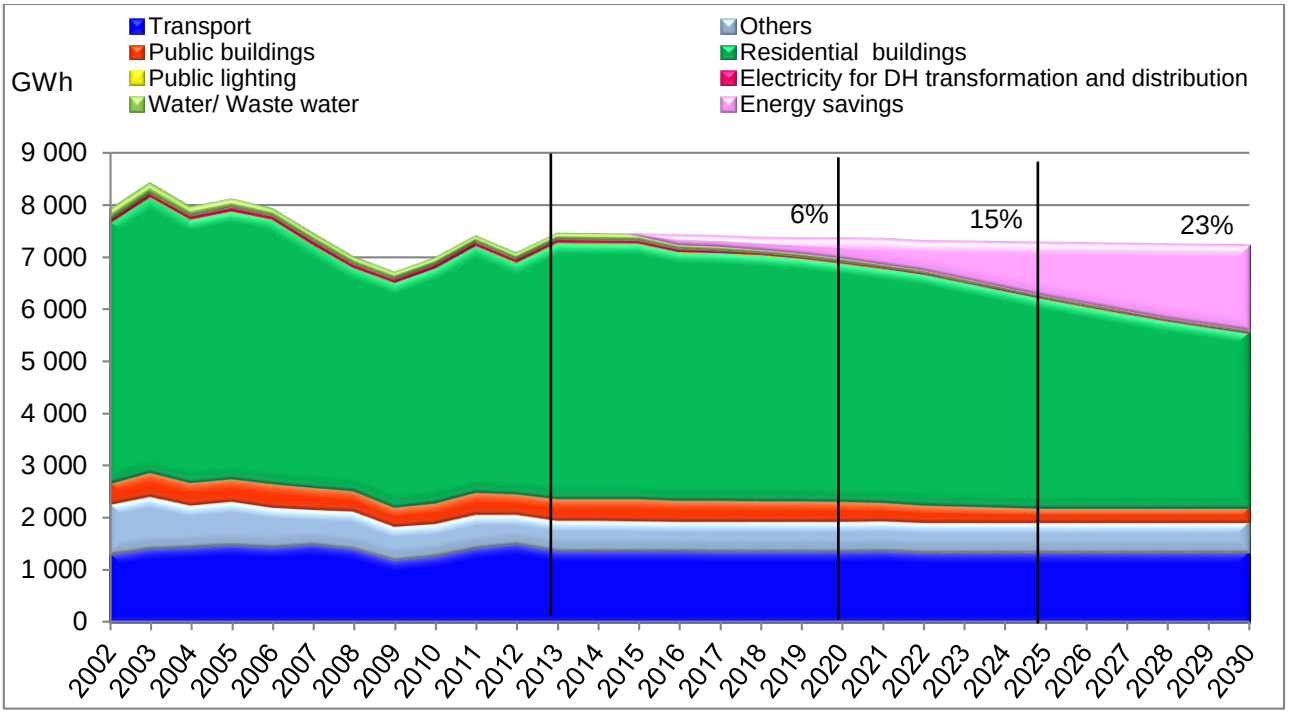


Figure 5.7. Targeted evolution of Energy balance of Zaporizhia 2002 to 2030 (excluding industry)

6 Conclusion

As outlined in Chapter 2 the primary goal of the City of Zaporizhia is to achieve the energy savings and environmental improvement targets of the SEAP by 2030. Urban energy efficiency assessment with TRACE was used to compile an investment pipeline and implementation plan to help the city in achieving its SEAP targets.

In the following it is briefly assessed to which extend the proposed investment project packages for the period 2017-2030 can contribute to the achievement of these targets.

1. Energy saving targets «From energy imports to energy exports» are **partly achievable:**

Target	Energy consumption in Baseline year 2012	Expected energy consumption after EE investment program in 2030	Potential contribution of the EE investment program to achieve the set target
67% reduction of space heating demand in 2418 multi-storey residential and 361 public buildings	2 082 GWh	536 GWh	**achievable**
67% reduction of natural gas consumption for district heating	3 550 GWh	856 GWh	**achievable**
100% replacement of natural gas with local renewables for heating of public buildings and hot water supply	856 GWh	62 GWh	93% are achievable according to recommended EE investment plan
Installation of renewable energy generation capacity of 100 MWe	100 MWe	30 MWe	30% are achievable (in sectors under CA control only)

2. Financial targets «City money should remain in the city» are **partly achievable:**

Target	Projected Energy costs without EE in 2030*	Projected Energy costs with EE in 2030*	Potential contribution of the EE investment program to achieve the set target
67% reduction of costs for space heating of residential buildings	240.2 mln USD	73.6 mln USD	**achievable**
80% reduction of costs for space heating of municipal public buildings	21.5 mln USD	4.2 mln USD	**achievable**
60% reduction of costs for hot water supply	60.4 mln USD	31.3 mln USD	48% are achievable according to recommended EE investment plan
50% reduction of costs for power supply of residential and public buildings and municipal utilities	197.0 mln USD	153.9 mln USD	22% are achievable (in sectors under CA control only)

* – according to forecasted energy prices in 2030 (please refer to Annex 5)

3. Environmental targets «Zaporizhia becomes a green city» are **partly achievable:**

Emissions of baseline year 2012 amount to 3 116.4 ths tones CO_2

Target	Emissions target	Projected Emissions with EE	Achievement potential
6 % reduction of CO2 emissions in comparison with the Baseline year 2012	Up to 2020: 2 929.4 ths tones CO_2	In 2020: 2 958.6 ths tones CO_2	5% are achievable (in sectors under CA control only)
30 % reduction of CO2 emissions in comparison with the Baseline year 2012	Up to 2030: 2 181.5 ths tones CO_2	In 2030: 2 460.1 ths tones CO_2	21% are achievable (in sectors under CA control only)

Despite the limitations on the potential energy savings it is important to note that the above recommended investment project packages only represent the municipal and residential sector which accounts for less than 30 % of overall city energy consumption. Other key energy consuming sectors such as industry and individual transport exhibit additional large energy saving potentials and can contribute to the achievement of the city's SEAP targets. The intervention and engagement of the City Administration and its utilities in energy efficiency initiatives and investment planning can showcase the city's energy efficiency commitment and create a strong trigger for activities in other non-municipal sectors to facilitate an urban energy efficiency transformation in the long- run.