City Energy Efficiency Report
City of Kyiv

Energy Efficiency Transformation in Ukrainian Cities

March 2015 – Review after Decision Workshop

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Content

List of abbreviations

CHP	Combined heat and power	IBRD	International Bank for Reconstruction and Development, World Bank Group
CA	City Authority	IFI	International Finance Institution
CEETI	City Energy Efficient Cities Initiative	IHS	Individual Heating Stations
CNG	Compressed Natural Gas	KPI	Key Performance Indicator
CoM	Covenant of Mayors, Assist Local Authorities in More Sustainable Local Energies	L, ltr.	Litre
CU	Communal Company	LED	Light Emitting Diode
DH	District heating	LLC	Limited Liability Company
DHW	Domestic Hot Water	LPG	Liquid Petroleum Gas
EBRD	European Bank for Reconstruction and Development	MHRP	Municipal Heat Reform Program in Ukraine (by USAID)
EE	Energy efficiency	MU	Municipal Company
EIB	European Investment Bank	PE	Public Enterprise
ELENA	European Local Energy Assistance	PEC	Primary Energy Consumption
EnPC	Energy Performance Contracting	RE	Renewable Energy
ESCO	Energy Service Company	REI	Relative Energy Intensity
ESMAP	Energy Sector Management Assistance Program	SCADA	*Supervisory Control and Data Acquisition*
FEC	Final Energy Consumption	SEAP	Sustainable Energy Action Plan
GDP	Gross Domestic Product	TA	Technical Assistance
GHG	Greenhouse gases	TRACE	Tool for Rapid Assessment of City Energy
GIZ	German International Development Co-operation	UAH	Ukrainian Hrivna (local currency)
GWh	Giga Watt Hours = Million Kilo Watt Hours	VSD	Variable Speed Drive, Frequency Control
HDD	Heating Degree Days	WB	The World Bank
HDI	Human Development Index	WWTP	Waste Water Treatment Plant
HOB	Heat only boiler		

1 Summary

CEETI, ESMAP and TRACE

The City Energy Efficiency Transformation Initiative (CEETI) is a 3-year technical assistance (TA) program led by the Word Bank's Energy Sector Management Assistance Program (ESMAP). The initiative helps cities identify, develop and mobilize finance for transformational investment programs in urban energy efficiency across sectors of municipal energy.

This report presents the key findings of the application of the Tool for Rapid Assessment of City Energy (TRACE) and the Energy Efficiency assessment for the city of Kyiv.

Process of the Energy Efficiency Assessment and Structure of the Report

The purpose of the EE assessment is to analyze the performance of areas of municipal energy, to prioritize areas of intervention and develop a set of energy efficiency measures which will provide the framework for the follow-up Energy Efficiency Program of the city. The process is accompanied by active communication with the city stakeholders 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 City Authority of Kyiv as well as utilities of municipal services. Data collection and interviews with stakeholders took place in November – December 2014. The results have been documented in the City Background Report.

Out of that report the Key Performance Indicators for the city of Kyiv have been calculated and aggregated into the TRACE model.

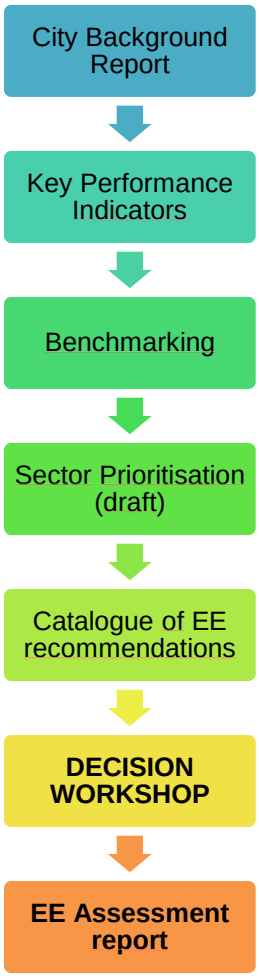
The benchmarking component of the TRACE tool enables the comparison of energy performance with other peer cities of similar characteristic. From this "Relative Energy Intensity" a rough estimate of the theoretical energy efficiency potential in each sector has been derived. → Chapter 3.

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. → Chapter 4.

A long list of possible energy efficiency recommendations have been collected from various sources and interviews. The preliminary evaluation leads to a set of Energy Efficiency recommendations by sector. → Chapter 6, 7 and 8,

Key sector features and challenges together (Chapter 5) with the EE potential analysis have been presented and discussed at the DECISION WORKSHOP in February 2015. Decision makers of the city and utilities agreed on the conceptual and integrated approach and confirmed the intervention areas for the EE program.

The present energy efficiency assessment report reflects the decisions of the workshop with key energy stakeholders of the city with confirmation of the sector priorities and a refined list of EE measures.



Energy efficiency targets

The city joined the European initiative "Covenant of Mayors" in 2011, but the preparation of a Sustainable Energy Action Plan (SEAP) is pending.

Targets, which have been defined in the Municipal Energy Plan 2012-2016 (elaborated in 2012), are the lowering of CO_2 emissions by 20% by 2020, reducing primary energy consumption by 10% and an increase use of renewable energies by approx. 1%.

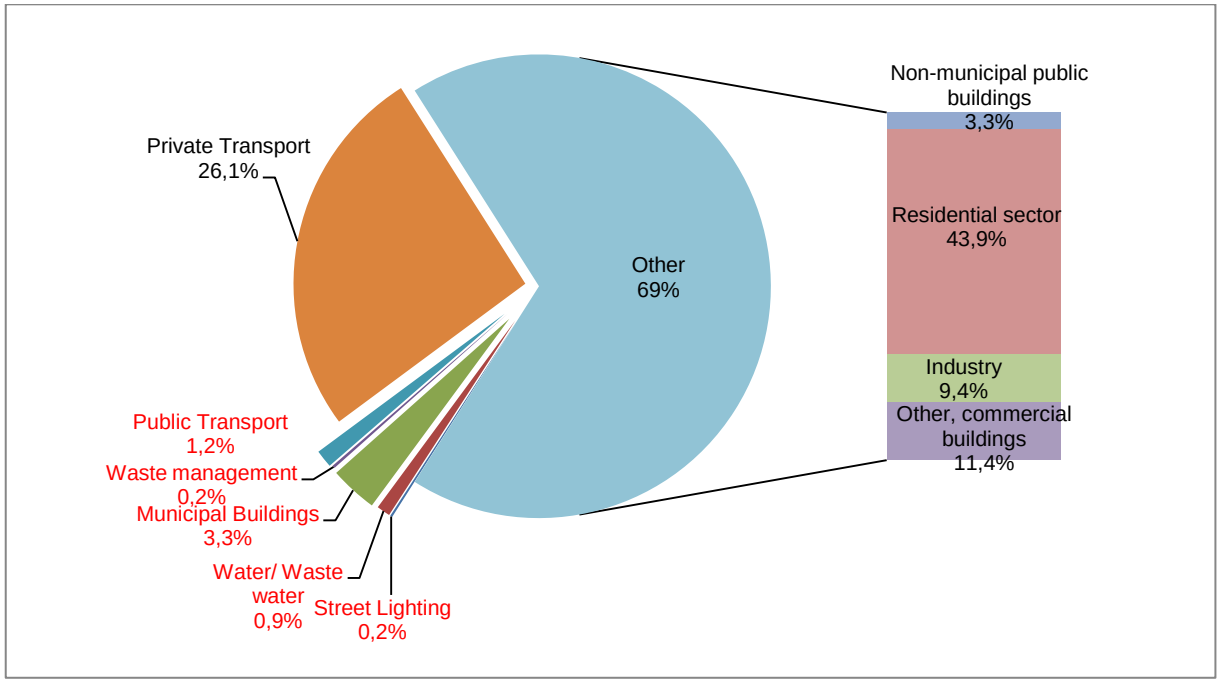
City background – energy consumption

Kyiv's primary energy consumption amounts to 48,190.7 GWh in 2013 with the highest share with natural gas of almost two thirds. The majority of gas is utilized for the generation of power and district heat for the distribution to various end consumers.

The residential sector is the largest energy consumer with more than 50 % of the city's final energy consumption as it is typical for all Ukrainian cities. This is followed by the private transport sector at 22% and the industry and commercial sector (including other buildings) at 16%.

Final energy consumption under direct control by the city is 2,349 GWh (5.8%) out of 40,179 GWh.

Figure 1: Share of Final Energy Consumption by sector in %



City background – budget and energy spending

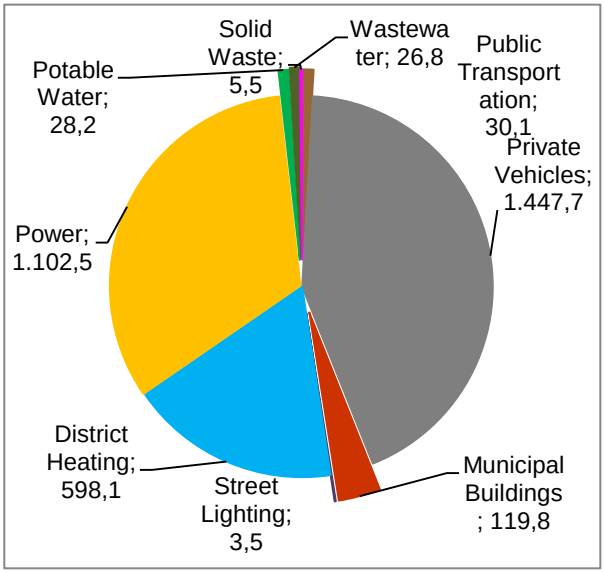
Kyiv, the capital of Ukraine had a population in 2013 of 2,868,700 inhabitants and is economically based on the sectors manufacturing industry, trade and services.

The municipal budget amounted to 2,889 million USD in 2013 with approximately 1,914 million USD spent on energy municipal services for public transport, public buildings, street lighting, waste, water supply and waste water disposal. The overall GDP in Kyiv was 36,402 million USD with 3,362 million USD (9%) spent on energy.

Major segments of energy spending like power (33%) and private vehicles (42%) are not under the control of the City Administration.

Energy Spending for Municipal sector facilities (municipal public transport, municipal buildings, street lighting, waste, water and waste water services) amount to 214 million USD in 2013, out of which more than 55% are spent for the energy supply of municipal buildings. Those 120 million USD make a share of 4.1 % of the annual municipal budget.

Figure 2: Share of spending for energy, in million USD in the year 2013



Even if the energy consumption in the sectors under direct control by the city administration is only 6% of the total city wide energy consumption the intervention in EE measures in those sectors is important for the city and for the city government.

First, because saving energy in those sectors will directly lead to the reductions of energy costs and reduce municipal budget spending or governmental subsidies. This in particular true for the expected perspective of drastic increase of energy cost, where investments in energy saving will counteract against consequent raise of end user tariffs and the risk of non-affordability of energy or services.

Second, EE investments in those sectors will have long-term and sustainable influence on some citywide sectors, such as (i) reduction of fuel consumption in private transport, due to the modal shift of transport towards lower specific energy consuming public transport, and (ii) reduction of energy consumption in the residential sector due to improved heat supply and consumption based billing at cost covering tariffs.

Third, investments in energy saving in urban infrastructure and facilities are well visible for the population and thus contributing to the public awareness on (i) resource saving, (ii) improvement of public services for the population, and finally (iii) on Ukraine's return to a sustainable growth path by right decisions for investments.

Benchmarking of Energy Performance of Kyiv

The benchmarking component of the TRACE tool is intended to assess the energy performance of the city compared to other peer cities. The application of TRACE delivers a set of 27 Key Performance Indicators (KPI) for the city of Kyiv.

Details of the benchmarking of Kyiv's KPIs are provided in Chapter 3 , while the following table provides a summary of observations by sector.

Table 1: Summary benchmarking of KPIs of Kyiv with selected peer cities

Sector	Selected KPI		Comparison of Performance with better performing cities	Theoretical EE potential
City wide energy	Annual Primary energy consumption per capita	55.73 MJ/capita	Medium performance Peer cities: Skopje, Sarajevo and Bratislava.	50%
	Annual Primary energy consumption per GDP	4.77 MJ/USD GDP	Low performance Peer cities: Vienna, Warsaw and Paris	50%
Public Transport	Specific energy consumption of Public Transport	0.4 MJ / passenger km	Medium performance Peer cities: Belgrade and Sarajevo	35% to 50%
Solid Waste	Annual Waste production	Approx. 400 kg/capita	Medium performance Peer cities: Sofia and Skopje	25%
	Solid Waste recycled	17%	Low performance	50-70%
Water supply and waste water	Energy Density of Potable Water Production (	0.66 kWh_e/m^3	Low performance Peer cities: Banja Luca or Vienna.	50%
	Energy Density of Wastewater Treatment	0.73 kWh_e/m^3	Lowest performance	50-60%
District Heat	Heat Loss from DH Network	18-19%	Low performance: Peer cities: Tallinn and cities in Western Europe	50%
Street lighting	Annual Electricity consumed per lit road	38 kWh_e/m	Low performance Peer cities: Tbilisi or Vienna	50%
Municipal public buildings	Annual Heat Consumption	186 kWh_{th}/m^2	Lowest performance	50-60%

The benchmarking demonstrates that the majority of performance **indicators rank low** (unfavorable) in terms of specific energy consumption, in particular for the sectors:

- **heat consumption** in **public buildings**,
- energy density for potable **water production and waste water t**reatment,
- specific energy consumption for **street lighting**,
- specific energy consumption of the **public transport** fleet
- specific energy **losses for heat d**istribution and
- Cross-sector: preprimary energy consumption per GDP and per capita,

This indicates a theoretical energy saving potential for the above sectors and KPIs is in the **range of 30 to 50%.**

Additional potentials for increase of the city performance are with the reduction of **waste volume** per capita and an increase of the share of waste **recycling.**

City authority Control

Due to various legal and regulatory frameworks and various types of ownership the City administration has different levels of control and degree of influence on end consumers of municipal energy and utilities. This relates to budget control, regulatory and enforcement power.

The CA remains in full control over the sectors of municipal public buildings and street lighting.

In addition the CA retains a certain degree of influence on the end energy consumer sectors of waste management and public transport, and limited influence on the sectors water supply and wastewater and district heating (due to ownership structure).

Table 2: Kyiv City authority's level of budget control and enforcement power on urban infrastructure sectors` energy consumption

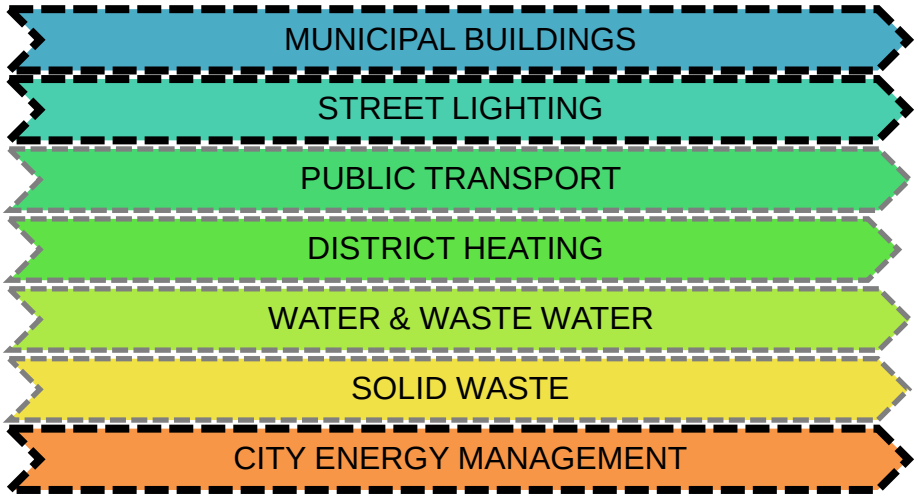
Sector	City Administration authority level of power		
	Regulatory	Budget control	Influence and enforcement
Public buildings	HIGH	HIGH	HIGH
Street lighting	HIGH	HIGH	HIGH
Public transport	HIGH	MEDIUM	HIGH
Waste	HIGH	MEDIUM	HIGH
Potable water supply	LOW	MEDIUM	MEDIUM
Wastewater	LOW	MEDIUM	MEDIUM
District heating	LOW	LOW	MEDIUM
Power supply	LOW	LOW	LOW
Gas supply	LOW	LOW	LOW
Private transport	LOW	LOW	LOW
Residential buildings	LOW	LOW	MEDIUM

Prioritized sectors and main priorities;

Sectors found to warrant a prioritized analysis are very much determined by the

- ✓ theoretical energy efficiency potential - "Relative Energy Intensity"
- ✓ level of spending for energy in the sector of municipal energy and
- ✓ the City authority's level of control

The Priority sectors for Energy Efficiency Intervention are (in priority order):



Cross sector priority

Final energy consumer sectors which are controlled by individual or commercial entities are not considered in the TRACE assessment, as the City Authority has no control and influence on their energy performance or energy budget spending. At this point, the following sectors are set aside and not pursued further, as they are individual or commercial controlled:

- Private vehicles
- Power and Gas supply
- Commercial sector/buildings
- Public, non-municipal buildings
- Residential sector
- 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.

Consideration of ongoing and committed investment programs and plans

The city of Kyiv and its utilities are implementing currently a number of investment programs funded by own resources and by international donor programs, such as:

In the municipal building sectors:

- Project “Energy efficiency in Kyiv budgetary institutions" supported by NEFCO and grant E5P Fund;
- Project «Municipal Energy Reform in Ukraine" supported by USAID;
- Project: “Performance Contracting of Energy Efficiency Measures in Kiev Public Buildings, supported by NEFCO, Kiev City, E5P, USAID and Sida;

In the water supply sector

- Project "Urban Infrastructure 2" Modernization of water supply and sewerage system supported by IBRD

The results and experience of those projects need to be considered for the planning and implementation of future EE measures in order to avoid overlapping, improve concepts and build on capacities.

The City of Kyiv has elaborated a comprehensive Municipal Energy Plan for 2012 to 2016. The city Administration of Kyiv has established the Kyiv Investment Agency which is proactive in developing EE investment projects. The EE investment recommendations of these plans have been screened and incorporated into the list of EE recommendations for the follow-up EE Transformation program.

In addition, the City Administration of Kyiv is developing in the frame of its obligations under the Covenant of Mayors Initiative a Sustainable Energy Action Plan (SEAP). The interrelation with the SEAP in both directions, a) the recommended EE measures can provide conceptual direction for the more detailed analysis in the SEAP and b) the general tendencies of the SEAP should be in line with the sectors and recommended EE measures to follow.

EE measures recommended for analysis in the EE Transformation Program

Based on the above justification of sectors, the discussion and preliminary decision at the Decision Workshop the list of EE measures comprise in total 33 EE measures, of which 25 are investment measures.

Recommended EE investment measures are categorized in short-term and long-term measures according to their preliminary implementation period, until 2020 and after 2020.

A) Short term EE Investment measures: Implementation period 2016 to 2020

Title	Components, extend	Indicative costs	Preliminary EE
Municipal Public Buildings (PB)			
Retrofit Program / thermo-modernization of Municipal educational, medical and other facilities	Total approx. 1,560 facilities including building shell, piping, including IHS on demand no EE on electricity consumption	Approximately 650 million USD	Annual savings of up-to 830 GWh, primary energy natural gas saving
Renewable energy individual heat generation for municipal education and medical facilities	including heat, pumps, biomass, solar heating for selected, for appropriate buildings according to demand, To limited extend, only if DH supply is not appropriate	Approximately 100- 245 million USD	Annual savings of 200 to 450 GWh, primary energy natural gas saving
Street Lighting (SL)			
Street Lighting Audit and Retrofit Program (replacement by high performing bulbs)	Approx. 130,000 bulbs, including public space lighting on demand Step-by-step rehabilitation of lighting poles to enable application of LED technology	Up to 43 million USD	Annual savings of up to 25 GWh, electricity
Municipal Public Transport (TM)			
Renovation of trolleybus fleet	*Details in EE transformation program*	Up to 4 million USD	Annual savings of up to 14 GWh, electricity
Modernization of metro indoor lighting systems	*Details in EE transformation program*	Up to 1 million USD	Annual savings of up to 1 GWh, electricity
Renovation of tramway fleet	*Details in EE transformation program*	Up to 1 million USD	Annual savings of up to 3 GWh, electricity
Extension of program for High performing traction systems for Metro trains (asynchronous drives)	Limited extension, test phase of innovative technology	n/a	
District Heating (DH)			
Installation of Individual heat substations and Heat meter (IHS)	For approx. 5,500 residential buildings , including SCADA and automatic balancing system	Approximately 330 million USD	Annual savings of up-to 1,500 GWh, gas saving
Boiler Houses reconstruction and rehabilitation Program including fuel switch for heat generation - gas to biomass (partly, small units)	Total approx.. 170 boiler houses	Approximately 80 million USD	Annual savings of up-to 125 GWh, gas
Installation of economizer units at boiler-houses	5 units for boilers	Approximately 18 million USD	Annual savings of up-to 220 GWh, gas
Reduction of power	assumption: 53 units for circuit	Approximately	Annual savings of

Title	Components, extend	Indicative costs	Preliminary EE
consumption for DH system; Pumping station reconstruction	pumps and fans and 6 pumping stations including controls and VSD, hydraulic couplings at boiler-houses;	40 million USD	up-to 70 GWh, electricity
Waste-to-Energy Project Extension of the waste incineration plant "Енергія"	one additional module of 50% capacity including flue gas cleaning	Approximately 40-80 million USD	n/a
Water & Waste Water (WW)			
Extension of the use of waste water of sludge for combustion and heat generation	EE/RE project at WWTP Bortnichi including sludge utilization	Approximately 25 million USD	Annual savings of up-to 50 GWh, electricity
Improve Efficiency of Pumps and Motors in water supply system (Desna water station)	1 pumping station of Desna (level-2)	Approximately 2 million USD	Annual savings of up-to 1.5GWh, electricity
Active Leak Detection and Pressure Management Program for potable water system	n/a	n/a	n/a
Installation of mini hydro power plant at outlet of WWTP	n/a	n/a	n/a
Solid Waste (WS)			
Intermediate Transfer Stations including sorting, recycling	Construction of 2 facilities, capacity to be analyzed	In the range of 100-200 million USD	Annual savings of up to 20 GWh, diesel
Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program including Fuel Efficient Waste Vehicle Operations training	limited extend for municipal trucks, and including a waste route optimization	Up to 80 million USD	Annual savings of up to 12 GWh, diesel

B) Long- term EE investment measures: Implementation period 2020 to 2025

Title	Components, extend	Indicative costs	Preliminary EE
Street lighting			
Street Lighting timing, dimming and management Program, integration of rehabilitation of electric supply system and Poles of SL (wiring, switches) in order to enable control (	Step-by-step rehabilitation of power supply network to enable control, timing and dimming Limited extend , for selected streets only	n/a	n/a, up to 10% savings
Municipal public transport			
Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	n/a	Up to 80 million USD	Annual savings of up to 20 GWh, diesel
Public Transportation Development with innovative vehicles	Limited to test phase with electric busses	Up to 13 million USD	Annual savings of up to 4 GWh, diesel
Promotion of Public Transport, increase attractiveness targeting to lower private motorized transport mode	Comprise wide range of investment activities, not only EE	Up to 1 million USD	Annual savings of up to 100 GWh, gasoline at individual transport
District Heating			
Installation of Waste-to-Energy incineration plant of capacity of 0.4 M t/a (50-80	Extension of the waste incineration plant "Енергія" Assumption on capacity 400.000	Approximately 240 million USD	Annual savings of up-to 200 GWh, gas

Title	Components, extend	Indicative costs	Preliminary EE
MW) for heat generation and feed-in to KE network	tons of waste/yr		
District heating network rehabilitation, pipeline replacement	Up-to 540 km DH distribution network	Approximately 380 million USD	Annual savings of up-to 570 GWh, gas
Water&Waste water			
Heat pump system for heat generation from sewage water at WWTP	Up to 100 MW heat generation capacity	n/a	n/a

C) Short term NON-INVESTMENT MEASURES: Implementation period 2016 to 2020

Title	Components, extend	Indicative costs	Preliminary EE
Municipal Public Buildings (PB)			
Energy Audits and feasibility study for Municipal educational, medical and other facilities	Audit program for 1,500 buildings	Approx. 3 million USD	Results in PB - 02
Waste management			
Development of comprehensive concept and solutions including Waste Infrastructure Planning	for the cycle of transport, use, recycling dumping (separate container sorting)	Approx. 1 million USD	n/a
Municipal Energy Management			
Awareness raising and EE promotion programs for all sectors (water, energy, waste reduction)	events, competitions, awards, print media, media campaigns	In the range of 1-2 million USD annually	n/a
Institutional and Capacity building program Establishment Energy Management system including Monitoring and Verification (target tracking)	Establishment of Municipal Energy Agency Continuation of EE Municipal task force	Approx. 0.5 million USD start-up and 1 million per annum	n/a
Municipal Building Inventory, Benchmarking and Energy Performance Monitoring Program in municipal buildings	*Details in EE transformation program*	Approx. 2 million USD	Results in PB - 02
Technical guideline and procedure for equipment and service purchasing and granting concessions,	comprising e.g. life-cycle cost assessment, Performance Standards for private bus operators, Procurement for New Street Lights, equipment in public facilities, standards for new building construction; Mandatory Building Energy Efficiency Codes for Existing and new Buildings	In the range of 0.5-1.5 million USD	n/a
Preparation of Energy Performance contracting , preparation of contracting frame and procurements of ESCO services	preparatory energy audits, tender documents	In the range of 0.5 million USD annually	Resulting from investment projects
EE Strategy and investment plan resulting in Capital investment planning	*Details in EE transformation program*	In the range of 0,2 million USD	Resulting from investment projects

Energy Efficiency Recommendations Matrix

		First costs	
		< 10 million USD	**> 10 million USD**
Primary Energy Saving Potential	**< 10 GWh/year**	• Renovation of trolleybus fleet • Modernization of metro indoor lighting systems • Renovation of tramway fleet • Improve Efficiency of Pumps and Motors in water supply system • Active Leak Detection and Pressure Management Program for potable water system • Installation of mini hydro power plant at outlet of WWTP • Street Lighting timing, dimming and management Program, integration of rehabilitation of electric supply system and Poles of SL • Heat pump system for heat generation from sewage water at WWTP • Energy Audits and feasibility study for Municipal facilities • Development of comprehensive concept and solutions including Waste Infrastructure Planning • Awareness raising and EE promotion programs for all sectors • Institutional and Capacity building program • Establishment Energy Management system including Monitoring and Verification • Municipal Building Inventory, Benchmarking and Energy Performance Monitoring Program in municipal buildings • Technical guideline and procedure for equipment and service purchasing and granting concessions, • Preparation of Energy Performance contracting • EE Strategy and investment plan resulting in Capital investment planning	• Extension of program for High performing traction systems for Metro trains • Public Transportation Development with innovative vehicles • Promotion of Public Transport, increase attractiveness targeting to lower private motorized transport mode
	> 10 GWh/year	•	• Retrofit Program / thermo-modernization of Municipal educational, medical and other facilities • Renewable energy individual heat generation for municipal education and medical facilities • Street Lighting Audit and Retrofit Program • Installation of Individual heat substations and Heat meter (IHS) • Boiler Houses reconstruction and rehabilitation Program including fuel switch for heat generation - gas to biomass • Installation of economizer units at boiler-houses • Reduction of power consumption for DH system; Pumping station reconstruction • Waste-to-Energy Project Extension of the waste incineration • Extension of the use of waste water of sludge for combustion + heat generation • Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program including Fuel Efficient Waste Vehicle Operations training • Replacement of municipal diesel bus fleet to hybrid • Installation of Waste-to-Energy incineration plant • District heating network rehabilitation, pipeline replacement

Резюме

CEETI, ESMAP та TRACE

Ініціатива енергоефективної трансформації міст (CEETI) - це проект технічної допомоги, який фінансується Світовим Банком протягом 3-х років в рамках Програми сприяння управлінню енергетичним сектором (ESMAP). Ініціатива допомагає містам визначити, розробити та мобілізувати фінансові ресурси для створення інвестиційних програм трансформації міської енергетичної ефективності у муніципальних секторах.

У цьому звіті представлені основні результати застосування Моделі для швидкої оцінки енергетики міста (TRACE) та оцінка енергоефективності міста Києва.

Процес оцінки енергоефективності та структура звіту

Метою Звіту з оцінки енергетичної ефективності міста є аналіз потенціалу ефективності муніципальних галузей, які споживають енергетичні ресурси, обрання пріоритетних напрямків їх діяльності та розроблення комплексу заходів щодо підвищення їх енергетичної ефективності, які будуть служити основою для подальшої розробки Програми енергетичної трансформації міста. Процес супроводжується активним спілкуванням із зацікавленими сторонами міста, для підтвердження результатів аналізу, зміцнення довіри та взаємодії.

Процес оцінки енергоефективності міста почався із збору необхідних даних та інформації від Київської міської державної адміністрації та комунальних підприємств. Зустрічі з зацікавленими сторонами (інтерв'ю) відбулися в листопаді - грудні 2014 року. З результатами аналізу вихідного стану міста можливо ознайомитись у Звіті.

Вихідні дані були застосовані для розрахунку ключових показників ефективності міста Києва, які потім були внесені до TRACE моделі.

Такий компонент моделі TRACE, як бенчмаркінг, дозволяє за аналогічними характеристиками порівняти показники енергетичної ефективності міста, яке досліджується, з показниками інших міст - еталонів. Компонент «Відносна енергетична ефективність» дозволив зробити грубу оцінку потенціалу енергетичної ефективності кожного сектору. → Глава 3.

Додатково були визначені пріоритети цільових секторів, витрати на енергію та рівень повноважень влади міста, який включає бюджетний контроль, регулювання та примусовий вплив на споживання енергетичних ресурсів. →Глава 4.

Рекомендацій з енергетичної ефективності, які сформовані у довгий перелік, були отримані з різних джерел, в тому числі з інтерв'ю. За попередньою оцінкою створено каталог рекомендацій з енергоефективності за секторами→ Глава 6, 7 та 8,

Ключові характеристики, наявні проблеми секторів (Глава 5) та аналіз потенціалу енергетичної ефективності були презентовані та обговорені на робочому семінарі у лютому 2015 року. Міська влада та комунальні підприємства міста домовилися про концептуальний і комплексний підхід у розробці Програми енергетичної ефективності.

Цей Звіт з оцінки енергетичної ефективності відображає рішення робочого семінару, який було проведено за участю ключових зацікавлених сторін від міста, які попередньо підтвердили галузеві пріоритети та переглянули рекомендації з енергетичної ефективності зі списку.

Цілі енергетичної ефективності

Місто долучилося до ініціативи Європейського Союзу «Угода мерів» в 2011 році, але підготовка Плану сталого енергетичного розвитку тільки очікується.

Цілі, які були визначні у Міському енергетичному плані (розроблений у 2012 році), це зниження емісії CO_2 на 20% до 2020 року, скорочення споживання первинної енергії на 10% та збільшення використання відновлювальної енергії приблизно на 1%.

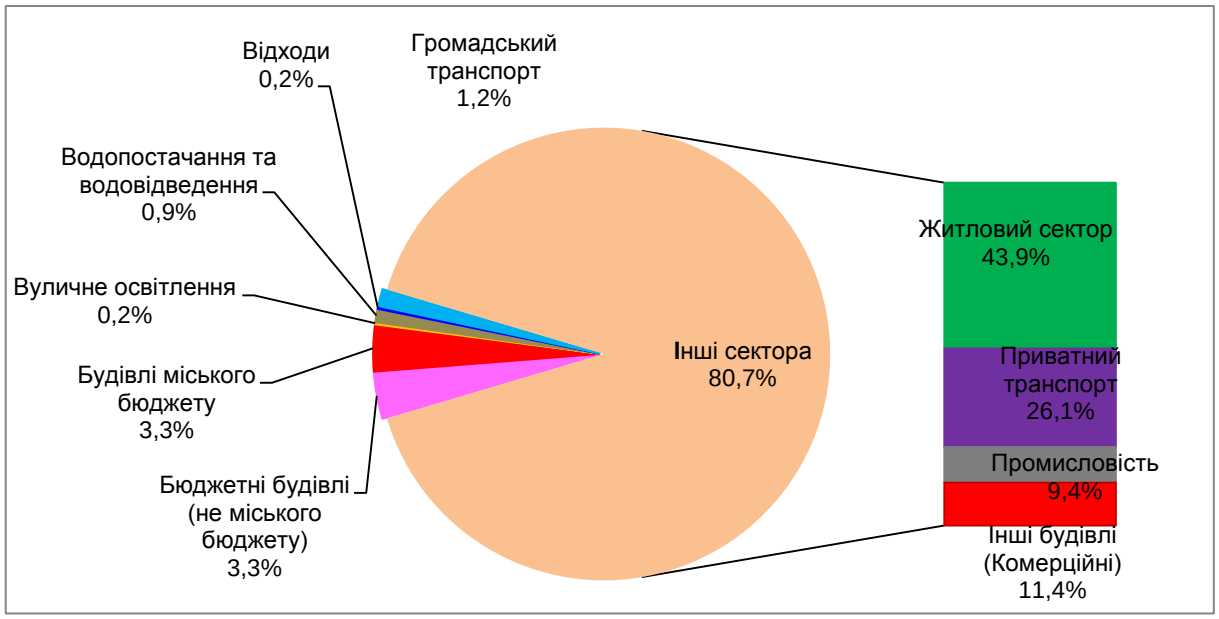
Вихідний стан міста - споживання енергетичних ресурсів

У 2013 році кількість спожитої первинної енергії становить 48 190,7 ГВт·год, з якої 2/3 складає споживання природного газу, більша частка якого використовується на виробництво електричної та теплової енергії для кінцевих споживачів.

Житловий сектор є найбільшим споживачем енергії - близько 50%, що характерно для всіх українських міст, за ним йдуть сектор приватного транспорту - 22%, промисловість та комерційний сектор (інші будівлі включно) -16%.

Кінцеве споживання енергетичних ресурсів, на яке місто має безпосередній вплив, становить 2 349 ГВт·год (5,8%) з 40 179 ГВт·год.

Рисунок 3: Кінцеве споживання енергії містом за 2013 рік

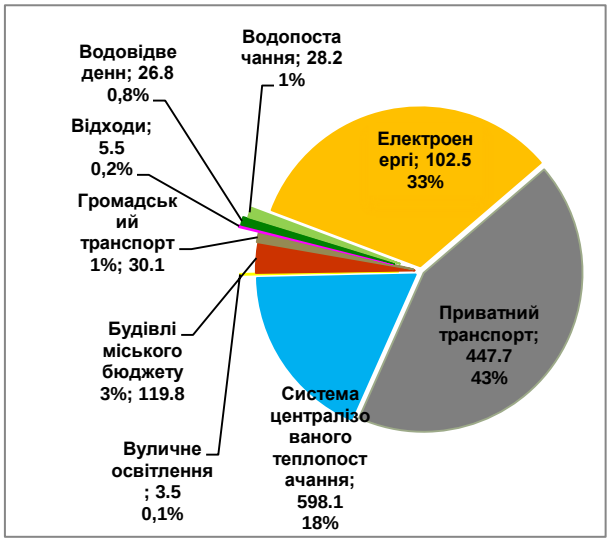


Вихідний стан міста - Витрати міського бюджету та міста в цілому на енергію

Місто Київ – столиця України. Населення у 2013 році склало 2 868 700 осіб. Розвинена промисловість, галузі обслуговування та торгівлі.

Міський бюджет у 2013 році налічував 2 889 мільйонів доларів США, з якого приблизно 1 914 мільйонів будо використано на енергозабезпечення секторів громадського транспорту, громадських будівель, вуличного освітлення, водопостачання та водовідведення, поводження з твердими побутовими відходами. Загальний валовий міський продукт Києва склав 36 402 мільйони доларів США, де 3 362 мільйони (9%) було витрачено на енергозабезпечення.Найбільші споживачі енергетичних ресурсів - сектори електропостачання (33%) та приватний транспорт (42%), не знаходяться під контролем міської влади.

Рисунок 4: Витрати на енергію, 2013, мільйони доларів США



Витрати на енергозабезпечення муніципальних секторів (міський громадський транспорт, громадські будівлі, вуличне освітлення, побутові відходи, водопостачання та водовідведення) склали 214 мільйонів доларів США у 2013 році, з яких 55% було витрачено на забезпечення енергетичними ресурсами громадських бюджетних будівель. Ці 120 мільйонів доларів США складали 4.1% від міського бюджету.

Навіть якщо споживання енергії в секторах, які знаходяться під безпосереднім контролем Адміністрації міста, становить всього лише 6% від загального споживання енергії в цілому по місту, впровадження заходів з енергетичної ефективності в цих секторах, має важливе значення для міста і для міського уряду.

По-перше, економія енергії в цих секторах безпосередньо призведе до зниження енергетичних витрат і скорочення міських видатків бюджету чи державних субсидій. Це, зокрема, відноситься до очікуваного різкого збільшення вартості енергії, де інвестиції в енергозбереження будуть протидією підвищенню тарифів для кінцевих споживачів і ризику втрати доступності енергії або послуг.

По-друге, інвестування заходів з енергозбереження в цих секторах матиме довгостроковий і стійкий вплив на деякі загальноміські сектори. Це (I) скорочення споживання палива приватним транспортом через перерозподіл видів транспортних перевезень у напрямку споживання більш низької питомої енергії громадським транспортом, (II) зниження споживання енергії в житловому секторі у зв'язку з поліпшенням системи теплопостачання і тарифікації.

По-третє, інвестиції в енергозбереження міської інфраструктури помітні населенню і тим самим сприяють підвищенню обізнаності громадськості про (I) ресурсозбереження, (II) поліпшення надання державних послуг для населення, і, нарешті, (III) спрямування України на шлях стійкого зростання шляхом прийняття правильних рішень для залучення інвестицій.

Бенчмаркінг енергетичної ефективності міста Києва

Бенчмаркінг дозволяє порівняти енергетичну ефективність міста Київ з іншими містами - еталонами на основі 27 ключових показників ефективності.

Детально процес бенчмаркінгу міста Києва розглянуто у Главі 3.
У наступній таблиці наводиться стисла інформація о характеристиках секторів.

Таблиця 3: Резюме бенчмаркінга по ключових показниках ефективності міста Києва.

Сектор	Обрані ключові показники ефективності		Порівняння ЕЕ досліджуваного міста з ЕЕ більш розвинених міст світу	Теоретичний потенціал ЕЕ
В цілому по місту	Споживання первинної енергії на душу населення,	55.73 ГДж/ос.	Середня ефективність Міста-еталони: Скоп'є, Сараєво, Братислава	50%
	Споживання первинної енергії на ВВП міста,	4.77 МДж/доларі в США ВВП міста	Низька ефективність Міста-еталони: Вена, Варшава та Париж	50%
Громадський транспорт	Питоме споживання енергії громадським транспортом,	0.4 МДж/пас·км	Середня ефективність Міста-еталони: Белград та Сараєво	35% - 50%
Побутові відходи	Кількість твердих побутових відходів (ТПВ), що утворюються в межах	приблизно 400 кг/ос.	Середня ефективність Міста-еталони: Софія та Скоп'є	25%

Сектор	Обрані ключові показники ефективності		Порівняння ЕЕ досліджуваного міста з ЕЕ більш розвинених міст світу	Теоретичний потенціал ЕЕ
	міста на душу населення			
	Відсоток ТПВ, що піддаються переробці	17%	Низька ефективність	50-70%
Водопостачання та водовідведення	Питоме споживання електроенергії на питне водопостачання	0.66 $кВт_е$·год/м³	Низька ефективність Міста-еталони: Баня Лука та Вена.	50%
	Питоме споживання електроенергії на водовідведення	0.73 $кВт_е$·год/м³	Дуже низька ефективність	50-60%
Централізоване теплопостачання	Відсоток втрат теплової енергії в мережах	18-19%	Низька ефективність Міста-еталони: Таллінн міста Східної Європи	50%
Вуличне освітлення	Питоме споживання електроенергії на км освітлених вулиць	38 $кВт_е$·год/км	Низька ефективність Міста-еталони: Тбілісі та Вена	50%
Громадські бюджетні будівлі	Споживання теплової енергії будівлями міського підпорядкування	186 $кВт_т$·год/м²	Дуже низька ефективність	50-60%

Порівняно з містами – еталонами з бази даних TRACE більшість показників є значно нижчими з точки зору питомого споживання енергії, зокрема для секторів:

- **Споживання первинної енергії на одиницю ВВП та душу населення**,
- **Споживання теплової енергії громадськими будівлями**,
- Питоме споживання електроенергії на **водовідведення та водопостачання** ,
- Питоме споживання енергії на потреби **вуличного освітлення**,
- Споживання енергії на душу населення транспортом міста
- Питоме споживання енергії на **громадським транспортом**
- Питомі втрати в системі розподілу теплової енергії

Теоретичний потенціал економії енергії в вищезазначених секторах та KPI складає **30-50%**.

Додатковий потенціал для підвищення ефективності міста зменшення обсягу ТПВ на душу населення і збільшення частки відходів на вторинну **переробку**.

Рівень контролю міської влади

Через різні правові відмінності та нормативні рамки і різних форм власності над об'єктами секторів, Міська адміністрація має різний рівень управління і ступеня впливу на кінцевих споживачів енергії та комунальні підприємства. Це стосується бюджетного контролю, регулювання та примусового впливу на споживання енергетичних ресурсів міською інфраструктурою.

Міська влада має повний контроль над сектором громадських бюджетних будівель та вуличного освітлення.

Крім того, міська влада зберігає певний ступінь впливу на кінцевих споживачів енергії в секторах управління твердими побутовими відходами та громадського транспорту, а також має обмежений вплив на сектори водопостачання і водовідведення та теплопостачання (через структуру власності).

Таблиця 4: Контроль міської влади Києва на рівень витрат з бюджету, регулювання та ступінь примусового впливу на споживання енергії секторами міста

Сектор	Рівень повноважень міської влади		
	Регулювання	**Контроль витрат з бюджету**	**Вплив**
Громадські будівлі	ВИСОКИЙ	ВИСОКИЙ	ВИСОКИЙ
Вуличне освітлення	ВИСОКИЙ	ВИСОКИЙ	ВИСОКИЙ
Громадський транспорт	ВИСОКИЙ	СЕРЕДНІЙ	ВИСОКИЙ
Відходи	ВИСОКИЙ	СЕРЕДНІЙ	ВИСОКИЙ
Питне водопостачання	СЕРЕДНІЙ	СЕРЕДНІЙ	ВИСОКИЙ
Водовідведення	СЕРЕДНІЙ	СЕРЕДНІЙ	ВИСОКИЙ
Централізоване теплопостачання	НИЗЬКИЙ	НИЗЬКИЙ	СЕРЕДНІЙ
Електропостачання	НИЗЬКИЙ	НИЗЬКИЙ	НИЗЬКИЙ
Газопостачання	НИЗЬКИЙ	НИЗЬКИЙ	НИЗЬКИЙ
Приватний транспорт	НИЗЬКИЙ	НИЗЬКИЙ	НИЗЬКИЙ
Житлові будинки	НИЗЬКИЙ	НИЗЬКИЙ	СЕРЕДНІЙ

Пріоритетні сектори;

Пріоритетність секторів визначається за наступними критеріями:

- ✓ теоретичний потенціал енергетичної ефективності - “Відносна енергетична ефективність”
- ✓ рівень витрат на оплату енергії за секторами
- ✓ рівень контролю міської влади

Пріоритети секторів щодо підвищення енергетичної ефективності (у порядку пріоритетності):

Пріоритетний перехресний сектор

Сектори кінцевого споживання енергії, які контролюються приватними або комерційними організаціями, не враховується при оцінці інструментом TRACE, так як міська влада не має права контролю і впливу на їх енергетичну ефективність або витрати на енергію з бюджету міста. *Ці* сектори показані нижче і не приймаються до розгляду надалі, Приватний контроль і Комерційний контроль:

- Приватний транспорт
- Електропостачання, Газопостачання
- Комерційні будівлі

- Громадські будівлі не міського підпорядкування
- Житловий сектор
- Промисловість

Це не обов'язково означає, що проекти енергоефективності не будуть розроблені в цих секторах, але порівняно з іншими секторами, вони навряд чи матимуть високий потенціал повернення коштів від впровадження заходів з енергетичної ефективності порівняно з секторами, які знаходяться під контролем міської влади.

Поточні і завершені інвестиційні програми і плани

В місті Києві на даний час реалізується ряд інвестиційних програм, що фінансуються за рахунок власних ресурсів, а також міжнародних донорських організацій, таких як:

У секторі громадських будівель:

- Проект "Енергозбереження в бюджетних будівлях м. Києва ", за підтримки NEFCO та гранту фонду E5P;
- Проект «Муніципальна енергетична реформа в Україні» за підтримки USAID;
- Проект: «Перфоманс - контрактінг заходів з підвищення енергетичної ефективності громадських будівель м. Києва, за підтримки NEFCO, міського бюджету, E5P, USAID і Sida;

У секторі водопостачання:

- Проект «Розвиток міської інфраструктури - 2» за підтримки IBRD, у якому передбачено модернізацію системи водопостачання та водовідведення.

Результати та досвід здійснення цих проектів необхідно враховувати при плануванні та здійсненні майбутніх заходів з енергетичної ефективності для того, щоб уникнути їх дублювання, поліпшити концепцію та створити необхідні потужності.

У 2012 році було розроблено комплексний Міський енергетичний план (до 2016 року), адміністрацією міста Києва створене Київське інвестиційне агентство, яке також займається розвитком інвестиційних проектів з енергетичної ефективності, які було переглянуто і включено до списку рекомендацій з енергетичної ефективності для подальшої розробки Програми енергоефективної трансформації.

Крім того, КМДА в рамках своїх зобов'язань у проекті «Угода мерів» розробляє План дій сталого енергетичного розвитку (SEAP). Взаємозв'язок проекту CEETI з SEAP розглядається у двох напрямках, а) рекомендовані заходи з енергетичної ефективності можуть забезпечити концептуальний напрямок подальшого більш детального аналізу в SEAP і б) загальні тенденції SEAP мають відповідати розглянутим секторам та слідувати рекомендованим заходам з енергетичної ефективності.

Рекомендації з енергетичної ефективності, які запропоновано до аналізу у Програмі енергетичної трансформації міста

Виходячи з вищезазначеного обґрунтування секторів, обговорення та попереднього рішення, яке було сформульовано на робочому семінарі, перелік заходів з енергетичної ефективності налічує 33 одиниці, з яких 25 є інвестиційними.

Рекомендовані інвестиційні заходи з енергетичної ефективності розділяються на короткострокові і довгострокові, відповідно до їх попереднього періоду реалізації - до 2020 року і після 2020 року.

А) Короткострокові Інвестиційні заходи з енергетичної ефективності: Термін реалізації 2016 - 2020

Назва	Опис	Орієнтовні витрати	Попередня економія
Громадські будівлім міського підпорядкування (РВ)			
Програма модернізації/ глибокої термомодернізації будівель навчальних,	Всього приблизно 1560 будівель. Включає модернізацію фасаду будівель, трубопроводів, при можливості	Приблизно 650 мільйонів доларів США	Щорічна економія 830 ГВт• год первинної енергії у вигляді

Назва	Опис	Орієнтовні витрати	Попередня економія
медичних, інших закладів	встановлення індивідуальних теплових пунктів. Не розглядає заходи ЕЕ у системі електропостачання		природного газу
Переведення системи теплопостачання всіх навчальних та медичних закладів на відновлювальні джерела енергії (ВДЕ) (індивідуальні теплові пункти)	Включає застосування теплових насосів, біомасу, сонячних колекторів, де це можливо. Вибіркове встановлення тільки у місцях, де немає можливості підключення до системи централізованого теплопостачання	Приблизно 100- 245 мільйонів доларів США	Щорічна економія від 200 до 450 ГВт• год, економія первинної енергії, природного газу
Вуличне освітлення (SL)			
Проведення аудиту та модернізації системи вуличного освітлення (установка високоефективних світильників)	Приблизно 130 000 ламп. Включає освітлення громадських будівель, де це необхідно. Поетапна модернізація опор освітлення для встановлення світодіодних світильників	До 43 мільйонів доларів США	Щорічна економія до 25 ГВт• год, економія електричної енергії
Громадський міський транспорт (TM)			
Оновлення тролейбусного парку	*Детально розглянуто в Програмі трансформації ЕЕ*	до 4 мільйонів доларів США	Щорічна економія до 14 ГВт• год, економія електричної енергії
Модернізація системи освітлення метрополітену	*Детально розглянуто в Програмі трансформації ЕЕ*	до 1 мільйона доларів США	Щорічна економія до 1 ГВт• год, економія електричної енергії
Оновлення трамвайного парку	*Детально розглянуто в Програмі трансформації ЕЕ*	до 1 мільйона доларів США	Щорічна економія до 13 ГВт• год, економія електричної енергії
Розширення програми впровадження високопродуктивних тягових систем для поїздів метро (асинхронних електроприводів)	Обмежене впровадження, фаза тестування інноваційних технологій	невизначено	
Централізоване теплопостачання (DH)			
Установка індивідуальних теплових пунктів та лічильників теплової енергії	Приблизно у 5 500 житлових будинків. Включає Впровадження SCADA-системи та системи автоматичного балансування	Приблизно 330 мільйонів доларів США	Щорічна економія до 1,500 ГВт• год, економія природного газу
Реконструкція та модернізація котелень, яка включає заміщення природного газу біопаливом (біомасою) для виробництва теплової енергії (частково, невеликі котельні)	Всього приблизно 170 котелень	Приблизно 80 мільйонів доларів США	Щорічна економія до 125 ГВт• год, економія природного газу
Встановлення конденсаційних	5 одиниць на котельню	Приблизно 18 мільйонів	Щорічна економія до 220 ГВт• год,

Назва	Опис	Орієнтовні витрати	Попередня економія
економайзерів в котельнях		доларів США	економія природного газу
Зниження споживання електричної енергії системою централізованого теплопостачання; Модернізація насосних станцій	За попередньою оцінкою : 53 циркуляційних насосів та вентиляторів та 6 насосних станцій Включає становлення частотно - регульованого приводу, гідромуфт	Приблизно 40 мільйонів доларів США	Щорічна економія до 70 ГВт• год, економія електричної енергії
Реконструкція сміттєспалювального заводу "Енергія" в сміттєспалювальну ТЕЦ	один додатковий модуль 50% потужності в тому числі з можливістю очищення димових газів	Приблизно 40-80 мільйонів доларів США	невизначено
Водопостачання та водовідведення (WW)			
Розширене використання мулового осаду стічних вод для спалювання та отримання теплової енергії	Проект енергоефективності та використання відновлювальної енергії на станції аерації Бортничі, який фінансується японськими інвесторами. Проект включає використання мулового осаду	Приблизно 25 мільйонів доларів США	Щорічна економія до 50 ГВт• год, економія електричної енергії
Підвищення ефективності насосів та електроприводів в системі водопостачання Деснянській водопровідній станції (II-й підйом)	Деснянській водопровідній станції (II-й підйом)	Приблизно 2 мільйона доларів США	Щорічна економія до 1.5 ГВт• год, економія електричної енергії
Програма впровадження системи активного виявлення витоків та управління тиском в системі водопостачання	невизначено	невизначено	невизначено
Встановлення мініГЕС на виході зі станції очищення відходів	невизначено	невизначено	невизначено
Тверді побутові відходи (WS)			
Будівництво перевалочних станцій, що включає процеси сортування, переробки	Будівництво 2 об'єктів, потужність необхідно проаналізувати	100-200 мільйонів доларів США	Щорічна економія до 20 ГВт• год, економія дизелю
Програма проведення аудиту, модернізації та заміни спецавтотранспорту, Підвищення ефективності споживання моторного палива при експлуатації сміттєвозів	Обмежене розширення спец автопарку, яке також включає оптимізацію маршрутів	80 мільйонів доларів США	Щорічна економія до 12 ГВт• год, економія дизелю

В) Довгострокові інвестиційні заходи: термін реалізації 2020- 2025

Назва	Опис	Орієнтовні витрати	Попередня економія
Вуличне освітлення			
Програма таймування, діммування та управління системою зовнішнього освітлення, модернізація електричної мережі (проводка, вимикачі) та опор освітлення	Поетапне відновлення мережі живлення, для впровадження таймування, діммування та управління зовнішнім освітленням	невизначено	невизначено, до 10% економії

Назва	Опис	Орієнтовні витрати	Попередня економія
для контролю споживання електричної енергії	Обмежене використання тільки для обраних вулиць		
Громадський транспорт			
Заміщення комунальних дизельних автобусів гібридними автобусами (дизель/електроенергія)	невизначено	до 80 мільйонів доларів США	Щорічна економія до 20 ГВт• год, економія дизелю
Розвиток громадського транспорту з впровадженням інноваційних видів транспорту	Обмеження через фазу тестування електричних автобусів	до 13 мільйонів доларів США	Щорічна економія до 4 ГВт• год, економія дизелю
Заохочення мешканців до використання громадського транспорту	Включає широкий спектр інвестиційних заходів, не тільки ЕЕ	до 1 мільйона доларів США	Щорічна економія до 100 ГВт• год, економія бензину в секторі приватного транспорту
Централізоване теплопостачання			
Встановлення сміттєспалювального заводу потужності 0,4 мільйони тон відходів у рік (50-80 МВт) для виробництва теплової енергії	Розширення потужності сміттєспалювального заводу «Енергія», приблизна потужність 0,4 мільйони тон відходів у рік	приблизно 240 мільйонів доларів США	Щорічна економія до 200 ГВт• год, економія природного газу
Реконструкція системи централізованого теплопостачання, заміна трубопроводів	до 540 км розподільчих мереж системи централізованого теплопостачання	приблизно 380 мільйонів доларів США	Щорічна економія до 570 ГВт• год, економія природного газу
Водопостачання та водовідведення			
Встановлення теплових насосів на очисних спорудах для генерації теплової енергії	Потужність до 100 МВт теплової енергії	невизначено	невизначено

С) Короткострокові НЕІНВЕСТИЦІЙНІ ЗАХОДИ: термін впровадження 2016 - 2020 роки

Назва	Опис	Орієнтовні витрати	Попередня економія
Громадські будівлі міського підпорядкування (РВ)			
Енергетичний аудит та техніко - економічне обґрунтування закладів навчальної, медичної сфери та інших будівель	Аудит 1 500 будівель	Приблизно 3 мільйони доларів США	Відображена у заході РВ - 02
Поводження с побутовими відходами			
Планування комплексної концепції створення інфраструктури поводження з відходами	Враховується цикл транспортування, використання, утилізації захоронення (сортування у окремі контейнери) ТПВ	приблизно 1 мільйон доларів США	невизначено
Муніципальний енергетичний менеджмент			
Розробка та проведення інформаційно-просвітницьких заходів (водопостачання, енергопостачання, зменшення обсягів відходів)	Події, конкурси, нагороди, друковані ЗМІ, медіа-кампаній	1-2 мільйони доларів США щорічно	невизначено
Створення в муніципалітеті робочої групи з підвищення енергоефективності інфраструктури міста,	Створення муніципального енергетичного агентства Продовження створення робочої групи з	Приблизно. 0.5 мільйони доларів США початкових	невизначено

Назва	Опис	Орієнтовні витрати	Попередня економія
впровадження системи моніторингу та верифікацій	енергозбереження	інвестицій та 1 мільйон у рік	
Програма бенчмаркінгу та моніторинг ефективності у громадських будівлях	*Детально розглянуто в Програмі трансформації ЕЕ*	Приблизно 2 мільйони доларів США	Відображена у заході РВ - 02
Інструкція з технічних питань, порядку придбання обладнання та послуг і надання пільг	Включає, наприклад, оцінку життєвого циклу вартості обладнання, стандарти ефективності транспортних засобів для приватних автобусних перевізників, закупівля нових вуличних світильників, устаткування для державних установ, стандартів для будівництва нових будівель; створення обов'язкових норми і правил ефективного будівництва в існуючих і нових будівлях	0.5-1.5 мільйонів доларів США	невизначено
Впровадження механізму перформанс-контрактингу, ЕСКО фінансування	Експрес енергоаудит, тендерні документи	0.5 мільйонів доларів США щорічно	В результаті впровадження інвестиційних проектів
Планування капітальних вкладень	*Детально розглянуто в Програмі трансформації ЕЕ*	0,2 мільйони доларів США	В результаті впровадження інвестиційних проектів

Матриця рекомендацій з енергетичної ефективності

		Орієнтовні витрати	
		< 10 мільйонів доларів США	**> 10** мільйонів доларів США
Попередня економія	< 10 ГВт• год	• Оновлення тролейбусного парку • Модернізація системи освітлення метрополітену • Оновлення трамвайного парку • Підвищення ефективності насосів та електроприводів в системі водопостачання Деснянській водопровідній станції • Програма впровадження системи активного виявлення витоків та управління тиском в системі водопостачання • Встановлення мініГЕС на виході зі станції очищення відходів • Програма таймування, діммування та управління системою зовнішнього освітлення, модернізація електричної мережі (проводка, вимикачі) та опор освітлення для контролю споживання електричної енергії • Встановлення теплових насосів на очисних спорудах для генерації теплової енергії • Будівництво перевалочних станцій, що включає процеси сортування, переробки • Енергетичний аудит та техніко - економічне обґрунтування закладів навчальної, медичної сфери та інших будівель • Планування комплексної концепції створення інфраструктури поводження з відходами • Розробка та проведення інформаційно-просвітницьких заходів (водопостачання, енергопостачання, зменшення обсягів відходів) • Створення в муніципалітеті робочої групи з підвищення енергоефективності інфраструктури міста, впровадження системи моніторингу та верифікацій • Програма бенчмаркінгу та моніторинг ефективності у громадських будівлях • Інструкція з технічних питань, порядку придбання обладнання та послуг і надання пільг • Впровадження механізму перформанс-контрактингу, ЕСКО фінансування • Планування капітальних вкладень	• Розширення програми впровадження високопродуктивних тягових систем для поїздів метро • Розвиток громадського транспорту з впровадженням інноваційних видів транспорту • Заохочення мешканців до використання громадського транспорту
	> 10 ГВт• год		• Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних, інших закладів • Переведення системи теплопостачання всіх навчальних та медичних закладів на відновлювальні джерела енергії • Проведення аудиту та модернізації системи вуличного освітлення • Установка індивідуальних теплових пунктів та лічильників теплової енергії • Реконструкція та модернізація котелень, яка включає заміщення природного газу біопаливом (біомасою) для виробництва теплової енергії • Встановлення конденсаційних економайзерів в котельнях • Зниження споживання електричної енергії системою централізованого теплопостачання; Модернізація насосних станцій • Реконструкція сміттєспалювального заводу "Енергія" в сміттєспалювальну ТЕЦ • Розширене використання мулового осаду стічних вод для спалювання та отримання теплової енергії • Програма проведення аудиту, модернізації та заміни спецавтотранспорту, Підвищення ефективності споживання моторного палива при експлуатації сміттєвозів • Заміщення комунальних дизельних автобусів гібридними автобусами • Встановлення сміттєспалювального заводу потужності 0,4 мільйони тон відходів у рік (50-80 МВт) для виробництва теплової енергії • Реконструкція системи централізованого теплопостачання, заміна трубопроводів

2 Introduction and Background to the Rapid Assessment Framework

The Tool for Rapid Assessment of City Energy (TRACE) is a central component of the Energy Efficient Cities Initiative (EECI), launched by the Energy Sector Management Assistance Program (ESMAP) in collaboration with the Urban Anchor. TRACE was piloted in 2010 and first deployed in 2012.

The purpose of TRACE is to identify technical and institutional measures that will improve the energy efficiency of the municipal infrastructure across the following sectors:

1) Municipal Buildings
2) Public Street Lighting
3) Power and district heat supply
4) Transportation (public and private)
5) Potable water supply and waste water treatment
6) Municipal Solid Waste

The organizational management practices with respect to energy efficiency of the City Authority (CA) that span all of the sectors above are also considered. Details are provided in the city background report.

The ultimate aim of TRACE is to identify ways in which energy efficiency can be improved by the CA and therefore reduce their expenditure on energy.

Sectors that will directly save the CA budget and over which it has direct control are labelled as 'City Authority'; while sectors that do not necessarily affect the CA's energy expenditure, relate to energy use principally in the private sector, and on which the CA may have limited influence are labelled as 'City Wide.' In such instances, the TRACE process identifies how these issues may be addressed through engagement, representation and other means.

3 Benchmarking of the current Energy Performance of the city

3.1 Introduction on Energy Performance Benchmarking for the city of Kyiv

The benchmarking component of the TRACE tool is intended to assess the energy performance of the city compared to other peer cities.

The following peer cities have been selected from TRACE database for the benchmark of Kyiv:

- Baku, Azerbaijan
- Banja Luka, Bosnia-Herzegovina
- Beijing, China
- Belgrade, Serbia
- Bucharest, Romania
- Gaziantep, Turkey
- Pristina, Kosovo
- Sarajevo, Bosnia-Herzegovina
- Skopje, Macedonia
- Sofia, Bulgaria
- Tbilisi, Georgia
- Warsaw, Poland
- Yerevan, Armenia
- Toronto, Canada

For the benchmarking of a few KPI the following additional Western European Cities have been considered as peer cities: Barcelona/Spain, Tallinn/ Estonia, Paris/France, Helsinki/ Finland.

The selection of peer cities is based on a similar level of the Human Development Index (HDI) and continental climatic conditions as well as a location in (Eastern) Europe to enable an appropriate comparison.

The criteria of the size of population has been applied for the benchmarking only to limited extend, as the cities of the TRACE database with a population level similar to Kyiv (at a range between 2 and 4 million people) are not very comparable in terms of HDI and climate conditions as well as their location at other continents.

KPI data for the chosen peer cities is used as a principal factor in sector prioritization in the TRACE tool.

The Key Performance Indicators for the city of Kyiv have been calculated and aggregated based on data and information received from the City Authority of Kyiv as well as interviews with stakeholders of the administration and utilities of municipal services. Data collection and interviews took place in November 2014. The availability and quality of city data and information of the city context is satisfying. Specific data on of sectors have been collected. No proxies have been used.

It was agreed with the City Administration and the World Bank team to apply data of the year 2013 as baseline data for the TRACE assessment and the following EE assessment.

For each sector, a number of Key Performance Indicators (KPIs) have been derived to indicate energy performance of the sector.

Figure 5: Key city statistics of 2013

№	Indicator	Unit	Value
1	Population	people	2,868,700
3	Municipal area (same as metropolitan area)	km^2	835,6
2	Population Density	People/km^2	3,433
4	Primary Energy Consumption	GWh	48,191
5	Employment rate	%	71.4 [2]
6	Human Development Index (HDI)[1]		0.734
7	Total city budget	Million USD	2,889[3]
8	Municipality expenditures for energy in public buildings	Million USD	120 4% of budget
9	Energy Spending (for sectors: municipal public transport, municipal buildings, street lighting, waste, water and waste water services)	Million USD	3,362
10	GDP (2013)[2]	Million USD	36,402

The economic and political framework for implementation of energy efficiency in the city of Kyiv is outlined in the section on the city background.

The following sections graphically present the data collected and give a benchmarking comparison to other cities around the world. A selection of benchmarking graphs is presented that most accurately reflect the energy use characteristics of the city. The data applied for the benchmarking are justified in the context in the city of Kyiv in detail in the section of city background.

TRACE calculates the theoretical EE potential by comparing the KPI of Kyiv with the KPI of better performing cities (with lower specific energy consumption). This allows a rough statement on the performance of Kyiv compared to the set of peer cities.
A high rank with a performance indicator pertains to a favorable effect on energy efficiency, i.e. comparatively, low consumption is judged to achieve a HIGH rank.

3.2 City Wide Energy Efficiency Benchmarking

Figure 6: Key Performance Indicators for City Wide Energy

Key Data			Key Performance Indicators (TRACE)	
Total electricity consumed, with industry	8,105.6	GWh	Electricity consumption (kWh_e/capita)	2,213.8
Total primary energy consumed with industry	173,486,435	GJ	Electricity consumption (kWh_e/GDP)	0.22
Total primary energy consumed, with industry	48,190.7	GWh	Primary energy consumption (MJ/capita)	55.73
Total kWh, primary energy consumed without industry	44,406.9	GWh	Primary energy consumption (MJ/GDP)	4.77
Energy Supply Cover	100	%		

[1] Source: UN Human Development reports; https://hdr.undp.org/en/data; Value for Ukraine 2013

[2] Source: Statistic Institute of Ukraine: http://www.ukrstat.gov.ua/operativ/operativ2008/vvp/vrp/vrp2008_r.htm

Figure 7: Primary Electricity Consumption per capita (kWhe/capita)

The city of Kyiv ranks medium for the performance indicator of Primary Electricity Consumption per capita in comparison with the peer cities with similar level of HDI. The theoretical energy saving potential for the city of Kyiv amounts to approximately 30 % to achieve a level of the better performing cities, such as: Tbilisi and Baku.

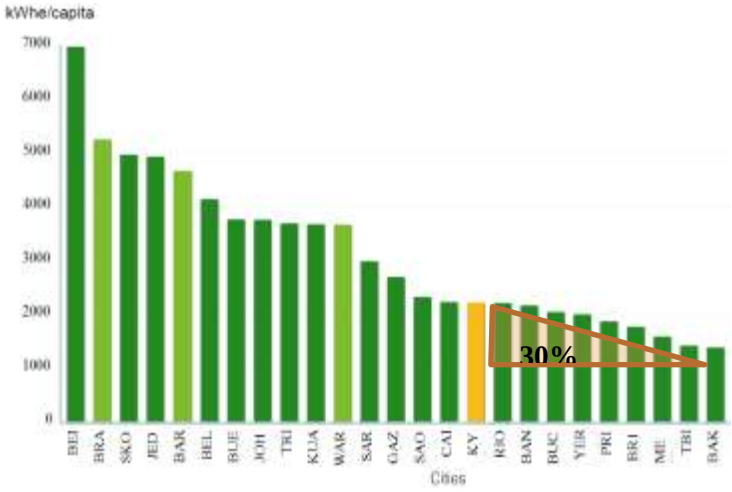
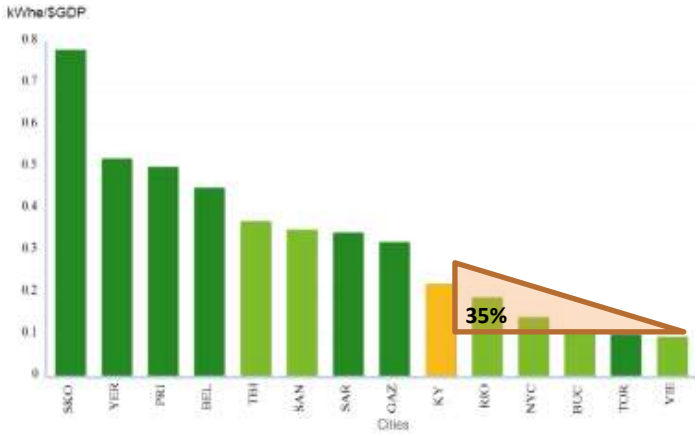


Figure 8: Primary Electricity Consumption (kWh_e/GDP)



The city of Kyiv ranks low for the performance indicator of Primary Electricity Consumption in kWh_e/GDP in comparison with the peer cities with similar level of HDI. The theoretical energy saving potential for the city of Kyiv amounts to approximately 35 % to achieve a level of the better performing cities, such as: Bucharest or Vienna.

Figure 9: Primary Energy Consumption (GJ/capita)

The city of Kyiv ranks medium for the performance indicator of Primary Energy Consumption per capita in comparison with the peer cities with similar climatic conditions. The theoretical energy saving potential for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities, such as: Skopje, Sarajevo and Bratislava.

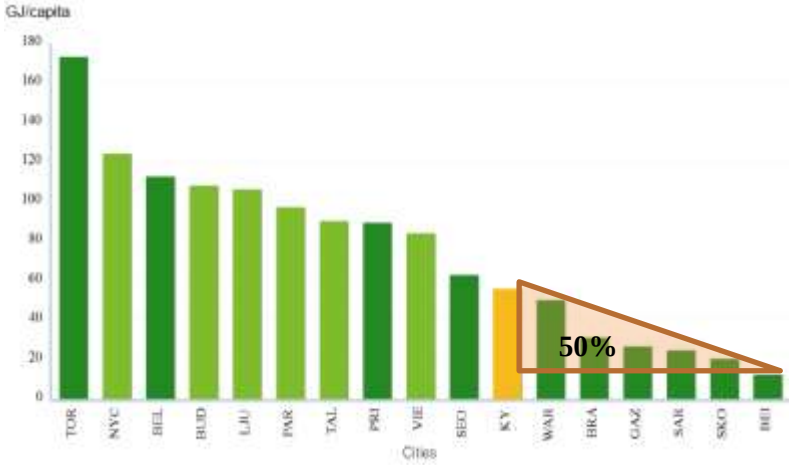
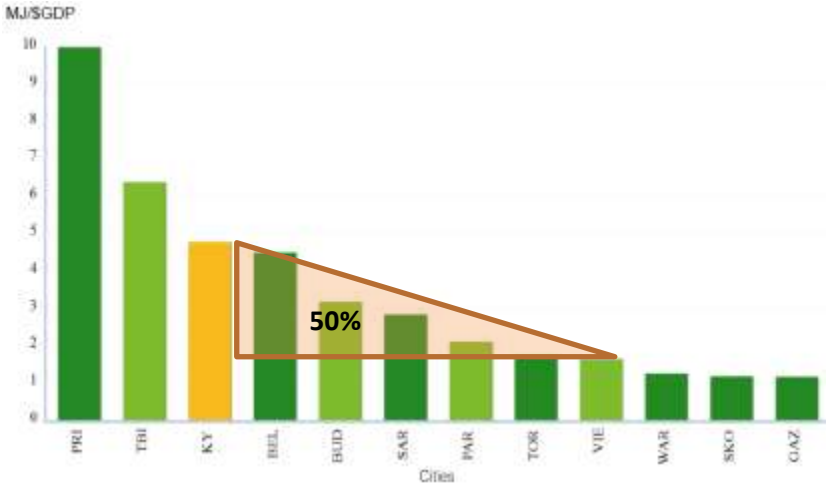


Figure 10: Primary Energy Consumption (MJ/USD GDP)



The city of Kyiv ranks low for the performance indicator of Primary Energy Consumption per USD of GDP in comparison with the peer cities with similar characteristic on HDI. The theoretical energy saving potential for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities, such as: Vienna, Warsaw and Paris. The indicator depends heavily on the GDP.

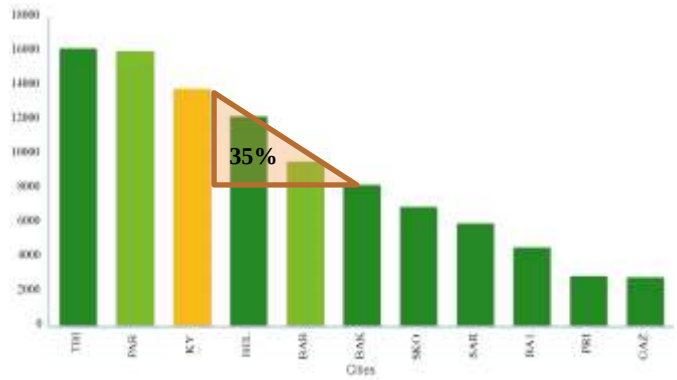
3.3 Transportation sector Benchmarking

Figure 11: KPI and key data for transport sector

Key Data		Key Performance Indicators (TRACE)	
Public transportation fuel consumption (MJ)	1,788,553,515	Total Transportation Energy Use Per Capita, MJ/capita	13 799
Private transportation fuel consumption (MJ)	37,797,653,311	Public Transport Energy Consumption, MJ/passenger km	0.402
Public transportation passenger million kilometers	4,453	Public Transportation Mode Split, %	14%
Private transportation passenger million kilometers	25,634	Private Transport Energy Consumption, MJ/passenger km	1.475
Transportation Mode Split (private motorized, public motorized, walk/cycle)	784 Metros	Meters of High Capacity Transit per 1000 People, m/1000 people	23.5
	540 trolleybus		
	1,492 bus		
	481 trams	Transportation Non-Motorized Mode Split, %	4%
	854,460 private transport and taxi		

The comparison with climate conditions of peer cities is not appropriate.

Figure 12: Total Transportation energy use per capita (MJ/capita)



The city of Kyiv ranks medium for the performance indicator of Transportation energy use per capita in comparison with the peer cities with similar characteristic on HDI. The theoretical energy saving potential for the city of Kyiv amounts to approximately 35% to achieve a level of the better performing cities, such as: Belgrade or Barcelona. However, the geographical extend and economic performance drives the demand of mobility and thus transports energy demand.

The city of Kyiv ranks medium for the performance indicator of Public Transport MJ/passenger km in comparison with the peer cities with similar characteristic on climate. The theoretical energy saving potential for the city of Kyiv amounts to approximately 35% to 50% to achieve a level of the better performing cities, such as Belgrade and Sarajevo respectively.

Figure 13: Public Transport MJ / passenger km

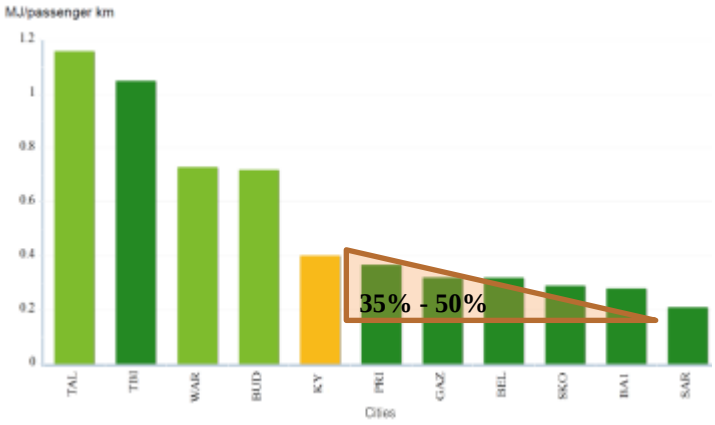
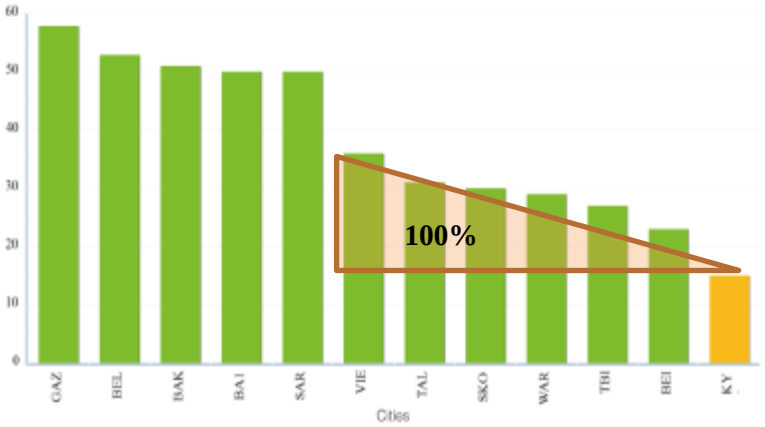


Figure 14: Public transport mode split (%)



The city of Kyiv ranks low for the performance indicator of Public transport mode split in comparison with the peer cities with similar characteristic on climate. There is the theoretical potential to increase the share of public transport use by 100% to achieve a level of the better performing cities, such as Vienna and Tallinn, at a level of 32%.

The city of Kyiv ranks low for the performance indicator of Meters of high capacity transit per 1000 people in comparison with the peer cities. A theoretical energy saving potential cannot be derived from this as the definition of facilities of high capacity transit in peer cities need to be considered (metro, light-rail, and tram).

The share of non-motorized transport in Kyiv is low at a level of less than 5% of passenger km.
The specific energy consumption for private transport per passenger kilometer is in Kyiv at the low level of the peer cities.

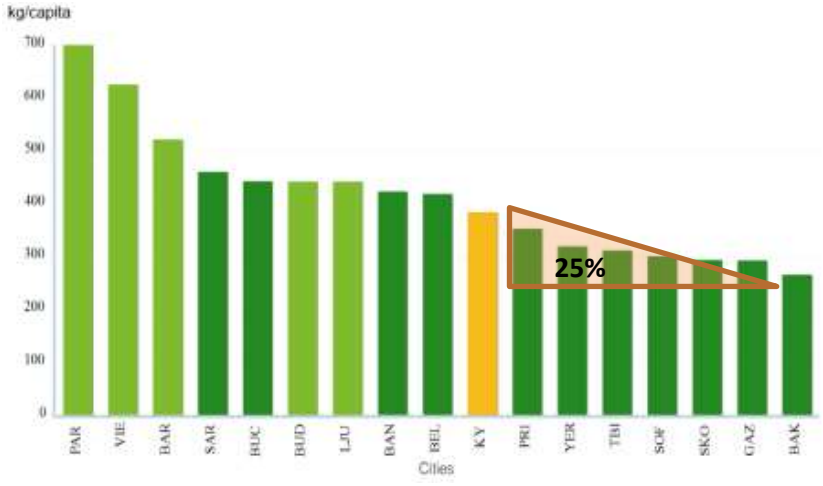
3.4 Solid Waste Sector Benchmarking

Figure 15: KPI and key data for solid waste sector

Key Data		Key Performance Indicators (TRACE)	
Amount of solid waste generated within the municipal boundary (tons)	1,100,000	Waste per capita (kg/capita)	383.45
Amount of solid waste that is recycled (tons), including waste incinerated	185,000	Capture rate of solid waste	100%
Amount of solid waste that goes to landfill (tons)	722,500	% of solid waste recycled	17%
		% of solid waste that goes to landfill	66%

The capture of solid waste amounts to almost 100%, of which 66% goes to the landfill. The very low percentage of waste recycled at about is according to official figures. The waste incineration plant of Kyiv is able to absorb annually some 150-180,000 tons MSW. In fact there is unofficial/illegal collection of recyclable fractions of the municipal waste which is processed for commercial sales.

Figure 16: Waste per Capita (kg/capita)



The city of Kyiv medium for the performance indicator of Waste per Capita in comparison with the peer cities with similar HDI characteristic. The theoretical potential to reduce the specific amount of waste at the city of Kyiv amounts to approximately 25 % to achieve a level of the better performing cities, such as: Sofia and Skopje.

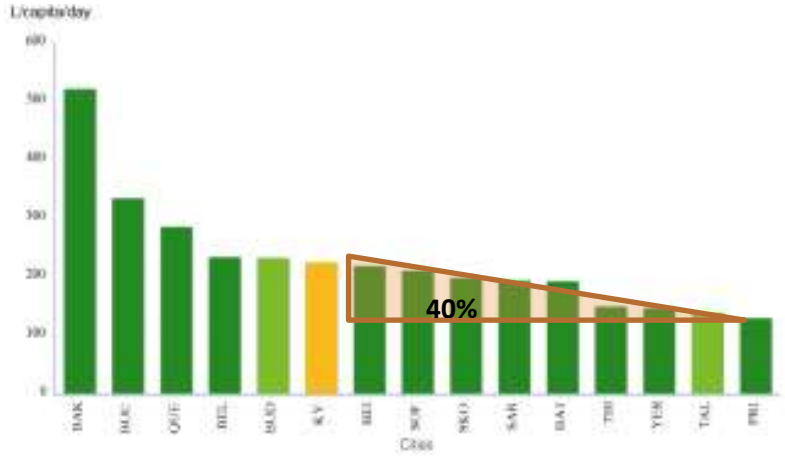
3.5 Water & Wastewater Sector Benchmarking

Figure 17: KPI and key data for water and waste water sector

Key Data		Key Performance Indicators (TRACE)	
Total amount of water sold (m^3)	235,116,100	Water consumption L/capita/day	224.55
Energy consumed to produce potable water (kWh_e)	197,481,700		
Total amount of potable water produced (m^3)	300,505,601	Energy density of potable water production (kWhe/m3)	0.66
Energy consumed to treat wastewater (kWh_e)	180,804,400		
Total amount of treated wastewater (m^3)	247,142,200	Energy density of wastewater treatment (kWhe/m3)	0.73
Energy expenditures of the water utility for potable water and wastewater treatment, USD	54,985,478		
Total expenditures of a water utility	219,257,549	Percentage of non revenue water [3]	5%
Number of households with potable water service	32,139		
Number of households with connection to the public sewage system	32,139	Electricity cost for water treatment (potable- and wastewater) as a percentage of the total water utility expenditures	25.08%
Average water rates (USD/m^3)	0.240		

[3] Technical waster losses amount to approximately 30%, but the sewage system collects rain water and waste water from other external sources. The TRACE model lacks precision for this KPI.

Figure 18: Water Consumption (l/capita/day)



The city of Kyiv ranks low for the performance indicator of Water Consumption per capita in comparison with the peer cities with similar HDI characteristic. The theoretical potential to reduce the specific amount of water consumption at the city of Kyiv amounts to approximately 40 % to achieve a level of the better performing cities, such as: Tallinn.

The city of Kyiv ranks low for the performance indicator of Energy Density of Potable Water Production in comparison with the peer cities with similar characteristic on climate. The theoretical energy saving potential for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities, such as Banja Luca or Vienna. However, this indicator highly depends on the conditions of availability of fresh water resources.

Figure 19: Energy Density of Potable Water Production (kWh_e/m^3)

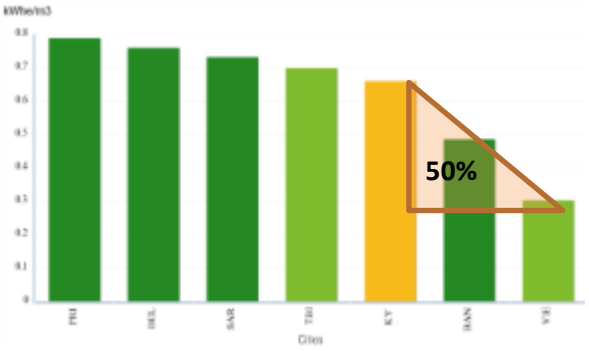
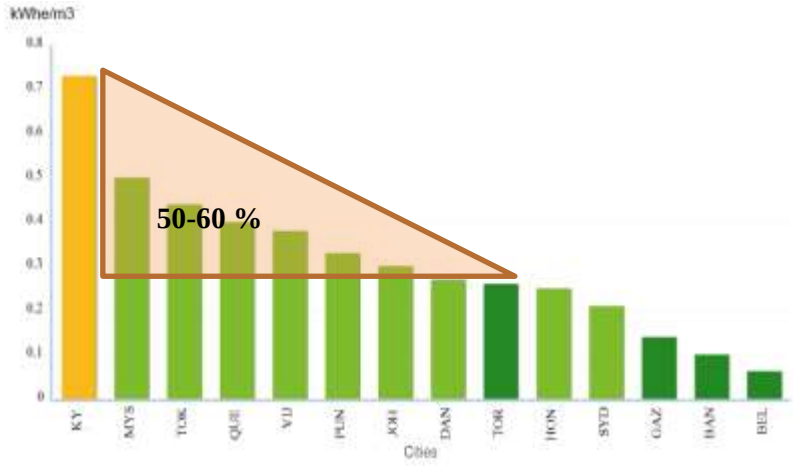


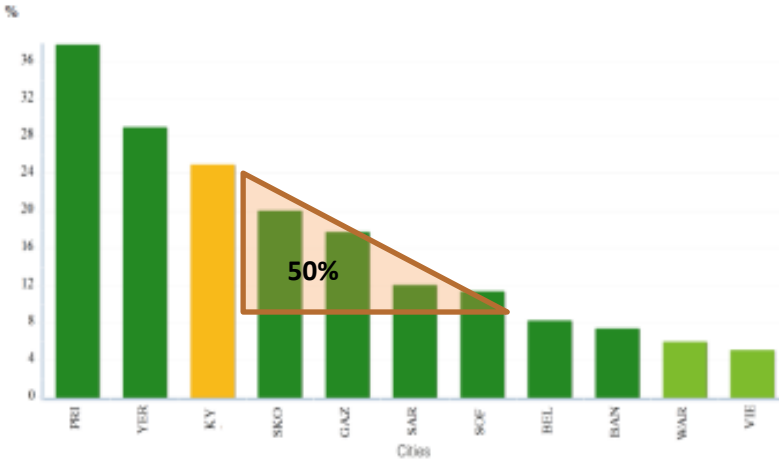
Figure 20: Energy Density of Wastewater Treatment (kWhe/m3)



The city of Kyiv ranks lowest for the performance indicator of Energy Density of Wastewater Treatment in comparison with all cities in TRACE comparisons. The energy saving potential for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities. The percentage of non-revenue water of a city as well as the availability of waste water treatment facilities needs to be considered for the evaluation of this indicator.

The city of Kyiv ranks low for the performance indicator of Share of Energy Costs of Total water Utility costs in comparison with the peer cities with similar characteristic on climate. The theoretical cost saving potential for the city of Kyiv amounts to approximately 50 % to achieve a level of the better performing cities, such as Sofia, Belgrade or Vienna. However, this indicator highly depends on the conditions of availability of fresh water resources and the electricity tariff.

Figure 21: Energy expenditures of the water utility for potable water and wastewater treatment (%)



In Kyiv a high percentage of supplied potable water is revenue to the sewer and a high percentage of collected wastewater is processed in the water treatment plant, both close to 100%, which consequently leads to high energy consumption and costs for the treatment. Peer cities with low level of treatment and collection rates have lower energy demand, but high environmental pollution.

3.6 Power & Heat Sector Benchmarking

Figure 22: KPI and key data for power and heat sector

Key Data		Key Performance Indicators (TRACE)	
Technical T&D losses (GWh_e)	1,024.5	Percent heat loss from network	18.3%
Non-technical T&D losses (GWh_e)	258.8	Percent total T & D losses	10.9%
Number of households with authorized electrical service	627,163	Percent of T & D loss due to non-technical	2.8%
Total electricity produced (GWh)	2,056		
Total electricity distributed (GWh)	9,365.8		

Figure 23: Heat Loss from DH Network in %

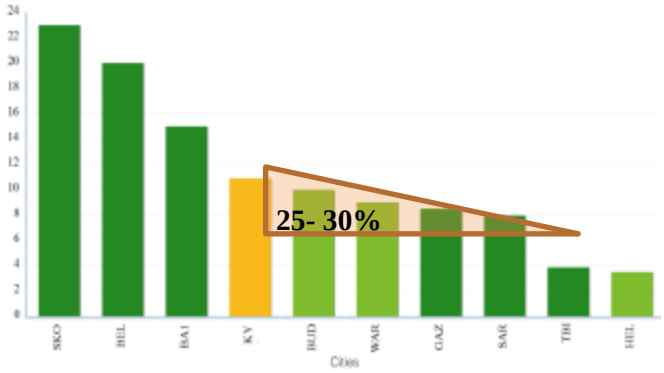
The city of Kyiv ranks low for the performance indicator of Heat Loss from Network in comparison with the peer cities with similar climatic characteristic.

The theoretical potential to reduce heat losses for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities, such as Tallinn at the loss level of DH network in Western Europe, below 8%.

Data for Kyiv need to be validated in the course of further assessment. The data of peer cities are not quite up-date and seem to contain estimations.

The city of Kyiv ranks medium for the performance indicator of power grid losses in comparison with the peer cities with similar characteristic.
The theoretical energy saving potential for the city of Kyiv amounts to approximately 25-30% to achieve a level of the better performing cities, such as power distribution networks in Western European cities at a level of 8% losses. The comparison with peer cities in the TRACE model is difficult, as they are not quite up-to-date and seem to be based on estimates and unknown assumptions.

Figure 24:Losses from electricity Transmission & Distribution grid



The Percent of Losses of the power Transmission & Distribution network due to non-technical Losses is in the city of Kyiv low. The collection rate, as reported by the power utility, is very high at a level of 99%. A comparison with TRACE peer cities in particular with development countries is not appropriate.

3.7 Public Lighting Benchmarking

Figure 25: KPI and key data for public lighting sector

Key Data		Key Performance Indicators (TRACE)	
Total electricity consumption of street lights (GWh_e)	61.4	Electricity consumed per km of lit roads (kWhe/km)	38 006.5
Total length of roads (km)	1,617		
Length of lit roads (km)	1,615	% of city roads lit	99.9%
Number of light poles	182,642 points 70,670 poles		
Total energy expenditure for street lights (USD)	3.5 million	Electricity consumed per light pole (by light point)	336.1 869 per pole
Average electric rates for street lights (USD/kWh)	0.058		

Figure 26: Electricity consumed per lit road (kWhe/km)

The city of Kyiv ranks low for the performance indicator of Electricity consumed per lit road km in comparison with the peer cities with similar characteristics.
The theoretical energy saving potential for the city of Kyiv amounts to approximately 50% to achieve a level of the better performing cities, such as Tbilisi or Vienna.

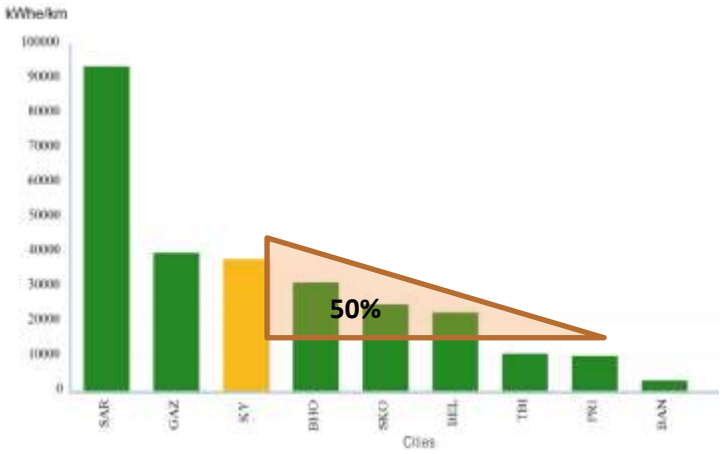
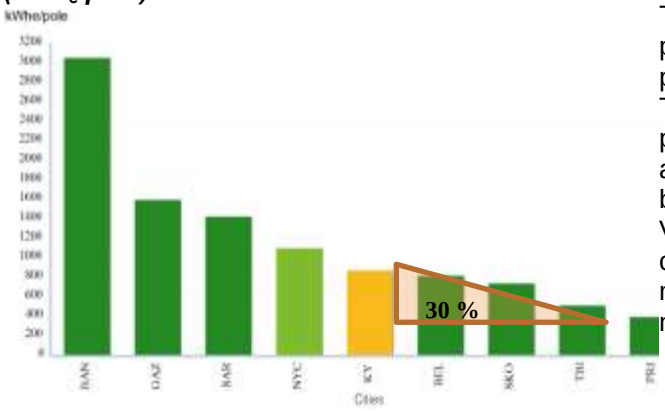


Figure 27: Electricity consumed per light pole (kWh$_e$/pole)



The city of Kyiv ranks medium for the performance indicator of Electricity consumed per light pole in comparison with all cities in TRACE comparisons. The energy saving potential for the city of Kyiv amounts to approximately 30% to achieve a level of the better performing cities, such as Tbilisi or Vienna. For the comparison of this indicator a clear distinction of light point and light pole is necessary and the architecture of street lighting needs to be considered.

With the availability of new technologies such as LED the energy saving potential for street lighting increases to 40-50%[4]. The percentage of Lit City Roads is almost 100%, as reported by the municipal street lighting company.

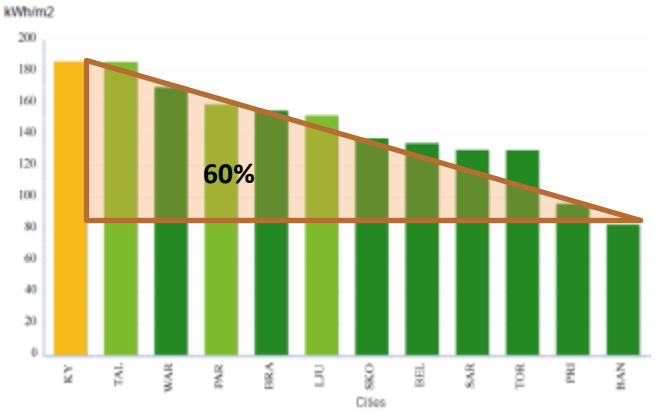
3.8 Municipal Buildings benchmarking

Figure 28: KPI and key data for municipal public buildings sector

Key Data		Key Performance Indicators (TRACE)	
Electricity consumption in municipal buildings (kWh$_e$)	147.1	Municipal buildings electricity consumption (kWhe/m2)	23.1
Fuel consumption in municipal buildings (kWh$_{th}$)	1,187		
Total energy expenditure for municipal buildings (USD)	119.7	Municipal buildings fuel consumption (kWht/m2)	186.37
Municipal buildings, floor area (m^2)	6,368,730		
Municipal buildings, average USD/kWh	0.094	Municipal buildings energy spend a percent of municipal budget	4.15
Commercial buildings, average USD/kWh	0.141		
Residential buildings, average USD/kWh	0.023		

The specific electricity consumption in municipal buildings is with approximately 23 kWh per m² low compared with all peer cities.

Figure 29: Municipal Buildings Heat Consumption (kWh$_{th}$/m^2)

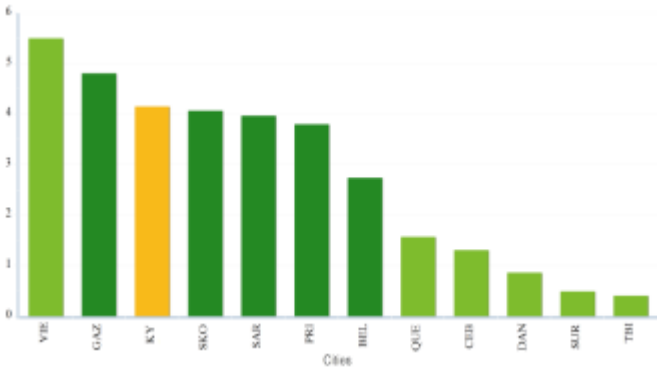


The city of Kyiv ranks lowest for the performance indicator of Municipal Buildings Heat Consumption in comparison with all peer cities of similar climatic characteristic. The theoretical energy saving potential for the city of Kyiv amounts up-to 60 % to achieve a level of Western European cities. The average level of best practice for this indicator (60 kWh/m²) could be applied. A comparison with cities listed in the TRACE model is not very appropriate due to the limited number of data and uncertain assumptions and sources on figures.

[4] It is assumed that LED technology replacement is not (or not widely) included in KPI of TRACE peer cities.

The share of spending of energy in municipal buildings amounts to approximately 4% of the Municipal Budget of Kyiv. This is at an average level compared with peer cities. A direct energy saving potential cannot be derived from this indicator. This indicator is for average performing cities in western Europe at a level of 2 to 3 %.

Figure 30: Percentage of Municipal Budget spending for energy in municipal buildings



3.9 Summary of Kyiv city benchmarking

In comparison with peer cities of the TRACE database the majority of performance indicators ranks low in terms of specific energy consumption, in particular for the sectors of:

- preprimary energy consumption per GDP and per capita,
- **heat consumption** in **public buildings**,
- energy density for potable **water production and waste water t**reatment,
- specific energy consumption for **street lighting**,
- energy use per capita for total **transport**
- specific energy consumption of the **public transport** fleet and
- specific energy losses for heat and power distribution

The theoretical energy saving potential for the above sectors and KPI is in the **range of 30 to 50%.**

Additional potentials for increase of the city performance are:

- the reduction of **waste volume** per capita and an increase of the share of waste **recycling**
- an increase of the **share of public transport** mode to reduce private, individual transport energy consumption.

The results of the benchmarking provide an indication for the prioritization of sectors with high energy saving potential.

4 Identifying Priority Sectors

The purpose of TRACE is to rapidly assess energy use in a city in order to identify and prioritize sectors, and indicate specific energy efficiency interventions.

Therefore it has been analyzed which sectors offer the highest energy saving potential that are both achievable due to the control and impact by the CA and financially viable.

The process for identifying priority sectors considers three main issues:

- the **proportionate spending on energy** in each sector either at a municipal level or for the entire city (public and private);
- the **relative energy intensity** of the sector, based upon the results of the benchmarking exercise and the consultant's professional opinion having reviewed each sector; and
- the **degree of control or influence** that the city government has over each sector or components of a particular sector, budgetary control being considered the most important factor.

4.1 Spending for energy in the city

Annual Budget of City in 2013	2,889 million USD

Figure 31: City Government Energy Spend

Total spending for energy in all sectors	3,362.1 Million **USD**
Energy Spending (for sectors: municipal public transport, municipal buildings, street lighting, waste, water and waste water services) in 2013 Of which for Municipal sector facilities	1,914.4 million USD 213.9 million USD
Of which energy spending for municipal buildings	119.8 million USD 4.1% of budget
Municipal sector Energy Spend as Percentage of Municipal Annual Budget	7.4%

A detailed analysis of the sectors is available in the city background report.

4.2 Relative Energy Intensity

The indication of the Relative Energy Intensity (REI) is based on the results of the benchmarking exercise and provides the theoretical potential for energy saving.

Figure 32: Comparison of sectors by spending for energy, REI and EE potential

Sector	Energy Spend (in million USD including VAT)	Theoretical Energy Savings Potential = Relative Energy Intensity	EE potential by implementation of the recommended set of measures
Public, municipal buildings	119.8	**50-60%**	50%
Street Lighting	3.5	**50%**	42%
District Heating	598.1	**30-40%**	11%
Public Transportation	30.1	**30-35%**	9%
Waste	5.5	**25%**	39%
Potable Water	28.2	**30-50%**	2%
Wastewater	26.8	**30-50%**	
Electricity sector	1,102.5	3%	0%
Private Vehicles	1,447.7	*10-20%*	*1%*

The spending for energy in Kyiv, without private transport sector, amounted in 2013 to a total of 3,362 million USD, including for private vehicles 1,448 million USD.

Figure 33: Costs of energy in Kyiv (in million USD, year 2013, total 3,362 million USD)

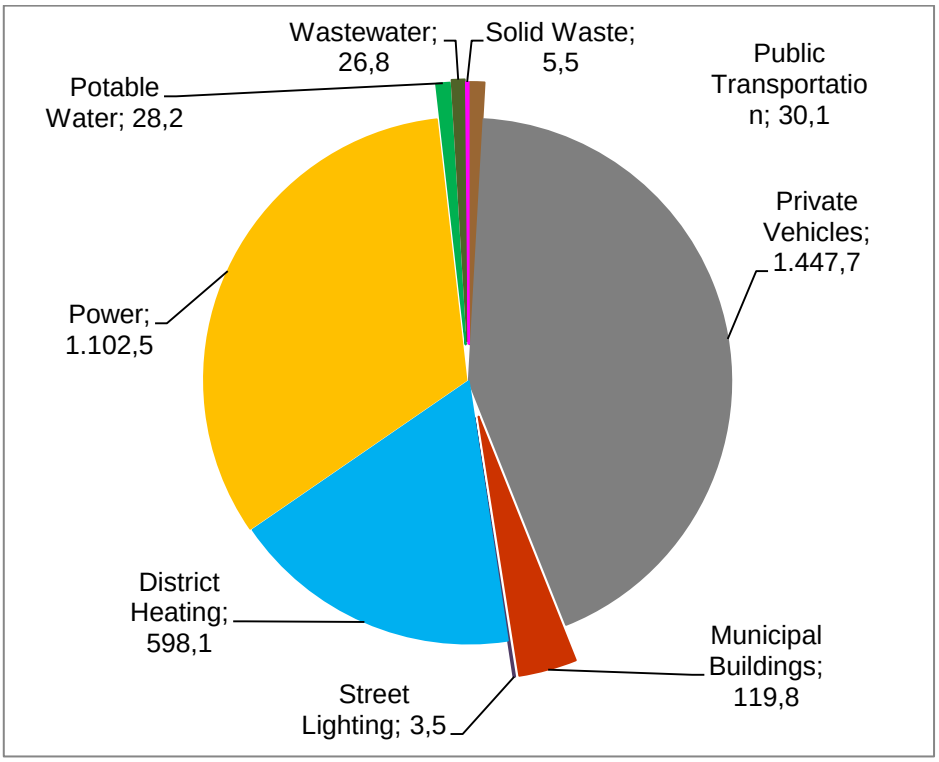
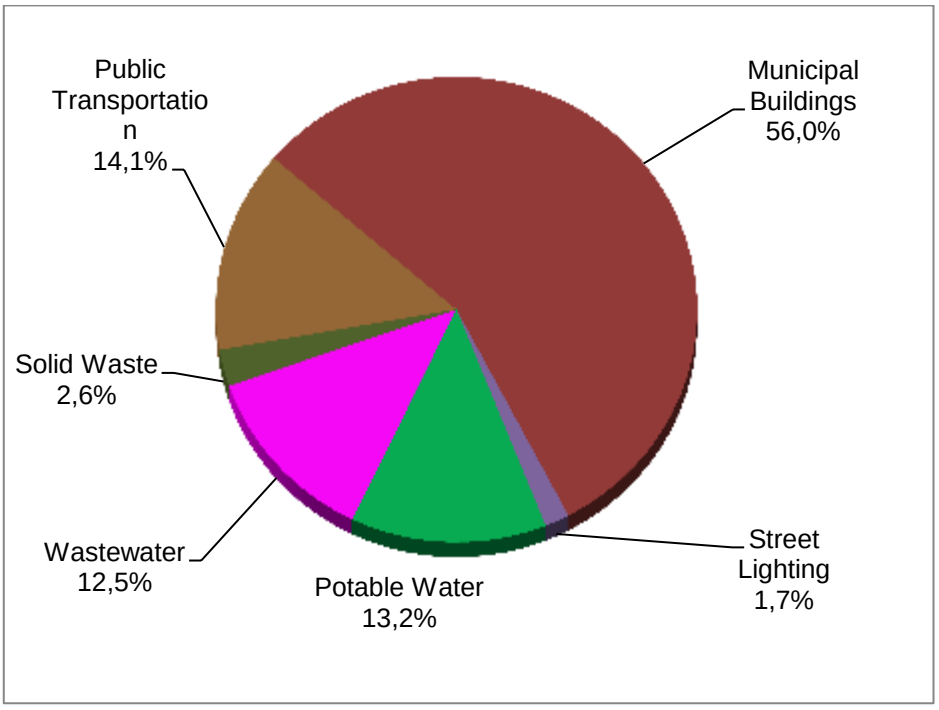


Figure 34: Spending for energy in Kyiv in 2013 for municipal sectors in % (Total 214 Million USD)



4.3 City authority level of control, influence and enforcement power

The **level of regulatory power, budget control and influence**/enforcement power of the Kyiv City Authority on the energy sector and urban infrastructure is summarized as follows.

Figure 35: Kyiv City authority level of budget control and enforcement power and urban infrastructure sectors` energy consumption

Sector	City Administration authority level of power		
	Regulatory	Budget control	Influence and enforcement
Public buildings	HIGH	HIGH	HIGH
Street lighting	HIGH	HIGH	HIGH
Public transport	HIGH	MEDIUM	HIGH
Waste	HIGH	MEDIUM	HIGH
Potable water supply	LOW	MEDIUM	MEDIUM
Wastewater	LOW	MEDIUM	MEDIUM
District heating	LOW	LOW	MEDIUM
Power supply	LOW	LOW	LOW
Gas supply	LOW	LOW	LOW
Private transport	LOW	LOW	LOW
Residential buildings	LOW	LOW	MEDIUM

The CA remains in full control over the sectors of **municipal public buildings** and **street lighting**.

In addition the CA retains a certain degree of influence on the end energy consumer sectors of **waste management and public transport, and limited influence on the sectors water supply and wastewater and district heating (due ownership structure).**

The energy consumption of the **private, individual transport** can be influenced by the CA to a certain extend only, for example by attracting passengers to shift to the public transport mode of mobility and by smoothing inner-city traffic flow.

A cross-sector horizontal area of EE activities is the Municipal Energy Management, which is 100 % controlled by the CA.

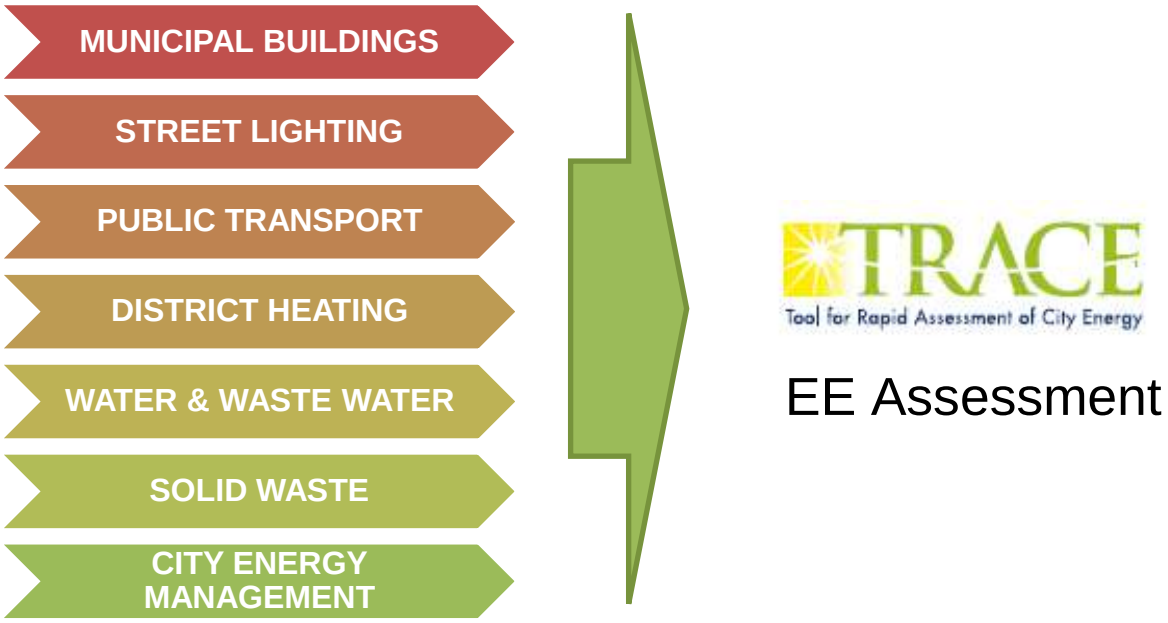
The Municipal Authority of Kyiv has **limited control** and influence on

A) the end consuming sectors of: Residential sector, commercial and industrial sector, private transport, non-municipal public buildings,
B) the district heating sector,
C) the power generation and distribution sector,
D) Gas distribution.

4.4 Prioritization of sectors

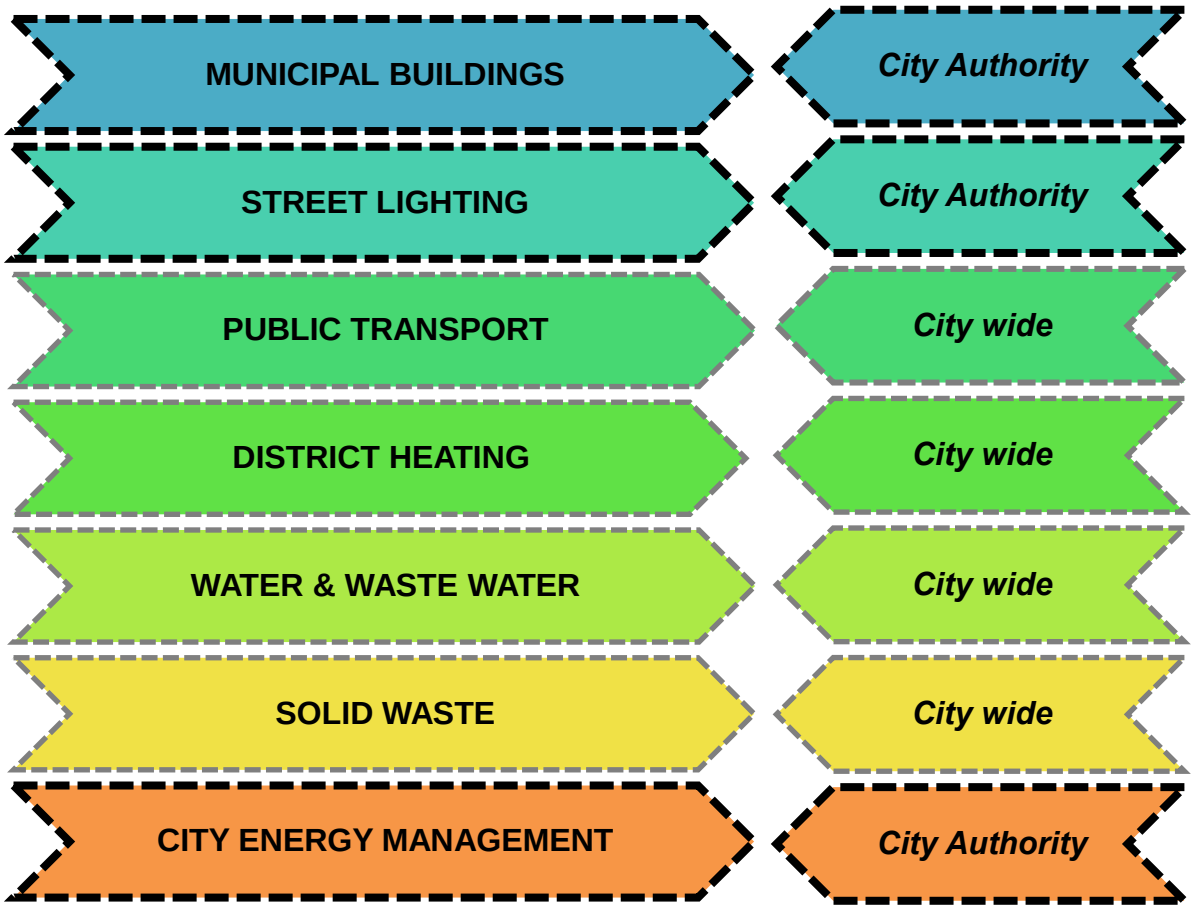
Consequently the EE recommendations for those sectors with limited control by the CA should receive lower/low priority.

The areas listed below will be the 7 sectors selected for detailed analysis and development of appropriate EE recommendations on the frame of TRACE.



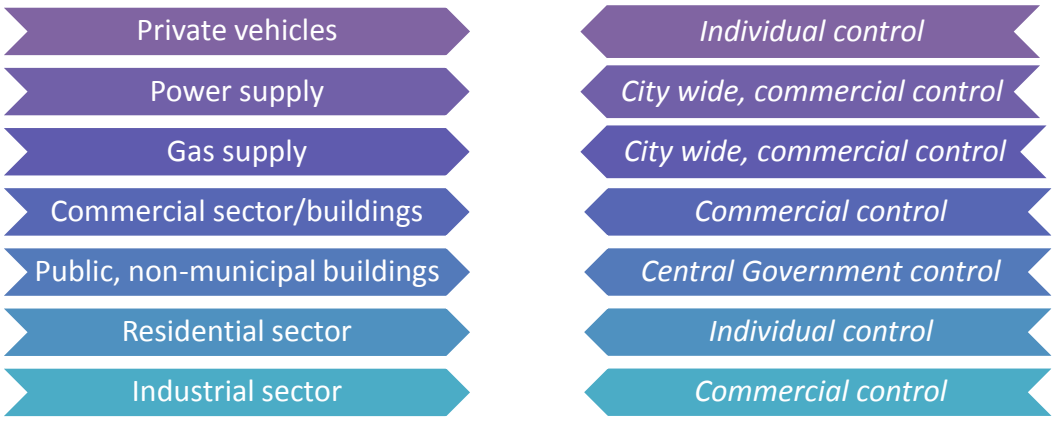
The level of use of the energy of a respective sector indicates in addition the degree of influence of the City Administration.

City wide energy means that the energy is spent for private, commercial and public entities, while City Authority means the energy is spent for areas or services, the City Authority has a jurisdiction.



Considering EE interventions in those sectors have the potential to reduce municipal budget spending for energy, multiplication and replication and to strengthen the degree of CA control.

Final energy consumer sectors which are controlled by individual or commercial entities are not considered in the TRACE assessment, as the City Authority has no control and influence on the energy performance or energy budget spending. *At this point, the following sectors are set aside and not pursued further.*



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.

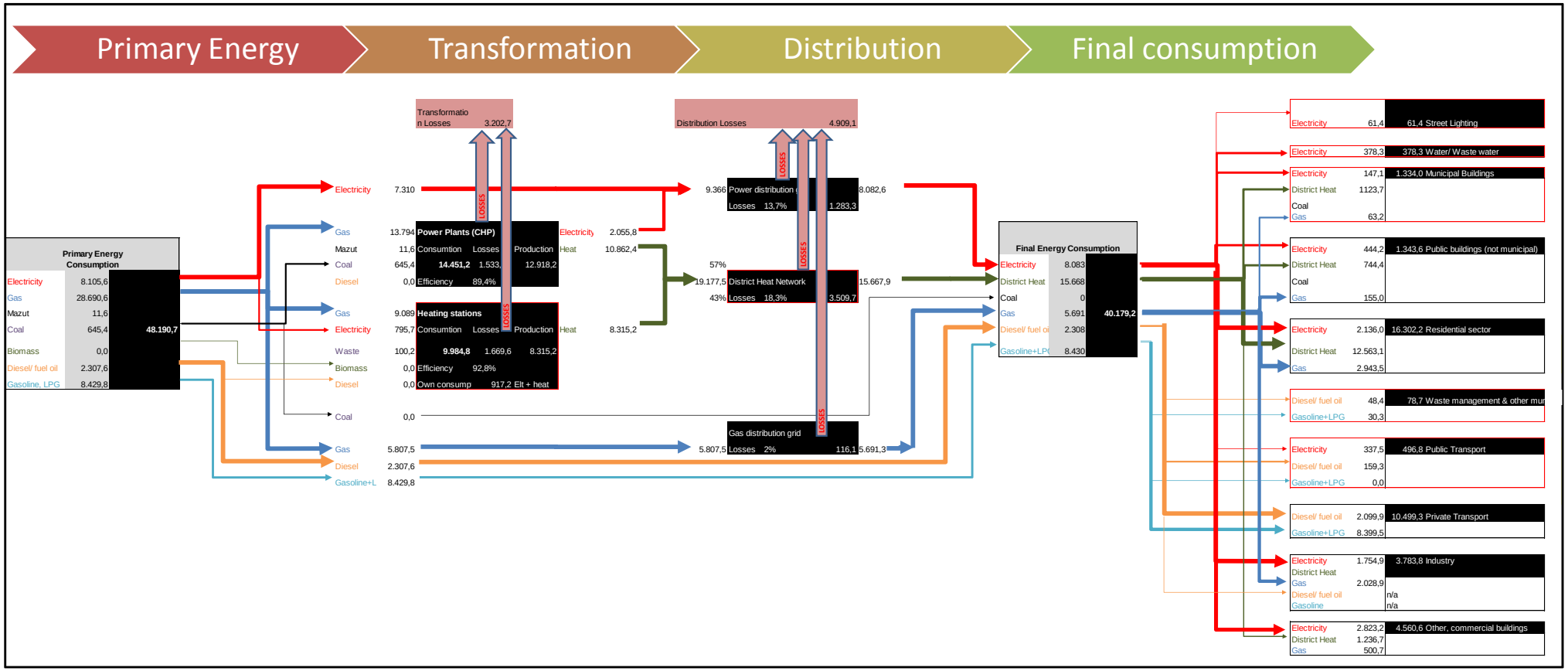
5 Brief Review of Sectors

A detailed analysis of the sectors is available in the city background report.

5.1 City wide energy

The Energy balance of Kyiv has been analyzed for the year 2013 and is presented graphically in a *Sankey* type Energy flow chart. The city controlled areas are marked with a read box. The energy flow of the city follows the logic of supply: Primary Energy → Transformation of Energy → Distribution → Final consumption. Note: As Primary Energy all imported energy to the city is considered.

Figure 36: Energy balance and Energy flow chart of Kyiv, 2013 (in GWh)



Kyiv's primary energy consumption amounts to 48,190.7 GWh in 2013 with highest consumption of natural gas of almost two third. The majority of gas is utilized for the generation of power and district heat for the distribution to various end consumers. There are a number of heat and power cogeneration facilities operated in the city of Kyiv.

Figure 37: Primary energy consumption by energy carrier

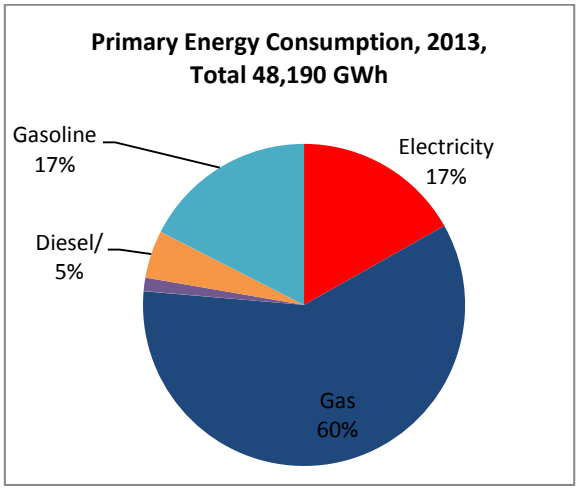
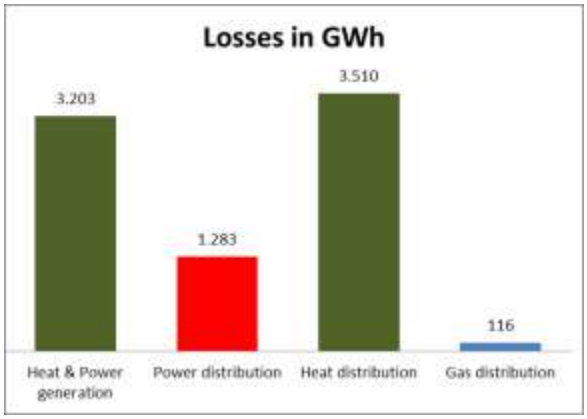


Figure 38: Losses in the energy transformation and distribution



13% of fuel input	*14% of power distribution*	*18% of heat distribution*	*2% of gas distribution*

The losses of energy transformation (generation sector) and distribution amount to 8,111 GWh representing 17% of PEC. The losses of the central heating system - in generation and distribution are at the level of twice the energy consumption of all public buildings in the city (municipal and no-municipal).

There are no shortages of energy supply registered in 2013. All households, public and commercial customers are connected to energy distribution systems and supplied with energy according to their needs.

Figure 39: Final energy consumption by energy carrier in %

The residential sector is the largest energy consumer with above 50 % of the city's **final energy consumption** as it is typical for all Ukrainian cities. This is followed by the private transport sector of 22% and industry and commercial sector (including other buildings) of 16%.

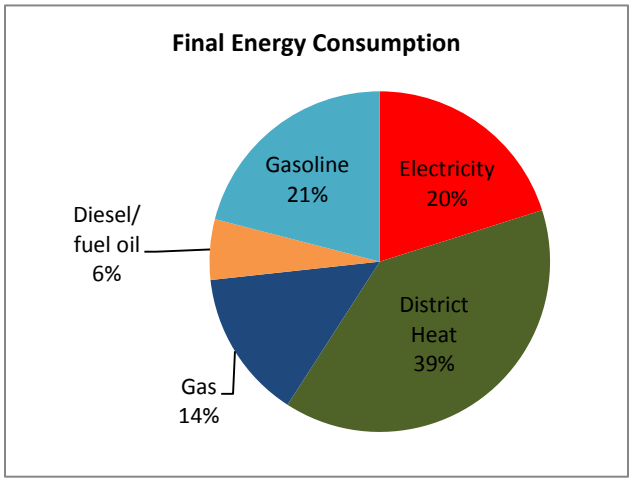
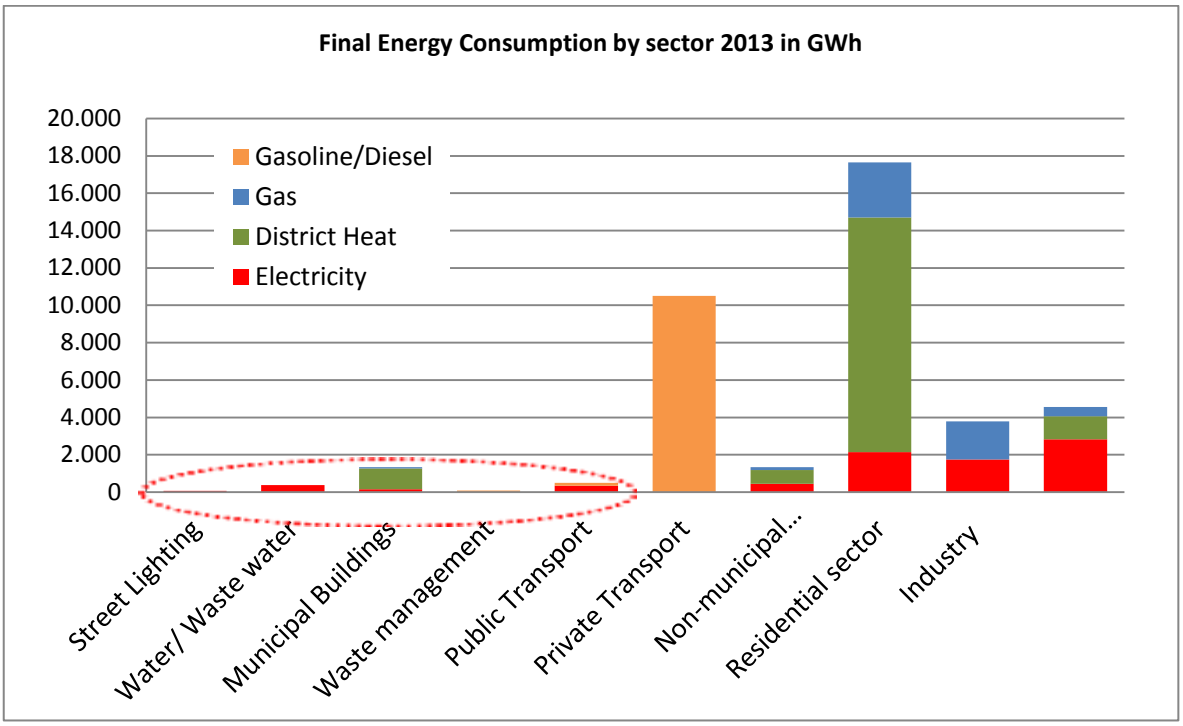


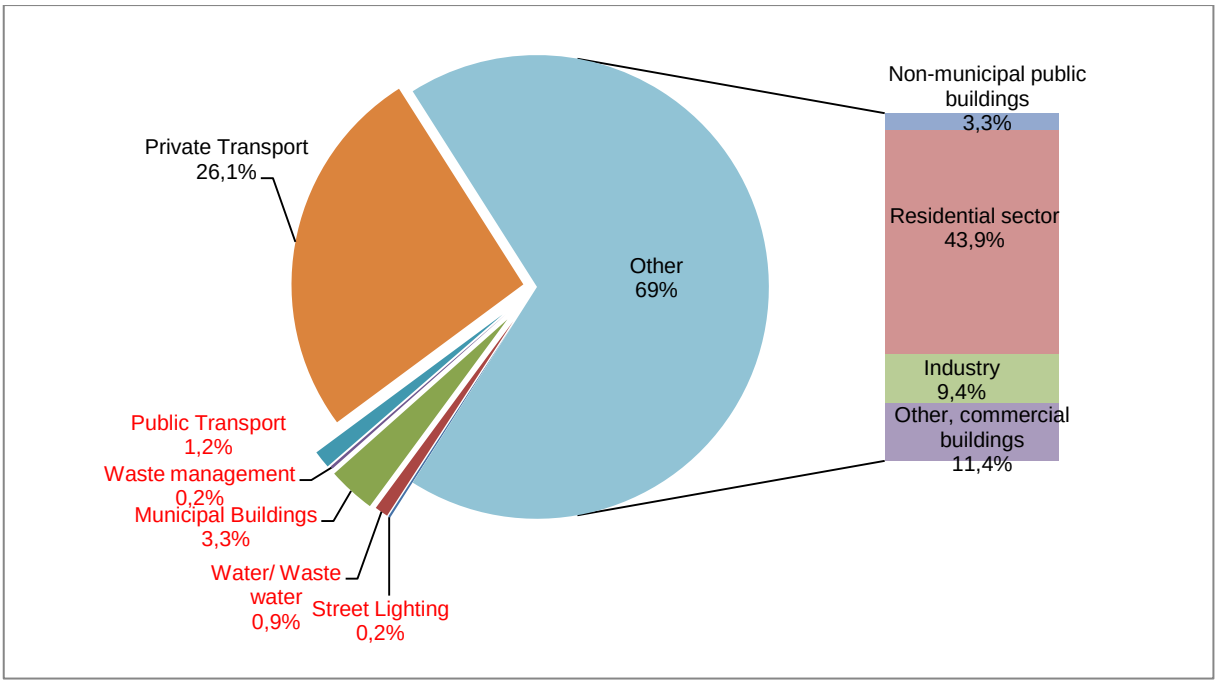
Figure 40: Final energy consumption by sector in 2013 in GWh



Natural gas, electricity and district heating are the dominant types of the final energy consumption, in particular in the residential sector.

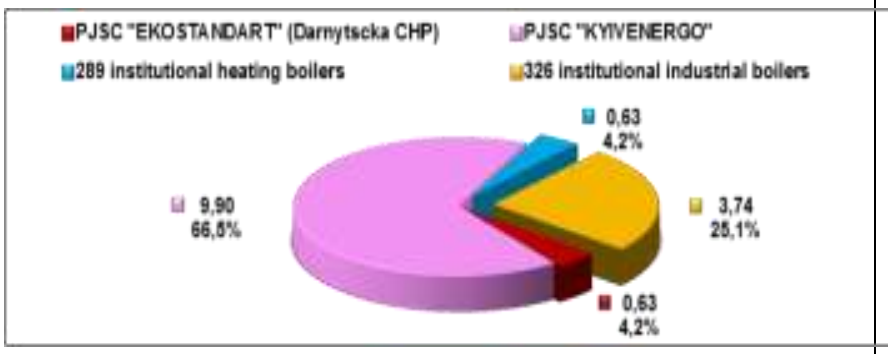
The final energy consumption of the sectors under control and influence by the city administration amounted in 2013 to 2,349 GWh which represents 5.8% of the overall city final energy consumption.

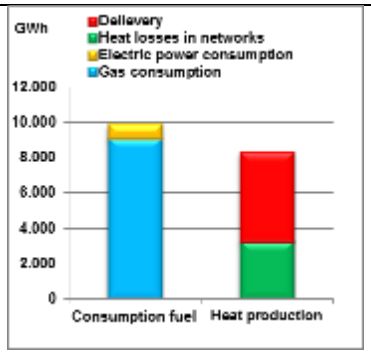
Figure 41: Final energy consumption by sector, 2013 in %

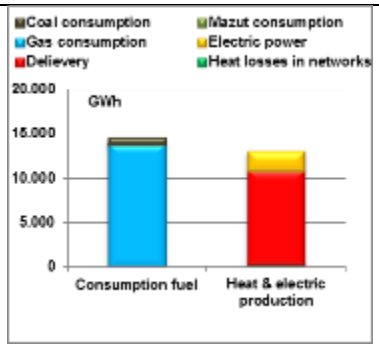


5.2 Heat generation and distribution - city wide

Operators of facilities/ utilities:	Kyiv centralized heat supply are provided by two large district heating companies and the large number of small institutional boiler: Overall, there exist 804 different heat generation units with total installed thermal capacity of more than 14.89 GW (13,000 Gcal/h).

	• PJSC "Kyivenergo"; produces the main part of the city heat energy, which are generated at the CHP-5, CHP-6, boiler that are managed by PJSC "Kyivenergo" affiliate "Heat networks", in total 174 boiler • "Kyivenergo"; affiliate "Zhytloteploenerho", incineration plant • PJSC "EKOSTANDART" (Darnytscka CHP); provides heat energy to customers placed on in central and southern areas of the Kyiv Left Bank. The total share in the energy supply system is about 12%, Thermal capacity -1.4 GW, fuelled by natural gas and coal. • 289 institutional heating boilers (building site networks) and 326 industrial boilers ***Figure 42: Structure of installed heat generation capacities, in GW***  The total connected heat load is PJSC "Kyivenergo" is 8.73 GW: 6.54 GW for heating and 1.26 GW for hot water. The company "Heat distribution networks" of PJSC "Kyivenergo" is in charge for transporting and does not have its own heat generation units, but is a wholesale buyer of heat energy from the CHPs, boilers and affiliate "Heat networks".
Level of CA control or influence:	The CA is a shareholder of both, PJSC "Kyivenergo" and PJSC "EKOSTANDART" and maintains influence on performance, while the decisions on operation and financing are with the board of the commercial companies.
City energy spent and energy use:	Individual heating stations of residential, commercial, non-municipal public and other buildings is not considered in this section, but the consumption is shown in the energy balance. Much of boilers are outdated and after more than 30 years operation, physically worn out which leads to the reduction to an operational capacity to one third. Average boiler combustion efficiency is 80-90%. Approximately 85% of the boilers have exceeded their operation life time. The amount of heat energy generated at PJSC "Kyivenergo" and PJSC "Ekostandart" in 2013 amounted to 19,178 GWh (16,490 Gcal). Of which production of "Kyivenergo" amounted to 92%. ***Figure 43: Comparison of fuel consumption and heat energy production*** ***Boiler-houses*** ***CHP***



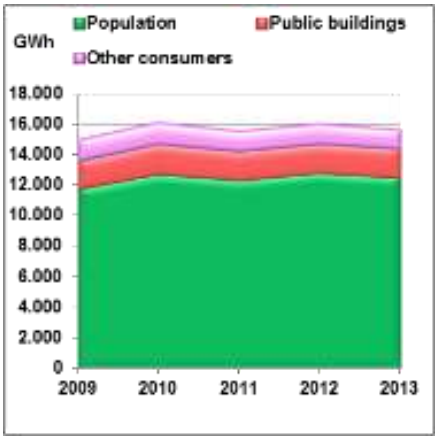


Heat network scheme is two-pipe ring. The length of the heating network is 2,275 km (in two-pipe) with diameters of pipelines is from 1,200 to 50 mm. The average heat losses in heat networks are about 18%, although there are heat network areas (branches) where losses are much higher.

The temperature control of heat delivery is done centrally at CHP and boiler houses, as so called Central Heating Points according to normative temperature chart - 150-70 °C, while real and actual temperature at some boiler is 120-70 °C.

The heat production for domestic hot water supply amounts to about 28%. DHW supply is unreliable and shrinking during off-heating season.

Figure 44: Total heat delivery to consumer groups



The energy input / gas consumption for the heat production is with the amount of 137 m^3/Gcal. The electricity consumption for heat production and distribution is high (49 kWh/Gcal). The main reasons for the high specific electricity consumption are: disconnection of consumers from the centralized heating system, technically outdated equipment; lack of hydraulic balancing at the consumer sites.

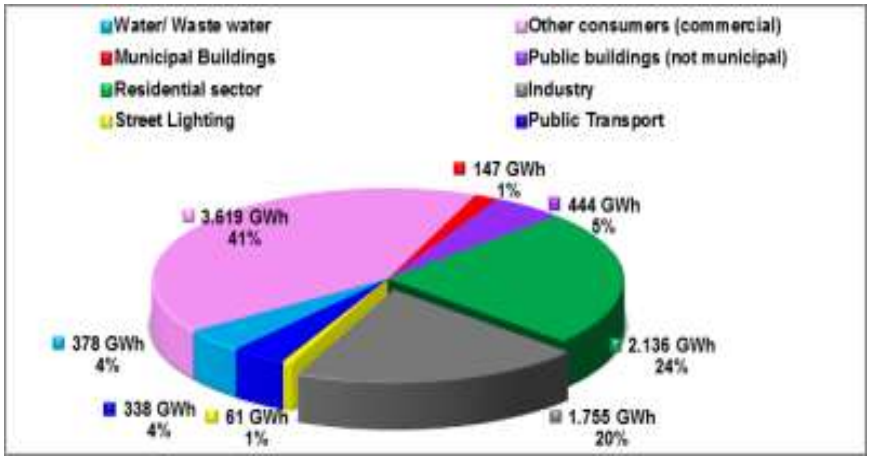
Condition of main equipment and EE potential:

The DH network was constructed in the 1970–80 years; today about two third of the DH network components are older than 15 years. The majority of the heat networks are laid in reinforced concrete troughs which are impassable channels. Thermal insulation of pipes made mainly by mineral wool and glass wool mats and is partly damaged.

Recently the government obliged the DH companies to decrease the gas consumption by 30%, as defined by the Resolution of Cabinet of Ministers of Ukraine 09.07.2014 № 296 "Some issue of providing natural gas population, enterprises, institutions and organizations by the end of the heating season 2014/15 year".

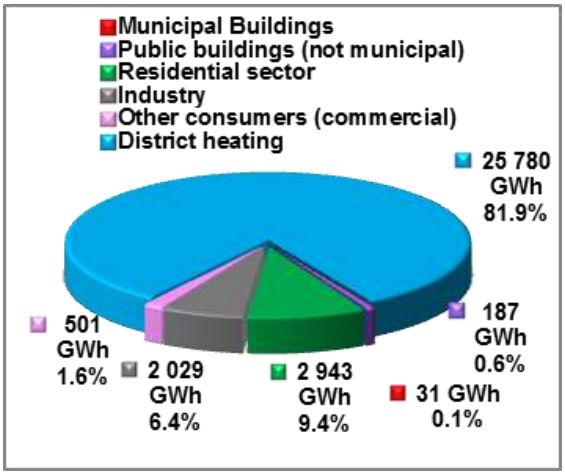
Gas tariffs for heating companies that produce heat for households shall increase during 2014-2017 in steps by 34%, 40%, 20% and 20%.

5.3 Power distribution - city wide

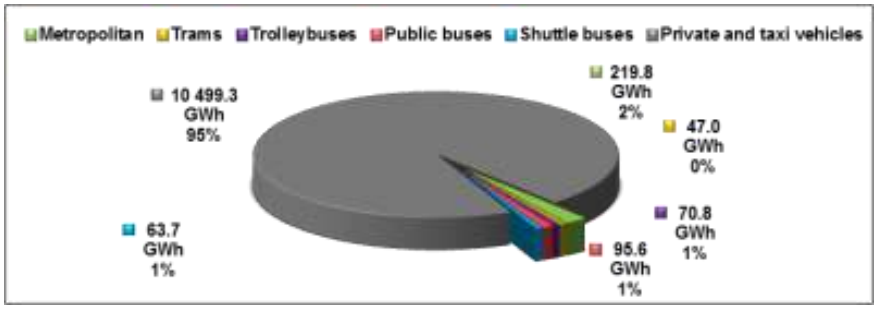
Operators of facilities/ utilities:	The power supply system of Kyiv and its suburban area are managed by the united energy complex, which is part of the Central Electric Power System and the Ukraine United Energy System. The main energy sources in Kyiv (including suburban area) are Darnytska CHP, CHP-6, CHP-5, HPS Kyiv and the Kyiv PSP. The installed capacity of these sources is 3,807 MW, including in Kyiv -1,380 MW.
Level of CA control or influence:	The power distribution system is not subject of municipal control or the municipal budget. Energy efficiency measures are under the responsibility of JSC "Kyivenergo". The electricity tariffs are regulated by the National Commission for State Energy and Public Utilities Regulation of Ukraine.
City energy spent and energy use:	In 2013 city electricity consumption in Kyiv was 8,083 GWh, including population consumption - 24%, other consumers - 41%, centralized water/waste water supply system -4%, public budget building - 7%, municipal public transport – 4% and street lighting - 1%. All households are connected and supplied by the power utility. ***Figure 45: Structure of city electricity consumption by consumers groups***  The costs of electricity in 2013 amounted to 1,102 million USD (Including VAT).
Condition of main equipment and EE potential:	Kyiv receives electric energy from Ukraine United Energy System through "Pivnichna" substation 330 kV, SS "Novokyyivska" 330 kV, SS “Brovary” 330 kV, SS "Zgovtneva" 330 kV. The technical transmission and distribution losses amount of 1,021 GWh which represents 10.9% of transmission energy. It is assumed, that the non-technical losses of 1.2 % are due to non-payment of bills and theft.

5.4 Gas distribution - city wide

Operators of facilities/ utilities:	The Kyiv gas supply system is in communal ownership and operated by PLSC “Kyivgas”.
Level of CA control or influence:	The gas distribution system is not subject of municipal control or the municipal budget. Energy efficiency measures are under the responsibility of PLSC “Kyivgas”. The gas distribution tariffs are regulated by the National Commission for State Energy and Public Utilities Regulation of Ukraine.
City energy spent and	In 2013, the city gas consumption amounted to 3,352 million $m^{3,}$ distributed as shown below Figure. The structure of gas consumption.

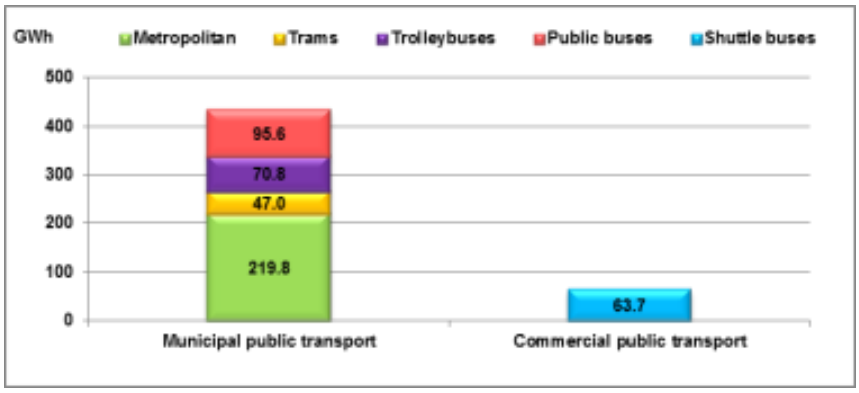
energy use:	Residential sector gas consumption is mainly used in multi-apartment buildings for cooking and preparation of domestic hot water. Gas supplied to individual houses (independent from DH network) is used in addition for the individual production of space heat. ***Figure 46: Structure of city gas consumption by consumers groups*** 
Condition of main equipment and EE potential:	Overall the gas supply system consists of gas pipelines of high, medium and low pressure with the total length almost 4,800 km, 1,400 gas distribution points and 629 cathode protection stations. The length of gas pipelines which is older than 40 years is nearly 520 km. Based on expert estimation, the technical losses in the gas distribution network amount to 2%.

5.5 Private Transport - city wide

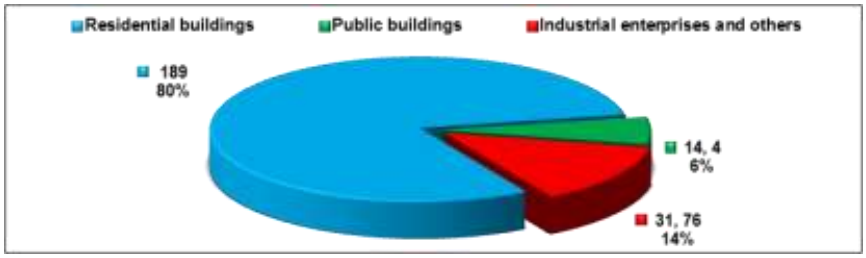
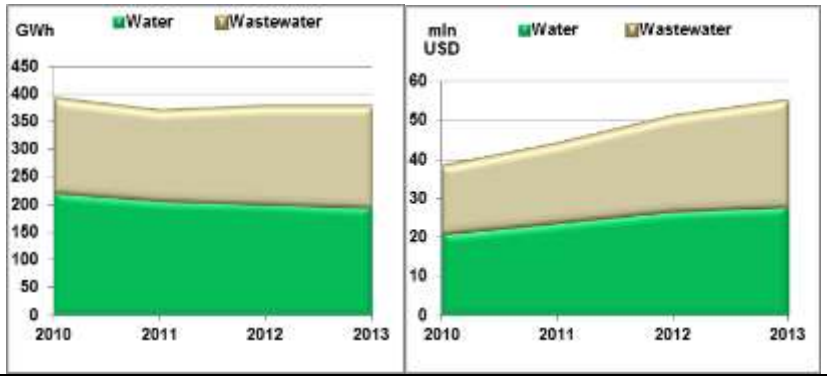
Operators of facilities/ utilities:	The transport energy consumption is dominated by private, individual vehicles. While the transport mode split referring to passenger-kilometers is estimated with 15% urban public transport, 4-5 % walk and cycling, above 80 % individual, private cars.
Level of CA control or influence:	The licensing of vehicle operation is performed by Ukrtransinspektsiya (State land transport security Inspectorate of Ukraine). The CA as no control and limited influence on the individual transport means.
City energy spent and energy use:	Private vehicles of individual motorized transport are with 95% the largest consumer of fuel and energy in city transport sector in 2013. The overall passenger turnover amounts to 30,090 million passenger km per year. With a total energy consumption of 10,996 GWh per year. The split of energy consumption for all transport is: 4% electricity, 20% diesel, 75% gasoline and 1% LPG. ***Figure 47: Share of energy consumption of transport sector***  The total number of registered private vehicles in Kyiv has been increased

	during 2008 - 2013 from 436,000 to 846,000 units. The overall level of private, individual motorization in Kyiv is 308 cars per 1,000 inhabitants.

5.6 Public Transport Sector - City wide and City Authority

Operators of facilities/ utilities:	The city public transport service is operated by: a) Transport companies with the CA as main shareholder: • municipal corporation "Kyivavtodor" • communal enterprises "Kyiv Metropoliten" and "Kyivpastrans" b) 37 commercial transport companies (for micro/ shuttle-busses)
Level of CA control or influence:	The CA maintains budget control and influence on the 2 municipal public transport companies. Commercial and private transportation services providers and taxi operators must register their vehicles in accordance with Ukrainian laws, to have relevant license and license card for each vehicle equipped according to established specifications. The local authority has full regulatory influence on the transport carriers of municipal ownership but also to certain extend to commercial transport companies.
City energy spent and energy use:	The three underground metro lines in Kyiv have of 67.4 km, which is considered as high capacity transit. The total volume of passenger transportation in 2013 was 438.5 million passengers, which is 35% of all passengers. Kyiv city public transport network includes 41 trolleybus lines, 19 tram lines, 69 city, 9 suburban bus lines and 54 minibus lines. Tram passenger account to 19% of total ground transportation The total number of inner-urban public transport passenger vehicles comprises 3,307 units (794 Metro, 481 trams, 540 trolleybuses, 972 municipal buses, 520 private taxis). A major part of the urban fleet consists of high, medium and small capacity buses ***Figure 48: City transport fuel and energy consumption (excluding taxi and private transport) in 2013*** 
Condition of main equipment and EE potential:	There is the opportunity to introduce higher vehicle emission standards in the process of providing new or the extension of licenses for public transportation. The energy consumption of the private, individual transport can be influenced by the CA to a certain extend only, for example by attracting passengers to shift to public transport mode of mobility and by smoothing inner-city traffic flow.

5.7 Potable Water and Wastewater– city wide

Operators of facilities/ utilities:	Water supply and waste water services are provided by the utility PJSC "Kyivvodocanal". It is a city wide service to all customer groups. The number of users of potable water (residential, public and commercial) is 32,139 (comprising 100% of residential sector of 2.85 million people) of which 100% are connected to the waste water collection and treatment system.
Level of CA control or influence:	The CA as a shareholder has control over "Kyivvodocanal" and maintains influence on operation, performance and financing.
City energy spent and energy use:	Annual water consumption in the city is 235 million m^3. ***Figure 49: Potable water consumption Structure in the city, million m^3***  The annual volume of sewage to be treated (including waste water from other sources and collected rain water) is 18,4 million m^3. For the operation purposes of the water supply and wastewater system 378,3 GWh of electricity have been consumed in 2013, of which 52% for water supply and 48% for wastewater. Average specific electricity consumption for water supply is 0.66 kWh/m^3 and for wastewater – 0.73 kWh/m^3. ***Figure 50: Electricity consumption and costs of PJSC "Kyivvodocanal" on water and wastewater service*** 
Condition of main equipment and EE potential:	The Kyiv centralized wastewater system consists of 34 sewage pumping stations, about 3,000 km of sewerage networks and Bortnychi aeration station. Bortnichi aeration station is the only wastewater treatment facility in Kyiv. The total length of the water supply network is 4,177 km. Considerable part of the water supply facilities, networks and equipment have exceeded the standard period of operation, which reduces the efficiency purification of potable water, increasing the cost of material and energy resources, increasing the cost of services. Technical losses in water supply amount to approx. 30%. In 2013 the number of water network leakages was almost 9,000. The length of the water supply network that

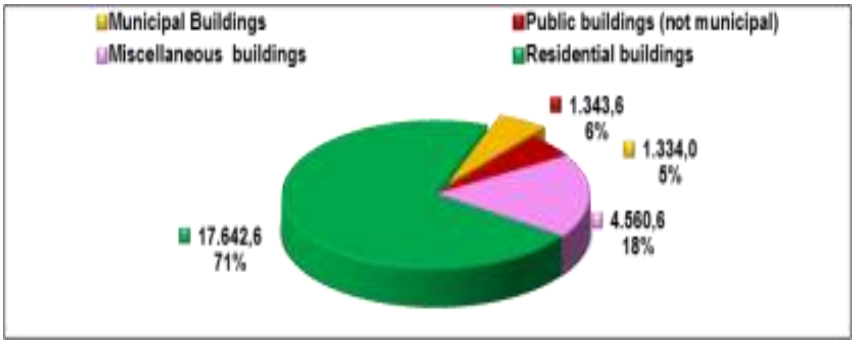
	needs to be replaced is 1 630,6 km, which is 39% of the total water supply pipeline length. The length of waste water treatment network that needs to be replaced is 843,2 km, which is 32% of the total wastewater pipeline length.
Ongoing investment programs for performance increase	IBRD Project "Urban Infrastructure 2" Modernization of water supply and sewerage system with total investment cost of USD 11.4 million (USD 9.3 million - IBRD loan and USD 2.1 million - Clean Technology Fund credit). The project includes: • Rehabilitation of pumping stations in Dnieprovska water station; • Reconstruction of pumping station "Krutohirna"; • Rehabilitation of water pumping stations Level 3 ate water station; • Modernization of cascade pumping stations. "Kyivvodocanal" planned and implements the program "Potable water of Kyiv 2011-2020".

5.8 Waste management – city wide

Operators of facilities/ utilities:	Decision the Kyiv City Administration from March 25, 2010 № 435/3873 informs that the waste removal services performer in the city is communal enterprise "Kyivkomunservis". Waste collection services, transportation and disposal of solid waste in the city are provided by 15 companies: 14 commercial and OJSC "Kyivspetstrans". In 2013 services collection, transportation and disposal of solid waste in the city has been provided by private companies on a city district level, among the largest: Ltd "Celtic" and the subsidiary "Altfater Kyiv", CJSC "Spetskomuntehnika", JSC "Kyivspetstrans» and Ltd «Kramar-Rysayklinh".
Level of CA control or influence:	OJSC "Kyivspetstrans" is an independent economic entity with share of the CA. The CA as has limited control over the commercial waste collection companies, but maintains full responsibility on the landfill.
City energy spent and energy use:	Total annual collection of solid waste in 2013 was 1,100,000 tons, of which: 10.9% are unofficially recycled (removed directed by residents to the secondary raw materials receiving points, illegally removed from containers, etc.), 5.9% officially recycled; 17.5% are incinerated (thermal neutralized) and 65.7% are dumped to the landfill sites. The waste incineration plant "Energy" operated by "Kyivenergo" affiliate "Zhytloteploenerho" has a capacity of 250,000 tonns/year. The heat produced of annually approx. 200 GWh is delivered, "Kyivenergo" heating system. ***Figure 51: The waste incineration plant "Energy"***  Up to 66% of generated solid waste are dumped in the 3 municipal landfills:

	Recyclable fragments of the waste volume amount to 0.7 million tons i.e. 63 % of the total, of which paper 30 %, metal 3 %, plastic 10 % and biomass 20 %. Services for the collection and removal of solid waste are provided by 300 special vehicles, for municipal landfills operation 31 vehicles, in total consuming in 2013 approx. 79 GWh, of which 60% diesel consumption.
Condition of main equipment and EE potential:	According to the waste management programs of the city the following energy performance improvements are necessary: : • construction of a solid waste processing facility; • extension of facilities for sorting waste; • replacement and up-grading of waste collection trucks including driver training; • awareness campaigns for reduction and separation of waste. At the landfill №5 it is possible to generate landfill gas. The use of the biogas for the production of heat or power is challenging.

5.9 Building sector – City wide and City Authority

Operators of facilities/ utilities:	The total energy consumption of all buildings in Kyiv of various types of usage and ownership amounted to 24,881 GWh in 2013, representing 62% of the total city consumption.
Level of CA control or influence:	The buildings of the city are the largest final energy consumers, of which almost 68% goes to the residential sector. The CA has no control and limited influence on the energy consumption of the residential sector. Apartments in multi-storey buildings are privatized.
City energy spent and energy use:	***Figure 52: Energy consumption structure of overall buildings of different ownership, GWh***  Public budget buildings energy consumption amounts to approximately 11% of the total city buildings final energy consumption: municipal Buildings- 5% and not municipal public buildings 6%.
Condition of main equipment and EE potential:	Through the installation of individual heating stations (IHS) over-heating of apartments can be reduced and better hydraulic balancing can be achieved. EE investments in improvement of the building performance and a decrease of the heat demand, e.g. building shell measures, remain challenging due to the ownership structure.

5.10 Municipal Buildings - city authority

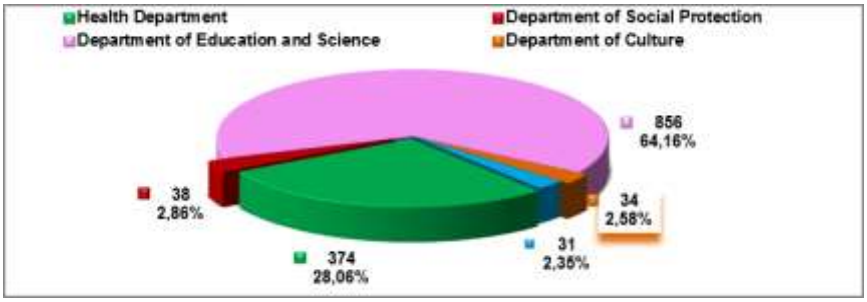
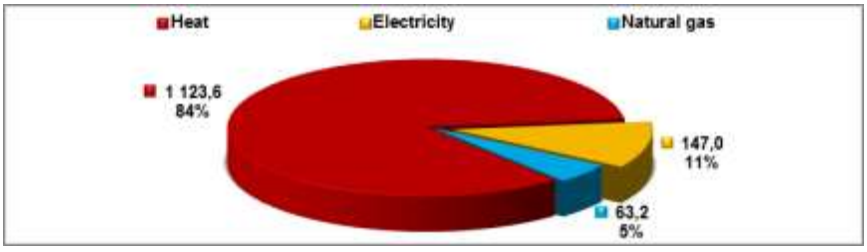
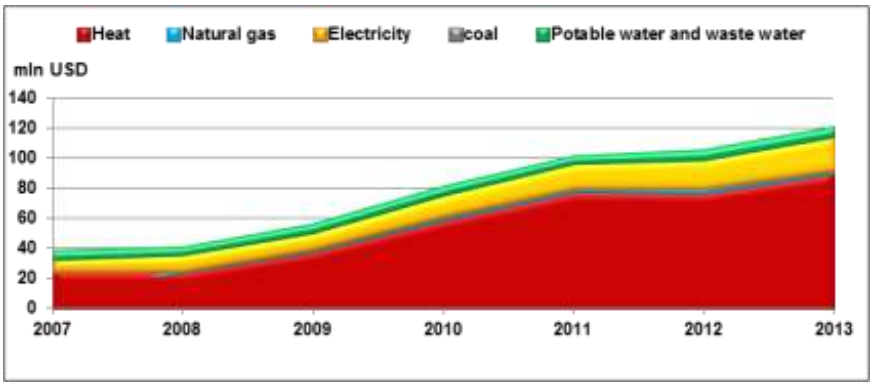
Operators of facilities/ utilities:	Public buildings can be divided into three types of budget funding: central government, regional and municipal buildings.
Level of CA control or influence:	The CA is not responsible for maintenance and introduction of energy efficiency in public buildings owned by the central government (state) and regional (oblast) government. The operators of the municipal public buildings are the departments of the CA: Department of Health and medical care, Department of Education and Science, Department of Culture and the Arts, Social Policy Management Department, Department of Family, Youth, Sports and Tourism.
City energy spent and energy use:	Municipal budget buildings' energy consumption occupies approx. 5,2% among the total city buildings consumption. In Kyiv, there are about 3,216 communal properties objects with a total heating area of 6,37 million m^2: • 1,435 communal property objects of the municipal subordination; • 1,781 object communal ownership of city district subordination. Heat energy consumption has the largest share (up to 84 %) of total energy consumption. The total amount of heat energy consumed in 2013 by municipal public buildings was 966,000 Gcal (1,123 GWh). In 2013 147 GWh of electric energy have been consumed by municipal public buildings. There is almost no supply of hot water from the district heating network for municipal public buildings. Gas consumption for heating and hot water preparation by individual boilers in municipal public building is about 5% for production of DHW and cooking mainly. ***Figure 53: Energy consumption structure of municipal public buildings of different ownership, GWh***  ***Figure 54: The structure of fuel and energy consumption, GWh***  The specific heating energy consumption is in the range of 130-230 kWh/m^2 in average 185 kWh/m² confirmed by various energy audits. The energy spending for municipal buildings amount to 119.8 million USD, which is 4.1% of the city budget and 56% of energy costs of the municipality (for sectors under CA control). There is a dynamic of energy costs for municipal buildings over the last 7 years of 200%.

	Figure 55: Dynamic of energy costs for municipal public buildings 
Condition of main equipment and EE potential:	The existing public buildings have been mostly built in the Soviet Union era in 1950-1970. They have large heat losses through the building envelope and require a significant amount of heat energy for space heating. Most buildings have received regular maintenance and repairs over 30 years.
Ongoing investment programs for performance increase	• Program "Energy efficiency in Kyiv budgetary institutions" by NEFCO and grant E5P. • Program "Thermo-rehabilitation of Kyiv public institutions". • Project USAID «Municipal Heating Reform in Ukraine": with Energy audits in typical public buildings Details are provided in section 6.

5.11 Public Lighting – City Authority

Operators of facilities/ utilities:	Operation and maintenance of outside city lighting is carried out by municipal enterprise "Kyivmisksvitlo". ME "Kyivmisksvitlo" provides lighting in 1,852 streets, 1,133 houses adjoining areas, 45 parks and 49 gardens, architectural - decorative lighting of 20 monuments, 4 bridges.
Level of CA control or influence:	ME “Kyivmisksvitlo" is a legal entity in 100% ownership of the municipality. Thus the CA maintains full control and influence for the public lighting sector.
City energy spent and energy use:	The total amount of electric energy consumption in 2013 was 61.32 GWh. The electricity consumption for street lighting during 2009 -2013 has been quite stable, while costs for energy in the same period has almost doubled to USD 29.07 million in 2013.
Condition of main equipment and EE potential:	The city exterior lighting network consists of 1,802.8 km of cable lines (66% laid in the ground), 2,250.7 km of overhead lines, 1,454 distribution systems (PV - switching-on and administration points), 182,642 lamps that are placed at 70,670 poles. ME “Kyivmisksvitlo" has 93 special vehicles. For street lighting mainly incandescent lamps, arc mercury fluorescent lamps, and sodium-vapor tube lamps are used. Currently 61% of installed bulbs are efficient high-pressure sodium-vapor bulbs at average capacity of 150 W. Specific electricity consumption for the number of lighting poles is 868.6 kWh / light point. The operation hours of the street lighting are 2,998 h/year.

Figure 56: Composition of street lighting by type and number of lamps

Light bulbs type		Average capacity of light point (W)	Number of light points
Sodium arc tube	DNaT	70	32, 881
		100	17, 689
		150	46, 410
		250	14, 041
		400	887
Arc mercury fluorescent	**DRL**	125	**2, 639**
		250	**17, 298**
		400	**577**
Metal halide			**577**
Incandescent lamps	**IL**		**234**
Arc mercury fluorescent	**DR)**		**645**
LED		180	900
other			47, 864
Total			149, 761

There is a demand for replacing approximately 22,000 bulbs with low performance, environmentally hazardous and energy-intensive (such as DLR).

In 2010 ME "Kyivmisksvitlo" implemented lighting management system "SUMO" Я-09, which provides control of functional, architectural - decorative outdoor lighting, illumination of Kyiv and consists of a control station and executive terminal points (as of 2013 – 1,400 pcs.).

6 Energy Efficiency Recommendations

6.1 Methodology for evaluation, selection and ranking of EE measures

The long-list of recommendations for energy efficiency originated from various sources in the course of the compilation of data, information and consultation with stakeholders as well as the TRACE model.

Sources for EE recommendations have been:

- listed EE recommendations of the **TRACE model**,
- measures which have been recommended and analyzed in the **Municipal Energy Plan** from 2012 to 2016 of the city of Kyiv,
- recommended EE measures which have been identified during **interviews with city administration and local stakeholders,** public utility "Kyivesko" and **utilitie**s,
- investment plans of the city administration, utilities and Kyiv Investment Agency,
- **best practice** EE recommendations from the expertise of the **consulting team.**

In addition EE investment measures and investment programs which have been commenced in 2014, such as IFI funded projects (IBRD "Urban Infrastructure 2", NEFCO / EBRD -"Energy efficiency in Kyiv budgetary institutions") and USAID - «Municipal Heating Reform in Ukraine", have been considered, as their implementation will provide EE benefits compared to the baseline of energy performance of the year 2013. Those EE measures and programs “on the way” are listed separately, because they are already prioritized.

A total set of 81 EE recommendations has been identified and preliminarily evaluated on their appropriateness. Those include also EE recommendations in the sectors with have been recommended as ‘low priority’, i.e. the power sector and private transport.

For that first selection the following **criteria on appropriateness** for the EE measure have been applied.

a) Degree of **control and influence** of the Municipal Authority on the sector

b) b) Degree of **competencies of the CA** or the stakeholder responsible for the implementation. Competencies of the CA comprise: Capacities of the utility or municipal staff to operate and maintain the project, equipment/ facility; Capacity to undertake project assessment, public procurement and implementation supervision; Experiences with similar previous projects; Available methods/equipment to verify energy savings. The assessment of the competencies follows the initial appraisal of the TRACE model

c) **Ease** of Implementation

d) Availability of the **local market** for the EE measure and maturity of the Ukrainian and local market for application, mainly related to absorption capacity for the technology and its operation

e) Availability of a **supporting framework**, in terms of regulatory, legal and municipal policy

f) Ability to achieve the **economic sustainability**; to establish and maintain the economic benefit in terms of revenues from the EE measure for the investor in the EE measure.

If one or more of the criteria b) to f) have been evaluated negatively, such as low or not guaranteed, the respective EE recommendation has been dropped for further consideration. The Recommended EE measures are of **different type**, nature:

- **Type I: investment** measures, which comprise the investment and installation of EE technology and equipment and generate physical energy savings
- **Type P: preparation** measures which are non-investment but preparing the framework or conditions for the smooth implementation of investment measures, such as feasibility studies, regulation, implementation mechanisms. It is recommended to link and combine those type P measures with investment measures.
- **Type A: Accompanying** measures, which are non-investment or low investment, which is enabling EE at low-cost, such as awareness raising, information and increasing capacities.

It is recommended to link and combine those type A measures on demand with investment measures to ensure their proper implementation, monitoring and results.

The following **assumptions** have been taken for the preliminary assessment of EE recommendations/ EE measures

- *Investment costs* at the level of 2013 prices, including import duties (on demand), installation, using the currency exchange rate of December 31, 2013 (1 USD = 82 UAH)
- *Emission factors* for primary energy carriers
- *Payback* is preliminarily calculated on the basis of annually saved energy costs. For this purpose the 5-year average tariff of the respective final energy carrier is used for the period 2015 to 2020
- The *implementation period* of the EE measure starts in 2016, with delivery of EE benefits in the year 2017 the earliest. Each EE measure is completed in 2020. EE benefits become valid in the energy balance of 2020.

6.2 EE recommendations in the sector Municipal public buildings

The following set of EE recommendations meet the basic criteria of appropriateness and have been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
PB-01	Renewable energy individual heat generation for municipal education and medical facilities	**I-Investment**	Heat pumps alongside with PB-03, PB-04, PB-05
PB-02	Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	**I-Investment**	1060 facilities including building shell, piping (no EE on electricity consumption)
PB-03	Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	**I-Investment**	180 facilities including building shell, piping (no EE on electricity consumption)
PB-04	Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	**I-Investment**	320 facilities including building shell, piping (no EE on electricity consumption)
PB-05	Municipal Building Inventory and Benchmarking and Monitoring Program	P-Preparation	
PB-06	Mandatory Building Energy Efficiency Codes for Existing and New Buildings	A-Accompanying	

The following projects with committed funding and implementation from 2014 have to be considered:

- "Energy efficiency in Kyiv budgetary institutions" by NEFCO and grant E5P Fund of total investments costs is 5.5 million USD (credit: 4.0 million USD, local budget: 1.5 million USD).
- "Thermo-rehabilitation of Kyiv public institutions" total investments costs is Euro 8.5 million (Euro 5.0 million loan from NEFCO and E5R Fund grant - Euro 1.5 million, from the local budget - Euros 2.0 million).
- Project USAID «Municipal Heating Reform in Ukraine": with Energy audits in 10 typical office buildings and 10 public buildings and implemented thermos-modernization of school № 233 and kindergarten №573. The total investment cost of the two projects is 14.9 million USD (sponsors are: Kyiv City Administration, USAID , other).
- A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures.[5]

[5] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

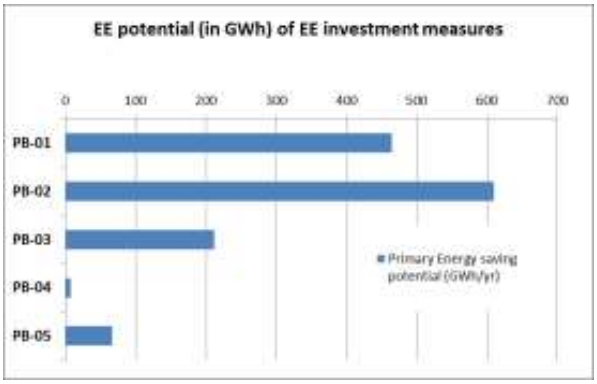
- Municipal building energy efficiency task force, as it shall be included in the Energy Management sector
- Municipal residential building audit and retrofit Program; as there are no considerable municipally owned residential buildings

The preliminary assessment of the recommended EE measures results into the following indicators. A first ranking of the EE measure has been undertaken on the highest energy saving potential.

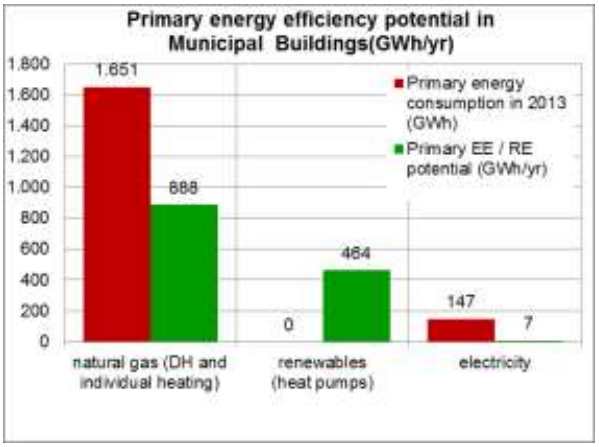
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (kt CO_2/a)	Preliminary payback time (years) [6]
PB-01	Renewable energy individual heat generation for municipal education and medical facilities	243,8	464,0 gas	93,7	11,9
PB-02	Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	444,6	609,9 gas	123,2	6,8
PB-03	Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	185,3	211,3 gas	42,7	8,2
PB-04	Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	13,3	7,3 gas	1,5	16,9
PB-05	Municipal Building Inventory and Benchmarking and Monitoring Program	14,6	66,7 gas	22,8	1,5
PB-06	Mandatory Building Energy Efficiency Codes for Existing and New Buildings	0,1	gas	0,0	

Figure 57: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) of recommended EE measures

Primary energy savings and payback time by EE measures



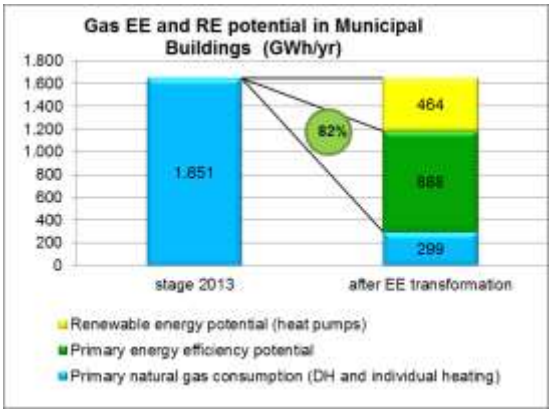
Primary energy savings by type of energy and RE



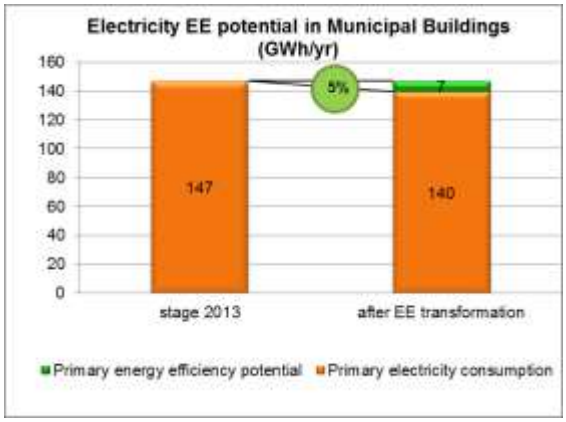
- Computer PowerSave Project
- Solar Hot Water Program
- Municipal administrative buildings Audit and Retrofit Program, as included in PB-03, PB-04 and PB-05
- Replacement of indoor lighting for all municipal public buildings, as no data for assessment is available the appropriateness is low
- Replacement of equipment for all kitchens in municipal public buildings
- Green Building Guidelines for New Municipal Buildings, included in PB-06

[6] The PBT is based on a rough estimate of the investment and it doesn't consider operation costs.

Potential gas savings



Potential electricity savings



The reduction of energy demand of municipal public kindergartens and various types of schools bears the largest potential to save district heating energy at a level of 610 GWh per year. The same level of savings of district heat can be achieved by the installation of individual heat generation units using renewable energy sources (such as heat pumps and biomass boilers).

This needs to be coordinated closely with the DH Company as a reduction of the heat load may result in negative effects for the DH system.

In addition substantial heat energy savings can be achieved by rehabilitation of administrative and medical buildings.

The indicative implementation frame of the pre-selected investment measures can be as follows:

Title of EE recommendation	Implementation perspective	Implementation Speed (years)	Possible start in
Renewable energy individual heat generation for municipal education and medical facilities	long-term	3 years	2017
Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	long-term	3 years	2016
Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	long-term	3 years	2017
Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	long-term	2 years	2017
Municipal Building Inventory and Benchmarking and Monitoring Program	short-term	2 years	2016
Mandatory Building Energy Efficiency Codes for Existing and New Buildings	short-term	2 years	2016

The **key stakeholders** for implementation of the recommended EE measures in this sector are:

- The municipal authority and the respective department in the CA, as the owner of the buildings
- Department of energy management, Education, Science, Youth and Sports, Culture, Health
- The directors of the facility
- The users of the facility

6.3 EE recommendations in the sector street lighting

The following set of EE recommendations meets the basic criteria of appropriateness and has been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
SL-01	Street Lighting Audit and Retrofit Program (replacement with LED)	**I-Investment**	including public space lighting on demand
SL-02	Traffic Signal Audit and Retrofit Program	**I-Investment**	assumption: 200 intersections, 12 lights per intersection
SL-03	Procurement Guide for New Street Lights	P-Preparation	implementation of life cycle cost assessment

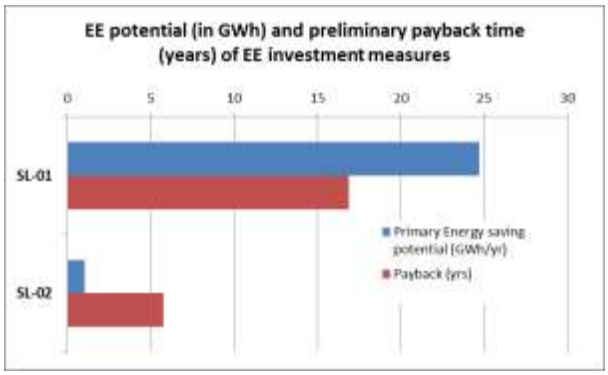
Presently there are no considerable EE investment programs in the sector.

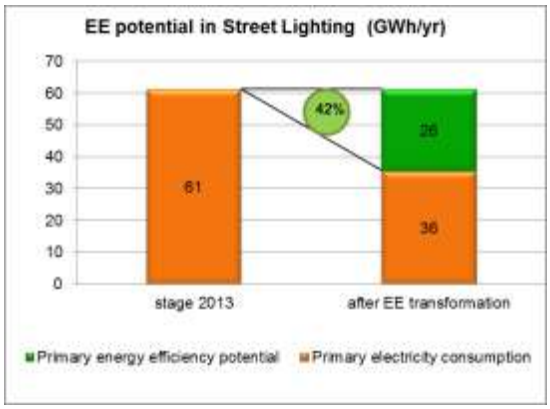
A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures. [7]

The preliminary assessment of the recommended EE measures results in the following indicators. A first ranking of the EE measures has been undertaken on the highest energy saving potential. All energy savings in the street lighting sector are Primary energy electricity savings.

Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (kt CO2/a)	Preliminary payback time (years)
SL-01	Street Lighting Audit and Retrofit Program (replacement with LED)[8]	43,0	24,7 electricity	26,9	10-16,9
SL-02	Traffic Signal Audit and Retrofit Program	0,6	1,0 electricity	1,1	5,8
SL-03	Procurement Guide for New Street Lights	0,0	0,0 electricity	0,0	0,0

Figure 58: Preliminarily calculated Primary energy saving potential of recommended EE measures and payback time





The indicative implementation frame of the pre-selected investment measures can be as follow:

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
SL-01	Street Lighting Audit and Retrofit Program (replacement with LED)	short-term	2 years	2016
SL-02	Traffic Signal Audit and Retrofit Program	short-term	2 years	2016
SL-03	Procurement Guide for New Street Lights	short-term	2 years	2016

The key stakeholders for implementation of the recommended EE measures in this sector are:

- The City Authority including a cooperation with infrastructure planning department
- The Street lighting municipal company ME “Kyivmisksvitlo”

[7] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- Integrated Public Lighting Assessment Program, as market and absorption capacity is low
- Street Signage Lighting Audit and Retrofit Program, no market
- Public Spaces Lighting Audit and Retrofit Program, integrated in measure SL-01
- Lighting Timing, dimming and management Program, integrated in measure SL-01

[8] Investments include replacement of electric network and poles Lighting Timing, dimming and management Program. It will be analyzed in more detail in the EE program/ profile.

- Cooperation with the power utility JSC "Kyivenergo" and JSC "Kyivoblenergo is required

6.4 EE recommendations in the sector district heating

The following set of EE recommendations meet the basic criteria of appropriateness and have been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
DH-01	Individual heat substation and Heat meter installation	**I-Investment**	1329+4142 residential buildings
DH-02	Installation of economizer units at boiler-houses	**I-Investment**	5 units for boilers
DH-03	Waste-to-Energy Project (Reconstruction the waste incineration plant "Енергія" to CHP plant)	**I-Investment**	Assumption: 100.000 tone waste/yr --> 25 MW capacity, of which 40% power
DH-04	Boiler Houses reconstruction and rehabilitation	**I-Investment**	65+16 BHs
DH-05	Central heat substation reconstruction	**I-Investment**	38 CHSs
DH-06	Installation of Hydraulic Couplings at boiler-houses	**I-Investment**	53 units for circuit pumps and fans
DH-07	Pumping stations construction and rehabilitation	**I-Investment**	6 pumping stations
DH-08	Fuel switch for heat generation - gas to biomass	**I-Investment**	
DH-09	District heating network rehabilitation, pipeline replacement	I-Investment	539,1 km

There are no on-going EE investments programs by IFI and of considerable extend in the sector.

A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures. [9]

The preliminary assessment of the recommended EE measures results in the following indicators. A first ranking of the EE measures has been undertaken on the highest energy saving potential.

Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
DH-01	Individual heat substation and Heat meter installation	333,6	1.460,5 gas	295,0	3,6
DH-02	Installation of economizer units at boiler-houses	18,4	225,1 gas	45,5	1,3
DH-03	Waste-to-Energy Project (Reconstruction the waste incineration plant "Енергія" to CHP plant)	120,0	200,0 gas	50,4	9,6
DH-04	Boiler Houses reconstruction and rehabilitation	78,4	124,4 gas	25,1	10,1
DH-05	Central heat substation reconstruction	18,2	77,5 gas	15,7	3,7
DH-06	Installation of Hydraulic Couplings at boiler-houses	27,3	66,6 gas	72,6	1,7
DH-07	Pumping stations	12,9	4,6 power	5,1	11,8

[9] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

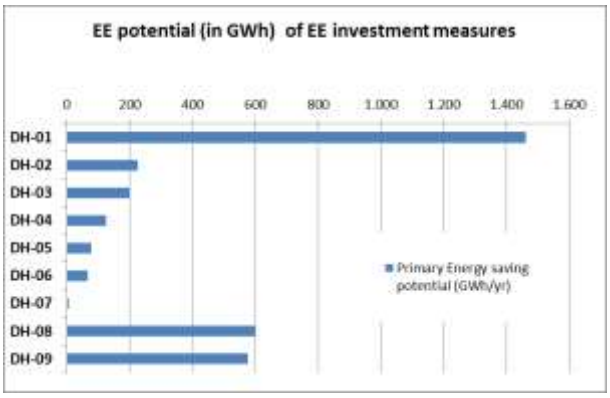
- Installation of flue gas treatment system at waste incineration plant "Енергія", included in DH-05
- Modernization of gas CHP plant "TEC-6", as no data available
- Modernization in Bortnichy of central aeration station as no data available

- Implementation of SCADA system

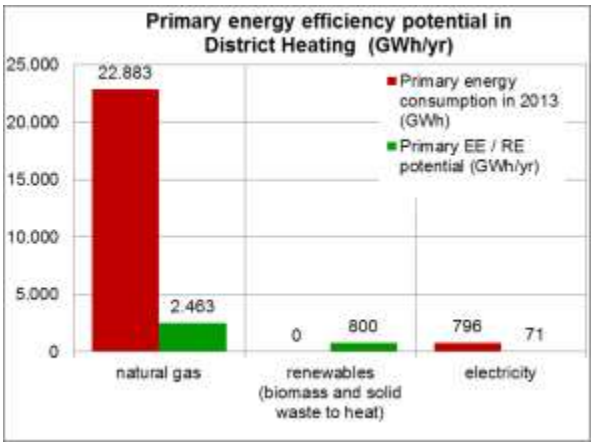
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
	construction and rehabilitation				
DH-08	Fuel switch for heat generation - gas to biomass	243,8	600,0 gas	121,2	6,5
DH-09	District heating network rehabilitation, pipeline replacement	382,9	575,7 gas	116,3	10,6

Figure 59: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) of recommended EE measures

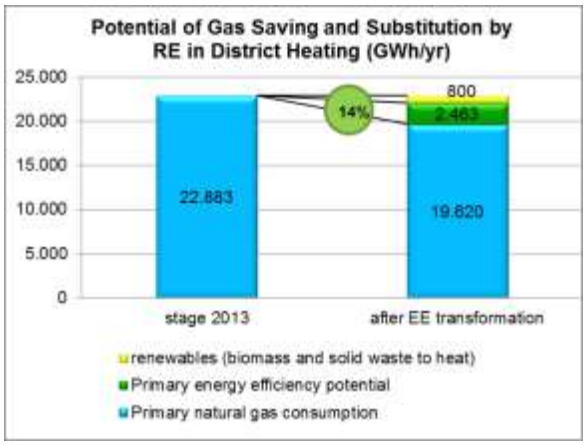
Primary energy savings and payback time by EE measures



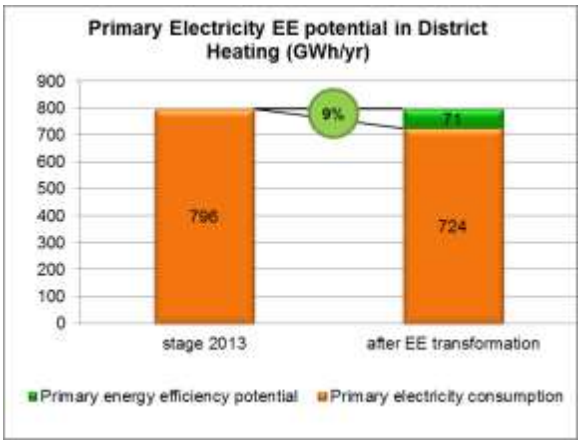
Primary energy savings by type of energy and RE



Potential gas savings



Potential electricity savings



The indicative implementation frame of the pre-selected investment measures can be as follow:

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
DH-01	Individual heat substation and Heat meter installation	long-term	5 years	2016
DH-02	Installation of economizer units at boiler-houses	short-term	2 years	2016
DH-03	Waste-to-Energy Project (Reconstruction the waste incineration plant "Енергія" to CHP plant)	long-term	5 years	2016
DH-04	Boiler Houses reconstruction and rehabilitation	long-term	4 years	2016
DH-05	Central heat substation reconstruction	short-term	3 years	2016

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
DH-06	Installation of Hydraulic Couplings at boiler-houses	short-term	1 year	2016
DH-07	Pumping stations construction and rehabilitation	short-term	2 years	2016
DH-08	Fuel switch for heat generation - gas to biomass	short-term	3 years	2017
DH-09	District heating network rehabilitation, pipeline replacement	long-term	15+ years	2020-25

The key stakeholders for implementation of the recommended EE measures in this sector are:

- PJSC "EKOSTANDART" (Darnytscka CHP);
- PJSC "Kyivenergo";
- "Zhytloteploenerho"
- CHP Darnytska

6.5 EE recommendations in the sector public transport

The following set of EE recommendations meets the basic criteria of appropriateness and has been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
TM-01	Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	**I-Investment**	
TM-02	Public Transportation Development with innovative vehicles (e.g. electric buses)	**I-Investment**	for existing municipal bus routes or new ones
TM-03	Promotion of Public Transport	A-Accompanying	making the public transport more attractive (information system, clean, punctual, new bus stops)
TM-04	Vehicle Emissions Standards for municipal and private bus operators	P-Preparation	set limits for vehicle emissions (private own fuel busses) for the granting of new operation licenses
TM-05	Renovation of trolleybus fleet	I-Investment	
TM-06	Modernization of metro indoor lighting systems	I-Investment	
TM-07	Renovation of tramway fleet	I-Investment	

Presently there are no considerable EE investment programs in the sector.

A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures. [10]

The preliminary assessment of the recommended EE measures results in the following indicators. A first ranking of the EE measures has been undertaken on the highest energy saving potential.

Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
TM-01	Replacement of municipal diesel bus fleet to hybrid	78,8	19,7 gasoline/ diesel	4,9	18,8

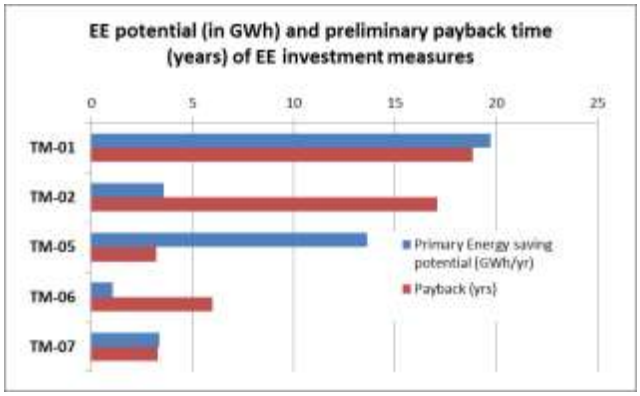
[10] TRACE model EE activities in this sector, which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- Car parking Management
- Traffic Flow Optimization
- Traffic Restraint Measures
- Travel Planning

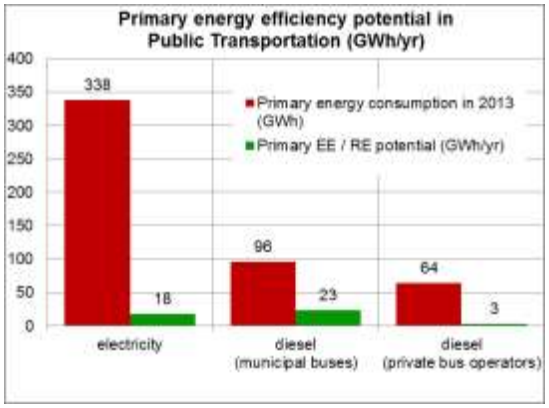
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
	(diesel/electric)				
TM-02	Public Transportation Development with innovative vehicles (e.g. electric buses)	13,0	3,6 gasoline/ diesel	1,5	17,1
TM-03	Promotion of Public Transport	0,2	105,0 gasoline/ diesel	26,1	
TM-04	Vehicle Emissions Standards for municipal and private bus operators	0,1	3,2 gasoline/ diesel	0,9	0,1
TM-05	Renovation of trolleybus fleet	4,0	1,7 electricity	14,8	13,0
TM-06	Modernization of metro indoor lighting systems	0,6	1,1 electricity	1,1	6,0
TM-07	Renovation of tramway fleet	1,0	0,4 electricity	3,7	13,3

Figure 60: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) and payback time of recommended EE measures

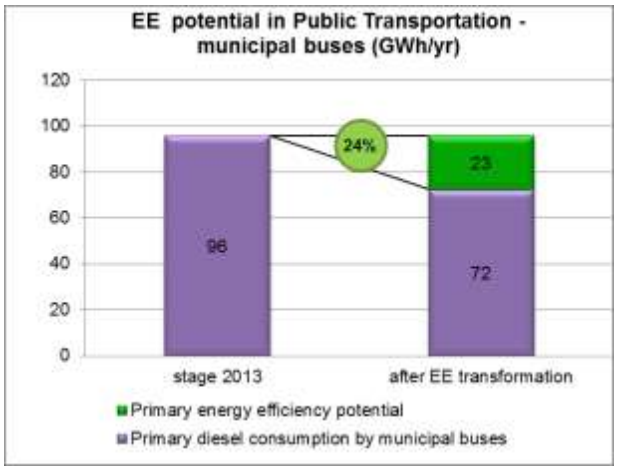
Primary energy savings and payback time by EE measures



Primary energy savings by type of energy and RE



Potential diesel savings



Potential electricity savings

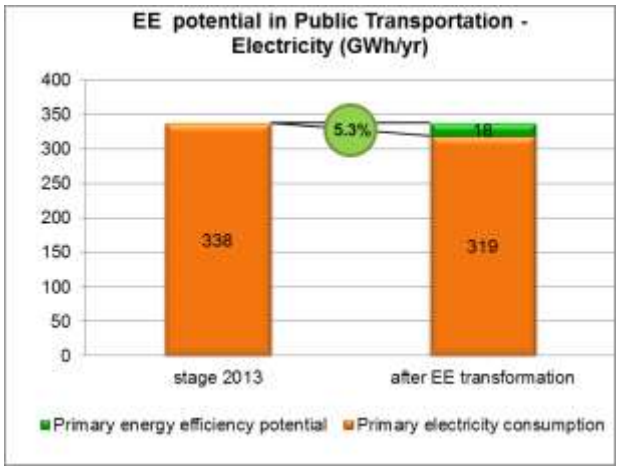
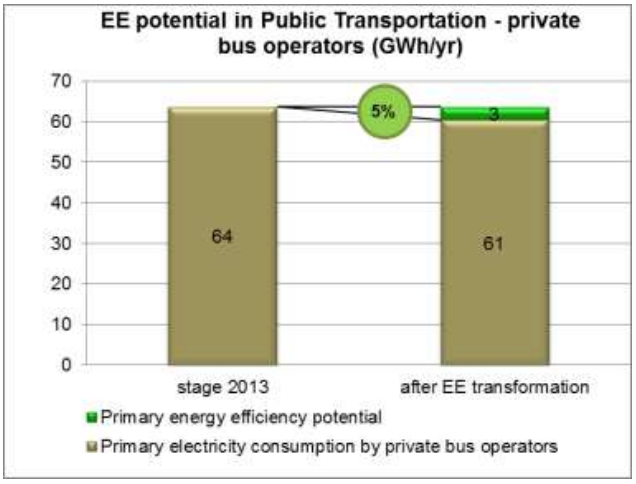


Figure 61: EE potential by measures for commercial public transport companies



The indicative implementation frame of the pre-selected investment measures can be as follow:

Code	Title of EE recommendation	Implementation perspective	Possible start in	Speed of Implementation, years
TM-01	Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	**long-term**	**2016**	**4 years**
TM-02	Public Transportation Development with innovative vehicles (e.g. electric buses)	**long-term**	2020	> 4 years
TM-03	Promotion of Public Transport	**long-term**	2020	> 4 years
TM-04	Vehicle Emissions Standards for municipal and private bus operators	**long-term**	2019	3 years
TM-05	Renovation of trolleybus fleet	short-term	2016	2 years
TM-06	Modernization of metro indoor lighting systems	short-term	2016	1 year
TM-07	Renovation of tramway fleet	short-term	2016	2 years

The key stakeholders for implementation of the recommended EE measures in this sector are:

c) Transport companies with the CA as main shareholder:

- municipal corporation "Kyivavtodor"
- communal enterprises “Kyiv Metropoliten" and "Kyivpastrans"

d) Commercial transport companies:

e) For vehicle licensing cooperation with Ukrtransinspektsiya

6.6 EE recommendations in the sector water and waste water supply

The following set of EE recommendations meets the basic criteria of appropriateness and has been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
WW-01	Use of waste water sludge for production of biogas	**I-Investment**	use of sludge, waste from waste company and food industry waste for biogas and CHP (approx. 10 MW)
WW-02	Improve Efficiency of Pumps and Motors in water supply system	**I-Investment**	i) 1 Pumping station for Dnipro Water Utility; ii) 1 pumping station of Desna (level-3); iii) 1 pumping station of Krutohirna; iv) 20 water pumping stations.
WW-03	Improve Efficiency of Pumps and Motors in water supply system	**I-Investment**	1 pumping station of Desna (level-2);
WW-04	Active Leak Detection and Pressure Management Programme for potable water system	**I-Investment**	

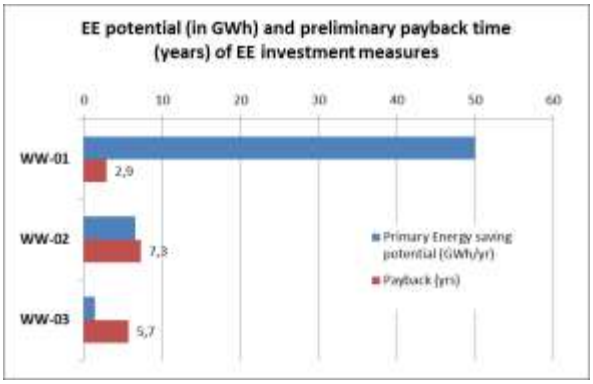
The above measure WW-02 is partly covered by the **IBRD Project "Urban Infrastructure 2" Modernization of water supply and sewerage system** with total investment cost of 11.4 million USD (9.3 million USD - IBRD loan and 2.1 million USD - Clean Technology Fund credit). The project includes:

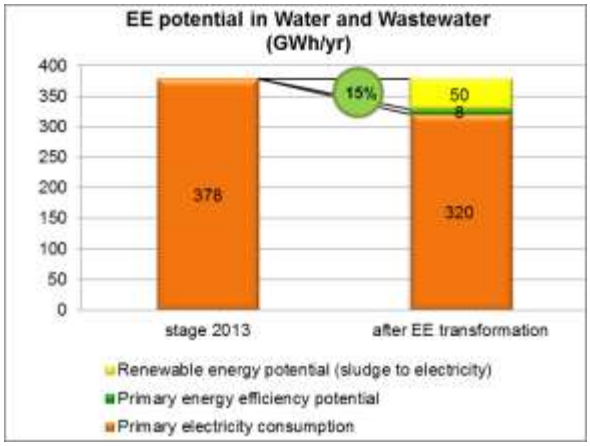
- Rehabilitation of pumping stations in Dnieprovska water station;
- Reconstruction of the energy utilities in pumping station "Krutohirna";
- Rehabilitation of water pumping stations Level 3 Desna water station;
- Modernization step-pumping stations.
- A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures. [11]

The preliminary assessment of the recommended EE measures results in the following indicators. A first ranking of the EE measures has been undertaken on the highest energy saving potential.

Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
WW-01	Use of waste water sludge for production of biogas	25,0	50,0 electricity	54,5	2,9
WW-02	Improve Efficiency of Pumps and Motors in water supply system	11,4	6,6 electricity	7,2	7,3
WW-03	Improve Efficiency of Pumps and Motors in water supply system	1,9	1,4 electricity	1,6	5,7
WW-04	Active Leak Detection and Pressure Management Program for potable water system	N/a			

Figure 62: Preliminarily calculated Primary energy saving potential of recommended EE measures and payback time





[11] TRACE model EE activities in this sector, which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- Prioritizing Energy Efficient Water Resources
- Auditing and Retrofit of Treatment Facilities
- Educational Measures, as included in EM measures
- Water Efficient Fixtures and Fittings
- Water Meter Program (individual at end consumer side)
- Improve Performance of System Networks
- Formation of Ring Main

The indicative implementation frame of the pre-selected investment measures can be as follow:

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
WW-01	Use of waste water sludge for production of biogas	long-term	3 years	2018
WW-02	Improve Efficiency of Pumps and Motors in water supply system	short-term	2 years	2015/16
WW-03	Improve Efficiency of Pumps and Motors in water supply system	short-term	1 year	2015/16

The key stakeholder for the implementation of the recommended EE measures in this sector the utility PJSC "Kyivvodocanal".

6.7 EE recommendations in the sector waste management

The following set of EE recommendations meet the basic criteria of appropriateness and have been preliminary assessed.

Code	Title of measure	Type	Comment/ additional information
WS-01	Landfill Gas Capture Program	**I-Investment**	use of sludge, waste from waste company for biogas and CHP (approx. 10 MW)
WS-02	Intermediate Transfer Stations including sorting and recycling, including composting station	**I-Investment**	Construction of 2 facilities
WS-03	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	**I-Investment**	
WS-04	Fuel Efficient Waste Vehicle Operations	A-Accompanying	includes non-investment measures, training etc.
WS-05	Waste Infrastructure Planning (connected to landfill site, containers)	I-Investment	The source for the investment figure is from the Municipal Energy Plan for this type of measure and includes investments in the sorting-container infrastructure

Presently there are no considerable EE investment programs in the sector.

A number of other EE activities as listed in the TRACE model have not been put forward or have been integrated in the set of recommended EE measures. [12]

[12] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- Waste Composting Program, as this can be combined with the transfer station
- EE in existing sorting and transfer facilities, not existing
- Waste to Energy Program, included in DH -03
- Waste Collection Route Optimization shall be included in infrastructure planning
- Water Meter Program (individual at end consumer side)
- Improve Performance of System Networks
- Formation of Ring Main

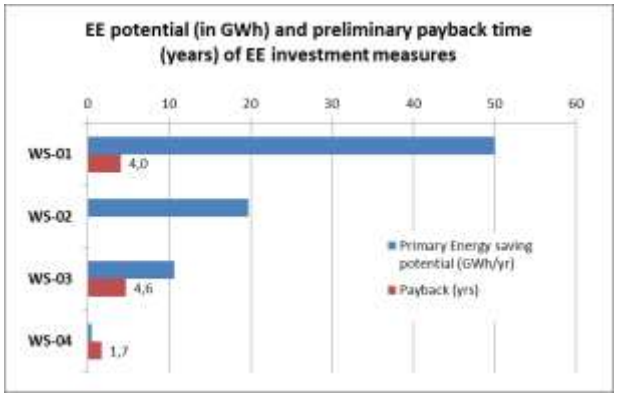
The preliminary assessment of the recommended EE measures results into the following indicators. A first ranking of the EE measure has been undertaken on the highest energy saving potential.

Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Emission saving (t CO2/a)	Preliminary payback time (years)
WS-01	Landfill Gas Capture Program	35,0	50,0 gas	54,5	4,0
WS-02	Intermediate Transfer Stations including sorting and recycling, including composting station	418,9	19,7 diesel	4,9	
WS-03	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	9,5	10,6 diesel	2,6	4,6
WS-04	Fuel Efficient Waste Vehicle Operations	0,2	0,5 diesel	0,1	1,7
WS-05	Waste Infrastructure Planning (connected to landfill site, containers)	77,5[13]	0,0	0,0	
	Planning and concept for the cycle of transport, use, recycling dumping (separate container sorting)	Approx. 1 million USD			

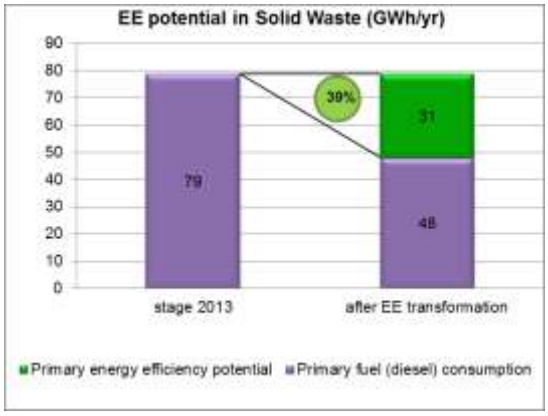
Energy savings will mainly be realized on diesel fuel. Accompanying effect is the reduction of waste volume.

Figure 63: Preliminary calculated Primary energy saving potential of recommended EE measures and payback time

Primary energy savings and payback time by EE measures



Primary energy savings , diesel



The indicative implementation frame of the pre-selected investment measures can be as follow:

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
WS-01	Landfill Gas Capture Program	long-term	3 years	2017
WS-02	Intermediate Transfer Stations including sorting and recycling, including composting station	short-term	2 years	2016
WS-03	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	short-term	2 years	2017
WS-04	Fuel Efficient Waste Vehicle Operations	short-term	1 year	2016
WS-05	Waste Infrastructure Planning (connected to landfill site, containers)	short-term	1 year	2016

[13] The source for the investment figure is from the Municipal Energy Plan for this type of measure and includes investments in the sorting-container infrastructure

The key stakeholders for implementation of the recommended EE measures in this sector are:

- The CA
- OJSC "Kyivspetstrans",
- JSC "Spetskomuntehnika"
- 15 private waste collection companies, among largest: Ltd "Celtic"; Dniprovsky district - Ltd "Celtic" and the subsidiary company “Altfater Kyiv", Pechersky district - CJSC "Spetskomuntehnika", Svyatoshinsky district - JSC "Kyivspetstrans» and Ltd «Kramar-Rysayklinh" Desnianskyi district - Ltd "Celtic".
- Cooperation with JSC "Kyivenergo" for incineration plant
- Cooperation with "Kyivproekt" and "Kyivspetstrans" on waste handling maps

6.8 EE recommendations in the Municipal Energy Management

The following set of EE recommendations meets the basic criteria of appropriateness and has been preliminarily assessed.

Code	Title of measure	Type	Comment/ additional information
EM-01	Awareness raising and EE promotion programs for all sectors	P-Preparation	events, competitions, awards, print media, media campaigns
EM-02	Capacity building programs	A-Accompanying	for operation staff EM, utilities
EM-03	EE Municipal task force	A-Accompanying	extension of EM department
EM-04	EE Strategy and investment plan	P-Preparation	including EE assessment
EM-05	Capital investment planning	P-Preparation	Preparation of pipeline for EE investments, financial structuring and fund raising
EM-06	Purchasing and service contracts	P-Preparation	procurement including life-cycle cost assessment
EM-07	Energy Performance contracting	P-Preparation	focus on street lighting and municipal buildings

The preliminary assessment of the recommended EE measures results in the following indicators. A first ranking of the EE measures has been undertaken on the highest energy saving potential.

Code	Title of EE recommendation	Investment costs (M USD)
EM-01	Awareness raising and EE promotion programs for all sectors	1,3
EM-02	Capacity building programs	0,5
EM-03	EE Municipal task force	0,2
EM-05	Capital investment planning	0,1
EM-07	Energy Performance contracting	0,1

The indicative implementation frame of the pre-selected investment measures can be as follows:

Code	Title of EE recommendation	Implementation perspective	Speed of Implementation, years	Possible start in
EM-01	Awareness raising and EE promotion programs for all sectors	long-term	3 years	2016
EM-02	Capacity building programs	short-term	3 years	2016
EM-03	EE Municipal task force	short-term	1 year	2016
EM-04	EE Strategy and investment plan	short-term	1 year	2016
EM-05	Capital investment planning	short-term	3 years	2016
EM-06	Purchasing and service contracts	short-term	2 years	2017
EM-07	Energy Performance contracting	Short-term	3 years	2017

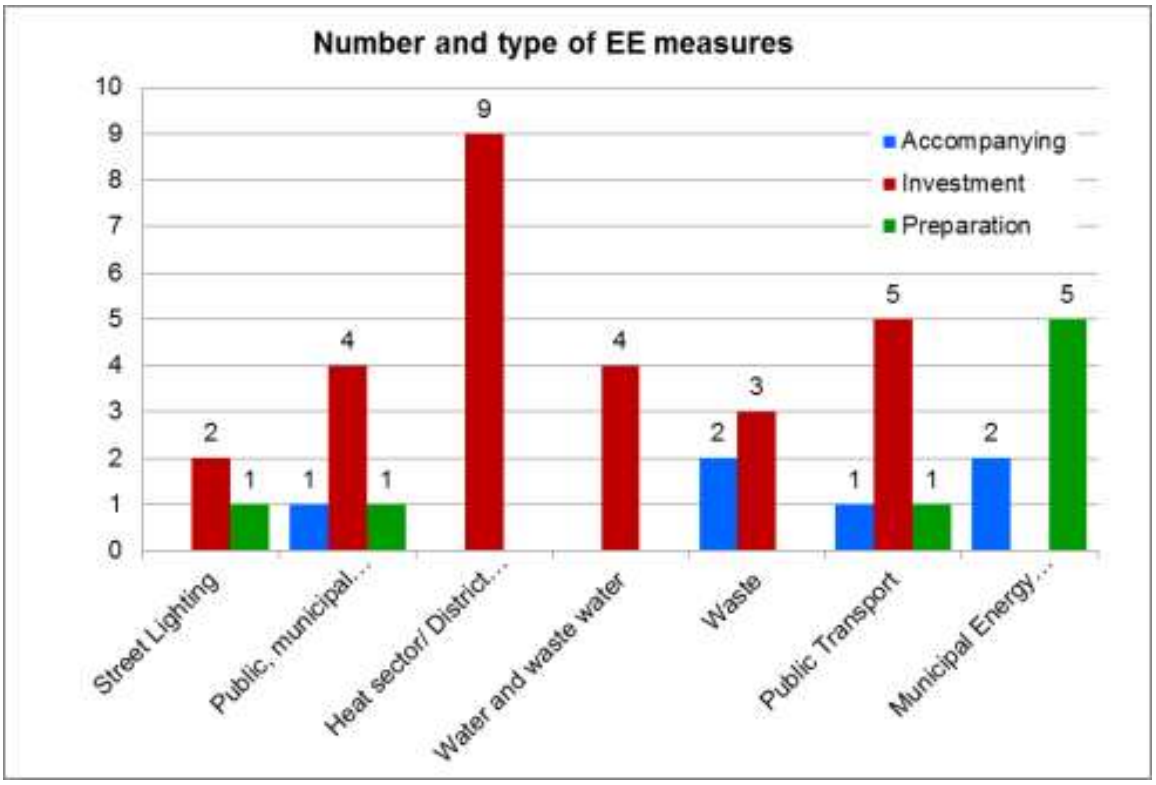
The key stakeholders for implementation of the recommended EE measures in this sector are:

- The CA and all energy users,
- Consultants
- Media
- National stakeholders
- Kyiv Investment Agency

6.9 Summary of potential benefits by the pre-selected EE recommendations

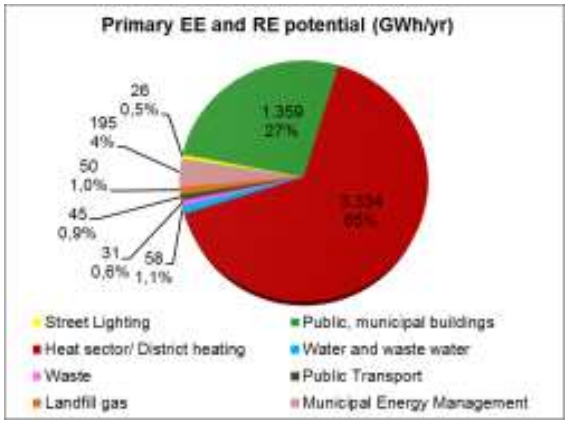
From the above analysis it is recommended to consider 41 EE measures, of which 27 are investment type; 8 preparation and 6 accompanying measures.

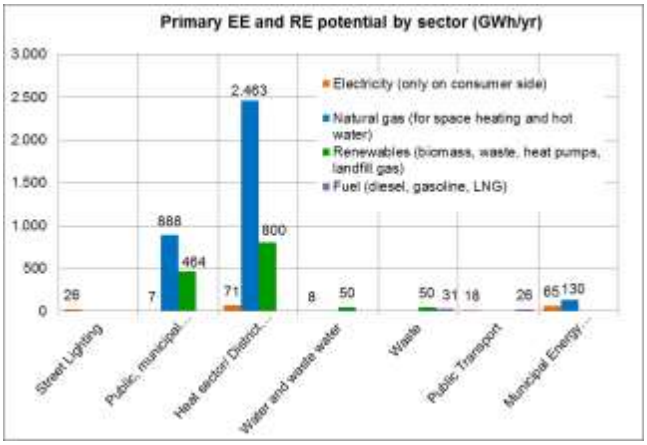
Figure 64: Number and type of EE measures recommended by sector



The overall primary energy savings by implementation of the 41 recommended measures will amount to annually 5,097 GWh of which energy saving in energy consumption amounts to 3,733 GWh (75%) and the substitution of conventional primary energy by renewable energy will be 1,364 GWh (25%)

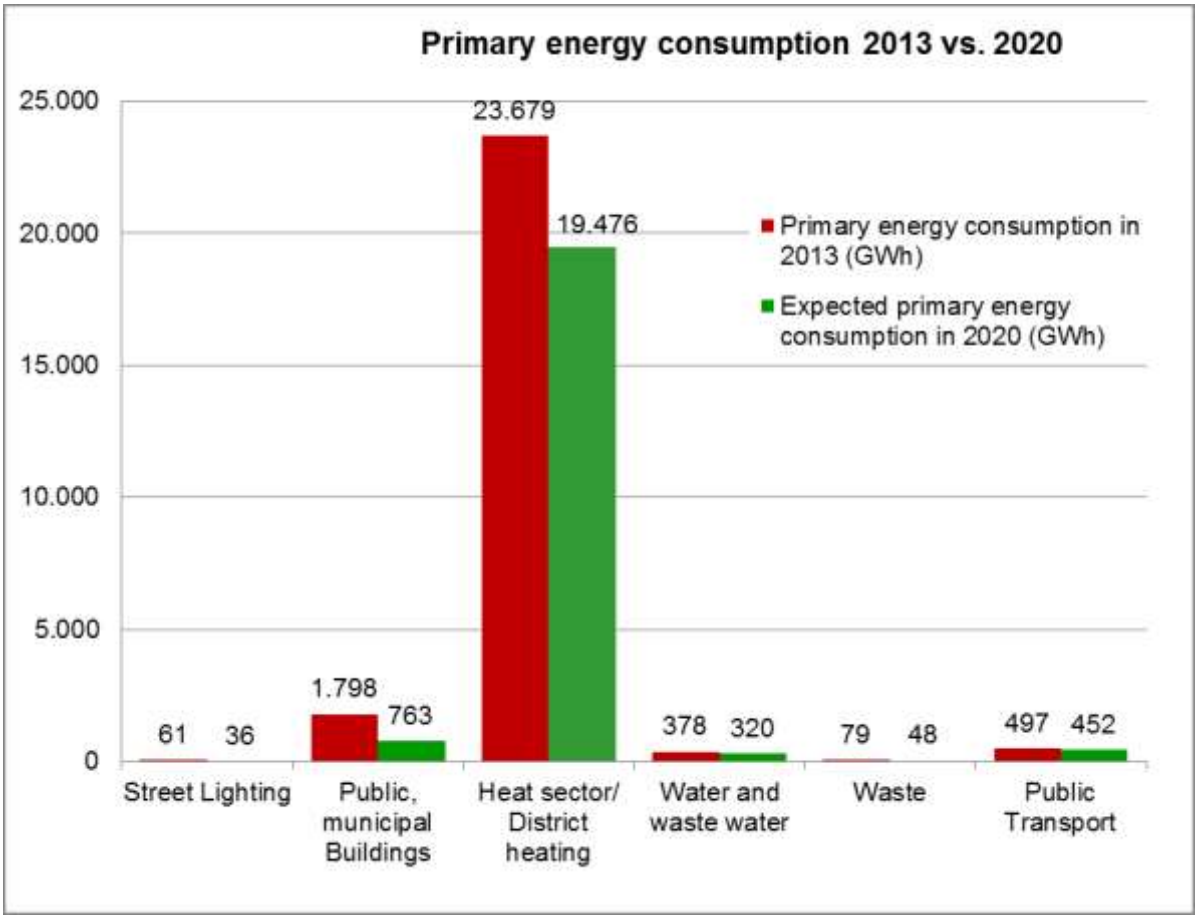
Figure 65: Primary energy saving potential by sector and type of energy





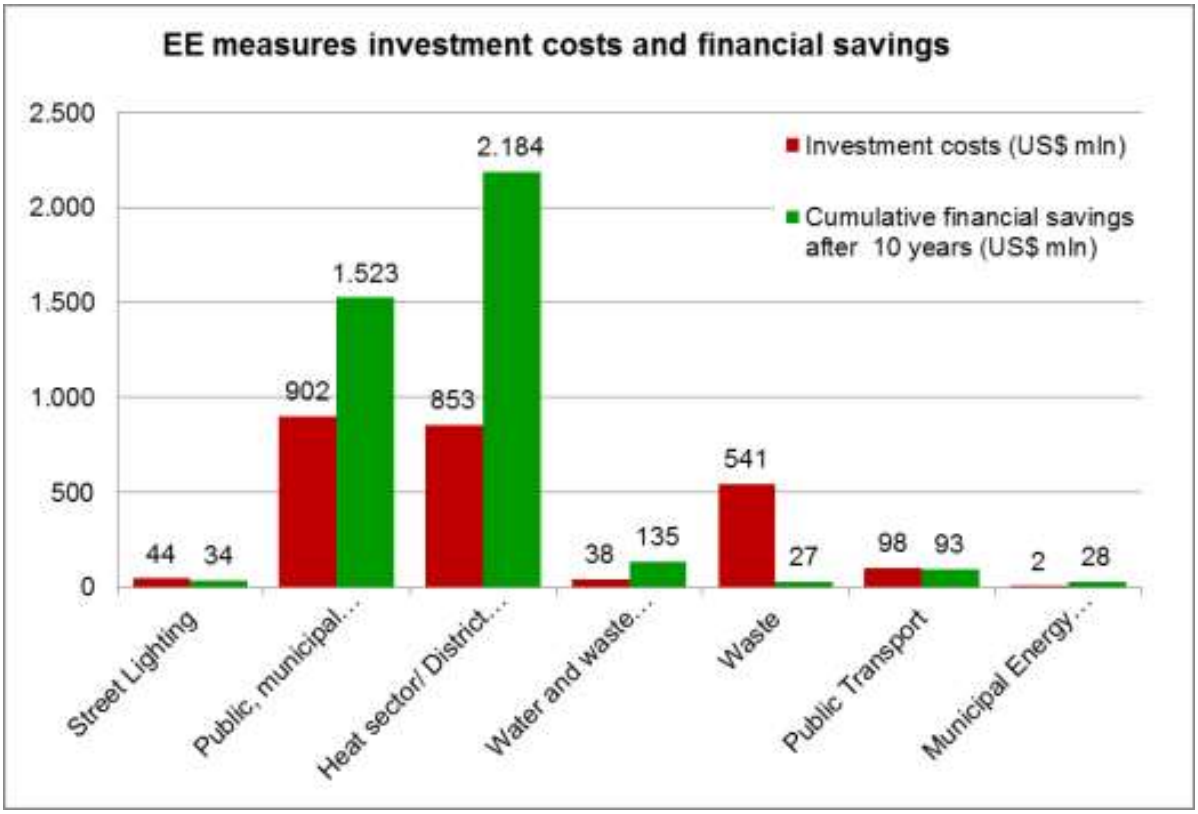
The implementation of the recommended EE measures until the year 2020 can reduce the primary energy consumption in the considered sectors by 20% (from 24,904 GWh in 2013 to 20,472 GWh in 2020). This savings potential would represent only 8% of the overall city's primary energy consumption (including industry, commercial, residential sector, which are not considered in the analysis).

Figure 66: Comparison of Primary energy consumption in the related sectors, of baseline year 2013 and forecast year 2020



The overall investment costs for the implementation of the 41 measures would be in the range of 2.0 to 2.5 billion USD, which can generate a 10-years cumulative saving of energy costs (considering a projection of energy tariffs) of a range between 3.5 to 4 billion USD.

Figure 67: Investment costs for EE recommendations and cumulative 10-years energy cost saving achievements (in million USD)



The largest savings (94%) of primary energy can be achieved in natural gas by 4,615 GWh which represents 486 million m³ gas of annual savings.

Figure 68: Primary energy saving and substitution by renewable energy potential (in GWh/year)