Energy Efficiency Assessment Report

City of Kamyanets-Podilsky

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	LNG	Liquid Natural Gas
EBRD	European Bank for Reconstruction and Development	MHRP	Municipal Heat Reform Programme 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	LPG	Liquefied Petroleum Gas

1 Executive 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.

ESMAP has established its Tool for Rapid Assessment of City Energy (TRACE) or the review of urban energy consuming sectors including performance, regulatory and institutional capacity issues with a view to identify investment and institutional measures towards an improvement in terms of energy efficiency in main municipal sectors.

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 Kamyanetz-Podisky.

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 Kamyanetz-Podisky 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 Kamyanetz-Podisky have been calculated and aggregated into the TRACE model.

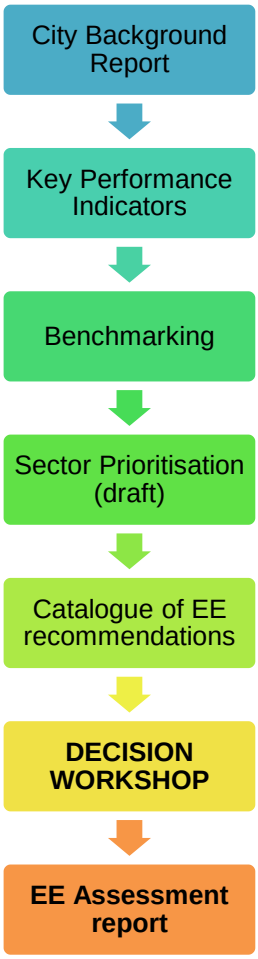
The benchmarking component of the TRACE tool enables the comparison of energy performance with other peer cities of similar characteristic. From this "Relative Energy Intensity" a rough estimate of the theoretical energy efficiency potential in each sector has been derived. → Chapter 3.

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 2012 and has prepared a Sustainable Energy Action Plan (SEAP), which targets the lowering CO2 emissions by 20% by 2020, gas consumption by 24%, heat (13%) and electricity consumption (30%).

City background – energy consumption

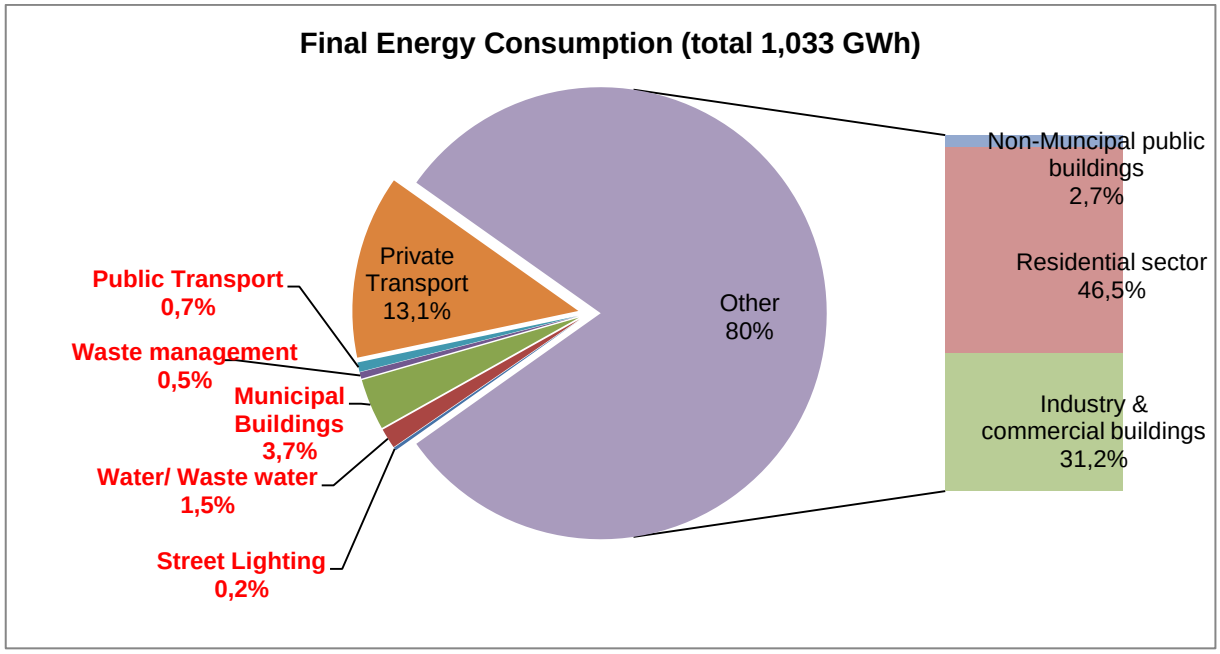
Kamyanetz-Podisky 's primary energy consumption amounts to 48,190.7 GWh in 2013 with the highest share with natural gas of almost two thirds. The majority of gas is utilized for the generation of power and district heat for the distribution to various end consumers.

The primary energy consumption in 2013 amount to 1,251 GWh, while the final energy consumption was at 1,033 GWh.

The residential sector is the largest energy consumer with more approx.46 % of the city's final energy consumption as it is typical for all Ukrainian cities. This is followed by the industry and commercial sector (including other buildings) at 31% and the private transport sector at 13%.

Final energy consumption under direct control by the city is 67GWh (6.5%) out of 1,033 GWh.

Figure 1: Share of Final Energy Consumption by sector



City background – budget and energy spending

Kamyanetz-Podisky, had a population in 2013 of 103,000 inhabitants and is economically based on the sectors engineering, food, light industry, construction materials and tourism.

The overall GDP[1] of Kamyanetz-Podisky amounted in 2013 to 397 million USD of which 43.5 million USD (11%) have been spent on energy.

The municipal budget amounted to 42.1 million USD in 2013 with approximately 7.3 million USD spent on energy municipal services for public transport, public buildings, street lighting, waste, water supply and waste water disposal.

Major segments of energy spending like power (23%) and private vehicles (43%) are not under the control of the City Administration.

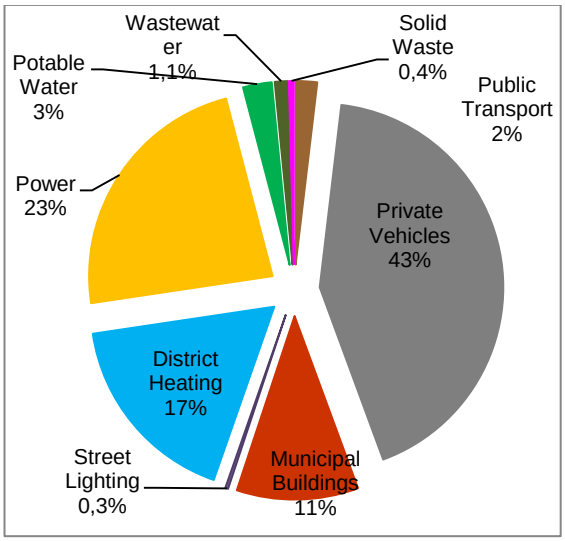


Figure 2: Share of spending for energy, 2013 in million USD

[1] Estimated on respective share of regional GDP, 2013

Energy Spending for Municipal sector facilities (municipal public transport, municipal buildings, street lighting, waste, water and waste water services) amount to 7.3 million USD in 2013, out of which more than 60% are spent for the energy supply of municipal buildings. Those 4.6 million USD make a share of 11 % of the annual municipal budget.

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 Kamyanetz-Podisky

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 Kamyanetz-Podisky.

Details of the benchmarking of Kamyanetz-Podisky '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 Kamyanetz-Podisky 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	30.3 GJ/capita	Medium performance Peer cities: Skopje and Sarajevo.	30%
	Annual Primary energy consumption per GDP	10.4 MJ/USD GDP	Low performance Peer cities: Tbilisi and Belgrade	50%
Public Transport	Specific energy consumption of Public Transport	0.14 MJ / passenger km	High performance Peer cities: Sarajevo	15%
Solid Waste	Annual Waste production	Approx. 590 kg/capita	Low performance Peer cities: Bucharest and Ljubljana	25%
	Solid Waste recycled	1 %	Very low performance	50-70%
Water supply and waste water	Energy Density of Potable Water Production (	1.31 kWh_e/m^3	Very Low performance (in 2013 before results of investment program)	30%
	Energy Density of Wastewater Treatment	0.78 kWh_e/m^3	Low performance (in 2013 before results of investment program)	30-50%
District Heat	Heat Loss from DH	13 %	Medium performance:	25-30%

Sector	Selected KPI		Comparison of Performance with better performing cities	Theoretical EE potential
	Network		Peer cities: cities in Western Europe	
Street lighting	Annual Electricity consumed per lit road	15 kWh_e/m	High performance Peer cities: Tbilisi or Vienna	30-40%
Municipal public buildings	Annual Heat Consumption	140 kWh_{th}/m^2	Low performance	50-60%

The benchmarking demonstrates that the majority of performance **indicators ranks 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,
- 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 is 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 water supply and wastewater, district heating, waste management and public transport.

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

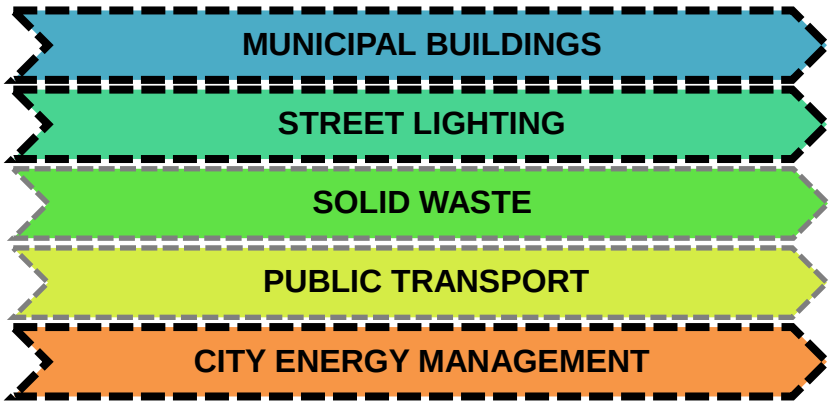
Sector	City Administration authority level of power		
	Regulatory	**Budget control**	**Influence and enforcement**
Public buildings	HIGH	HIGH	HIGH
Street lighting	HIGH	HIGH	HIGH
District heating	MEDIUM	LOW	HIGH
Public transport	MEDIUM	MEDIUM	MEDIUM
Potable water supply	MEDIUM	LOW	HIGH
Wastewater	MEDIUM	LOW	HIGH
Waste	HIGH	MEDIUM	HIGH
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 order):



Cross sector priority

Lower priority is given to the sectors District Heating and Water&Waste water because of the committed and ongoing energy efficiency investment programs funded by IFI projects.

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 supply
- 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 Kamyanetz-Podisky and its utilities are implementing currently a number of investment programs funded by own resources and international donor programs, such as:

In the district heating sector:

- Kamyanetz-Podisky "Miskteplovodenerhiya " projecst on Remote leakage measuring, new gas-fired CHPs and biomass boilers supported by own funds,
- District heating reconstruction program , in final negotiation for funding by IBRD,
- "Demonstration project DemoUkrainaDH in Kamyanets-Podilsky" on IHS, funded by NEFCO and SIDA

In the water supply & waste water sector

- Kamyanetz-Podisky Vodokanal project "Reconstruction of power-consuming equipment of water supply and sanitation" , funded 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.
Related components of those investment programs will **not** be considered in the list of recommended EE measures as they are already committed or under implementation, but they will deliver energy savings in the target year 2020 compared to the baseline year 2013.

The City of Kamyanetz-Podisky has elaborated a comprehensive Municipal Energy Plan (MEP) for 2012 to 2016 and Sustainable Energy Plan (SEAP). 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.

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 16 EE measures, of which 10 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, administrative, other (cultural) facilities	Total approx. 220,000 sqm building area including building shell, piping, including IHS on demand ,(no EE in electricity consumption)	Approximately 24 million USD	Annual savings of up-to 26 GWh, gas
Street Lighting (SL)			
Street Lighting Audit and Retrofit Program (replacement by high performing bulbs or LED)	Approx. 800 bulbs (only for Mercury and conventional), including public space lighting on demand	Approximately 0.5 million USD	Annual savings of 0.6 GWh, electricity
Solid Waste (WS)			
Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program including Fuel Efficient Waste Vehicle Operations training program	Estimate 10 – 12 units replacement; includes non-investment measures, training etc.	In the range of 0.8 million USD	Annual savings of up to 1.5 GWh, diesel
Intermediate Transfer Stations including sorting and recycling, including Waste Infrastructure Planning (connected to landfill site, containers)	Construction of one facility, capacity to be analyzed	In the range of 5-10 million USD	Annual savings of up to 1 GWh, diesel. With additional revenue sources.

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

Title	Components, extend	Indicative costs	Preliminary EE
Municipal Public Buildings (PB)			
Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals)	To limited extend, only if DH supply is not appropriate; Heat pumps and biomass (woodchips/pellets) alongside with PB-02	Approximately 3 to 4 million USD	Annual savings of up to 13 GWh, gas
Program for Solar Hot Water production of selected public buildings	(e.g. at hospitals)	Approximately 0.3 million USD	Annual savings of 0.2 GWh, gas
Solid Waste (WS)			
Landfill Gas Capture Program and power generation unit (use of green tariff, approach PPP operator)	Including CHP for generation own power (assumed capacity of 1 MWel); *Details in EE transformation program*	Up to 4 million USD	Annual savings of up to 5 GWh, electricity *To be analyzed*
Biogas plant including power generation unit ; using sorted biowaste and industrial biowaste	for heat generation (approach of PPP operator)	In the range between 2-4 million USD	*To be analyzed*

Title	Components, extend	Indicative costs	Preliminary EE
Municipal public transport			
Promotion of Public Transport, increase attractiveness targeting to lower private motorized transport mode	making the public transport more attractive (information system, clean, punctual, new bus stops), *Details in EE transformation program*	Up to 0.2 million USD	Annual savings of up to 1,2 GWh, gasoline in individual transport
Replacement of municipal diesel bus fleet to innovative vehicles	Step-by step in the course of bus replacement schedule, such as hybrid diesel/ electric	Up to 2 million USD	Annual savings of up to 1 GWh, diesel

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, administrative, other (cultural) facilities	Audit program for 70 to 80 buildings	Approx. 0.3 million USD	Results in PB - 02/03/04
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 0.1 million USD annually	Not primary for municipality
EE Municipal task force and Capacity building program Establishment Energy Management system including Monitoring and Verification (target tracking)	Including Municipal Building Inventory, Benchmarking and Energy Performance Monitoring Program municipal buildings	Approx. 0.1 million USD	n/a
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, and building performance codes	In the range of 0.1 to 0.2 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 0.05 - 0.1 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 0,05 million USD	Resulting from investment projects

EE Measures not to be considered as priority, because investment programs has already been committed, are:

District heating	Water and Waste water
Implemented: Remote leakage measuring of the DH system, Investment programs: Boiler Houses construction and rehabilitation ; Heat generation facilities to replace the capacity of the CHP: Two new boiler houses (BH) with total capacity 42 MW intended to operate the BH at least partly by biofuels (wood chips, pellets); Individual heat substation and Heat meter installation in residential houses alongside with Replacement of circuit pump and equipment with VSD at Boiler-house; Installation of cogeneration plant for coverage of own consumption; Fuel switch for heat generation - gas to biomass; Replacement of DH transmission pipelines;	Up to 80% of EE potential in the sector will be explored by that Completed program, including: Full reconstruction of the pumping stations and 8.0 km of new water supply and water treatment pipelines

Energy Efficiency Recommendations Matrix

		First costs	
		< 1 million USD	**> 1 million USD**
Primary Energy Saving Potential	**< 1 GWh/year**	• Street Lighting Audit and Retrofit Program • Program for Solar Hot Water production of selected public buildings • Promotion of Public Transport, increase attractiveness targeting to lower private motorized transport mode • Energy Audits and feasibility study for Municipal educational, medical, administrative, other (cultural) facilities • Awareness raising and EE promotion programs for all sectors • EE Municipal task force and Capacity building program - Establishment Energy Management system including Monitoring and Verification (target tracking) • Technical guideline and procedure for equipment and service purchasing and granting concessions • Preparation of Energy Performance contracting , preparation of contracting frame and procurements of ESCO services • EE Strategy and investment plan resulting in Capital investment planning	• Intermediate Transfer Stations including sorting and recycling, including Waste Infrastructure Planning (connected to landfill site, containers)
	> 1 GWh/year	• Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program including Fuel Efficient Waste Vehicle Operations training program	• Retrofit Program / thermo-modernization of Municipal educational, medical, administrative, other (cultural) facilities • Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals) • Landfill Gas Capture Program and power generation unit • Biogas plant including power generation unit ; using sorted biowaste

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 рамках програми ESMAP було створено Інструмент для швидкої оцінки енергетики міста (TRACE), що дозволяє дослідити споживання енергетичних ресурсів найбільш енергоємними муніципальними секторами, проаналізувати потенціал їх ефективності, наявність нормативних та інституційних потужностей, з метою виявлення можливостей інвестування та впровадження заходів, спрямованих на поліпшення енергетичної ефективності в основних муніципальних секторах.

У цьому звіті представлені основні результати застосування Моделі для швидкої оцінки енергетики міста (TRACE) та оцінка енергоефективності міста Кам'янця - Подільського.

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 Кам'янець - Подільської 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 Кам'янця - Подільського, 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 2012 році та підготувало Плану дій сталого енергетичного розвитку, цілями якого є зниження емісії CO_2 на 20% до 2020 року, споживання природного газу на 24%, теплової (13%) та електричної (30%) енергії.

Вихідний стан міста - споживання енергетичних ресурсів

У 2013 році кількість спожитої первинної енергії становить 1 151 ГВт·год, з якої 2/3 складає споживання природного газу, більша частка якого використовується на виробництво електричної та теплової енергії для кінцевих споживачів.

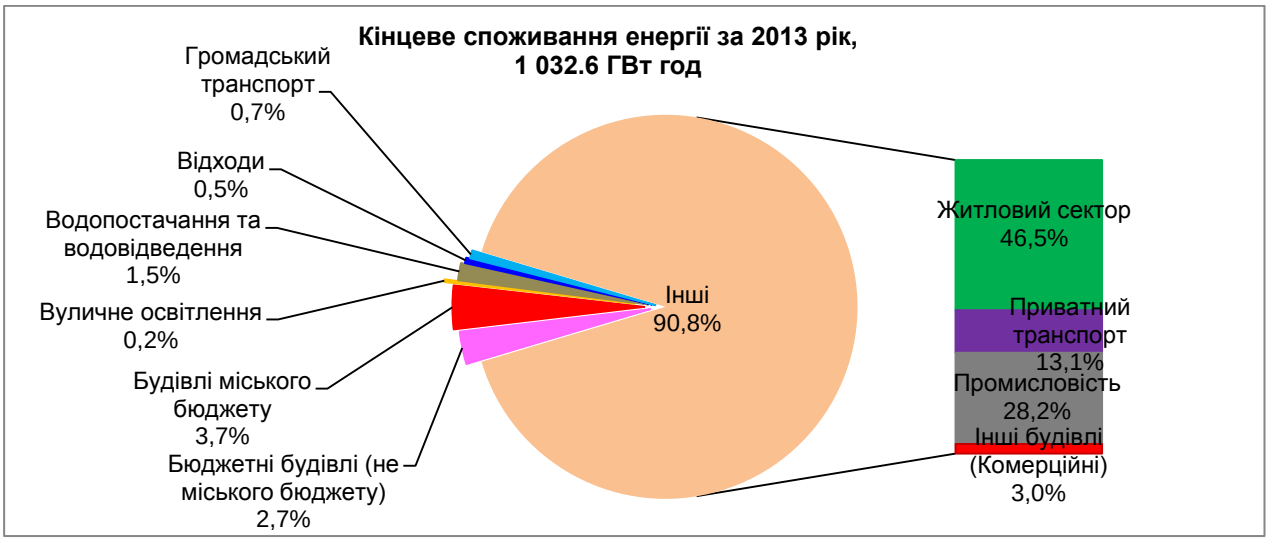
Споживання первинної енергії у 2013 році становить 1 151 ГВт·год, у той час кінцеве споживання міста становить 1 033 ГВт·год.

Житловий сектор є найбільшим споживачем енергії - близько 46% від кінцевого споживання енергетичних ресурсів, що характерно для всіх українських міст, за ним йдуть промисловість та комерційний сектор (інші будівлі включно) -31% та сектор приватного транспорту - 13%,

Значна частина споживачів енергетичних ресурсів міста використовує природний газу як первинну енергію (72%), в тому числі природний газ на побутові потреби та теплову енергію (51% та 21% відповідно) кінцевих споживачів

Кінцеве споживання енергетичних ресурсів, на яке місто має безпосередній вплив, становить 67 ГВт·год (6%) з 1 033 ГВт·год.

Рисунок 3: Кінцеве споживання енергії містом за 2013 рік



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

Населення міста Кам'янця - Подільського у 2013 році склало 103 000 осіб. Розвинена інженера, машинобудівна, харчова галузь, туризм.

Загальний валовий міський продукт[2] Кам'янця - Подільського склав 397 мільйони доларів США, де 43.5 мільйони (11%) було витрачено на енергозабезпечення.

[2] Приблизна оцінка частки міста в регіональному ВРП, 2013

Міський бюджет у 2013 році налічував 42.1 мільйони доларів США, з якого приблизно 7.3 мільйони будо використано на енергозабезпечення секторів громадського транспорту, громадських будівель, вуличного освітлення, водопостачання та водовідведення, поводження з твердими побутовими відходами.

Найбільші споживачі енергетичних ресурсів - сектори електропостачання (23%) та приватний транспорт (43%), не знаходяться під контролем міської влади.

Витрати на енергозабезпечення муніципальних секторів (міський громадський транспорт, громадські будівлі, вуличне освітлення, побутові відходи, водопостачання та водовідведення) склали 7.3 мільйони доларів США у 2013 році, з яких 60% було витрачено на забезпечення енергетичними ресурсами громадських бюджетних будівель. Ці 4.6 мільйони доларів США складали 11% від міського бюджету.

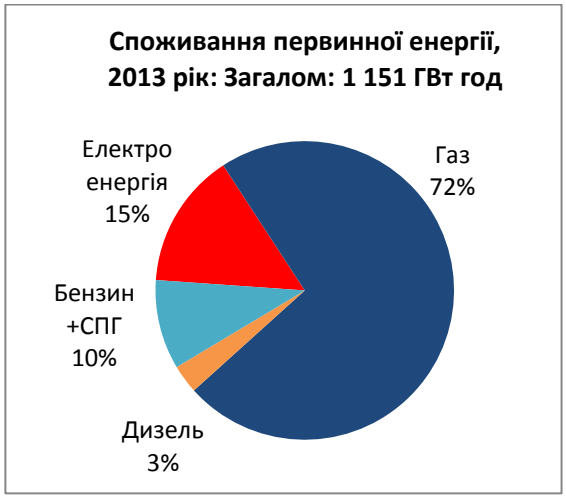


Рисунок 4: Витрати на енергію, 2013

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 Кам'янця - Подільського

Бенчмаркінг дозволяє порівняти енергетичну ефективність міста, яке досліджується, з іншими містами - еталонами на основі 27 ключових показниках ефективності міста Кам'янця - Подільського.

Детально процес бенчмаркінгу міста Кам'янця - Подільського розглянуто у Главі 3.
У наступній таблиці наводиться стисла інформація о характеристиках секторів.

Таблиця 3: Резюме бенчмаркінга за ключовими показниками ефективності міста Кам'янця - Подільського

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,	30.3 ГДж/ос.	Середня ефективність Міста-еталони: Скоп'є, Сараєво,	30%
	Споживання первинної енергії на ВВП міста,	10.4 МДж/доларів США ВВП міста	Низька ефективність Міста-еталони: Тбілісі та Белград	50%
Громадський транспорт	Питоме споживання енергії громадським транспортом,	0.14 МДж/пас·км	Висока ефективність Міста-еталони: Сараєво	15%
Побутові відходи	Кількість твердих побутових відходів (ТПВ), що утворюються в межах міста на душу населення	приблизно 590 кг/ос.	Низька ефективність Міста-еталони: Бухарест, Любляни	25%
	Відсоток ТПВ, що піддаються переробці	1%	Дуже низька ефективність	50-70%
Водопостачання та водовідведення	Питоме споживання електроенергії на питне водопостачання	1.31 $кВт_е$·год/м³	Дуже низька ефективність (у 2013 без результатів інвестиційних програм)	30%
	Питоме споживання електроенергії на водовідведення	0.78 $кВт_е$·год/м³	Низька ефективність (у 2013 без результатів інвестиційних програм)	30-50%
Централізоване теплопостачання	Відсоток втрат теплової енергії в мережах	13%	Середня ефективність Міста-еталони: міста Східної Європи	25-30%
Вуличне освітлення	Питоме споживання електроенергії на км освітлених вулиць	15 $кВт_е$·год/км	Низька ефективність Міста-еталони: Тбілісі та Вена	30-40%
Громадські бюджетні будівлі	Споживання теплової енергії будівлями міського підпорядкування	140 $кВт_т$·год/м²	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 теплової енергії громадськими будівлями**,
- Питоме споживання електроенергії на **водовідведення та водопостачання** ,
- Перехресний сектор: споживання первинної енергії на одиницю ВВП та душу населення

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, що підпадають під вторинну **переробку.**

Рівень контролю міської влади

Із-за різних правових, нормативних рамок 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 водопостачання та водовідведення, теплопостачання, управління твердими побутовими відходами та громадського транспортую Класифікація рівня контролю міської влади на сектори було підтверджено керівниками міста під час робочого семінару.

Таблиця 4: Контроль міської влади Кам'янця - Подільського на рівень витрат з бюджету, регулювання та ступінь примусового впливу на споживання енергії секторами міста

Сектор	**Рівень повноважень міської влади**		
	Регулювання		**Регулювання**
Громадські будівлі	ВИСОКИЙ	ВИСОКИЙ	ВИСОКИЙ
Вуличне освітлення	ВИСОКИЙ	ВИСОКИЙ	ВИСОКИЙ
Централізоване теплопостачання	СЕРЕДНІЙ	НИЗЬКЕ	ВИСОКИЙ
Громадський транспорт	СЕРЕДНІЙ	СЕРЕДНІЙ	СЕРЕДНІЙ
Питне водопостачання	СЕРЕДНІЙ	НИЗЬКЕ	ВИСОКИЙ
Водовідведення	СЕРЕДНІЙ	НИЗЬКЕ	ВИСОКИЙ
Відходи	ВИСОКИЙ	СЕРЕДНІЙ	ВИСОКИЙ
Електропостачання	НИЗЬКЕ	НИЗЬКЕ	НИЗЬКЕ
Газопостачання	НИЗЬКЕ	НИЗЬКЕ	НИЗЬКЕ
Приватний транспорт	НИЗЬКЕ	НИЗЬКЕ	НИЗЬКЕ
Житлові будинки	НИЗЬКЕ	НИЗЬКЕ	СЕРЕДНІЙ

Пріоритети секторів;

Пріоритетність секторів визначається за наступними критеріями:

- ✓ теоретичний потенціал енергетичної ефективності - "Відносна енергетична ефективність"
- ✓ рівень витрат на енергію по секторах
- ✓ рівень контролю міської влади

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

Пріоритетний перехресний сектор

Нижчий пріоритет віддається секторам централізованого теплопостачання, водопостачання та водовідведення через завершені і поточних інвестиційні програми енергоефективності, що фінансуються за рахунок проектів МФО.

Сектор кінцевого споживання енергії, які контролюється 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.

Розгляд поточних і завершених інвестиційних програм і планів

В місті Кам'янця - Подільського на даний час реалізується ряд інвестиційних програм, що фінансуються за рахунок власних ресурсів, а також міжнародних донорських організацій, таких як:
Сектор централізованого теплопостачання:

- Проект КП «Міськтепловоденергія» - будівництво котелень з встановленням когенераційних установок, котелень на біомасі, дистанційне вимірювання витоку
- «Реабілітація та модернізація споруд водопостачання та водовідведення м. Кам'янця - Подільського - 2014», за підтримки IBRD
- Програма реконструкції системи централізованого теплопостачання, на стадії обговорення з IBRD
- Демонстраційний проект DemoUkrainaDH - встановленя індивідуальних теплових пунктів, за підтримки NEFCO та SIDA

Водопостачання та водовідведення:

- Проект "Розвиток міської інфраструктури" - реконструкція енергоємного обладнання системи водопостачання і водовідведення в м. Кам'янці - Подільському, за підтримки IBRD

Компоненти цих інвестиційних програм не розглядатимуться в переліку рекомендацій енергетичної ефективності, тому що вони знаходяться на стадії реалізації та вже узгоджені, але вони будуть давати економію енергії в балансі цільового 2020 року в порівнянні з базовим 2013 роком.

Було розроблено Муніципальний енергетичний план (2012 - 2016 року) та План дій сталого енергетичного розвитку (SEAP), енергоефективних заходи з яких було переглянуто і включено до списку рекомендацій з енергетичної ефективності для подальшої розробки Програми енергоефективної трансформації.

Рекомендації з енергетичної ефективності, які рекомендовано 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 16 одиниці, з яких 10 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 бюджетні будівлі (PB)			
Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних закладів, за рахунок кредитів та часткового фінансування з міського бюджету	Загальна площа - 220 000 м^2. Включає модернізацію фасаду будівель, трубопроводів, при можливості встановлення індивідуальних теплових пунктів.	Приблизно 24 мільйонів доларів США	Щорічна економія 26 ГВт• год економія первинної енергії, і природного газу
Вуличне освітлення (SL)			
Програма проведення аудиту та модернізації системи вуличного освітлення (установка високоефективних чи свотодіодних світильників)	Приблизно 800 ламп (тільки ртутні та лампи розжарювання) Включає освітлення громадських будівель, де це необхідно.	Приблизно 0.5 мільйонів доларів США	Щорічна економія до 0.6 ГВт• год, економія електричної енергії
Тверді побутові відходи (WS)			
Програма технічного обслуговування та модернізації автопарку або підвищення ефективності споживання моторного палива при експлуатації сміттєвозів	Заміна приблизно 10-12 автобусів. Включає також не інвестиційні заходи, тренінги водіїв	0.8 мільйонів доларів	Щорічна економія до1.5 ГВт• год, економія дизелю
Будівництво перевалочних станцій, що включає процеси сортування, та планування інфраструктури поводження з відходами (окремі контейнери)	Будівництво одного об'єкту, потужність необхідно проаналізувати	5-10 мільйонів доларів США	Щорічна економія до 1 ГВт• год, економія дизелю. Можливість отримати додатковий прибуток

В) Довгострокові інвестиційні заходи: термін реалізації 2020- 2025

Назва	Опис	Орієнтовні витрати	Попередня економія
Громадські бюджетні будівлі (PB)			

Переведення системи теплопостачання всіх навчальних та медичних закладів на відновлювальні джерела енергії (ВДЕ) (автономні теплові пункти)	Обмежене застосування, тільки там, відсутня можливість підключення до системи централізованого теплопостачання Включає застосування теплових насосів, біомасу (щепа/пелети), сумісно з РВ - 02	Приблизно 3 - 4 мільйонів доларів США	Щорічна економія 0 до 13 ГВт• год, економія природного газу
Програма приготування гарячої води за рахунок сонячної енергії	(наприклад у лікарнях)	Приблизно 0.3 мільйонів доларів США	Щорічна економія 0 до 0.2 ГВт• год
Побутові відходи (WS)			
Програма вилучення газу з полігону ТПВ та виробництво електричної енергії (зелений тариф) на базі	Встановлення когенераційної установки (потужність 1 МВт) *Детально розглянуто в Програмі трансформації ЕЕ*	До 4 мільйонів доларів США	Щорічна економія 0 до 5 ГВт• год Необхідно проаналізувати
Будівництво біогазової станції, генерація електричної енергії; використання попередньо відібраних біологічних та промислового відходів	Виробництво теплової енергії (державне приватне партнерство)	2 - 4 мільйони доларів США	Необхідно проаналізувати
Громадський транспорт			
Заохочення мешканців до використання громадського транспорту, і,як наслідок, зменшення користуванням приватним транспортом	підвищення привабливості громадського транспорту (інформаційна система, чистота, швидкість, пунктуальність, нові зупиночні комплекси) *Детально розглянуто в Програмі трансформації ЕЕ*	до 0.2 мільйони доларів США	Щорічна економія до 1.2 ГВт• год, економія бензину в секторі приватного транспорту
Заміщення комунальних дизельних автобусів інноваційними	Поетапне змішення гібридними автобусами (дизель/електроенергія)	До 2 мільйонів доларів США	Щорічна економія до 1 ГВт• год, економія дизелю

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

Назва	Опис	Орієнтовні витрати	Попередня економія
Громадські будівлі (РВ)			
Енергетичний аудит та техніко - економічне обґрунтування закладів навчальної, медичної сфери та інших будівель	Аудит 70 -80 будівель	Приблизно 0.3 мільйони доларів США	Відображена у заході РВ - 02/03/04
Муніципальний енергетичний менеджмент			
Розробка та проведення інформаційно-просвітницьких заходів (водопостачання, енергопостачання, зменшення обсягів відходів)	Події, конкурси, нагороди, друковані ЗМІ, медіа-кампаній	0.1 мільйона доларів США щорічно	невизначено

Назва	Опис	Орієнтовні витрати	Попередня економія
Створення в муніципалітеті робочої групи з підвищення енергоефективності інфраструктури міста, впровадження системи моніторингу та верифікацій	Створення муніципального енергетичного агентства Продовження створення робочої групи з енергозбереження	Приблизно. 0.1 мільйон доларів США	невизначено
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	0.1-0.2 мільйонів доларів США	невизначено
Впровадження механізму перформанс-контрактингу, ЕСКО фінансування	Експрес - енергоаудит, тендерні документи	0.05 -0.1 мільйона доларів США щорічно	В результаті впровадження інвестиційних проектів
Планування капітальних вкладень	*Детально розглянуто в Програмі трансформації ЕЕ*	0,05 мільйони доларів США	В результаті впровадження інвестиційних проектів

Наступні заходи не розглядались у якості пріоритетних, оскільки інвестиційні програми все були впроваджені.

Централізоване теплопостачання	Водопостачання та водовідведення
Вже впроваджено: Виявлення протікань у системі централізованого теплопостачання Інвестиційні програми: • Модернізація та будівництво котелень • Встановлення когенераційних установок для покриття споживання електроенергії котельними: дві нові котельні загальною потужністю 42 МВт, з використанням (що найменш частково) біопалива (пелет, щепи) • Установка індивідуальних теплових пунктів та лічильників теплової енергії в житлових будівлях разом із заміною мережних насосів та встановленням приладів частотного регулювання на котельнях • Встановлення когенераційних установок для покриття споживання електроенергії котельними • Заміщення природного газу біопаливом (біомасою) для виробництва теплової енергії • Модернізація мереж централізованого теплопостачання, заміна трубопроводів	80% потенціалу енергетичної ефективності вичерпано попередніми програмами: - Повна реконструкція насосних станцій та заміна 8.0 км. трубопроводів

Матриця рекомендацій з енергетичної ефективності

		Орієнтовні витрати	
		< 1 мільйонів доларів США	**> 1 мільйонів доларів США**
Попередня економія	**< 1 ГВт• год**	• Програма проведення аудиту та модернізації системи вуличного освітлення (установка високоефективних чи свотодіодних світильників) • Програма приготування гарячої води за рахунок сонячної енергії • Заохочення мешканців до використання громадського транспорту, і,як наслідок, зменшення користуванням приватним транспортом • Енергетичний аудит та техніко - економічне обґрунтування закладів навчальної, медичної сфери та інших будівель • 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 • Інструкція з технічних питань, порядку придбання обладнання та послуг і надання пільг • Впровадження механізму перформанс-контрактингу, ЕСКО фінансування • Планування капітальних вкладень	• Будівництво перевалочних станцій, що включає процеси сортування, та планування інфраструктури поводження з відходами (окремі контейнери)
	> 1 ГВт• год	• Програма технічного обслуговування та модернізації автопарку або підвищення ефективності споживання моторного палива при експлуатації сміттєвозів	• Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних закладів, за рахунок кредитів та часткового фінансування з міського бюджету • Переведення системи теплопостачання всіх навчальних та медичних закладів на відновлювальні джерела енергії • Програма вилучення газу з полігону ТПВ та виробництво електричної енергії (зелений тариф) на базі • Будівництво біогазової станції, генерація електричної енергії; використання попередньо відібраних біологічних та промислового відходів

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 money 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 Kamyanets-Podilsky

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 Kamyanetz-Podilsky:

- 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
- Vienna, Austria
- Ukrainian cities of Odessa and Kiev (for limited available benchmark data)

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

The criteria of the size of population has not been applied for the benchmarking, as the size of population of the city of Kamyanets-Podilsky at 0.1 million people ranges at the lower end of the cities of the TRACE database. The number of peer cities would be too small.

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 Kamyanetz-Podilsky have been calculated and aggregated based on data and information received from the City Authority of Kamyanetz-Podilsky 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 satisfactory. Specific data on 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 the 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	102,296
3	Municipal area (same as metropolitan area)	km^2	27.87
2	Population Density	$People/km^2$	3,670
4	Primary Energy Consumption	GWh	1,151.4
5	Primary Electricity consumption	GWh	169
6	Employment rate (official rate in 2013)	%	98 %
7	Human Development Index (HDI)[3]		0.734
8	Total city budget	USD	42,093,135
9	Municipality expenditures for energy in municipal public buildings	USD	4,647,463 11% of budget
10	GDP (2013)[4]	USD	396,690,619

The Economic and political framework for implementation of energy efficiency in the city of Kamyanets-Podilsky 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 Kamyanets-Podilsky 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)	
Primary Energy Consumption per Capita	11,255.8	kWh/capita/annum	Electricity consumption (kWh_e/capita)	1391.07
Primary Electricity Consumption per Capita	1,391	kWh_e/capita/annum	Electricity consumption (kWh_e/GDP)	0.43
Thermal Energy Consumption per Capita	2,121	kWh_T/capita/annum	Primary energy consumption (MJ/capita)	30.29
Primary Energy Consumption per & GDP	2.90	kWh/USD	Primary energy consumption (MJ/GDP)	10.45
Energy Supply Cover	100	%		

The city of Kamyanets-Podilsky ranks high for the performance indicator of Primary Electricity Consumption per capita in comparison with the peer cities with similar level of HDI. The theoretical

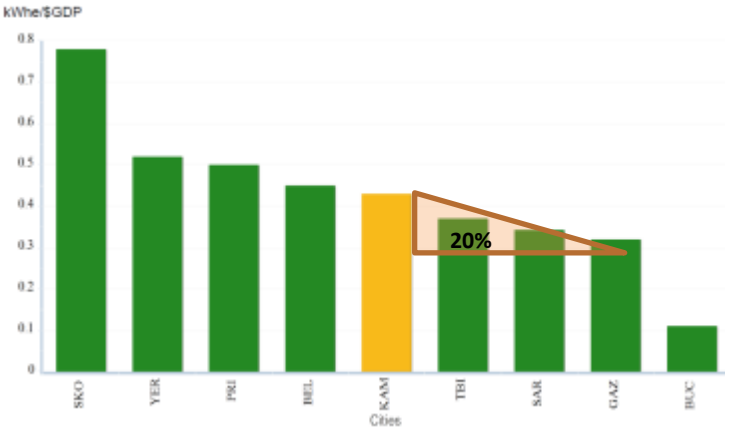
[3] Source: UN Human Development reports; https://hdr.undp.org/en/data; Value for Ukraine 2013

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

Calculated on the basis of Kamenetz-Podolsky region GRP

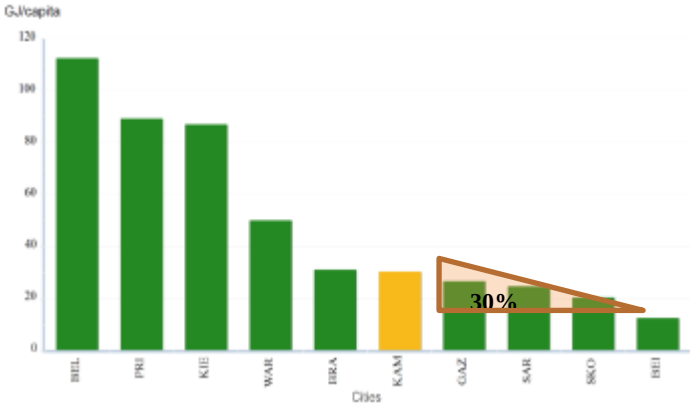
energy saving potential for the city of Kamyanets-Podilsky amounts to less than 10 % to achieve a level of the better performing cities, such as Baku.

Figure 7: Primary Electricity Consumption (kWe / GDP)



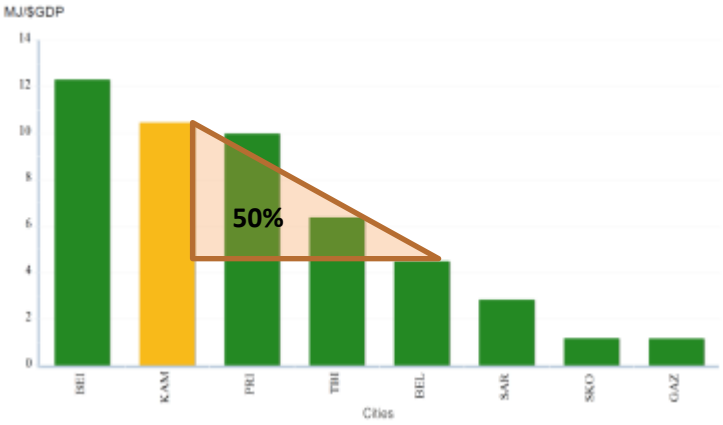
The city of Kamyanets-Podilsky ranks medium for the performance indicator of Primary Electricity Consumption in kWe / GDP in comparison with the peer cities with similar level of HDI. The theoretical energy saving potential for the city of Kamyanets-Podilsky amounts to approximately 20 % to achieve a level of the better performing cities, such as: Tbilisi and Sarajevo.

Figure 8: Primary Energy Consumption (GJ / capita)



The city of Kamyanets-Podilsky 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 Kamyanets-Podilsky amounts to approximately 30 % to achieve a level of the better performing cities, such as: Skopje and Sarajevo.

Figure 9: Primary Energy Consumption (MJ / USD GDP)



The city of Kamyanets-Podilsky 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 Kamyanets-Podilsky amounts to approximately 50 % to achieve a level of the better performing cities, such as: Tbilisi or Belgrade. Reason for this low performance is the low level of economic output of Kamyanets-Podilsky. The improvement of that indicator depends heavily on the GDP development.

3.3 Transportation sector Benchmarking

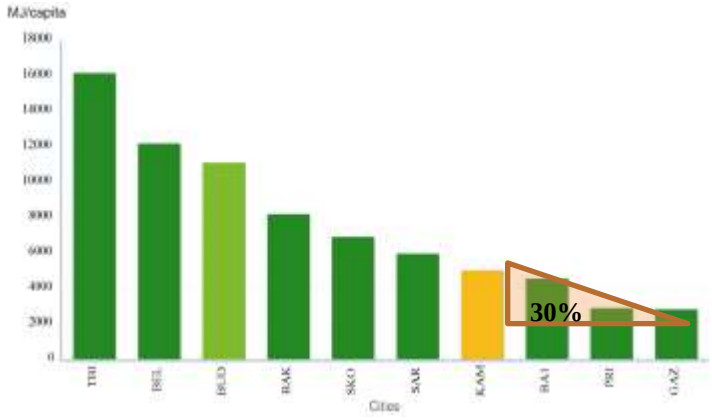
Figure 10: KPI and key data for transport sector

Key Data		Key Performance Indicators (TRACE)	
Public transportation fuel consumption (MJ)	25 363 513		
Private transportation fuel consumption (MJ)	487 743 049	Public Transport Energy Consumption, MJ/passenger km	0.140
Public transportation passenger kilometers	180 630 100	Public Transportation Mode Split, %	40%
Private transportation passenger kilometers	263 385 000	Private Transport Energy Consumption, MJ/passenger km	1.852
Transportation Mode Split (private motorized, public motorized, walk/cycle)	9 buses 188 Shuttle buses (minibuses) 765 taxi 15 009 private transport		

There is no high capacity transit in Kamyanets-Podilsky, such as metro and light rail.

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

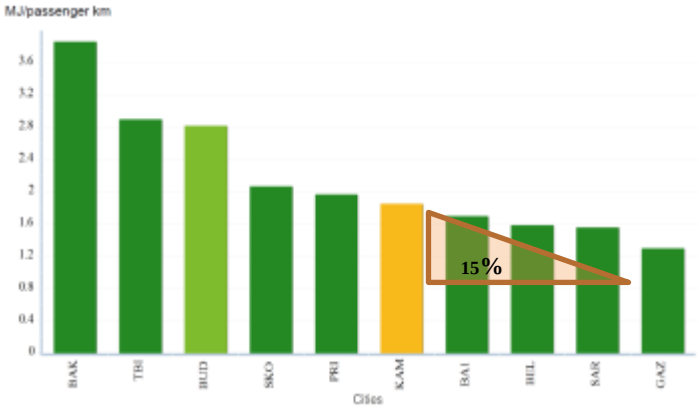
Figure 11: Total Transportation energy use per capita (MJ/capita)



The city of Kamyanets-Podilsky ranks high 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 Kamyanets-Podilsky amounts to approximately 20-30 % to achieve a level of the better performing cities, such as Pristina. However, the geographical extend and economic performance drives the demand of mobility and thus transport energy demand.

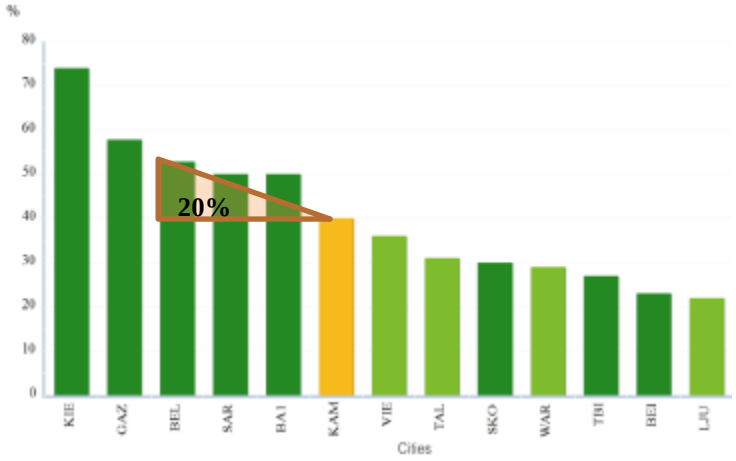
The city of Kamyanets-Podilsky ranks high for the performance indicator of Public Transport MJ / passenger km in comparison with the peer cities with similar characteristic.

Figure 12: Private Transport Energy Consumption MJ / passenger km



The city of Kamyanets-Podilsky ranks high for the performance indicator of Private Transport Energy Consumption MJ / passenger km in comparison with the peer cities with similar characteristic on HDI. The theoretical energy saving potential for the city of Kamyanets-Podilsky amounts to approximately 10-20 % to achieve a level of the better performing cities, such as Sarajevo.

Figure 13: Public transport mode split (%)



The city of Kamyanets-Podilsky ranks medium 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 20% to achieve a level of the better performing cities, such as Belgrade and Sarajevo, at a level of 50%.

The share of non-motorized transport in Kamyanets-Podilsky is low at a level of less than 5% of passenger km.

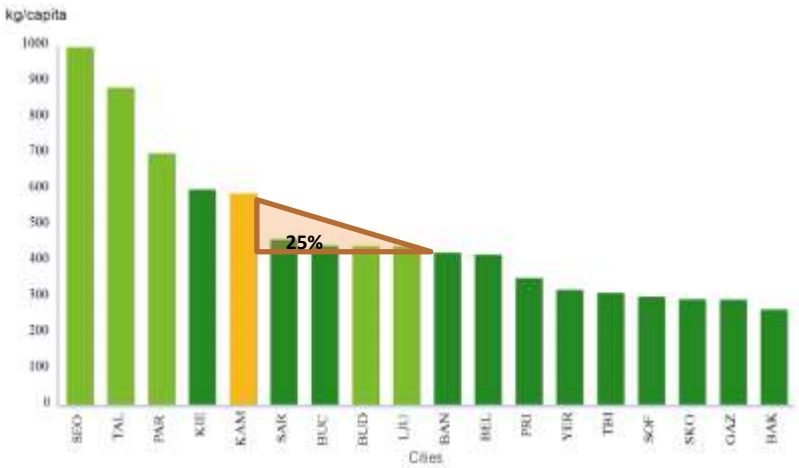
3.4 Solid Waste Sector Benchmarking

Figure 14: KPI and key data for solid waste sector

Key Data		Key Performance Indicators (TRACE)	
Amount of solid waste generated within the municipal boundary (tons)	60 178	Waste per capita (kg/capita)	588.27
Amount of solid waste that is recycled (tons)	720	Capture rate of solid waste	100%
Amount of solid waste that goes to landfill (tons)	59 448	% of solid waste recycled	1.2%
Waste per capita (kg/capita)	588.27	% of solid waste that goes to landfill	98%

The capture of solid waste amounts to almost 100%, which all goes to the landfill. The very low percentage of waste recycled is according to official figures. In fact there is unofficial/illegal collection of recyclable fractions of the municipal waste which is processed for commercial sales.

Figure 15: Waste per Capita (kg / capita)



The city of Kamyanets-Podilsky ranks low 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 Kamyanets-Podilsky amounts to approximately 25 % to achieve a level of the better performing cities, such as: Bucharest and Ljubljana.

3.5 Water & Wastewater Sector Benchmarking

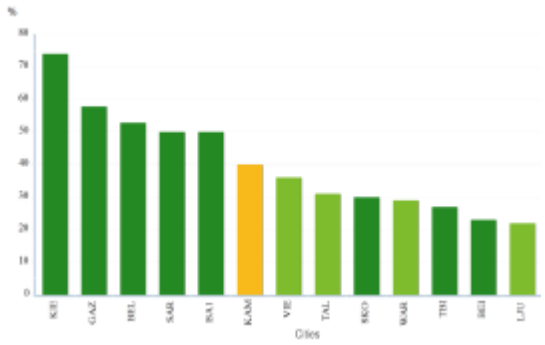
Figure 16: KPI and key data for water and waste water sector

Key Data		Key Performance Indicators (TRACE)	
Total amount of water sold (m^3)	5 597 594	Water consumption L/capita/day	149.92
Energy consumed to produce potable water (kWh_e)	11 132 480		
Total amount of potable water produced (m^3)	8 501 701	Energy density of potable water production (kWhe/m3)	1.31
Energy consumed to treat wastewater (kWh_e)	3 855 540		
Total amount of treated wastewater (m^3)	4 942 465	Energy density of wastewater treatment (kWhe/m3)	5
Energy expenditures of the water utility for potable water and wastewater treatment, $	1 585 624		
Total expenditures of a water utility	5 621 549	Percentage of non revenue water [5]	27.21
Number of households with potable water service	39 486		
Number of households with connection to the public sewage system	33 089	Electricity cost for water treatment (potable- and wastewater) as a percentage of the total water utility expenditures	0.78
Average water rates ($/$m^3$)	0.3		

The water consumption in liter/capita and day ranks at the low end compared with peer cities, which demonstrates a good performance. In Kamyanets-Podilsky a high percentage of supplied potable water is returned to the sewer and a of that 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.

The energy density for potable water production **is the highest** among peer cities. However, this indicator is heavily depending on the availability of water resources and the topography if the city.
Similar observations have been made for the energy density of waste water treatment at the high level of 0,78 kWh per m³. Peer cities with low level of treatment and collection rates have lower energy demand, but high environmental pollution.

Figure 17: Energy costs for water treatment in % of total costs



The electricity cost for water treatment (potable and wastewater) as a Percentage of Total Water Utility Expenditures are at 29% thereby ranking low, i.e. unfavourable, in comparison with peer cities due to the above mentioned situation.

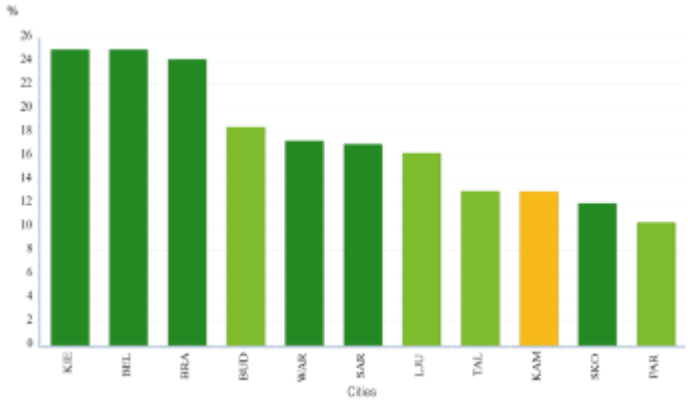
[5] Technical waster losses amount to approximately 30%, but the sewage system collects rain water and waste water from other external sources. The TRACE model lacks precision for this KPI.

3.6 Power & Heat Sector Benchmarking

Figure 18: KPI and key data for power and heat sector

Key Data		Key Performance Indicators (TRACE)	
Technical T&D losses (kWhe)	25 471 692	Percent heat loss from network	13
Non-technical T&D losses (kWhe)	n/a	Percent total T & D losses	15.1
Number of households with authorized electrical service	41 000	Percent of T & D loss due to non-technical	n/a
Total electricity produced (kWh)	168 229 684		

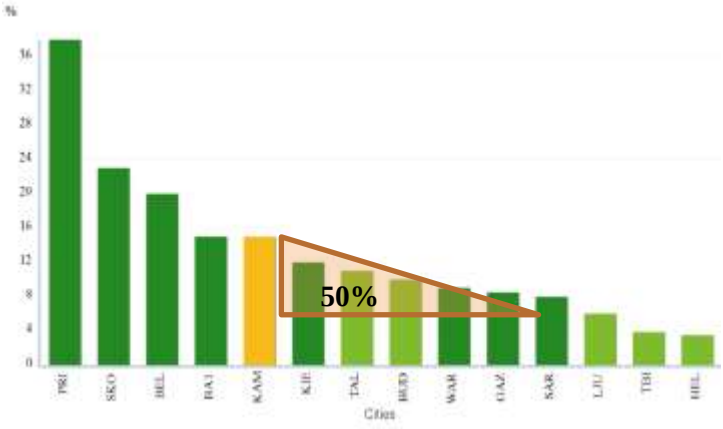
Figure 19: Heat Loss from DH Network in %



The city of Kamyanets-Podilsky ranks high for the performance indicator of Heat Loss from Network in comparison with the peer cities with similar climatic characteristic. A level of 13% heat losses is reported by the DH company and demonstrates, in fact, a good performance. Data for Kamyanets-Podilsky need to be validated in the course of further assessment. However, a reduction of losses by 25% is achievable to reach the level of > 10% as good performing cities in Western Europe.
The data of peer cities are not quite up-dated and seem to contain estimations.

The city of Kamyanets-Podilsky 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 Kamyanets-Podilsky amounts to approximately 40-50 % 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 20: Losses from electricity Transmission & Distribution grid



The Percentage of Losses of the power Transmission & Distribution network due to Non-Technical Losses is in the city of Kamyanets-Podilsky is 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 21: KPI and key data for public lighting sector

Key Data		Key Performance Indicators (TRACE)	
Total electricity consumption of street lights (kWhe)	2 247 747	Electricity consumed per km of lit roads (kWhe/km)	14 846.41
Total length of roads (km)	181	% of city roads lit	83.6
Length of lit roads (km)	151	Electricity consumed per light pole (by light point)	413.19
Number of light poles	5 440		
Total energy expenditure for street lights ($)	111 714		
Average electricity rate for street lights ($/kWh)	0.050		

The specific electricity consumed for Lit Roads in Kamyanets-Podilsky with 15 MWh per km and the specific electricity consumed at 413 kWh per Light Pole are low compared with peer cities. But compared to New York Kamyanets-Podilsky specifically consumes half; compared to cities in Western Europe or developing countries Kamyanets-Podilsky consumes specifically double.

With the availability of new technologies such as LED the energy saving potential for street lighting increases to 40-50%[6]. The percentage of lit city roads is 100%, as reported by the municipal street lighting company.

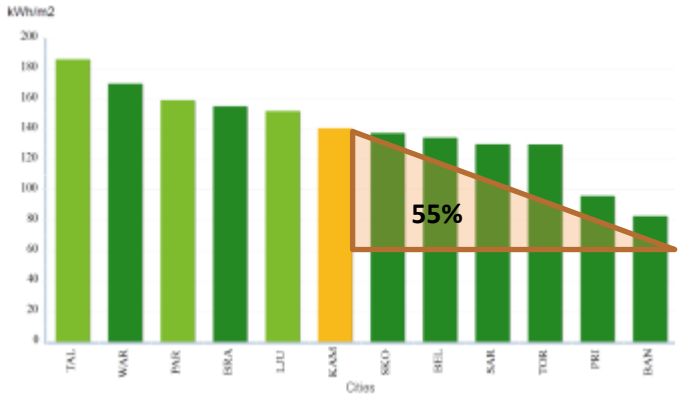
3.8 Municipal Buildings benchmarking

Figure 22: KPI and key data for municipal public buildings sector

Key Data		Key Performance Indicators (TRACE)	
Electricity consumption in municipal buildings (kWhe)	7 004 040	Municipal buildings electricity consumption (kWhe/m2)	31.91
Fuel consumption in municipal buildings (kWht)	30 857 998		
Total energy expenditure for municipal buildings ($)	4 647 463	Municipal buildings fuel consumption (kWht/m2)	140.59
Municipal buildings, floor area (m^2)	219 484		
Municipal buildings, average $/kWh	0.088	Municipal buildings energy spend a percent of municipal budget	11.04
Commercial buildings, average $/kWh	0.112		
Residential buildings, average $/kWh	0.019		

The specific electricity consumption in Municipal Buildings is with approximately 30 kWh per sqm low compared with all peer cities.

***Figure 23**: Municipal Buildings Heat Consumption (kWht / m2)*

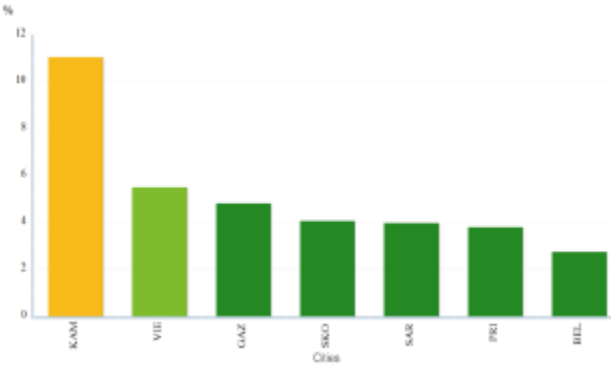


The city of Kamyanets-Podilsky ranks medium to low for the performance indicator of Municipal Buildings Heat Consumption in comparison with the peer cities with similar climatic characteristic. The theoretical energy saving potential for the city of Kamyanets-Podilsky amounts to approximately 50 to 60 % to achieve a level of the better performing cities, such as Banja Luka and Western European cities. The average level of best practice for this indicator of 60 kWh/sqm 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.

[6] 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 11%of the Municipal Budget of Kamyanets-Podilsky. This is very high compared with peer cities. A direct energy saving potential cannot be derived from this indicator as it highly depends on the total budget of the city. For average performing cities in western Europe this indicator is at a level of 2 to 3 %.

Figure 24: Percentage of Municipal Budget spending for energy in municipal buildings



3.9 Summary of Kamyanets-Podilsky 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,

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 comparison 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 also 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	42.1 million USD

City Government Energy Spend

Energy Spending (for sectors: municipal public transport, municipal buildings, street lighting, waste, water and waste water services) in 2013	7.35 million USD
Of which energy spending for municipal buildings	4,65 million USD 11% of budget
Energy Spend as Percentage of Annual Budget	17.5%

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 25: 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	4.65	**50-60%**	56%
Street Lighting	0.11	**30-50%**	32%
District Heating	7.50	**25-30%**	18%
Public Transportation	0.82	**<20%**	6%
Waste	0.19	**25%**	55%
Potable Water	1.1	**30%**	16%
Wastewater	0.49	**30-50%**	
Electricity sector	18.43	8%	0%

The spending for energy in Kamyanets-Podilsky, without the private transport sector, amounted in 2013 to a total 24.9 million USD, including private vehicles 43.4 million USD.

Figure 26: Costs of energy in Kamyanets-Podilsky (in million USD, year 2013, total 43.4million USD)

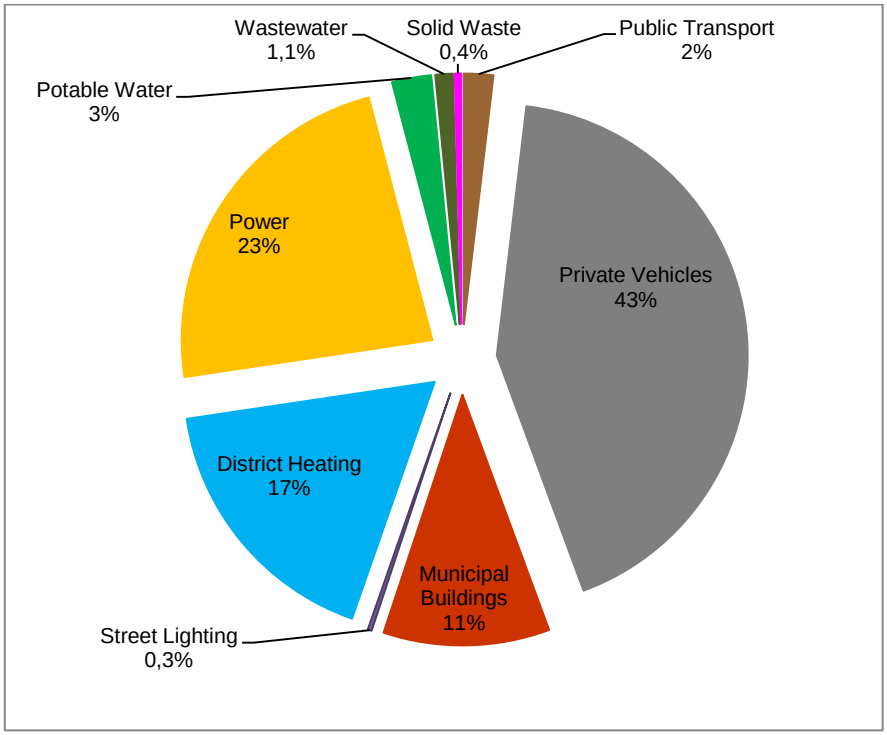
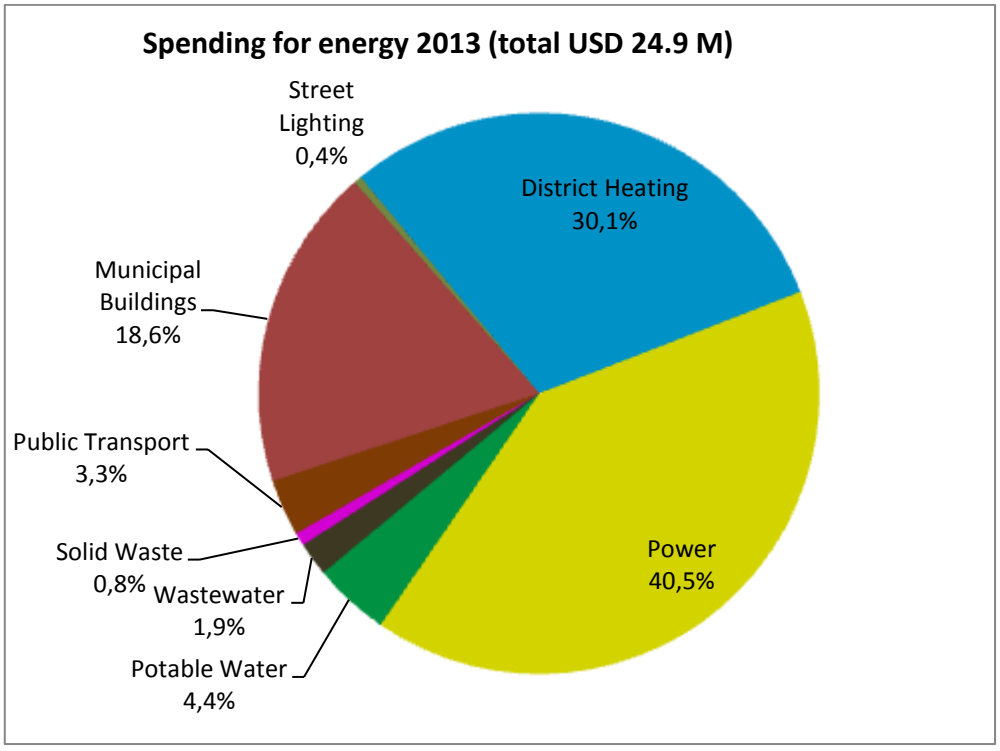


Figure 27: Spending for energy in Kamyanets-Podilsky in 2013, without private transport sector



4.3 City authority level of control, influence and enforcement power

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

Figure 28: Kamyanets-Podilsky 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
District heating	MEDIUM	LOW	HIGH
Public transport	MEDIUM	MEDIUM	MEDIUM
Potable water supply	MEDIUM	LOW	HIGH
Wastewater	MEDIUM	LOW	HIGH
Waste	HIGH	MEDIUM	HIGH
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 and municipal utilities of **water supply and wastewater disposal**, **district heating and waste management.** Only parts of the public transport sector are controlled by the CA, but they can take influence on commercial operators.

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.

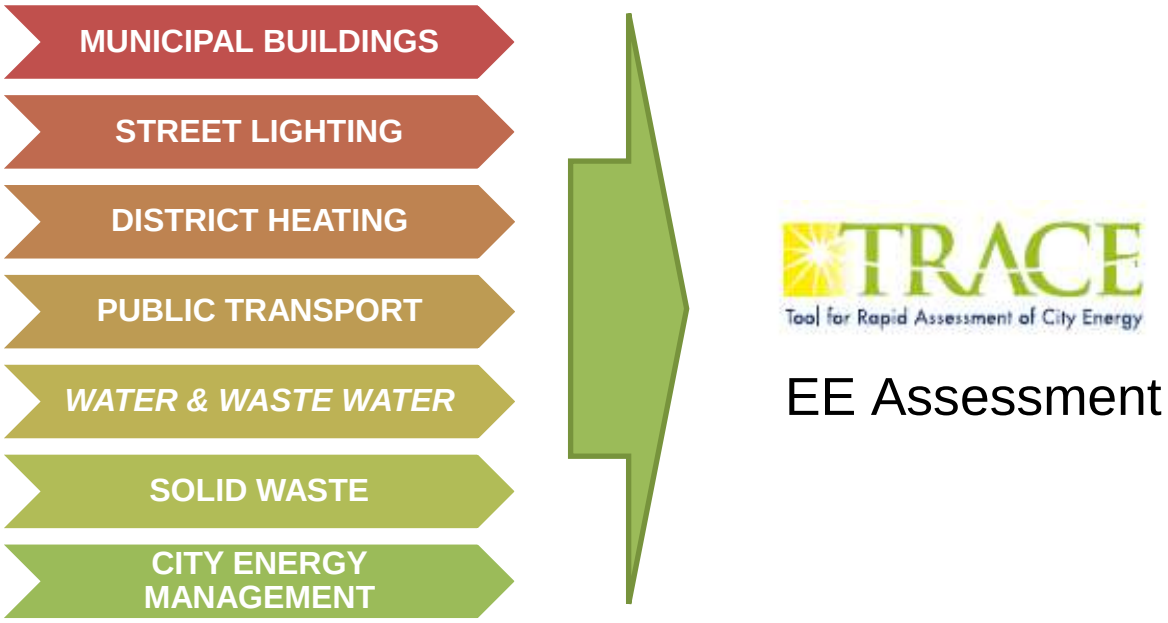
The Municipal Authority of Kamyanets-Podilsky has **limited control** and influence on

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

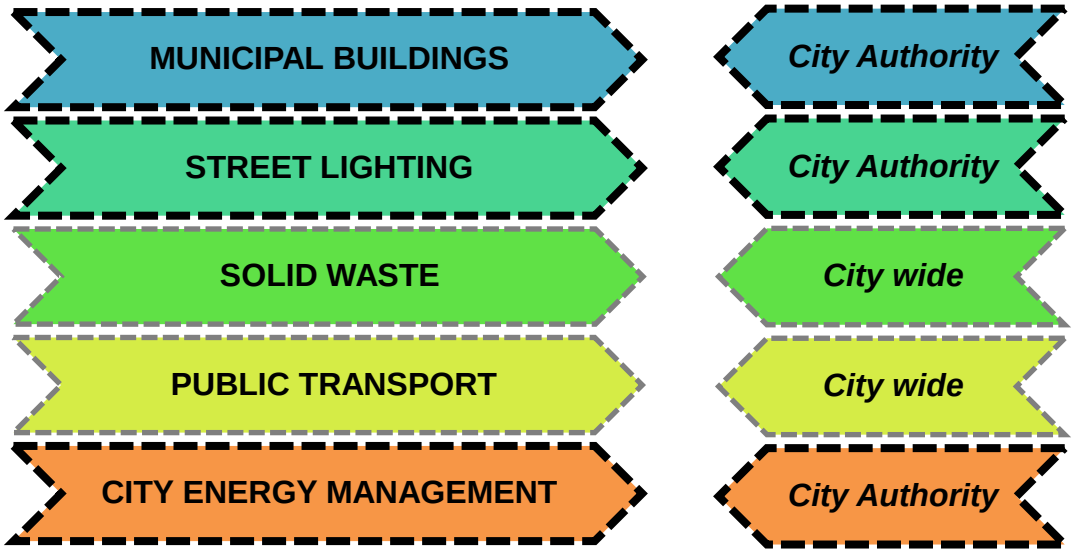
The areas listed below will be the 7 sectors selected for detailed analysis and development of appropriate EE recommendations on the frame of TRACE.



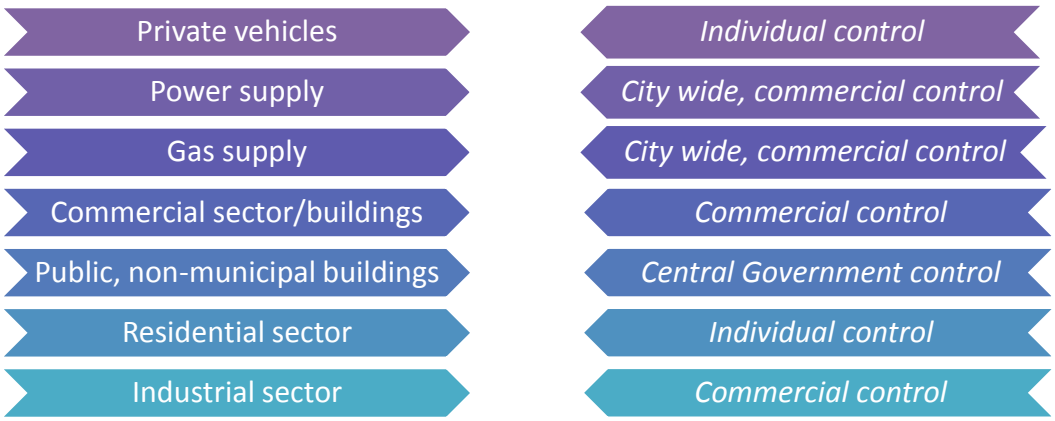
The sector of water and waste water is of high priority, but a large share of EE potential will be explored in the sector due to recently completed and ongoing investment program, financed by IFIs.

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.



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.

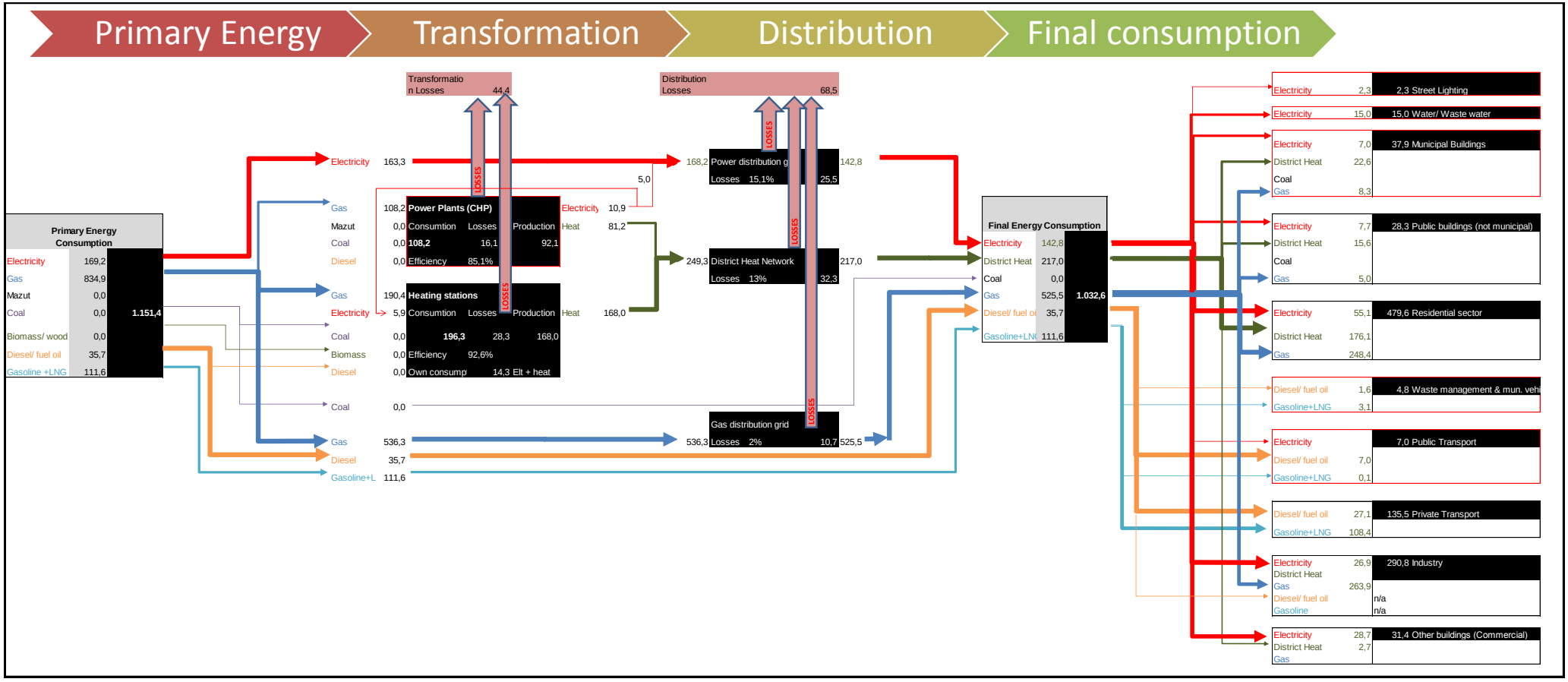
5 Brief Review of Sectors

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

5.1 City wide energy

The Energy balance of Kamyanets-Podilsky has been analyzed for the year 2013 and is presented graphically in a *Sankey* type Energy flow chart. The city controlled reas 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.

Figure 29: Energy balance and Energy flow chart of Kamyanets-Podilsky, 2013 (in GWh)



Kamyanets-Podilsky's primary energy consumption amounts to 1,151 GWh in 2013 with the highest consumption of natural gas of above two thirds. The majority of gas is utilized in boilers of the central heating system and the power plant (CHP) to generate district heat for various end consumers.

Figure 30: Primary energy consumption by energy carrier

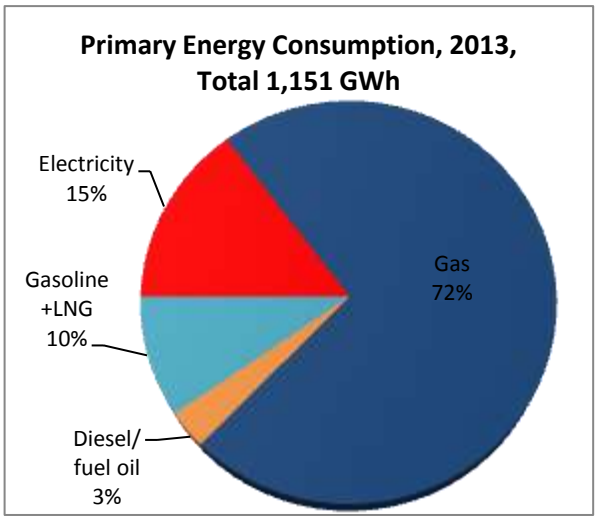
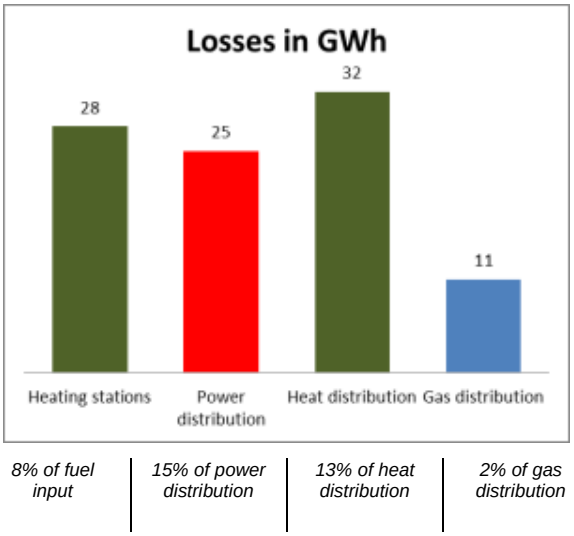


Figure 31: Losses in the energy transformation and distribution



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.

The residential sector is the largest energy consumer with approximately 50 % of the city's **final energy consumption** as it is typical for all Ukrainian cities. This is followed by the industry and commercial sector (including other buildings) of 30 % and private transport sector of 14%.

Figure 32: Final energy consumption by sector in 2013, in GWh

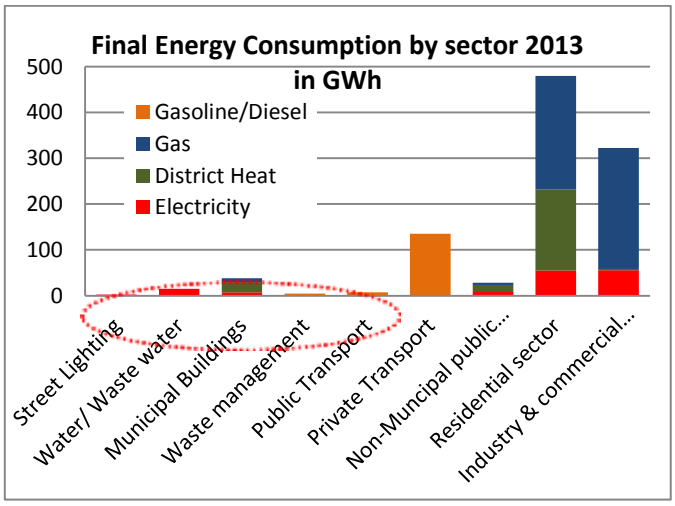
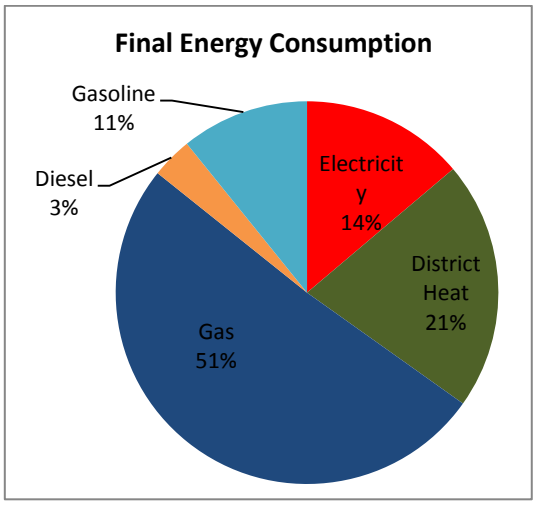


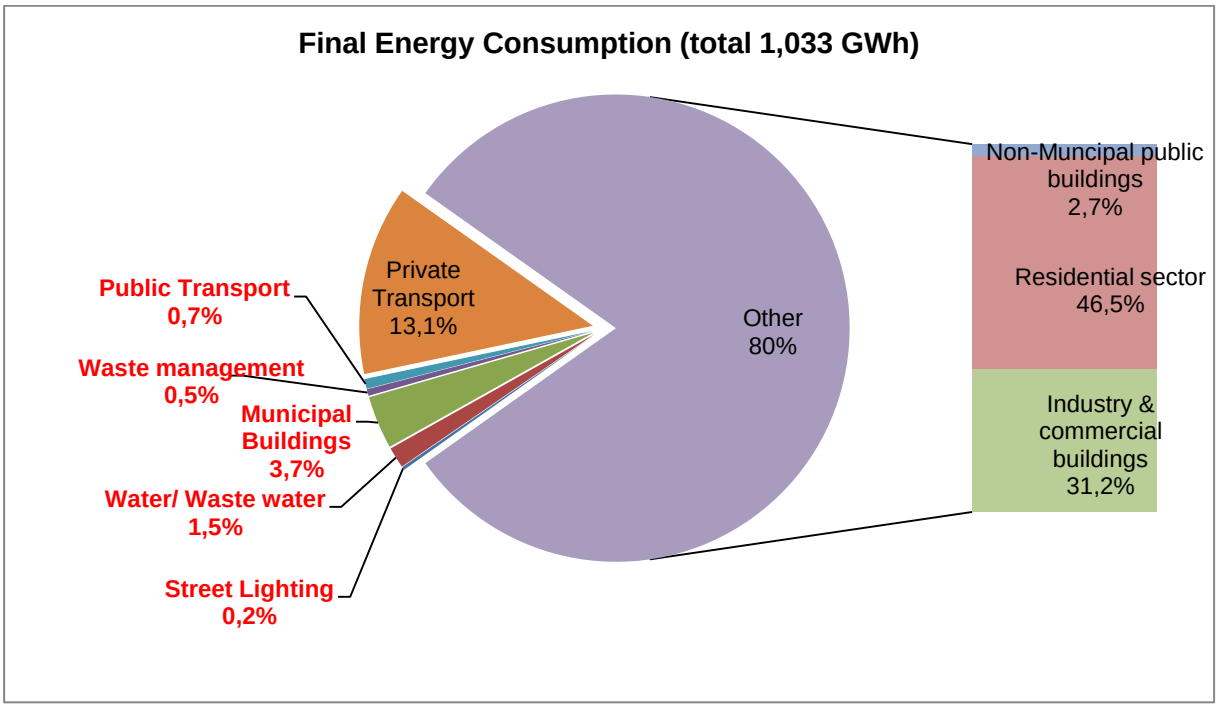
Figure 33: Final energy consumption by energy carrier in %



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

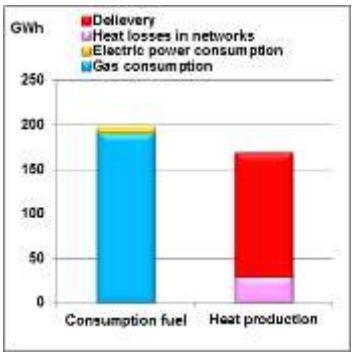
The final energy consumption of the sectors under control and influence of the city administration in 2013 amounted to 67 GWh which represents 6.5 % of the overall city final energy consumption.

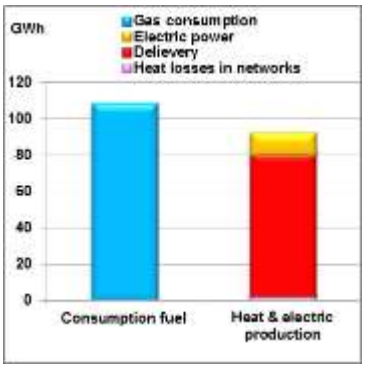
Figure 34: Final energy consumption by sector, 2013



5.2 Heat generation and distribution - city wide

Operators of facilities/ utilities:	The municipal enterprise “Miskteplovodenerhiya” provides space heat and domestic hot water services to customers of the central heating system.
Level of CA control or influence:	The CA as a key shareholder has control over MU "Miskteplovodenerhiya " and maintains influence on operation, performance and financing.
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. The DH company operates 11 boiler-houses, 1 CHP and 1 rented boiler house with a total capacity of 269.788 Gcal/h (313.8 MW). Many boilers are outdated and physically worn out which leads to the reduction to an operational capacity of one third, at a level of 103 Gcal/h. There is a significant excess of installed thermal capacity. The thermal load of the equipment was at 55-65%. Approximately 85% of the boilers have exceeded their operational life time. The CHP produces heat energy and electricity. The design electricity capacity of CHP is 12 MW and thermal capacity is 128 Gcal / h. However, the CHP is in very poor condition – it was built in 1954, and is scheduled to close in 2017. The CHP provides heating service for 50% of consumers. The DH company has the urgent demand to substitute the heat generation capacity of the CHP. The production capacity of the heating company amounts for space heat delivery at 93.372 Gcal/h and for hot water supply 9.628 Gcal/h. The heat networks length is 73 km. The heat losses in the DH network amount to 13%, caused by hydraulic losses, network water losses and heat losses in the pipelines. ***Figure 35: Comparison of fuel consumption and heat energy production*** ***Boiler-houses*** ***CHP***





The specific consumption of natural gas at the CHP station is 165 m^3/ Gcal, which is an indicator of low performance due to the using of the outdated equipment. The specific consumption of natural gas at the boiler houses is 148 m^3 / Gcal.

The electricity consumption for heat production and distribution is with 27.6 kWh/Gcal representing an average to low level of performance. Reasons for the specific electricity consumption are: technically outdated equipment; lack of hydraulic balancing at the consumer sites.

The DH company operates 23 Central Heating Sub-stations (CHS), all of them used for DHW preparation and 43 units of IHS (individual heating sub-stations) at the residential building side to deliver DHW.

Condition of main equipment and EE potential:

The DH network was constructed in the 1970–80 years. As of today 72% of the DH network components are older than 20 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 is partly damaged.

The consumption of space heat supply is metered at 81% of residential customers at building level (in substation, billing is realized according to the share of heated area) and at 95% of public and commercial customers.

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%.

Past, ongoing and planned investment programs:

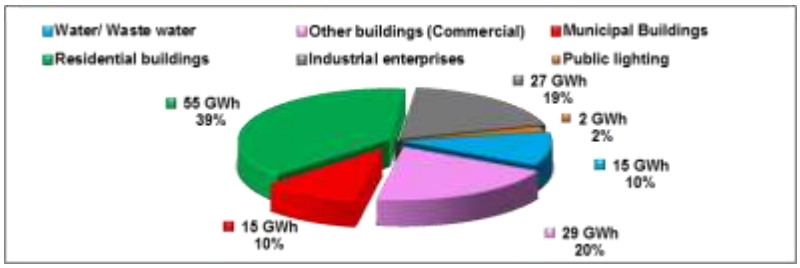
Implemented:

- Remote leakage measuring of the DH system, by own resources of DH company

Investment plans and programs:

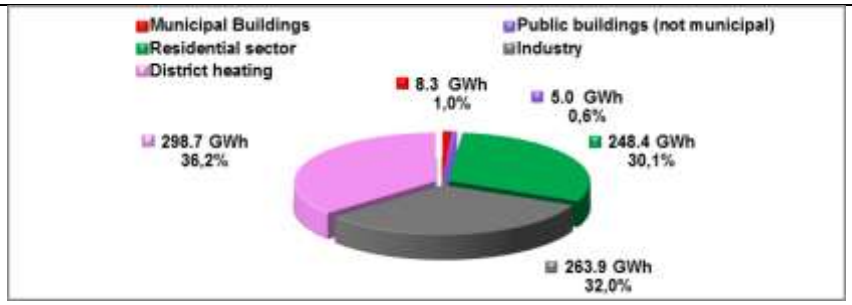
- Heat generation facilities to replace the capacity of the CHP: Two new boiler houses (BH) with total capacity 42 MW intended to operate the BH at least partly by biofuels (wood chips, pellets); 15 M USD loan financing from WorldBank is in discussion;
- New gas-fired CHPs of total capacity 2.2 MW (4 smaller units) to cover own demand of DH company;
- Two new biomass boilers of total capacity 2 MW.
- replacement of DH transmission pipelines;

5.3 Power distribution - city wide

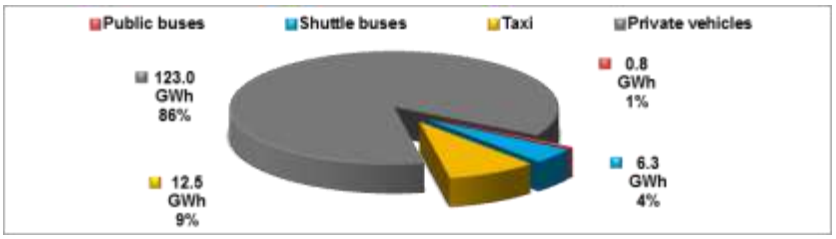
Operators of facilities/ utilities:	Electric power supply is carried out by power utility PJSC "Khmelnitskoblenergo" and their activities comprise electricity purchase, transmission and distribution to consumers of Khmelnitsky region.
Level of CA control or influence:	The power distribution system is not subject of municipal control or the municipal budget. Energy efficiency measures are under the responsibility of PJSC "Khmelnitskoblenergo". 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 Kamyanets-Podilsky was 142.6 GWh. All households are connected and supplied by the power utility. ***Figure 36: Structure of city electricity consumption by consumers groups*** 
Condition of main equipment and EE potential:	In Kamyanets-Podilsky a hydro power station with a capacity of 0.3 MW is located, which is privately owned. Generated electricity is transferred to the national power system operator. In addition there is the above mentioned CHP, owned by ME "Miskteplovodenerhiya". The electricity is used for own needs by ME "Miskteplovodenerhiya." Kamyanets-Podilsky power supply is operated through 4 substations at 110/35/10 kV. The peak power transmission capacity is 49 MW. The technical transmission and distribution losses amount of 25.5 GWh which represents 15% of transmission energy.

5.4 Gas distribution - city wide

Operators of facilities/ utilities:	The gas supply in Kamyanets-Podilsky is provided by Kamyanets-Podilsky branch of the OJSC "Khmelnitskgaz". Allmost all apartments and buildings in Kamyanets-Podilsky are supplied by natural gas, which is mainly used in multi-apartment buildings for cooking and preparation of domestic hot water. Gas supplied to individual houses is used in addition for the individual production of space heat.
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 OJSC "Khmelnitskgaz". The gas distribution tariffs are regulated by the National Commission for State Energy and Public Utilities Regulation of Ukraine.
City energy spent and energy use:	In 2013, the city gas consumption amounted to 87.8 million m^3 (835 GWh). ***Figure 37: Structure of city gas consumption by consumers groups***

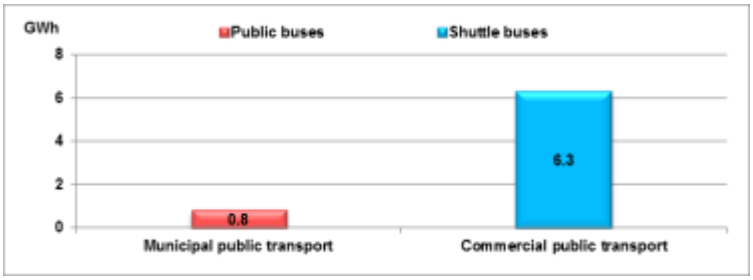
	
Condition of main equipment and EE potential:	OJSC "Khmelnitskgaz" operates 1,390 km of gas pipelines. Based on expert estimation, the technical losses in the gas distribution network of “Khmelnitskgaz” amount to 2%.

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 30% urban public transport, 10% walk and cycling, 60% 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 at 86% the largest consumer of fuel and energy in city transport sector in 2013 . The overall passenger turnover amounts to 444 million passenger km per year. With a total energy consumption of 142.5 GWh per year. The split of energy consumption for all transport is: 24% diesel, 74% gasoline and 1% LPG. ***Figure 38: Share of energy consumption of transport sector***  The total number of registered private vehicles is 15,009 units. The overall level of private, individual motorization in Kamyanets - Podilsky is 147 cars per 1,000 inhabitants.

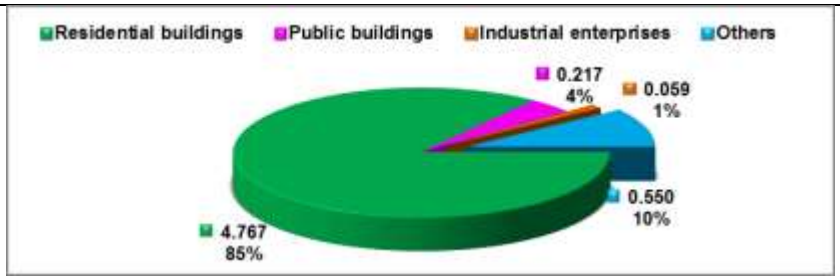
5.6 Public Transport Sector - City wide and City Authority

Operators of facilities/ utilities:	The city public transport service is operated by: • Transport company with the CA as main shareholder: CE "Komuntranservis" • Commercial transport companies: LLC "Trans-Podillya", subsidiary Company "Verona" private enterprise "Podilsky Niva",5 enterprises - legal entities (JSC "ATP 16808", SE "Vyeron", LTD "Auto Service", LLC "Trans – Podillya, MP "Camellia") and 124 private carriers serving the residents on 31 lines (29 private and 5 public).

Level of CA control or influence:	The CA maintains budget control and influence on the municipal public transport company "Komuntranservis". Commercial and private transportation service providers and taxi operators must register their vehicles in accordance with Ukrainian laws, to have a 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 a certain extend to commercial transport companies.
City energy spent and energy use:	In Kamyanets-Podilsky approximately 21 million people (rides) were served by public transport services in 2013 including: municipal buses - < 5%, all other by minibuses. Preferential transportation is provided by all city trolleybuses. The total numbers of inner-urban public transport vehicles comprise 197 units (9 - municipal buses, 188 – shuttle buses/private minibuses). ***Figure 39: City transport fuel and energy consumption (excluding taxis 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 commercial licenses for public transportation companies. 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 municipal utility "Miskteplovodenerhiya ". It is a city wide service to all customer groups. The number of users of potable water (residential, public and commercial) is 90,400 people, for sewerage services – 76,600 people.
Level of CA control or influence:	The CA as a key shareholder has control over "Miskteplovodenerhiya " and maintains influence on operation, performance and financing.
City energy spent and energy use:	Annual water consumption in the city is 5.6 million m³. The actual specific consumption per capita amounts to 148 liters / day. ***Figure 40: The water consumption Structure in the city, million m^3***

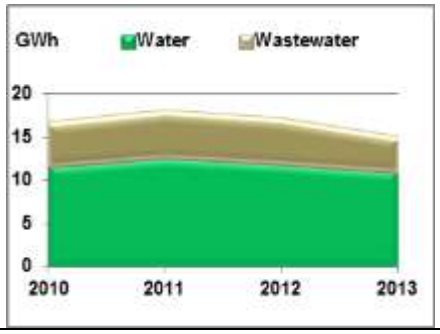


The annual volume of sewage to be treated (including waste water from other sources and collected rain water) is 4.9 million m³.

For the operation purposes of the water supply and wastewater system 15 GWh of electricity have been consumed in 2013, of which 75% for water supply.

Average specific electricity consumption for water supply is 1.31 kWh / m^3 and for wastewater – 0.78 kWh / m^3.

Figure 41: Electricity consumption of MU Miskteplovodenerhiya on water and wastewater service



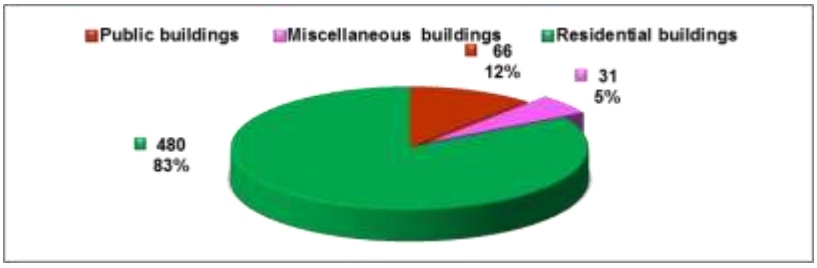
Condition of main equipment and EE potential:	The total length of the water supply network is 342 km. Technical losses in water supply amount to approx. 38%. In 2013 the number of water network leakages was 324. The length of the water supply network that needs to be replaced is 176 km, which is 54% of the total water supply pipeline length. The length of waste water sewage network that need to be replaced is 84 km, which is more than 50% of the total waste water sewage network.
Completed and ongoing investment programs:	The project "Reconstruction of power-consuming equipment of water supply and sanitation" has been almost completed. The project was funded by a USD 5.14 million loan by the IBRD. Components of the project are: full reconstruction of the pumping stations and 8.0 km of new water supply and water treatment pipelines. The installations result in the reduction of technical water losses, a reduction of the number of accidents at the water supply and waste water system and an improvement of the reliability and quality of water. In 2013 energy savings of 21.3% have been achieved. Annual savings amount to about 1.34 GWh at a value of 1.66 million UAH (in 2013).

5.8 Waste management – city wide

Operators of facilities/ utilities:	Solid waste collecting services are operated by municipal enterprise " SpetsKomunTrans",
Level of CA control or	The CA as has limited control over the commercial waste collection

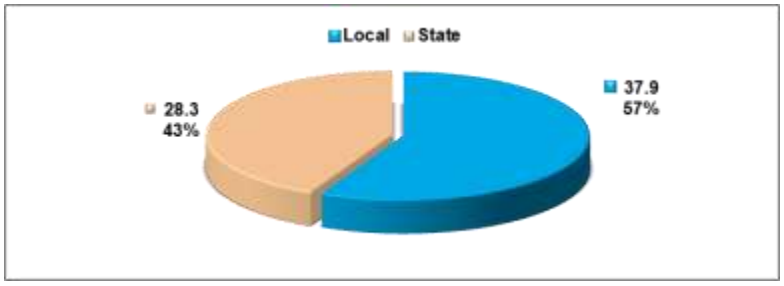
influence:	companies, but maintains full responsibility on the landfill.
City energy spent and energy use:	In Kamyanets-Podilsky there are in total approximately 41,000 entities which generate solid municipal waste, of which 702 are commercial and public, the remaining are households. Total annual solid waste collection in Kamyanets-Podilsky in 2013 is 60,178 tons. A very low percentage of 1.2% of the waste is recycled. Recyclable fragments of the waste volume amount to 60% of a total volume of 36,100 tons, of which plastic is 9 % and biomass is 46 %. Due to lack of waste sorting and a transfer station all waste goes to the landfill, which will reach the absorption capacity in a short period of time. Special vehicles that collect and transport solid waste have consumed 39,010 liters of diesel and 160,740.5 m^3 of liquefied petroleum gas(LPG) in 2013.
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; • implementation of separate waste collection systems in residential sector; • reconstruction of partially completed facilities for sorting waste; • replacement and up-grading of waste collection trucks including driver training; • awareness campaigns for reduction and separation of waste; • analysis of the potential for extraction of landfill gas; • analysis of potential for processing facilities of automobile tires to diesel fuel.
Ongoing initiatives:	The city submitted an application to the Netherlands-Ukrainian sustainable energy platform to participate in the competition for funding feasibility studies on solid waste reuse as an energy source. In 2013 the application was put on the list of projects selected for implementation and now are in an approval process at the Agency (the Ministry of Economy of the Netherlands).

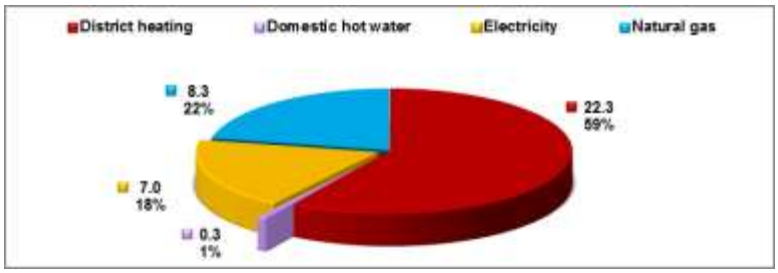
5.9 Building sector – City wide and City Authority

Operators of facilities/ utilities:	The total energy consumption of all buildings in Kamyanets-Podilsky of various types of usage and ownership amounted to 577.2 GWh in 2013, representing 56% of the final city energy consumption.
Level of CA control or influence:	The buildings of the city are the largest final energy consumers, of which 83% 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 42: Energy consumption structure of overall buildings of different ownership, GWh*** 

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.
Past, ongoing and planned investment programs:	Implemented: • Installation of Individual Housing Sub-station (IHS) at 21 large residential building blocks (9 floor apartment buildings), Investment costs 1 M EUR, financed through a NEFCO loan and an E5P grant. • Extension of IHS installation (+ 21 IHS) in cooperation and funding by DemoUkraine Investment plans and programs: installation of IHS at heat transfer points in the buildings, mainly for public buildings Delayed investment program: installation of further 67 IHS due to need of cost/benefit analysis.

5.10 Municipal Buildings - city authority

Operators of facilities/ utilities: Level of CA control or influence:	The operator of the municipal public buildings are the departments of the CA: Department of Health and medical care, Education and Science, Culture and the Arts, Administrative buildings.
City energy spent and energy use:	In Kamyanets-Podilsky there are 114 public municipal buildings with local budget funding with a total area of 219,483 m^2. The largest part of public buildings is occupied by the Department of Education, Youth and Sports buildings at 63% (139,248 m^2) and they have the largest proportion of energy consumption. Municipal budget buildings can be divided into two types of budget funding: central government and municipal buildings. ***Figure 43: Structure of energy consumption of public buildings according to their ownership, GWh***  Municipal budget buildings' fuel and energy consumption covers approx. 7% of the total city buildings consumption. The total amount of heat energy consumed in 2013 by municipal public buildings was 19,149 Gcal. Consumption of electricity in municipal public buildings is high at 18% of the total energy consumption (in 2013 7.0 GWh, which is caused by extensive illumination of historic buildings (this is at the balance of the city department for culture) and electric heating. There is almost no supply of hot water from the district heating network

	for municipal public buildings. The gas consumption for heating and hot water preparation by individual boilers in municipal public building boilers amounted to 8.3 GWh per annum. ***Figure 44: The structure of fuel and energy consumption, GWh***  The specific heating energy consumption is in the range of 130-230 kWh / $m^{2.}$
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.

5.11 Public Lighting – City Authority

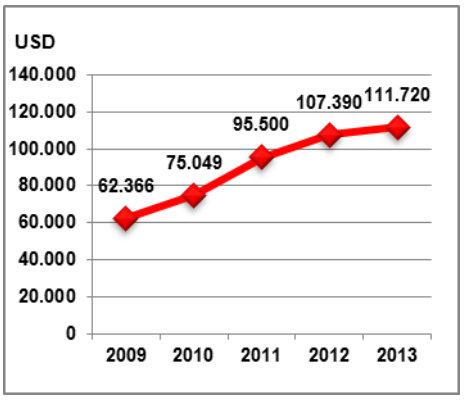
Operators of facilities/ utilities:	Operation, and maintenance of outside city lighting is carried out by municipal enterprise "Misklift-Svitlo". "
Level of CA control or influence:	CE "Misklift-Svitlo" is a legal entity in 100% ownership of the municipality. Thus the CA maintains full control and influence for the public lighting sector. Proper illumination of streets and parks is an important issue for the tourism branch of the city.
City energy spent and energy use:	The total volume of electricity consumption SCE "Misklift-Svitlo" in 2013 was 2.33 GWh. The electricity consumption for street lighting during 2009 -2013 has been quite stable, while the costs for energy in the same period have almost doubled. ***Figure 45: Annual costs for street lighting*** 
Condition of main equipment and EE potential:	For street lighting mainly incandescent lamps, arc mercury fluorescent lamps, and sodium-vapor tube and some LED lamps are used. Currently 86 % of installed bulbs are efficient high-pressure sodium-vapor energy saving and some LED bulbs. The operation hours of the street lighting are 3,872 h/year.

Figure 46: Composition of street lighting by type and number of lamps

Light bulbs type	Average capacity of light point (W)	Number of light points
Sodium lamp arc tube	100	2 550
Sodium lamp arc tube	150	1 800
Sodium lamp arc tube	70	100
Arc mercury fluorescent lamps	400	*Not working 530*
Metal Halide Bulbs	150	200
Energy saving lamps	36	360
LED lamps	12	401
LED lamps with fixtures	72	29
Total		**5 440**

The frequency for the replacement of conventional bulbs is 3 to 4 years. The annual cost for replacement and maintenance of conventional bulbs (equipment + installation) amounts to USD 103,400.

There is a need to replace the arc mercury and metal halide lamps.

6 Energy Efficiency Recommendations

6.1 Methodology for evaluation, selection and ranking of EE measures

The long-list of recommendations for energy efficiency originate from various sources in the course of the compilation of data, information, 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 **SEAP and Municipal Energy Plan** of the city of Kamyanets-Podilsky,
- recommended EE measures which have been identified during **interviews with city administration and local stakeholders, utilitie**s,
- **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, NEFCO, DemoUkraina) 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 73 EE recommendations has been identified and preliminarily evaluated on their appropriateness. Those include also EE recommendations in the sectors which 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) 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 from further consideration.
The Recommended EE measures are of **different types**:

- **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 and which are 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	Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	I-Investment	139 248 sqm including building shell, IHS, piping (no EE in electricity consumption)
PB-02	Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals)	I-Investment	Heat pumps and biomass (woodchips/pellets) alongside with PB-03, PB-06
PB-03	Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	I-Investment	57 087 sqm including building shell, IHS, piping (no EE in electricity consumption)
PB-04	Municipal administrative buildings Audit and Retrofit Program	I-Investment	12 912 sqm including building shell, IHS, piping (no EE in electricity consumption)
PB-05	Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	I-Investment	10 237 sqm including building shell, IHS, piping (no EE in electricity consumption)
PB-06	Replacement of kitchen equipment for all municipal public buildings	I-Investment	
PB-07	Solar Hot Water Program	I-Investment	
PB-08	Municipal Building Inventory and Benchmarking and Monitoring Program	P-Preparation	
PB-09	Mandatory Building Energy Efficiency Codes for Existing Buildings	A-Accompanying	

There are no considerable EE investment programs on-going 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 into the following indicators. A first ranking of the EE measure has been undertaken on the highest energy saving potential.

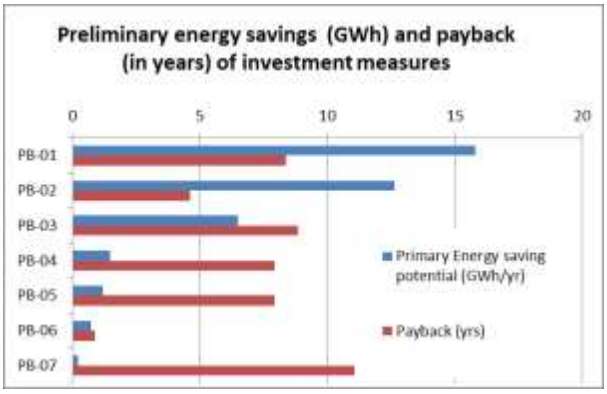
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Saving of energy carrier	Emission saving (kt CO2/a)	Preliminary payback time (years)
PB-01	Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	16,29	15,80	Primary-gas	3,19	8,37
PB-02	Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals)	3,58	12,62	Primary-gas	2,55	4,60
PB-03	Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	7,05	6,48	Primary-gas	1,31	8,84
PB-04	Municipal administrative buildings Audit and Retrofit Program	1,43	1,46	Primary-gas	0,30	7,91
PB-05	Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	1,13	1,16	Primary-gas	0,23	7,91
PB-06	Replacement of kitchen equipment for all municipal public buildings	0,14	0,70	Primary-electricity	0,76	0,85
PB-07	Solar Hot Water Program	0,32	0,21	Primary-gas	0,04	12,56
PB-08	Municipal Building Inventory and Benchmarking and Monitoring Program	0,01	0,19	all Final energy of the sector	0,07	0,26
PB-09	Mandatory Building Energy Efficiency Codes for Existing Buildings	0,01		Primary-gas		n/a

[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:

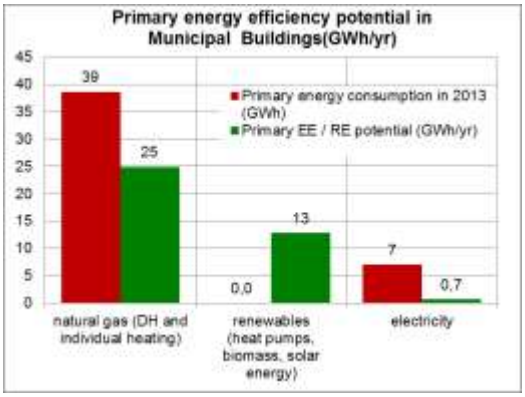
- Municipal Building Energy Efficiency Task Force, as it shall be included in the Energy Management sector
- Municipal Residential building Audit and Retrofit Program; as there are no considerable municipally owned residential buildings
- Computer PowerSave Project, not appropriate
- Green Building Guidelines for New Municipal Buildings, due to limited number of new construction expected
- Replacement of indoor lighting for all municipal public buildings (incandescent bulbs and T5 with reflector of LED)

Figure 47: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) and payback time of recommended EE measures

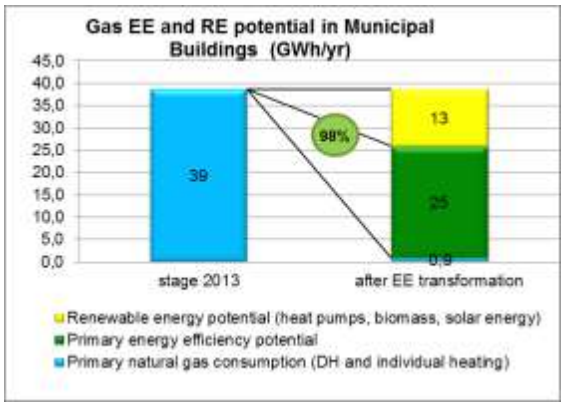
Primary energy savings and payback time by EE measures



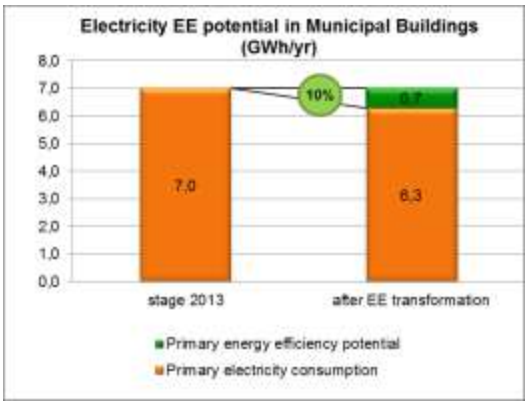
Primary energy savings by type of energy and RE



Potential gas savings by EE and RE



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 16 GWh per year. A similar level of 12.5 GWh 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:

Code	Title of EE recommendation	Implementation perspective	Possible start in	Implementation Speed (years)
PB-01	Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.)	long-term	2016	3 years
PB-02	Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals)	short-term	2017	2 years
PB-03	Municipal medical facilities Audit and Retrofit Program (hospitals, policlinics, etc.)	long-term	2017	3 years
PB-04	Municipal administrative buildings Audit and Retrofit Program	long-term	2016	2 years
PB-05	Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.)	long-term	2017	2 years
PB-06	Replacement of kitchen equipment for all municipal public buildings	long-term	2017	3 years
PB-07	Solar Hot Water Program	short-term	2016	2 years
PB-08	Municipal Building Inventory and Benchmarking and Monitoring Program	short-term	2016	2 years
PB-09	Mandatory Building Energy Efficiency Codes for Existing and New Buildings	long-term	2016	3 years

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
- The directors of the facility
- The users of the facility
- Municipal company “Miskteplovodenerhiya”

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.

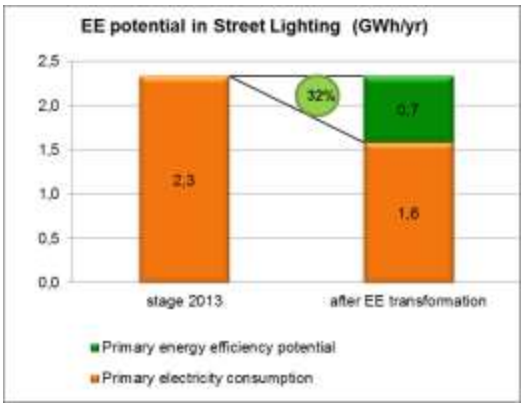
Code	Title of measure	Type	Comment/ additional information
SL-01	Street Lighting Audit and Retrofit Program (replacement with LED)	I-Investment	including public space lighting on demand replacement of remaining mercury and metal halide bulbs (on demand also HP sodium vapor)
SL-02	Procurement Guide for 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.[8]

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)	1,46	0,74	Primary-electricity	1-2
SL-02	Procurement Guide for New Street Lights	0,00	0,00	Primary-electricity	

Figure 48: Preliminarily calculated Primary energy saving potential of recommended EE measures



[8] 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
- Traffic Signal Audit and Retrofit Program, limited market
- 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, limited market

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
SL-01	Street Lighting Audit and Retrofit Program (replacement with LED)	short-term	2016	2 years
SL-02	Procurement Guide for New Street Lights	short-term	2016	2 years

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 special municipal enterprise "Misklift-Svitlo"
- Cooperation with the power utility PJSC "Khmelnitskoblenergo" 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	Fuel switch for heat generation - gas to biomass	I-Investment	biomass boilers of 8 MW total heat capacity (not included in IBRD Project)
DH-02	Boiler Houses construction and rehabilitation	I-Investment	i) construction of 2 BHs (Крип'якевича,3 та Поліклініка); ii)rehabilitation of 3 BHs (Жукова,2, Тімірязєва,123, Кн.Коріатовичів,56)
DH-03	Individual heat substation and Heat meter installation	I-Investment	82 residential buildings
DH-04	Installation of cogeneration plant for coverage of own consumption	I-Investment	mini-CHP unit of 1,4 MWe at Крип'якевича boiler house
DH-05	Individual heat substation and Heat meter installation in residential houses alongside with Replacement of circuit pump and equipment with VSD at Boiler-house	I-Investment	21 residential buildings
DH-06	Implementation of SCADA system	I-Investment	connection of 3 rehabilitated BHs and 2 newly constructed BHs to SCADA
DH-07	District heating network rehabilitation, pipeline replacement	I-Investment	IBRD Project: replacement of 2,8 km of distribution and transmission pipeline system

On-going EE investment programs funded by IBRD in the sector are covering DH 01, DH – 02, DH-07.

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.

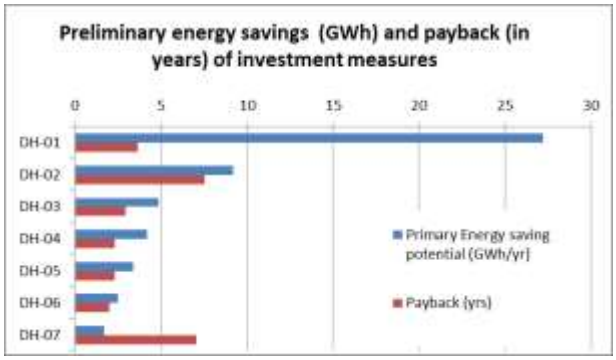
[9] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- District heating network rehabilitation, pipeline insulation and maintenance, as the remaining pipeline system of 82% of distribution and transmission is presumed to show good performance.

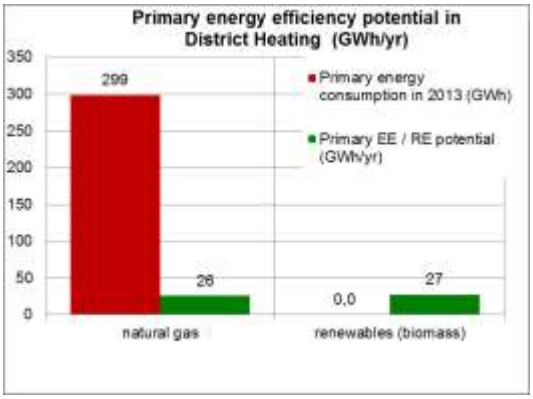
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Saving of energy carrier	Emission saving (t CO2/a)	Preliminary payback time (years)
DH-01	Fuel switch for heat generation - gas to biomass	7,00	27,20	Primary-gas	5,49	3,65
DH-02	Boiler Houses construction and rehabilitation	9,76	9,17	Primary-gas	1,85	7,54
DH-03	Individual heat substation and Heat meter installation	2,00	4,85	Primary-gas	0,98	2,92
DH-04	Installation of cogeneration plant for coverage of own consumption	1,61	4,20	Electricity generated by CHP, primary gas saving	2,29	2,31
DH-05	Individual heat substation and Heat meter installation in residential houses alongside with of circuit pump and equipment with VSD at Boiler-house	1,10	3,38	Electricity generated by CHP, primary gas saving	0,68	2,30
DH-06	Implementation of SCADA system	0,69	2,47	Primary-gas	0,50	1,98
DH-07	District heating network rehabilitation, pipeline replacement	1,67	1,69	Primary-gas	0,34	7,03

Figure 49: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) and payback time of recommended EE measures

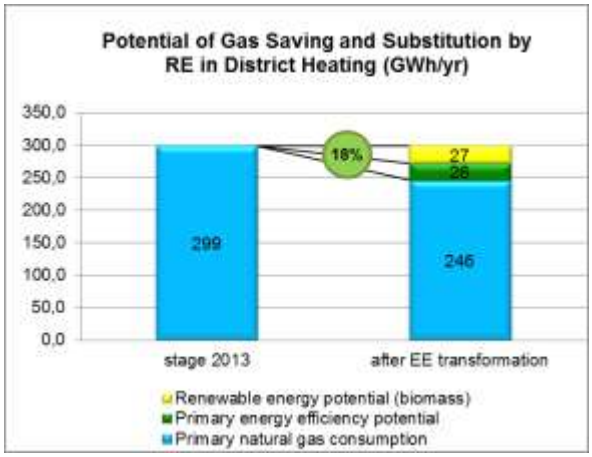
Primary energy savings and payback time by EE measures



Primary energy savings by type of energy and RE



Potential gas savings



Potential electricity savings by measure DH-04 and DH 05 amount to approx. 7 GWh. This is secondary energy as it is produced by CHP (existing and newly planned). The primary energy saving will be gas (considered in gas EE).

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
DH-01	Fuel switch for heat generation - gas to biomass	short-term	2016	2 years
DH-02	Boiler Houses construction and rehabilitation	short-term	2016	2 years
DH-03	Individual heat substation and Heat meter installation	long-term	2016	3 years
DH-04	Installation of cogeneration plant for coverage of own consumption	short-term	2016	2 years
DH-05	Individual heat substation and Heat meter installation in residential houses alongside with Replacement of circuit pump and equipment with VSD at Boiler-house	short-term	2016	1 year
DH-06	Implementation of SCADA system	short-term	2017	2 years
DH-07	District heating network rehabilitation, pipeline replacement	short-term	2016	2 years

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

- Municipal company “Miskteplovodenerhiya”

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	Public Transportation Development with innovative vehicles (e.g. electric buses)	I-Investment	in addition to existing municipal bus routes or new ones
TM-02	Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	I-Investment	
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 private bus operators	P-Preparation	set limits for vehicle emissions (private mini-busses) for the granting of new operation licenses

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.

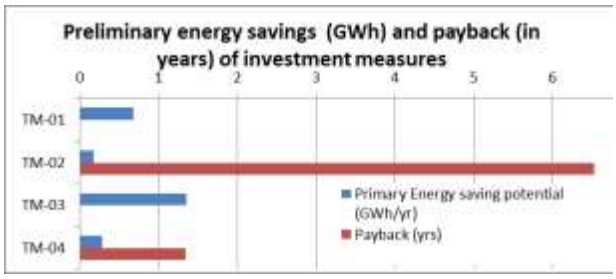
[10] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- Municipal Vehicle Fleet Efficiency Program, as there is the very low number of such very specialized vehicles
- Car parking Management
- Traffic Flow Optimization
- Traffic Restraint Measures
- Travel Planning

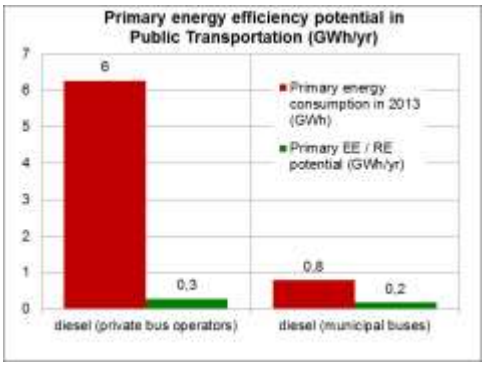
Code	Title of EE recommendation	Investment costs (M USD)	Primary EE (GWh/a)	Saving of energy carrier	Emission saving (t CO2/a)	Preliminary payback time (years)
TM-01	Public Transportation Development with innovative vehicles (e.g. electric buses)	1,63	0,68	Gasoline	0,17	
TM-02	Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	0,24	0,17	Diesel	0,04	6,53
TM-03	Promotion of Public Transport	0,20	1,35	Gasoline	0,34	
TM-04	Vehicle Emissions Standards for private bus operators	0,08	0,28	Diesel	0,08	1,34

Figure 50: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) and payback time of recommended EE measures

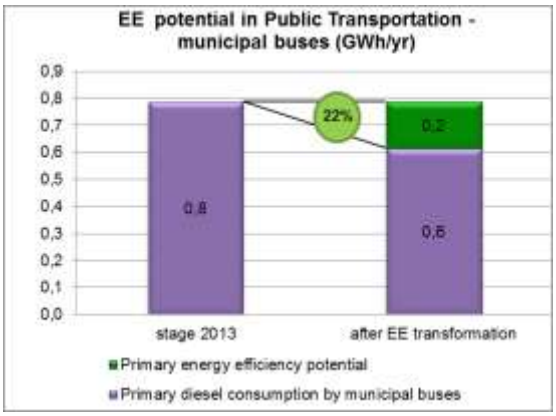
Primary energy savings and payback time by EE measures



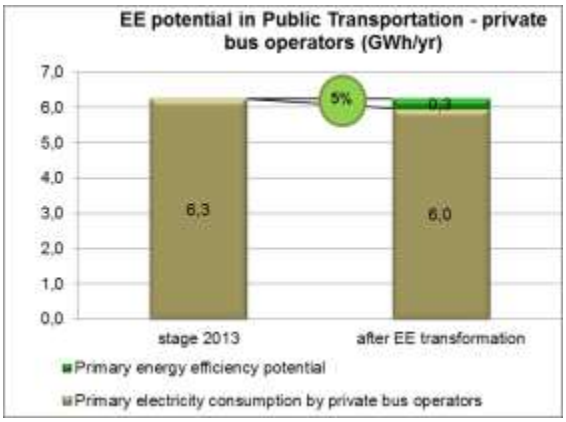
Primary energy savings by type of energy and RE



Potential diesel savings



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	Public Transportation Development with innovative vehicles (e.g. electric buses)	long-term	2020	> 4 years
TM-02	Replacement of municipal diesel bus fleet to hybrid (diesel/electric)	long-term	2020	> 4 years
TM-03	Promotion of Public Transport	Long-term	2020	> 4 years
TM-04	Vehicle Emissions Standards for private bus operators	long-term	2019	3 years

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

- Transport company with the CA as main shareholder CE "Komuntranservis"

- Commercial transport companies: LLC "Trans-Podillya", subsidiary Company "Verona" private enterprise "Podilsky Niva",5 enterprises - legal entities (JSC "ATP 16808", SE "Vyeron", LTD "Auto Service", LLC "Trans –Podillya, MP "Camellia")

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.

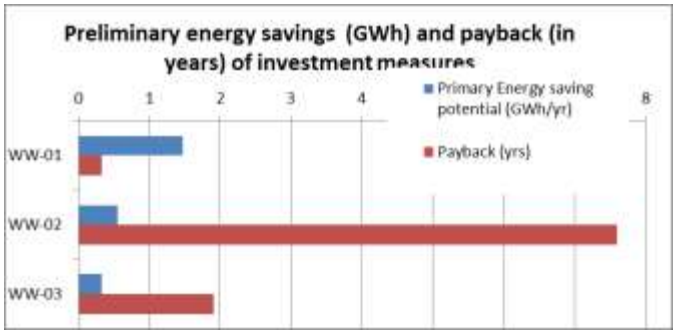
Code	Title of measure	Type
WW-01	Improve Efficiency of Fans and Motors at WWTP	I-Investment
WW-02	Active Leak Detection and Pressure Management Programme for potable water system	I-Investment
WW-03	Improve Performance of System Networks	I-Investment

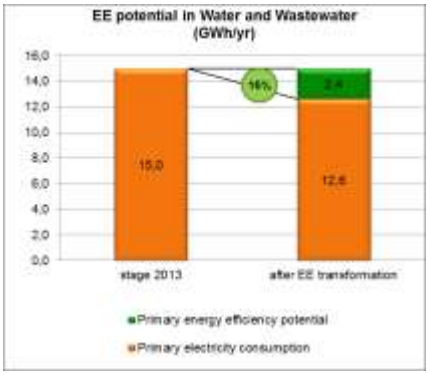
The above measure WW-01 and WW-03 are widely covered by the “Reconstruction of power-consuming equipment of water supply and sanitation" funded by IBRD and completed in 2014/15

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)	Saving of energy carrier	Emission saving (t CO2/a)	Preliminary payback time (years)
WW-01	Improve Efficiency of Fans and Motors at WWTP	0,12	1,47	Primary-electricity	1,61	0,33
WW-02	Active Leak Detection and Pressure Management Programme for potable water system	1,00	0,56	Primary-electricity	0,61	7,59
WW-03	Improve Performance of System Networks	0,15	0,33	Primary-electricity	0,36	1,91

Figure 51: 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
- Use of waste water sludge for production of biogas
- Educational Measures, included in EM
- Water Efficient Fixtures and Fittings
- Water Meter Programme (individual at end consumer side)
- 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	Possible start in	Speed of Implementation, years
WW-01	Improve Efficiency of Fans and Motors at WWTP	short-term	2016	1 year
WW-02	Active Leak Detection and Pressure Management Programme for potable water system	long-term	2017	3 years
WW-03	Improve Performance of System Networks	short-term	2016	1 year

The key stakeholder for the implementation of the recommended EE measures in this sector the municipal enterprise "Miskteplovodenerhiya "

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	Including CHP for generation own power (assumed 1 MW)
WS-02	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	I-Investment	10 units and 2 new units
WS-03	Intermediate Transfer Stations including sorting and recycling, including composting station	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)	A-Accompanying	

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]
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)
WS-01	Landfill Gas Capture Program	3,50	5,00
WS-02	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	0,60	1,43
WS-03	Intermediate Transfer Stations including sorting and recycling, including composting station	6,00	1,19
WS-04	Fuel Efficient Waste Vehicle Operations	0,01	0,02
WS-05	Waste Infrastructure Planning (connected to landfill site, containers)	0,25	0,00

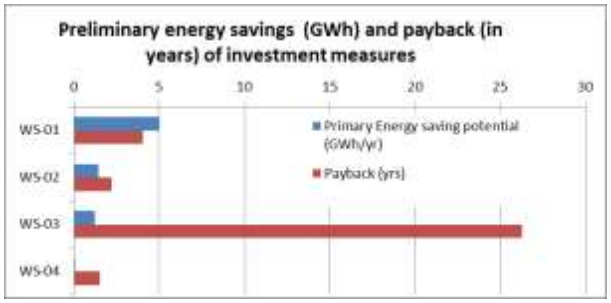
[12] TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- 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, not appropriate
- Waste Collection Route Optimization shall be included in infrastructure planning

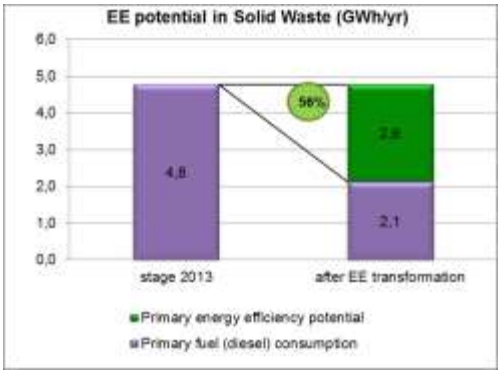
Energy savings will mainly be realized on diesel fuel.

Figure 52: Preliminarily 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	Possible start in	Speed of Implementation, years
WS-01	Landfill Gas Capture Program	long-term	2017	3 years
WS-02	Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program	short-term	2017	2 years
WS-03	Intermediate Transfer Stations including sorting and recycling, including composting station	short-term	2016	2 years
WS-04	Fuel Efficient Waste Vehicle Operations	short-term	2016	1 year
WS-05	Waste Infrastructure Planning (connected to landfill site, containers)	short-term	2016	1 year

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

- The CA,
- municipal enterprise " SpetsKomunTrans".

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	Purchasing and service contracts	P-Preparation	procurement including life-cycle cost assessment
EM-05	Energy Performance contracting	P-Preparation	focus on street lighting and municipal buildings
EM-06	EE Strategy and investment plan	P-Preparation	including EE assessment
EM-07	Capital investment planning	P-Preparation	Preparation of pipeline for EE investments, financial structuring and fund raising

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	0,08
EM-02	Capacity building programs	0,10

Code	Title of EE recommendation	Investment costs (M USD)
EM-03	EE Municipal task force	0,09
EM-04	Purchasing and service contracts	0,01
EM-05	Energy Performance contracting	0,05
EM-06	EE Strategy and investment plan	0,02
EM-07	Capital investment planning	0,05

It is assumed, that awareness raising measures for municipal energy management result in saving at all final energy consumers (including residential sector), while the majority of EM measures will focus on the reduction of energy consumption in the sectors of municipal control.

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

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

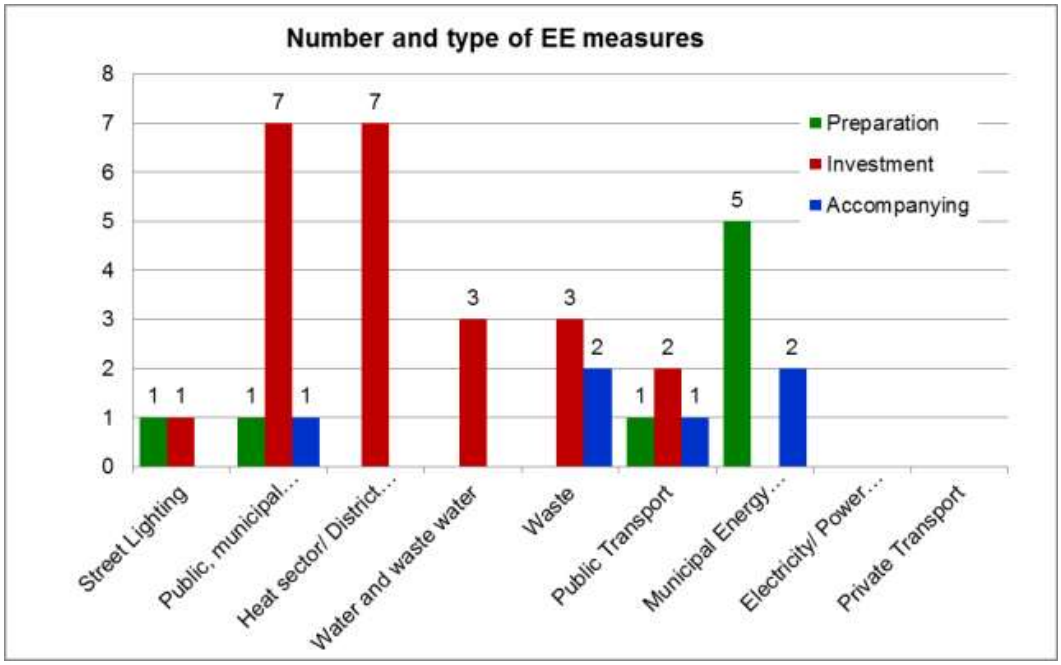
The key stakeholders for implementation of the recommended EE measures in this sector are:

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

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

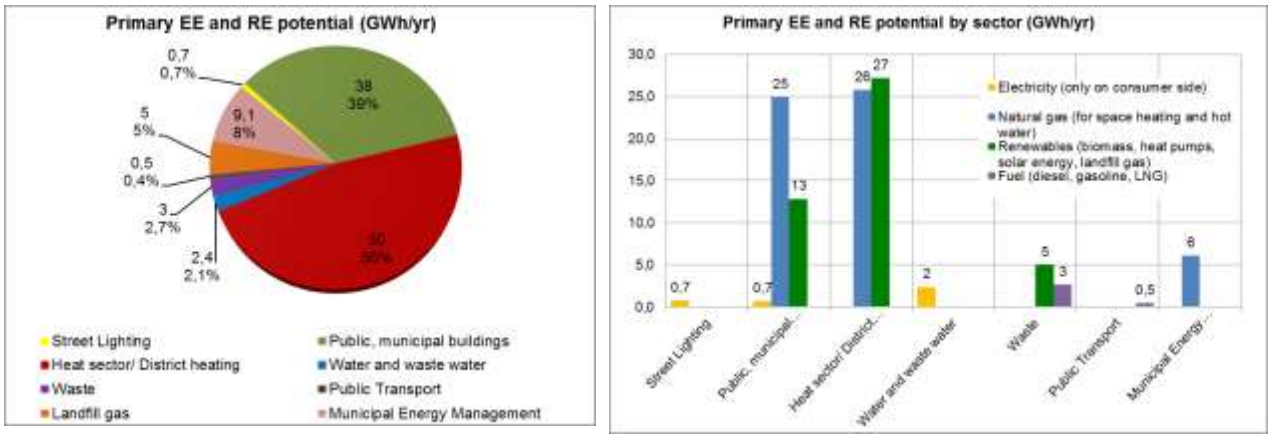
From the above analysis it is recommended to consider 37 EE measures, of which 23 are investment type; 8 preparation and 6 accompanying measures.

Figure 53: Number and type of EE measures recommended by sector



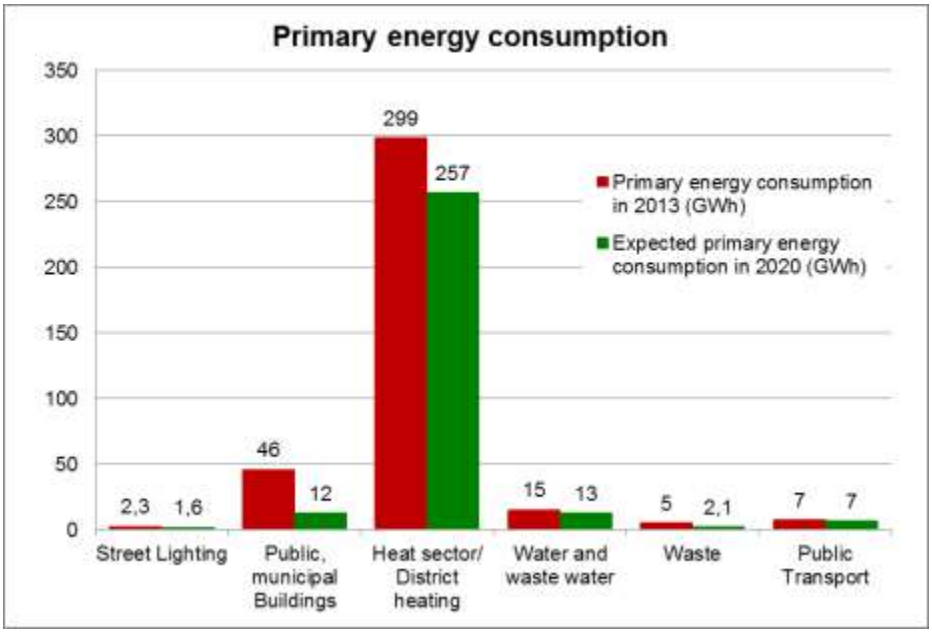
The overall primary energy savings by implementation of the 37 recommended measures will amount to annually in the range of 110 to 120 GWh of which energy saving in energy consumption amounts to 60% and the substitution of conventional primary energy by renewable energy approx.40%.

Figure 54: Primary energy saving potential by sector and type of energy



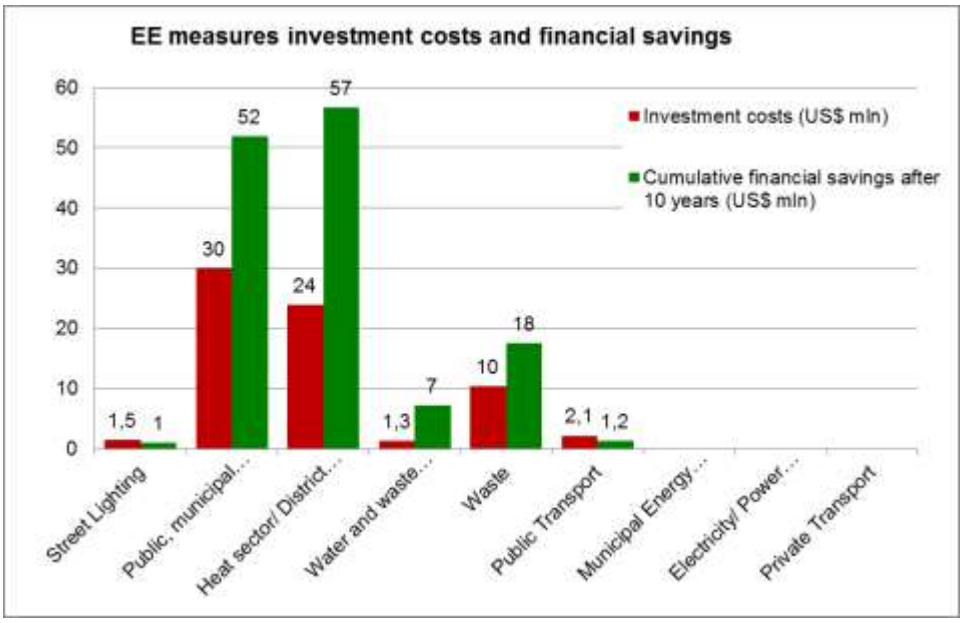
The implementation of the recommended EE measures until the year 2020 can reduce the primary energy consumption in the considered sectors by up to 25% (from 479 GWh in 2013 to 365 GWh in 2020). This savings potential would represent only 10% of the overall city's primary energy consumption (including industry, commercial, residential sector, which are not considered in the analysis).

Figure 55: 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 37 measures will be in the range between 60 to 70 million USD, which can generate a 10-years cumulative saving of energy costs (considering a projection of energy tariffs) of up-to 135 million USD.

Figure 56: Investment costs for EE recommendations and cumulative 10-years energy cost saving achievements (in million USD)



The largest savings of primary energy can be achieved in natural gas 88%, equal to approx. 10 million m³ gas of annual savings.

Figure 57: Primary energy saving and substitution by renewable energy potential