

City Energy Efficiency Report City of Ternopil

Energy Efficiency Transformation in
Ukrainian Cities

March 2015 - Review after Decision Workshop



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Content

| | | |
|----------|---|-----------|
| 1 | Summary | 1 |
| | Резюме | 10 |
| 2 | Introduction and Background to the Rapid Assessment Framework | 20 |
| 3 | Benchmarking of the current Energy Performance of the city | 20 |
| 3.1 | <i>Introduction on Energy Performance Benchmarking for the city of Ternopil</i> | 20 |
| 3.2 | <i>City Wide Energy Efficiency Benchmarking</i> | 21 |
| 3.3 | <i>Transportation sector Benchmarking</i> | 23 |
| 3.4 | <i>Solid Waste Sector Benchmarking</i> | 24 |
| 3.5 | <i>Water & Wastewater Sector Benchmarking</i> | 24 |
| 3.6 | <i>Power & Heat Sector Benchmarking</i> | 26 |
| 3.7 | <i>Public Lighting Benchmarking</i> | 27 |
| 3.8 | <i>Municipal Buildings benchmarking</i> | 28 |
| 3.9 | <i>Summary of Ternopil city benchmarking</i> | 29 |
| 4 | Identifying Priority Sectors | 30 |
| 4.1 | <i>Spending for energy in the city</i> | 30 |
| 4.2 | <i>Relative Energy Intensity</i> | 30 |
| 4.3 | <i>City authority level of control, influence and enforcement power</i> | 32 |
| 4.4 | <i>Prioritization of sectors</i> | 32 |
| 5 | Brief Review of Sectors | 34 |
| 5.1 | <i>City wide energy</i> | 34 |
| 5.2 | <i>Heat generation and distribution - city wide</i> | 37 |
| 5.3 | <i>Power distribution - city wide</i> | 38 |
| 5.4 | <i>Gas distribution - city wide</i> | 39 |
| 5.5 | <i>Private Transport - city wide</i> | 40 |
| 5.6 | <i>Public Transport Sector - City wide and City Authority</i> | 40 |
| 5.7 | <i>Potable Water and Wastewater– city wide</i> | 41 |
| 5.8 | <i>Waste management – city wide</i> | 42 |
| 5.9 | <i>Building sector – City wide and City Authority</i> | 43 |
| 5.10 | <i>Municipal Buildings - city authority</i> | 43 |
| 5.11 | <i>Public Lighting – City Authority</i> | 44 |
| 6 | Energy Efficiency Recommendations | 46 |

| | | |
|-----|---|----|
| 6.1 | <i>Methodology for evaluation, selection and ranking of EE measures</i> | 46 |
| 6.2 | <i>EE recommendations in the sector Municipal public buildings</i> | 47 |
| 6.3 | <i>EE recommendations in the sector street lighting</i> | 49 |
| 6.4 | <i>EE recommendations in the sector district heating</i> | 51 |
| 6.5 | <i>EE recommendations in the sector public transport</i> | 53 |
| 6.6 | <i>EE recommendations in the sector water and waste water supply</i> | 55 |
| 6.7 | <i>EE recommendations in the sector waste management</i> | 57 |
| 6.8 | <i>EE recommendations in the Municipal Energy Management</i> | 58 |
| 6.9 | <i>Summary of potential benefits by the pre-selected EE recommendations</i> | 59 |

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 Program in Ukraine (by USAID) |
| EE | Energy efficiency | MU | Municipal Company |
| EIB | European Investment Bank | PE | Public Enterprise |
| ELENA | European Local Energy Assistance | PEC | Primary Energy Consumption |
| EnPC | Energy Performance Contracting | RE | Renewable Energy |
| ESCO | Energy Service Company | REI | Relative Energy Intensity |
| ESMAP | Energy Sector Management Assistance Program | SCADA | <i>Supervisory Control and Data Acquisition</i> |
| FEC | Final Energy Consumption | SEAP | Sustainable Energy Action Plan |
| GDP | Gross Domestic Product | TA | Technical Assistance |
| GHG | Greenhouse gases | TRACE | Tool for Rapid Assessment of City Energy |
| GIZ | German International Development Co-operation | UAH | Ukrainian Hrivna (local currency) |
| GWh | Giga Watt Hours = Million Kilo Watt Hours | VSD | Variable Speed Drive, Frequency Control |
| HDD | Heating Degree Days | WB | The World Bank |
| HDI | Human Development Index | WWTP | Waste Water Treatment Plant |
| HOB | Heat only boiler | | |

1 Summary

CEETI, ESMAP and TRACE

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

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

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 Ternopil 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 Ternopil have been calculated and aggregated into the TRACE model.

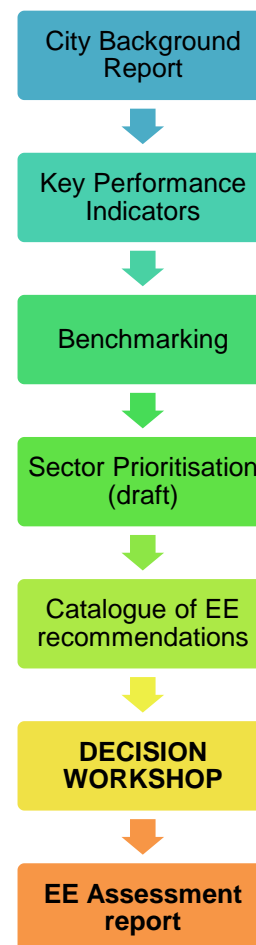
The benchmarking component of the TRACE tool enables the comparison of energy performance with other peer cities of similar characteristic. From this "Relative Energy Intensity" a rough estimate of the theoretical energy efficiency potential in each sector has been derived. → [Chapter 3](#).

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%).

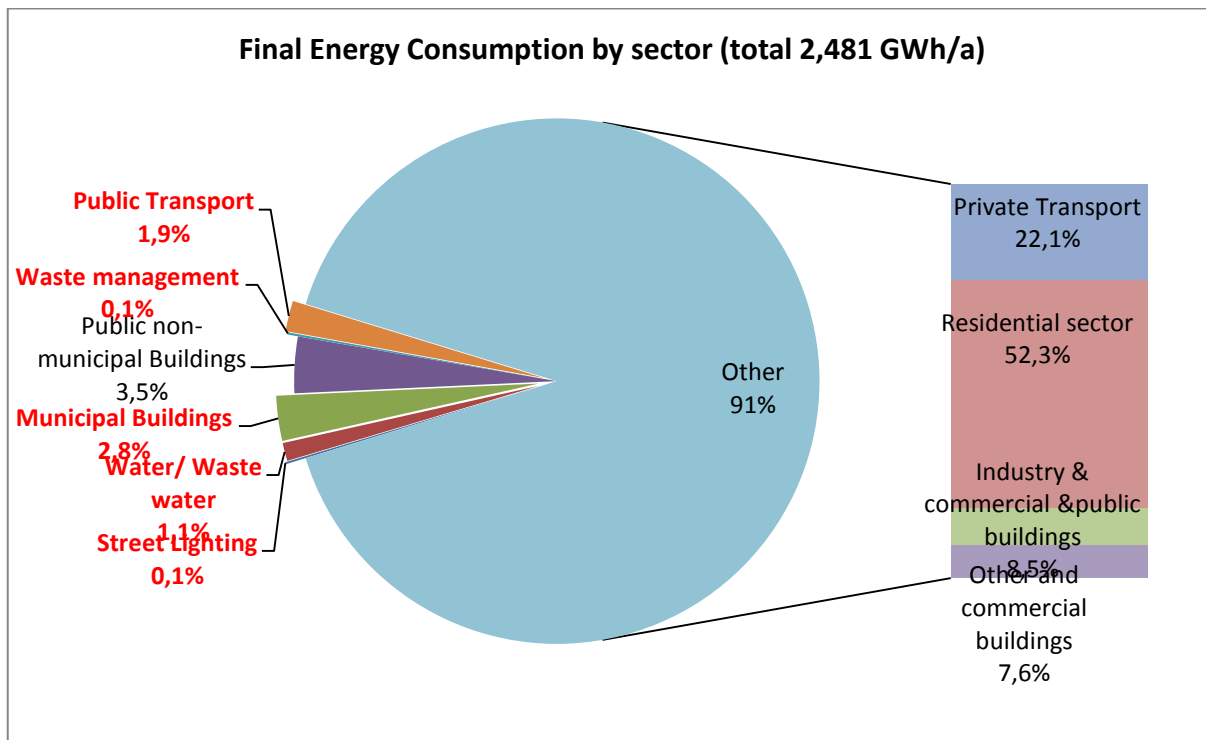
City background – energy consumption

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

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

Final energy consumption under direct control by the city is 149.2 GWh (6%) out of 2,481 GWh.

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



City background – budget and energy spending

Ternopil had a population in 2013 of 218,000 inhabitants and is economically based on the sectors manufacturing industry, trade and services.

The overall GDP¹ of Ternopil amounted in 2013 to 708 million USD of which 140 million USD (20%) have been spent on energy.

The municipal budget amounted to 99 million USD in 2013 with approximately 17.8 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 (30%) and private vehicles (44%) are not under the control of the City Administration.

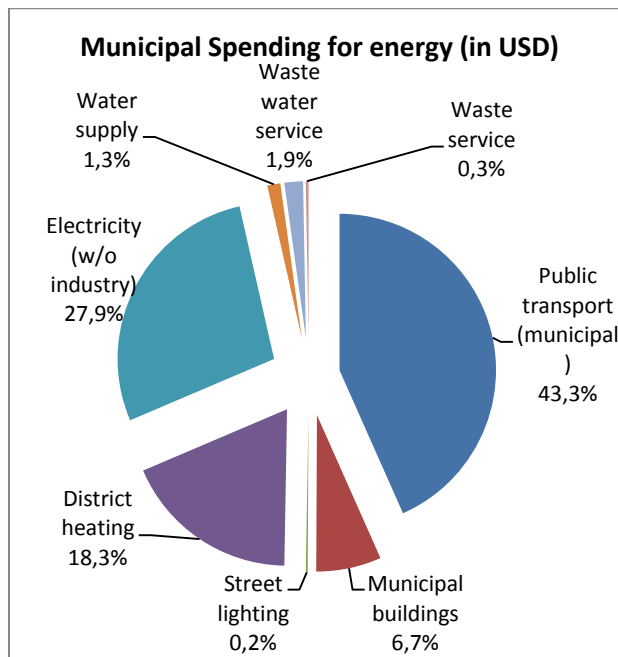


Figure 2: Share of spending for energy, 2013

Energy Spending for Municipal sector facilities (municipal public transport, municipal buildings, street lighting, waste, water and waste water services) amount to 17.7 million USD in 2013, out of which more

1 Estimated on respective share of regional GDP, 2013

than 45% are spent for the energy supply of municipal buildings. Those 17,7 million USD make a share of 8.1 % 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 Ternopil

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 Ternopil.

Details of the benchmarking of Ternopil'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 Ternopil 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 | 41.4 GJ/capita | Medium performance Peer cities: Skopje and Bratislava. | 50% |
| | Annual Primary energy consumption per GDP | 13.9 MJ/USD GDP | Low performance Peer cities: Tbilisi and Belgrade | 50% |
| Public Transport | Specific energy consumption of Public Transport | 0.5 MJ / passenger km | Medium performance Peer cities: Belgrade and Sarajevo | 35% to 50% |
| Solid Waste | Annual Waste production | Approx. 500 kg/capita | Low performance Peer cities: Sofia and Pristina | 40% |
| | Solid Waste recycled | 1 % | Very low performance | 50-70% |
| Water supply and waste water | Energy Density of Potable Water Production (| 0.67 kWh _e /m ³ | Low performance Peer cities: Banja Luca or Vienna. | 50% |
| | Energy Density of Wastewater Treatment | 0.86 kWh _e /m ³ | Very low performance | 50-60% |
| District Heat | Heat Loss from DH Network | 12 % | Medium performance: Peer cities: cities in Western Europe | 40-50% |

| Sector | Selected KPI | | Comparison of Performance with better performing cities | Theoretical EE potential |
|----------------------------|--|---------------------------------------|---|--------------------------|
| Street lighting | Annual Electricity consumed per lit road | 7.7 kWh _e /m | High performance Peer cities: Tbilisi or Vienna | 40-50% |
| Municipal public buildings | Annual Heat Consumption | 163 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** treatment,
- specific energy consumption for **street lighting,**
- specific energy consumption of the **public transport** fleet, and
- Cross-sector: preprimary energy consumption per GDP and per capita,

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

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

City authority Control

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

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

In addition the CA retains a certain degree of influence on the end energy consumer sectors of water supply and wastewater, district heating, waste management and public transport.

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

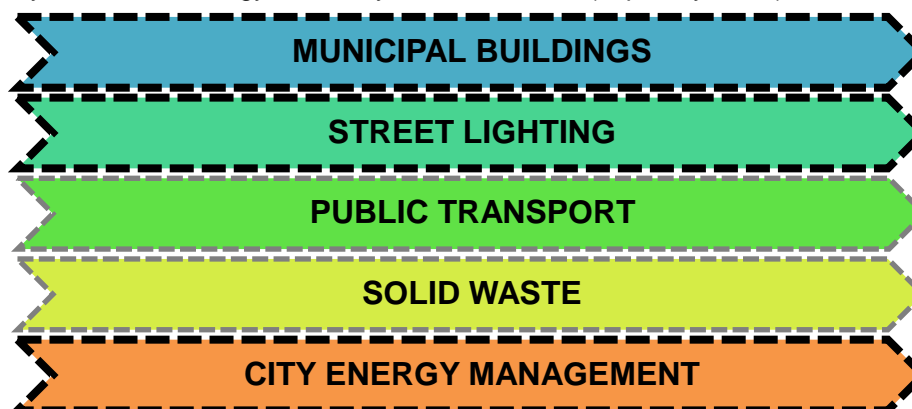
| Sector | City authority level of power | | |
|-----------------------|-------------------------------|----------------|---------------------------|
| | Regulatory | Budget control | Influence and enforcement |
| Public buildings | HIGH | HIGH | HIGH |
| Street lighting | HIGH | HIGH | HIGH |
| District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



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 Ternopil and its utilities are implementing currently a number of investment programs funded by international donor programs, such as:

In the district heating sector:

- Ternopil District Heating Project supported by EBRD and E5P grant;
- District heating reconstruction program, funding by IBRD

In the water supply & waste water sector

- Ternopil Vodokanal project «Rehabilitation and Upgrade Water and Wastewater Facilities - 2014», funded by IBRD

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 Ternopil 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 18 EE measures, of which 11 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 and medical facilities by municipal and loan sources | Total approx. 258,402 sqm building area including building shell, piping, including IHS on demand | Approximately 28 million USD | Annual savings of up-to 27 GWh, primary energy natural gas saving |
| Retrofit Program / thermo-modernization of Municipal educational and medical facilities under EnPC scheme (ESCO or municipal EE fund) | | | |
| Replacement of indoor lighting for all municipal public buildings | (T5 with reflector or LED), all buildings to 10 kWh/m ² for lighting | Approximately 0.6 million USD | Annual savings of 0.8 GWh, electricity |
| Street Lighting (SL) | | | |
| Street Lighting Audit and Retrofit Program (replacement by high performing bulbs) | Approx. 2,100 bulbs(only for Mercury and conventional), including public space lighting on demand | Approximately 0.7 million USD | Annual savings of 0.5 GWh, electricity |
| Solid Waste (WS) | | | |
| Intermediate Transfer Stations including sorting, including Waste Infrastructure Planning (separate container sorting) | Construction of one facility, capacity to be analyzed | In the range of 8-12 million USD | Annual savings of up to 1 GWh, diesel |

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 | To limited extend, only if DH supply is not appropriate, including heat, pumps, biomass, Solar water heating is an option for (3-4) public swimming pools | Approximately 5 to 8 million USD | Annual savings of 10-20 GWh, gas |
| Street lighting | | | |
| Street Lighting timing, dimming and management Program, integration of rehabilitation of electric supply system and Poles of SL (wiring, switches) in order to enable control | Including step-by-step rehabilitation of power supply network to enable control, timing and dimming Limited extend for selected streets only | Approximately 0.5 million USD | Annual savings of 0.5 GWh, electricity |

| 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), <i>Details in EE transformation program</i> | Up to 0.3 million USD | Annual savings of up to 3 GWh, gasoline in individual transport |
| Public Transportation Development for new district | with electric trolley busses | Up to 6 million USD | Annual savings of up to 1 GWh, gasoline in individual transport |
| Solid Waste (WS) | | | |
| Landfill Gas Capture Program and power generation unit (use of green tariff, approach PPP operator) | <i>Details in EE transformation program</i> | Up to 10 million USD | <i>To be analyzed</i> |
| Waste Pyrolysis Project | for heat generation (approach of PPP operator) | In the range between 3-5 million USD | <i>To be analyzed</i> |

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 and medical facilities | Audit program for 80 to 100 buildings | Approx. 0.3 million USD | Results in PB - 02/03 |
| 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 0.1-0.2 million USD annually | Not primary for municipality |
| Institutional 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. 0.2 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, Mandatory Building Energy Efficiency Codes for Existing and new Buildings | 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 0.1 million USD annually | Resulting from investment projects |
| EE Strategy and investment plan resulting in Capital investment planning | <i>Details in EE transformation program</i> | In the range of 0,05 million USD | Resulting from investment projects |

C) Long term NON-INVESTMENT MEASURES: Implementation period 2020 to 2025

| Title | Components, extend | Indicative costs | Preliminary EE |
|--|---|-----------------------|--------------------|
| Municipal Energy Management | | | |
| Establishment of Municipal EE fund (financing instrument to provide loans) | <i>Details in EE transformation program</i> | Approx. 2 million USD | Results in PB - 02 |

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

| District heating | Water and Waste water |
|---|---|
| <ul style="list-style-type: none"> - Performance increase of boiler-houses by rehabilitation - Fuel switch for heat generation - gas to biomass - District heating network rehabilitation, pipeline replacement - Solar heating plant (long-term) - Hydraulic balancing of the DH system - Installation of cogeneration plant for coverage of own demand - Implementation of SCADA system - Replacement of circuit pumps and equipment with VSD | <ul style="list-style-type: none"> - Improve Efficiency of Pumps and Motors in water supply and WWTP - Active Leak Detection and Pressure Management Program for potable water system |

Energy Efficiency Recommendations Matrix

| | | First costs | |
|---------------------------------|--------------|--|---|
| | | < 1 million USD | > 1 million USD |
| Primary Energy Saving Potential | < 1 GWh/year | <ul style="list-style-type: none"> • Replacement of indoor lighting for all municipal public buildings • Street Lighting Audit and Retrofit Program • Street Lighting timing, dimming and management Program, integration of rehabilitation of electric supply system and Poles of SL • Promotion of Public Transport, increase attractiveness targeting to lower private motorized transport mode • Energy Audits and feasibility study for Municipal educational and medical facilities • Awareness raising and EE promotion programs for all sectors • Institutional and Capacity building program - Establishment Energy Management system including Monitoring and Verification • 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 • Establishment of Municipal EE fund | <ul style="list-style-type: none"> • Waste Pyrolysis Project • Intermediate Transfer Stations including sorting, including Waste Infrastructure Planning (separate container sorting) |
| | > 1 GWh/year | | <ul style="list-style-type: none"> • Retrofit Program / thermo-modernization of Municipal educational and medical facilities • Renewable energy individual heat generation for municipal education and medical facilities • Public Transportation Development for new district • Landfill Gas Capture Program and power generation unit |

Резюме

CEETI, ESMAP та TRACE

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

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

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 Тернопільської міської адміністрації та комунальних підприємств. Зустрічі з зацікавленими сторонами (інтерв'ю) відбулися в листопаді 2014 рок. З результатами аналізу вихідного стану міста можливо ознайомитись у Звіті.

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

Такий компонент моделі TRACE, як бенчмаркінг, дозволяє по аналогічним характеристикам порівняти показники енергетичної ефективності міста з показниками інших міст - еталонів, а 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](#).

Рекомендації з енергетичної ефективності, з яких було сформовано довгий перелік, були отримані з різних джерел, в тому рахунку з інтерв'ю. За попередньою оцінкою створено каталог рекомендацій з енергоефективності за секторами → [Глава 6, 7 та 8](#).

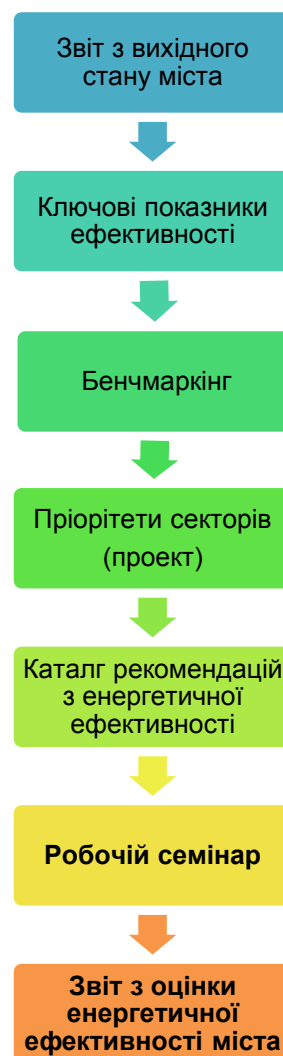
Ключові характеристики, наявні проблеми секторів ([Глава 5](#)) та аналіз потенціалу енергетичної ефективності були презентовані та обговорені на робочому семінарі у лютому 2015 року. Міська влада та комунальні підприємства міста домовилися про концептуальний і комплексний підхід у розробці Програми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

Цілі енергетичної ефективності

Місто долучилося до ініціативи Європейського Союзу «Угода мерів» в 2012 році та підготувало План сталого енергетичного розвитку (SEAP), цілями якого є зниження емісії CO₂ на 20% до 2020 року, споживання природного газу на 24%, теплової (13%) та електричної (30%) енергії.

Вихідний стан міста - споживання енергетичних ресурсів



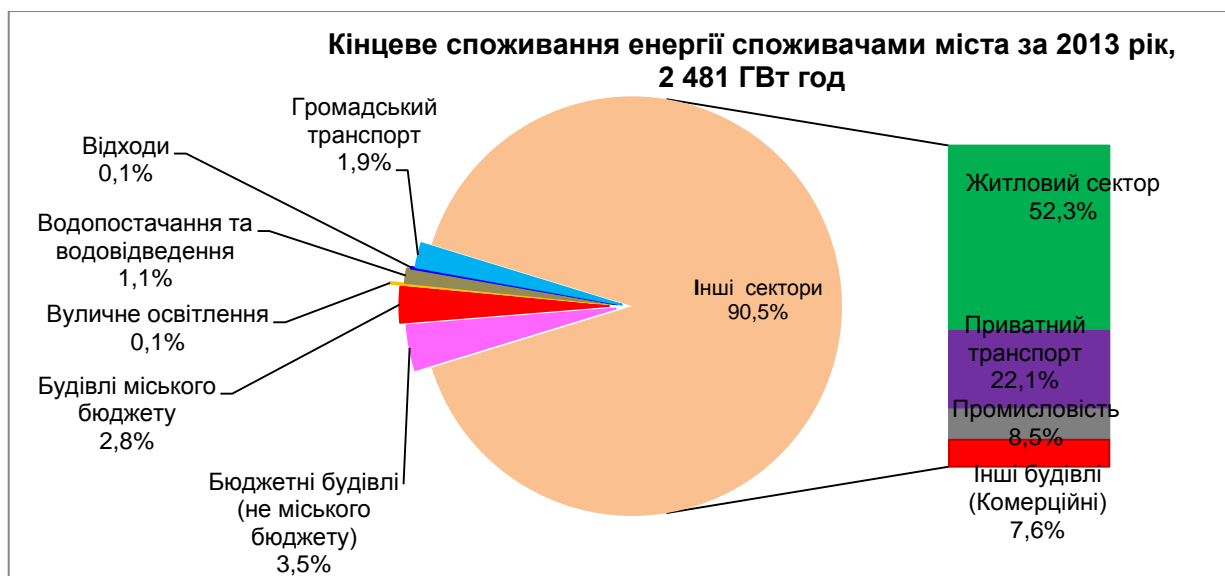
У 2013 році кількість спожитої первинної енергії становить 2 727 ГВт·год, з якої 2/3 складає споживання природного газу, більша частка якого використовується на виробництво електричної та теплової енергії для кінцевих споживачів.

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

Значна частина споживачів енергетичних ресурсів міста використовує природний газ як первинну енергію (62%), в тому числі природний газ на побутові потреби та теплову енергію (38% та 23% відповідно) кінцевих споживачів

Кінцеве споживання енергетичних ресурсів, на яке місто має безпосередній вплив, становить 149.2 ГВт·год (6%) з 2 481 ГВт·год.

Рисунок 3: Кінцеве споживання енергії містом за 2013 рік



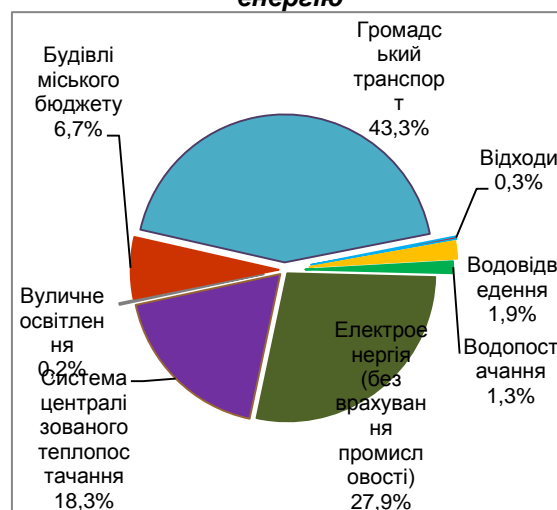
Вихідний стан міста - Витрати міського бюджету та міста в цілому на енергію

Населенням міста Тернопіль у 2013 році склало 218 000 осіб. Розвинена промисловість, галузі обслуговування та торгівлі. Загальний валовий міський продукт² Тернополя склав 708 мільйони доларів США, де 140 мільйони (20%) було витрачено на енергозабезпечення.

Міський бюджет у 2013 році налічував 99 мільйонів доларів США, з якого приблизно 17.8 мільйонів було використано на енергозабезпечення секторів громадського транспорту, громадських будівель, вуличного освітлення, водопостачання та водовідведення, поводження з твердими побутовими відходами.

Найбільші споживачі енергетичних ресурсів - сектори електропостачання (30%) та приватний транспорт (44%), не знаходяться під контролем міської влади.

Рисунок 4: Витрати муніципалітету на енергію



² Приблизна оцінка частки міста в регіональному ВРП, 2013

Витрати на енергозабезпечення муніципальних секторів (міський громадський транспорт, громадські будівлі, вуличне освітлення, побутові відходи, водопостачання та водовідведення) склали 17.7 мільйонів доларів США у 2013 році, з яких 45% було витрачено на забезпечення енергетичними ресурсами громадських бюджетних будівель. Ці 17.7 мільйонів доларів США склали 8.1% від міського бюджету.

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

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

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

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

Бенчмаркінг енергетичної ефективності міста Тернопіль

Бенчмаркінг дозволяє порівняти енергетичну ефективність міста, яке досліджується, з іншими містами - еталонами на основі 27 ключових показників ефективності міста Тернополя.

Детально процес бенчмаркінгу міста Тернополя розглянуто у [Главі 3](#).

У наступній таблиці наводиться стисла інформація о характеристиках секторів.

Таблиця 3: Резюме бенчмаркінга за ключовими показниками ефективності міста Тернополя

| 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, | 41.4 ГДж/ос. | Середня ефективність Міста-еталони: Скоп'є, Сараєво, Братислава | 50% |
| | Споживання первинної енергії на ВВП міста, | 13.9 МДж/доларів США ВВП міста | Низька ефективність Міста-еталони: Тбілісі та Белград | 50% |
| Громадський транспорт | Питоме споживання енергії громадським | 0.5 МДж/пас·км | Середня ефективність | 35% - 50% |

| Сектор | Обрані ключові показники ефективності | Порівняння ЕЕ досліджуваного міста з ЕЕ більш розвинених міст світу | Теоретичний потенціал ЕЕ |
|----------------------------------|--|---|---|
| | транспортном, | Міста-еталони: Белград та Сараєво | |
| Побутові відходи | Кількість твердих побутових відходів (ТПВ), що утворюються в межах міста на душу населення | приблизно 500 кг/ос. | Середня ефективність Міста-еталони: Софія та Прістина 40% |
| | Відсоток ТПВ, що піддаються переробці | 1% | Дуже низька ефективність 50-70% |
| Водопостачання та водовідведення | Питоме споживання електроенергії на питне водопостачання | 0.67 кВт _е ·год/м ³ | Низька ефективність Міста-еталони: Баня Лука та Вена. 50% |
| | Питоме споживання електроенергії на водовідведення | 0.86 кВт _е ·год/м ³ | Дуже низька ефективність 50-60% |
| Централізоване тепlopостачання | Відсоток втрат теплової енергії в мережах | 12% | Середня ефективність Міста-еталони: міста Східної Європи 40-50% |
| Вуличне освітлення | Питоме споживання електроенергії на км освітлених вулиць | 7.7 кВт _е ·год/км | Низька ефективність Міста-еталони: Тбілісі та Вена 40-50% |
| Громадські бюджетні будівлі | Споживання теплової енергії будівлями міського підпорядкування | 163 кВт _т ·год/м ² | Дуже низька ефективність 50-60% |

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

- **Споживання теплової енергії громадськими будівлями,**
- Питоме споживання електроенергії на **водовідведення та водопостачання**,
- Питоме споживання енергії на потреби **вуличного освітлення,**
- Питоме споживання енергії на **громадським транспортом**
- Питомі втрати в системі розподілу теплової енергії
- **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, тепlopостачання, управління твердими побутовими відходами та громадського транспорту. Класифікація рівня контролю міської влади на сектори було підтверджено керівниками міста під час робочого семінару.

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

| Сектор | Рівень повноважень міської влади | | |
|--------------------------------|----------------------------------|-------------|-------------|
| | Регулювання | Регулювання | Регулювання |
| Громадські будівлі | ВИСОКИЙ | ВИСОКИЙ | ВИСОКИЙ |
| Вуличне освітлення | ВИСОКИЙ | ВИСОКИЙ | ВИСОКИЙ |
| Централізоване тепlopостачання | СЕРЕДНІЙ | СЕРЕДНІЙ | СЕРЕДНІЙ |
| Громадський транспорт | ВИСОКИЙ | СЕРЕДНІЙ | ВИСОКИЙ |
| Питне водопостачання | НИЗЬКИЙ | СЕРЕДНІЙ | СЕРЕДНІЙ |
| Водовідведення | НИЗЬКИЙ | СЕРЕДНІЙ | СЕРЕДНІЙ |
| Відходи | ВИСОКИЙ | СЕРЕДНІЙ | ВИСОКИЙ |
| Електропостачання | НИЗЬКИЙ | НИЗЬКИЙ | НИЗЬКИЙ |
| Газопостачання | НИЗЬКИЙ | НИЗЬКИЙ | НИЗЬКИЙ |
| Приватний транспорт | НИЗЬКИЙ | НИЗЬКИЙ | НИЗЬКИЙ |
| Житлові будинки | НИЗЬКИЙ | НИЗЬКИЙ | 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

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

- Приватний транспорт
- Електропостачання
- Газопостачання
- Комерційні будівлі
- Громадські будівлі не міського підпорядкування
- Житловий сектор
- Промисловість

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

Розгляд поточних і завершених інвестиційних програм і планів

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

Сектор централізованого теплопостачання:

- Проект модернізації системи централізованого теплопостачання міста Тернопіль, за підтримки EBRD та гранту E5P;
- Програма реконструкції системи централізованого теплопостачання, у стадії обговорення з IBRD

Водопостачання та водовідведення:

- «Реабілітація та модернізація споруд водопостачання та водовідведення м. Тернополя - 2014», 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 сталого енергетичного розвитку (SEAP), енергоефективних заходів 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 18 одиниць, з яких 11 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 (РВ) | | | |
| Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних закладів, за рахунок кредитів | Загальна площа - 258 402 м ² . Включає модернізацію фасаду | Приблизно 28 мільйонів доларів США | Щорічна економія 27 ГВт• год |

| Назва | Опис | Орієнтовні витрати | Попередня економія |
|--|--|-------------------------------------|--|
| та часткового фінансування з міського бюджету | будівель, трубопроводів, при можливості встановлення індивідуальних теплових пунктів. | | економія первинної енергії, і природного газу |
| Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних закладів, через укладання договорів типу «перфоманс - контрактінг» (ЕСКО або муніципальний фонд) | | | |
| Модернізація системи зовнішнього освітлення громадський бюджетних будівель | Т5 з рефлекторами або світлодіодні лампи, всі будівлі 10 кВт год/м ² на освітлення | Приблизно 0.6 мільйонів доларів США | Щорічна економія 0.8 ГВт• год, економія електричної енергії |
| Вуличне освітлення (SL) | | | |
| Програма проведення аудиту та модернізації системи вуличного освітлення (установка високоефективних світильників) | Приблизно 2 100 ламп (тільки ртутні та лампи розжарювання) Включає освітлення громадських будівель, де це необхідно. | Приблизно 0.7 мільйонів доларів США | Щорічна економія до 0.5 ГВт• год, економія електричної енергії |
| Тверді побутові відходи (WS) | | | |
| Будівництво перевалочних станцій, що включає процеси сортування, та планування інфраструктури поводження з відходами (окремі контейнери) | Будівництво одного об'єкту, потужність необхідно проаналізувати | 8-12 мільйонів доларів США | Щорічна економія до 1 ГВт• год, економія дизелю |

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, сонячних колекторів (для 3-4 громадських басейнів). | Приблизно 5- 8 мільйонів доларів США | Щорічна економія від 10 до 20ГВт• год, економія природного газу |
| Вуличне освітлення | | | |
| Програма таймування, дімування та управління зовнішнім освітленням, модернізація електричної мережі (проводка, вимикачі) та опор освітлення з тим щоб вести контроль споживання електричної енергії | Поетапне відновлення мережі живлення, для впровадження таймування, дімування та управління зовнішнім освітленням Обмежене використання тільки для обраних вулиць | Приблизно 0.5 мільйонів доларів США | Щорічна економія 0.5 ГВт год, економія електричної енергії |

| 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) | до 0.3 мільйони доларів США | Щорічна економія до 3 ГВт• год, економія бензину в секторі приватного транспорту |
| Розвиток громадського транспорту для нового житлового району | Використання електробусів | До 6 мільйонів доларів США | Щорічна економія до 1 ГВт• год, економія бензину в секторі приватного транспорту |
| Побутові відходи | | | |
| Отримання газу з полігону ТПВ з подальшою генерацією електричної енергії (зелений тариф, ДПП) | <i>Детально розглянуто в Програмі енергоефективної трансформації міста</i> | До 10 мільйонів доларів США | Необхідно проаналізувати |
| Проект піролізу ТПВ | Для генерації електричної енергії (можливість державно - приватного партнерства) | 3-5 мільйонів доларів США | Необхідно проаналізувати |

С) 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 80 -100 будівель | Приблизно 0.3 мільйони доларів США | Відображена у заході РВ - 02/03 |
| Муніципальний енергетичний менеджмент | | | |
| Розробка та проведення інформаційно-просвітницьких заходів (водопостачання, енергопостачання, зменшення обсягів відходів) | Події, конкурси, нагороди, друковані ЗМІ, медіа-кампаній | 0.1-0.2 мільйони доларів США щорічно | Не є першочерговим для міста |
| 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. 0.2 мільйони 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, | 0.1-0.2 мільйонів доларів США | невизначено |

| Назва | Опис | Орієнтовні витрати | Попередня економія |
|--|--|----------------------------------|--|
| | устаткування для державних установ, стандартів для будівництва нових будівель; створення обов'язкових норми і правил ефективного будівництва в існуючих і нових будівлях | | |
| Впровадження механізму перформанс-контракту, ЕСКО фінансування | Підготовчий енергоаудит, тендерні документи | 0.1 мільйона доларів США щорічно | В результаті впровадження інвестиційних проектів |
| Планування капітальних вкладень | <i>Детально розглянуто в Програмі трансформації ЕЕ</i> | 0,05 мільйони доларів США | В результаті впровадження інвестиційних проектів |

D) Довгострокові НЕІНВЕСТИЦІЙНІ ЗАХОДИ: термін впровадження 2016 - 2020 роки

| Назва | Опис | Орієнтовні витрати | Попередня економія |
|--|--|----------------------------------|------------------------------|
| Муніципальний енергетичний менеджмент | | | |
| Створення Муніципального фонду фінансування проектів з ЕЕ (фінансовий інструмент надання кредитів) | <i>Детально розглянуто в Програмі трансформації ЕЕ</i> | Приблизно 2 мільйони доларів США | Відображена у заході РВ - 02 |

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

| Централізоване теплопостачання | Водопостачання та водовідведення |
|---|---|
| <ul style="list-style-type: none"> Встановлення когенераційних установок для покриття споживання електроенергії котельними Модернізація мереж централізованого теплопостачання, заміна трубопроводів Заміщення природного газу біопаливом (біомасою) для виробництва теплової енергії Підвищення ефективності котелень Будівництво сонячної теплової станції (довгострокове) Впровадження SCADA-системи Заміна мережних насосів та обладнання їх пристроями частотного регулювання Гідралічне балансування системи централізованого теплопостачання | <ul style="list-style-type: none"> Підвищення ефективності насосів та електроприводів в системах водопостачання та водовідведення, модернізація очисних споруд та каналізаційних насосних станцій, підвищення ефективності водопроводів (проект IBRD) Програма впровадження системи активного виявлення витоків та управління тиском в системі водопостачання |

Матриця рекомендацій з енергетичної ефективності

| | | Орієнтовні витрати | |
|--------------------|--------------|---|--|
| | | < 1 мільйонів доларів США | > 1 мільйонів доларів США |
| Попередня економія | < 1 ГВт• год | <ul style="list-style-type: none"> Модернізація системи зовнішнього освітлення громадський бюджетних будівель Програма проведення аудиту та модернізації системи вуличного освітлення Програма таймування, дімування та управління зовнішнім освітленням, модернізація електричної мережі (проводка, вимикачі) та опор освітлення з тим щоб вести контроль споживання електричної 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-контракту, ЕСКО фінансування Планування капітальних вкладень Створення Муніципального фонду фінансування проектів з ЕЕ | <ul style="list-style-type: none"> Проект піролізу ТПВ Будівництво перевалочних станцій, що включає процеси сортування, та планування інфраструктури поводження з відходами (окремі контейнери) |
| | > 1 ГВт• год | | <ul style="list-style-type: none"> Програма модернізації/ глибокої термомодернізації будівель навчальних, медичних закладів Переведення системи тепlopостачання всіх навчальних та медичних закладів на відновлювальні джерела енергії Розвиток громадського транспорту для нового житлового району Отримання газу з полігону ТПВ з подальшою генерацією електричної енергії |

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 Ternopil

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 Ternopil:

- Baku, Azerbaijan
- Banja Luka, Bosnia-Herzegovina
- Beijing, China
- Belgrade, Serbia
- Bucharest, Romania
- Gaziantep, Turkey
- Pristina, Kosovo
- Ukrainian cities of Odessa and Kiev (for limited available benchmark data)
- Sarajevo, Bosnia-Herzegovina
- Skopje, Macedonia
- Sofia, Bulgaria
- Tbilisi, Georgia
- Warsaw, Poland
- Yerevan, Armenia

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

The criteria of the size of population has not been applied for the benchmarking, as the size of population of the city of Ternopil at 0.2 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 Ternopil have been calculated and aggregated based on data and information received from the City Authority of Ternopil as well as interviews with stakeholders of the administration and utilities of municipal services. Data collection and interviews took place in November 2014. The availability and quality of city data and information of the city context is satisfying. Specific data on of sectors have been collected. No proxies have been used.

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

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

Figure 4: Key city statistics of 2013

| No | Indicator | Unit | Value |
|----|--|------------------------|-----------------------------|
| 1 | Population | people | 218,600 |
| 3 | Municipal area (same as metropolitan area) | km ² | 59 |
| 2 | Population Density | People/km ² | 3,705 |
| 4 | Primary Energy Consumption | GWh | 2,727 |
| 5 | Employment rate | % | 90 % |
| 6 | Human Development Index (HDI) ³ | | 0.734 |
| 7 | Total city budget | USD | 99,095,378 |
| 8 | Municipality expenditures for energy in public buildings | USD | 8,077,902 8% of budget |
| 9 | Energy Spending (for sectors: municipal public transport, municipal buildings, street lighting, waste, water and waste water services) | USD | 17,787,250 18% of budget |
| 10 | GDP (2013) ⁴ | USD | 708,246,620 |

The Economic and political framework for implementation of energy efficiency in the city of Ternopil 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 Ternopil 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 5: Key Performance Indicators for City Wide Energy

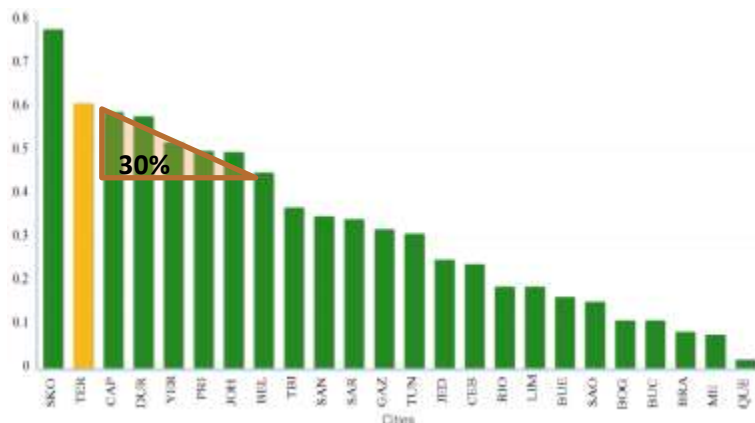
| Key Data | | | Key Performance Indicators (TRACE) | |
|--|--------|--------------------------------|--|---------|
| Primary Energy Consumption per Capita | 11,506 | kWh/capita/annum | Electricity consumption (kWh _e /capita) | 1686.59 |
| Primary Electricity Consumption per Capita | 1,687 | kWh _e /capita/annum | Electricity consumption (kWh _e /GDP) | 0.61 |
| Thermal Energy Consumption per Capita | 2,613 | kWh _T /capita/annum | Primary energy consumption (MJ/capita) | 41.42 |
| Primary Energy Consumption per & GDP | 3.85 | kWh/USD | Primary energy consumption (MJ/GDP) | 13.86 |
| Energy Supply Cover | 100 | % | | |

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 Ternopil region GRP

The city of Ternopil ranks low for the performance indicator of Primary Electricity Consumption per capita in comparison with the peer cities with similar level of HDI. The theoretical energy saving potential for the city of Ternopil amounts to approximately 20 % to achieve a level of the better performing cities, such as: Tbilisi and Baku.

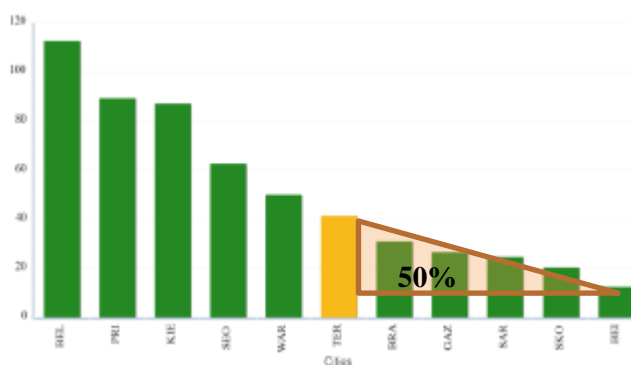
Figure 6: Primary Electricity Consumption (kWe / GDP)



The city of Ternopil ranks low 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 Ternopil amounts to approximately 30 % to achieve a level of the better performing cities, such as: Yerevan, Pristina and Belgrade.

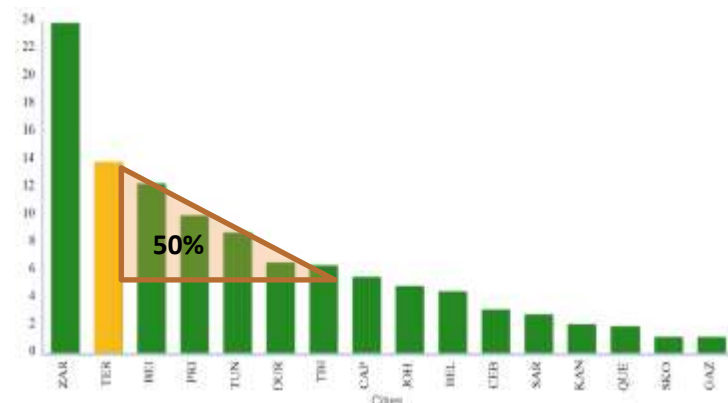
The city of Ternopil ranks medium for the performance indicator of Primary Energy Consumption per capita in comparison with the peer cities with similar climatic conditions. The theoretical energy saving potential for the city of Ternopil amounts to approximately 50 % to achieve a level of the better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

Figure 7: Primary Energy Consumption (GJ / capita)



The city of Ternopil 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 Ternopil 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 Ternopil. The improvement of that indicator depends heavily on the GDP development.

Figure 8: Primary Energy Consumption (MJ / USD GDP)



3.3 Transportation sector Benchmarking

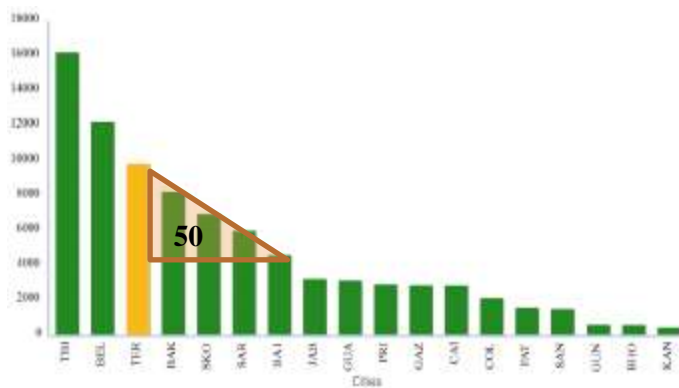
Figure 9: KPI and key data for transport sector

| Key Data | | Key Performance Indicators (TRACE) | |
|---|--------------------------|--|--------|
| Public transportation fuel consumption (MJ) | 167 691 499 | Total Transportation Energy Use Per Capita, MJ/capita | 9806.4 |
| Private transportation fuel consumption (MJ) | 1 975 986 847 | Public Transport Energy Consumption, MJ/passenger km | 0.467 |
| Public transportation passenger kilometers | 359 149 000 | Public Transportation Mode Split, % | 0 |
| Private transportation passenger kilometers | 958 410 000 | Private Transport Energy Consumption, MJ/passenger km | 4 |
| Transportation Mode Split (private motorized, public motorized, walk/cycle) | 49 trolleybus | Metres of High Capacity Transit per 1000 People, m/1000 people | 26 |
| | 219 bus | | |
| | 687 taxi | Transportation Non-Motorized Mode Split, % | 2.062 |
| | 63 894 private transport | | |

There is no high capacity transit in Ternopil, such as metro and light rail.

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

Figure 10: Total Transportation energy use per capita (MJ/capita)



The city of Ternopil ranks low 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 Ternopil amounts to approximately 50 % to achieve a level of the better performing cities, such as: Banja Luka and Skopje. However, the geographical extend and economic performance drives the demand of mobility and thus transports energy demand.

Figure 11: Public Transport MJ / passenger km

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

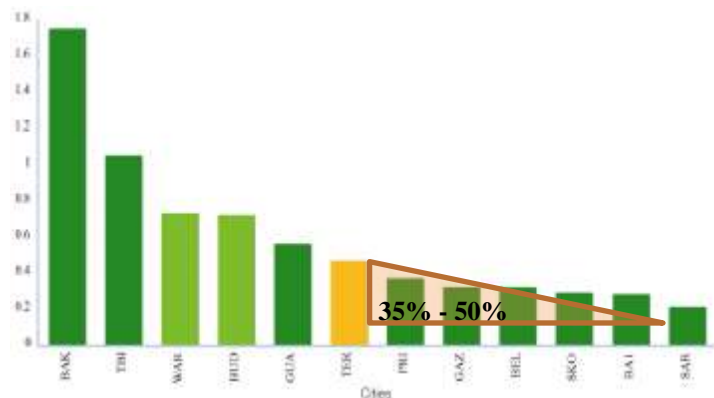
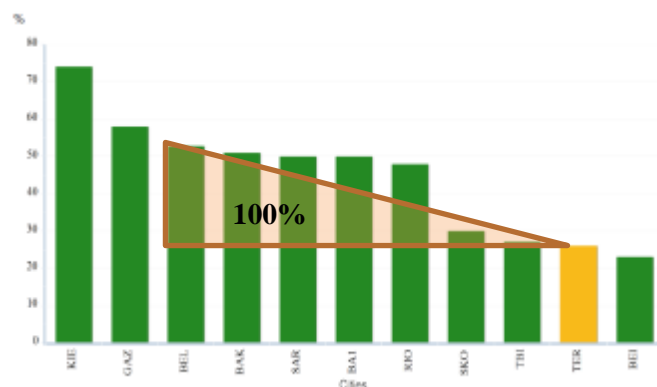


Figure 12: Public transport mode split (%)



The city of Ternopil ranks low for the performance indicator of Public transport mode split in comparison with the peer cities with similar characteristic on climate. There is the theoretical potential to increase the share of public transport use by 100% to achieve a level of the better performing cities, such as Belgrade and Sarajevo, at a level of 50%.

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

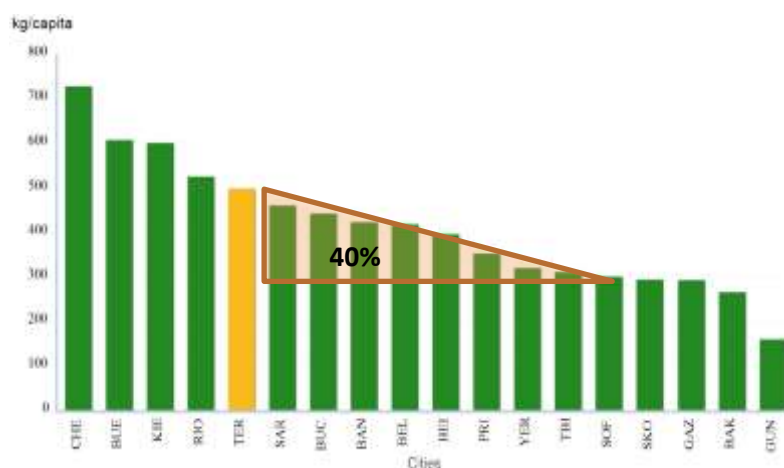
3.4 Solid Waste Sector Benchmarking

Figure 13: KPI and key data for solid waste sector

| Key Data | | Key Performance Indicators (TRACE) | |
|---|---------|--|--------|
| Amount of solid waste generated within the municipal boundary (tonne) | 108 910 | Waste per capita (kg/capita) | 498.22 |
| Amount of solid waste that is recycled (tone) | 695 | Capture rate of solid waste | 100 |
| Amount of solid waste that goes to landfill (tone) | 108 215 | % of solid waste recycled | 0.64 |
| Amount of solid waste generated within the municipal boundary (tone) | 108 910 | % of solid waste that goes to landfill | 99.36 |

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 14: Waste per Capita (kg / capita)



The city of Ternopil 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 Ternopil amounts to approximately 40 % to achieve a level of the better performing cities, such as: Sofia and Pristina.

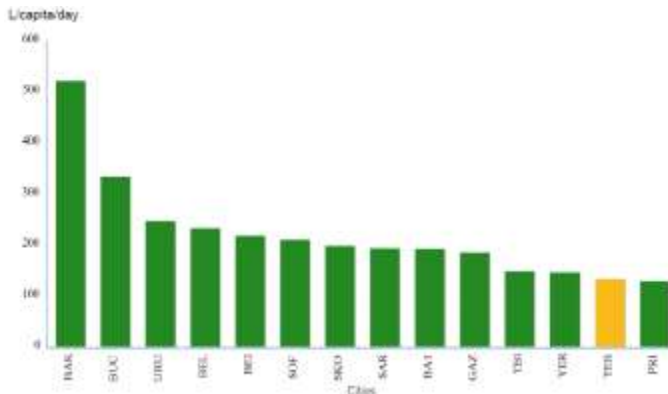
3.5 Water & Wastewater Sector Benchmarking

Figure 15: KPI and key data for water and waste water sector

| Key Data | Key Performance Indicators (TRACE) |
|----------|------------------------------------|
|----------|------------------------------------|

| Key Data | | Key Performance Indicators (TRACE) | |
|---|------------|--|--------|
| Total amount of water sold (m ³) | 11 397 100 | Water consumption L/capita/day | 133.15 |
| Energy consumed to produce potable water (kWh _e) | 11 712 900 | Energy density of potable water production (kWh _e /m ³) | 0.67 |
| Total amount of potable water produced (m ³) | 17 362 | Energy density of wastewater treatment (kWh _e /m ³) | 5 |
| Energy consumed to treat wastewater (kWh _e) | 15 773 700 | Percentage of non revenue water ⁵ | 46 |
| Total amount of treated wastewater (m ³) | 18 401 | Electricity cost for water treatment (potable- and wastewater) as a percentage of the total water utility expenditures | 0.86 |
| Energy expenditures of the water utility for potable water and wastewater treatment, \$ | 3 919 902 | | |
| Total expenditures of a water utility | 8 515 589 | | |
| Number of households with potable water service | 83 992 | | |
| Number of households with connection to the public sewage system | 80 759 | | |
| Average water rates (\$/m ³) | 0.75 | | |

Figure 16: Water Consumption (l / capita / day)



The city of Ternopil ranks high for the performance indicator of Water Consumption per capita in comparison with the peer cities with similar HDI characteristic. There is little theoretical potential for the city of Ternopil to decrease the consumption.

⁵ Technical water 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.

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

Figure 17: Energy Density of Potable Water Production (kWhe / m3)

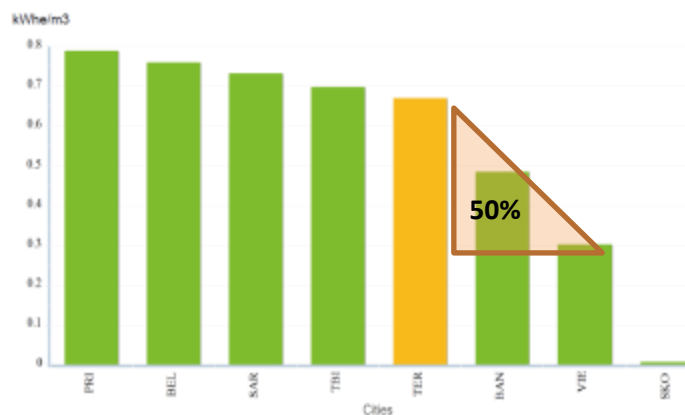
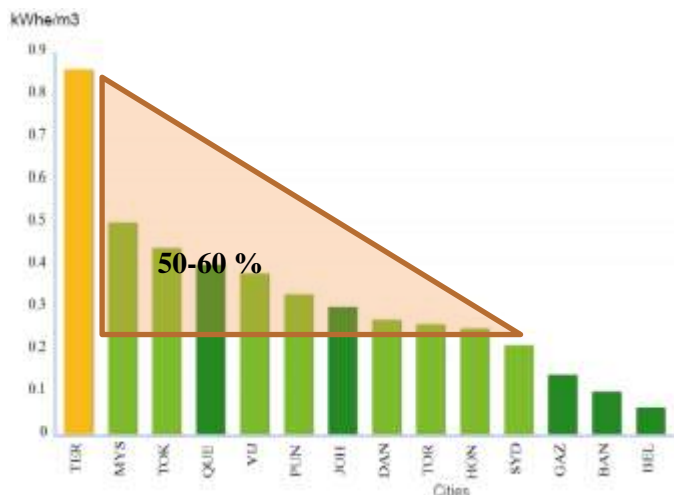


Figure 18: Energy Density of Wastewater Treatment (kWhe / m3)



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

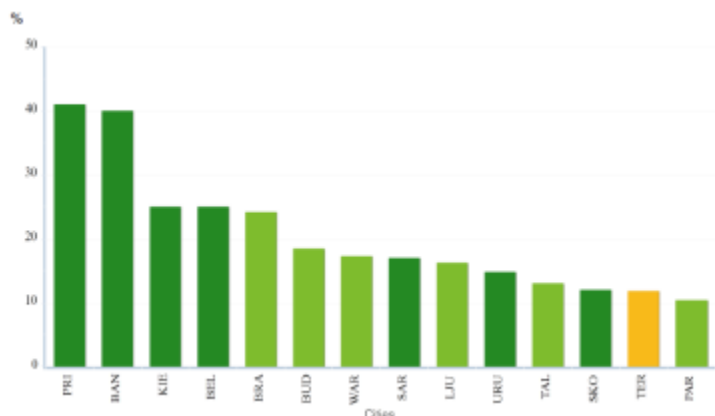
In Ternopil a high percentage of supplied potable water is revenue to the sewer and a of that a high percentage of collected wastewater is processed in the water treatment plant, both close to 100%, which consequently leads to high energy consumption and costs for the treatment. Peer cities with low level of treatment and collection rates have lower energy demand, but high environmental pollution. The electricity cost for water treatment (potable and wastewater) as a Percentage of Total Water Utility Expenditures are at 45% thereby ranking highest in comparison with peer cities due to the above mentioned situation. Similar observations have been made for the energy density of waste water treatment at the high level of 0,86 kWh per m³.

3.6 Power & Heat Sector Benchmarking

Figure 19: KPI and key data for power and heat sector

| Key Data | | Key Performance Indicators (TRACE) | |
|---|-------------|--|-------|
| Technical T&D losses (kWhe) | 49 115 000 | Percent heat loss from network | 11.82 |
| Non-technical T&D losses (kWhe) | 654 700 | Percent total T & D losses | 12.05 |
| Number of households with authorized electrical service | 83 343 | Percent of T & D loss due to non-technical | 1.33 |
| Total electricity produced (kWh) | 432 194 400 | | |

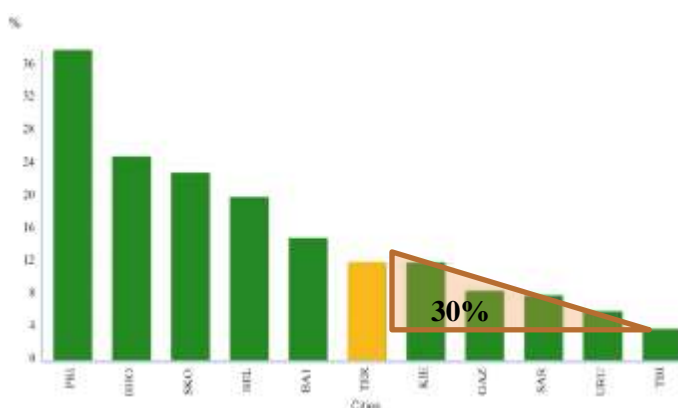
Figure 20: Heat Loss from DH Network in %



The city of Ternopil ranks high for the performance indicator of Heat Loss from Network in comparison with the peer cities with similar climatic characteristic. A level of 12% heat losses is reported by the DH company and demonstrates, in fact, a good performance. Data for Ternopil need to be validated in the course of further assessment. The data of peer cities are not quite up-date and seem to contain estimations.

The city of Ternopil 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 Ternopil amounts to approximately 30% to achieve a level of the better performing cities, such as power distribution networks in Western European cities at a level of 8% losses. The comparison with peer cities in the TRACE model is difficult, as they are not quite up-to-date and seem to be based on estimates and unknown assumptions.

Figure 21: Losses from electricity Transmission & Distribution grid



The Percent of Losses of the power Transmission & Distribution network due to Non-Technical Losses is in the city of Ternopil 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 22: KPI and key data for public lighting sector

| Key Data | | Key Performance Indicators (TRACE) | |
|---|-----------|--|----------|
| Total electricity consumption of street lights (kWhe) | 2 672 100 | Electricity consumed per km of lit roads (kWhe/km) | 7 740.73 |
| Total length of roads (km) | 345.2 | | |
| Length of lit roads (km) | 345.2 | % of city roads lit | 100 |
| Number of light poles | 8 248 | | |
| Total energy expenditure for street lights (\$) | 176 539 | Electricity consumed per light pole (by light point) | 323.97 |
| Average electric rates for street lights (\$/kWh) | 0.066 | | |

The specific electricity Consumed of Lit Roads in Ternopil with 7,700 kWh per km and the specific Electricity Consumed are with 324 kWh per Light Pole are low compared with peer cities. 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.

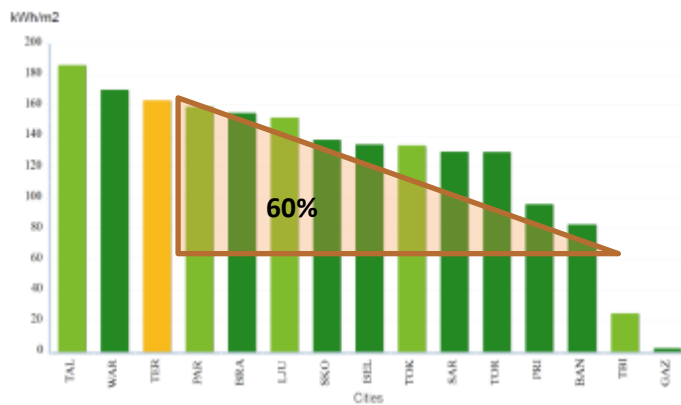
3.8 Municipal Buildings benchmarking

Figure 23: KPI and key data for municipal public buildings sector

| Key Data | | Key Performance Indicators (TRACE) | |
|---|------------|--|--------|
| Electricity consumption in municipal buildings (kWhe) | 7 311 800 | Municipal buildings electricity consumption (kWhe/m ²) | 19.45 |
| Fuel consumption in municipal buildings (kWht) | 61 334 417 | | |
| Total energy expenditure for municipal buildings (\$) | 8 077 902 | Municipal buildings fuel consumption (kWht/m ²) | 163.16 |
| Municipal buildings, floor area (m ²) | 375 919 | | |
| Municipal buildings, average \$/kWh | 0.09 | Municipal buildings energy spend a percent of municipal budget | 8.15 |
| Commercial buildings, average \$/kWh | 0.35 | | |
| Residential buildings, average \$/kWh | 0.02 | | |

The specific electricity consumption in Municipal Buildings is with approximately 20 kWh per sqm low compared with all peer cities.

Figure 24: Municipal Buildings Heat Consumption (kWht / m²)

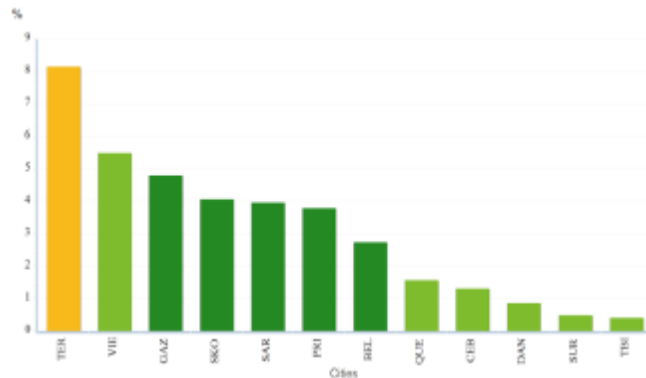


The city of Ternopil ranks low for the performance indicator of Municipal Buildings Heat Consumption in comparison with the peer cities with similar climatic characteristic. The theoretical energy saving potential for the city of Ternopil amounts to approximately 50 to 60 % to achieve a level of the 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.

Figure 25: Percentage of Municipal Budget spending for energy in municipal buildings

The share of spending of energy in municipal buildings amounts to approximately of the 8% Municipal Budget of Ternopil. This is very high compared with peer cities. A direct energy saving potential cannot be derived from this indicator. This indicator is for average performing cities in western Europe at a level of 2 to 3 %.



3.9 Summary of Ternopil 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 treatment,**
- specific energy consumption for **street lighting,**
- energy use per capita for total **transport**
- specific energy consumption of the **public transport fleet**

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 both achievable due to the control and impact by the CA and financially viable.

The process for identifying priority sectors considers three main issues:

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

4.1 Spending for energy in the city

| | |
|--|-------------------------------|
| Annual Budget of City in 2013 | 99 095 378 USD |
| City Government Energy Spend | |
| Energy Spending (for sectors: municipal public transport, municipal buildings, street lighting, waste, water and waste water services) in 2013 | 17 787 250 USD |
| Of which energy spending for municipal buildings | 8,077,902 USD 8% of budget |
| Energy Spend as Percentage of Annual Budget | 18% |

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 26: 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 | 8.1 | 50-60% | 77% |
| Street Lighting | 0.2 | 40-50% | 35% |
| District Heating | 22.0 | 30% | 16% |
| Public Transportation | 5.2 | 20-35% | 6% |
| Waste | 0.4 | 30-50% | 48% |
| Potable Water | 1.6 | 30% | 33% |
| Wastewater | 2.3 | 30-50% | |
| Electricity sector | 33.4 | 3% | 0% |
| Private Vehicles | 66.7 | 20% | 1% |

The spending for energy in Ternopil, without private transport sector, amounted in 2013 to a total 73.2 million USD, including private vehicles 139 million USD.

Figure 27: Costs of energy in Ternopil (in million USD, year 2013, total 139 million USD)

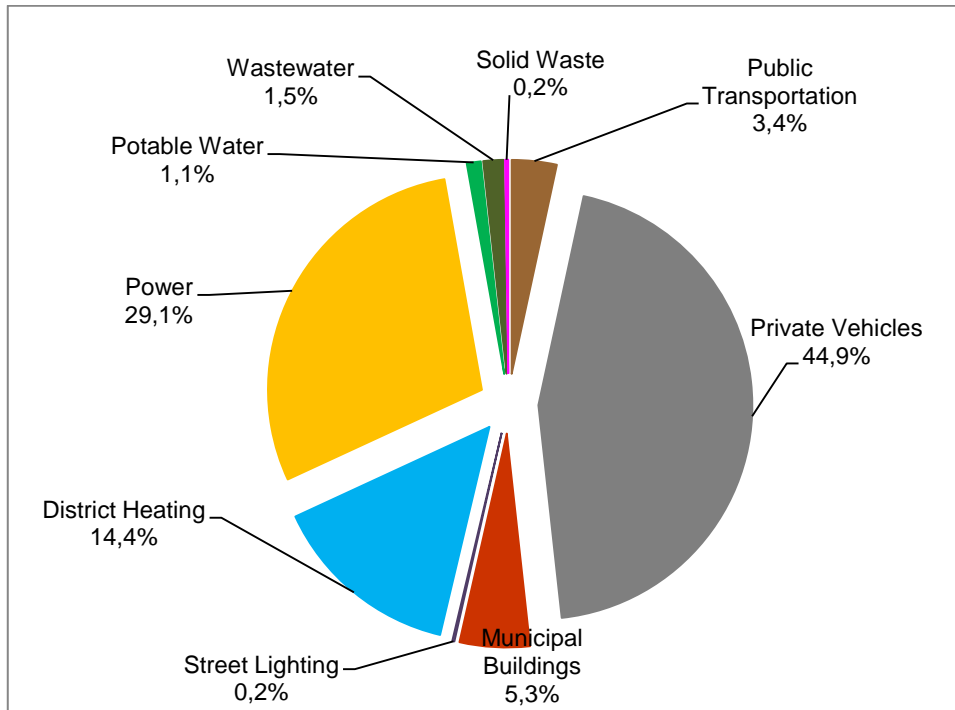
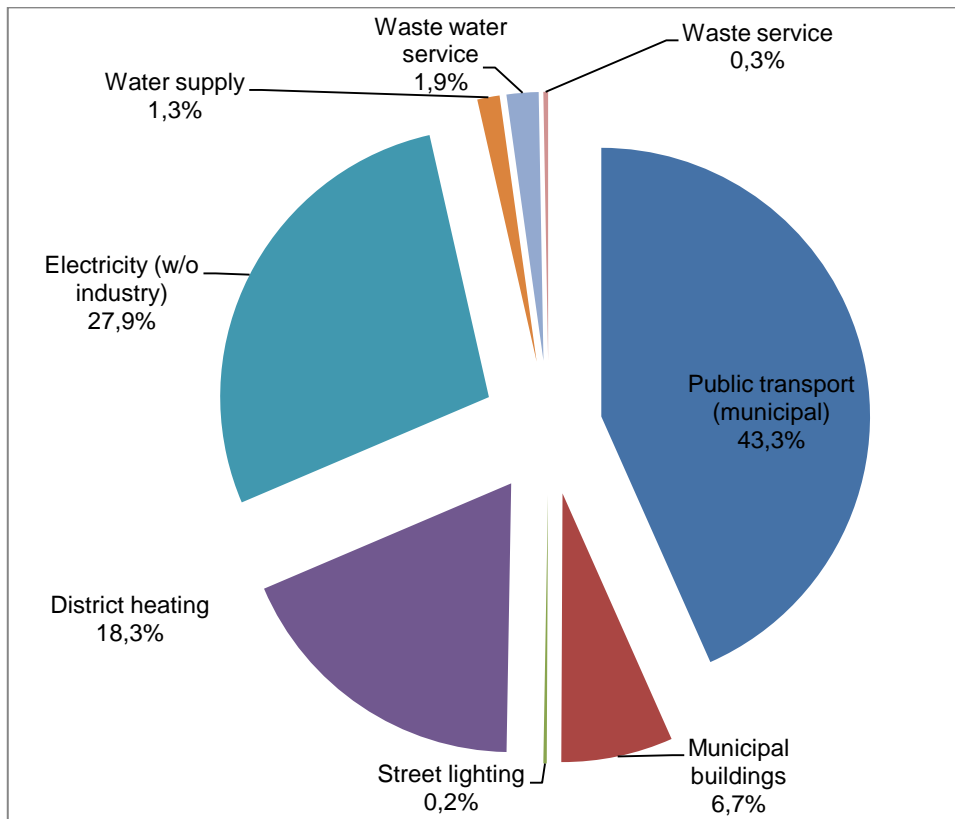


Figure 28: Municipal spending for energy in Ternopil in 2013, without private transport sector (Total 17.8 million USD)



4.3 City authority level of control, influence and enforcement power

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

Figure 29: Ternopil City authority level of budget control and enforcement power and urban infrastructure sectors` energy consumption

| Sector | City authority level of power | | |
|-----------------------|-------------------------------|----------------|---------------------------|
| | Regulatory | Budget control | Influence and enforcement |
| Public buildings | HIGH | HIGH | HIGH |
| Street lighting | HIGH | HIGH | HIGH |
| District heating | MEDIUM | MEDIUM | MEDIUM |
| Public transport | HIGH | MEDIUM | HIGH |
| Potable water supply | LOW | MEDIUM | MEDIUM |
| Wastewater | LOW | MEDIUM | MEDIUM |
| 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 of **water supply and wastewater disposal, district heating, waste management and public transport**.

The energy consumption of the **private, individual transport** can be influenced by the CA to a certain extent 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 Ternopil has **limited control** and influence on

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



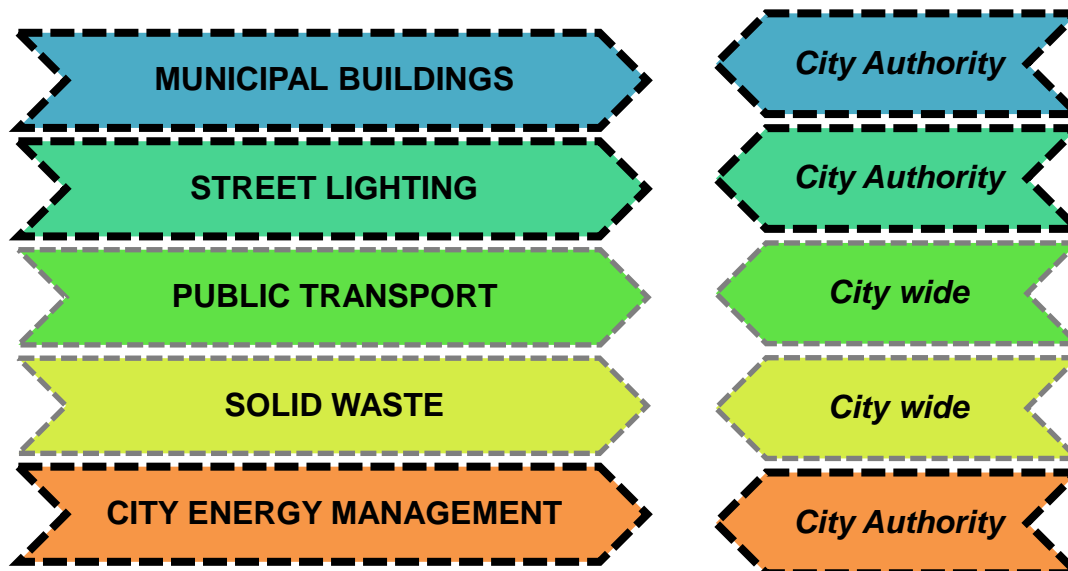
The level of use of the energy of a respective sector indicates in addition the degree of influence of the City Administration.

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.

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. The classification of the level of control has been confirmed by the city leaders during the decision workshop.

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

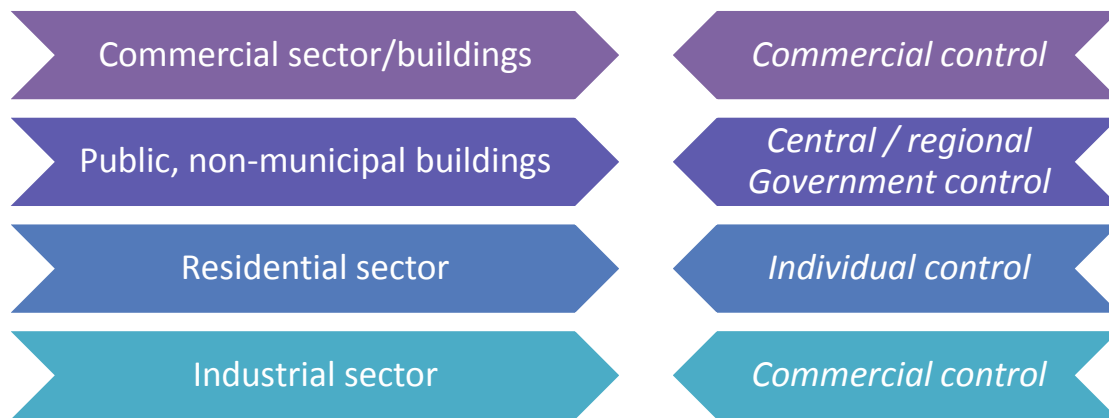


Cross sector priority

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

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 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.

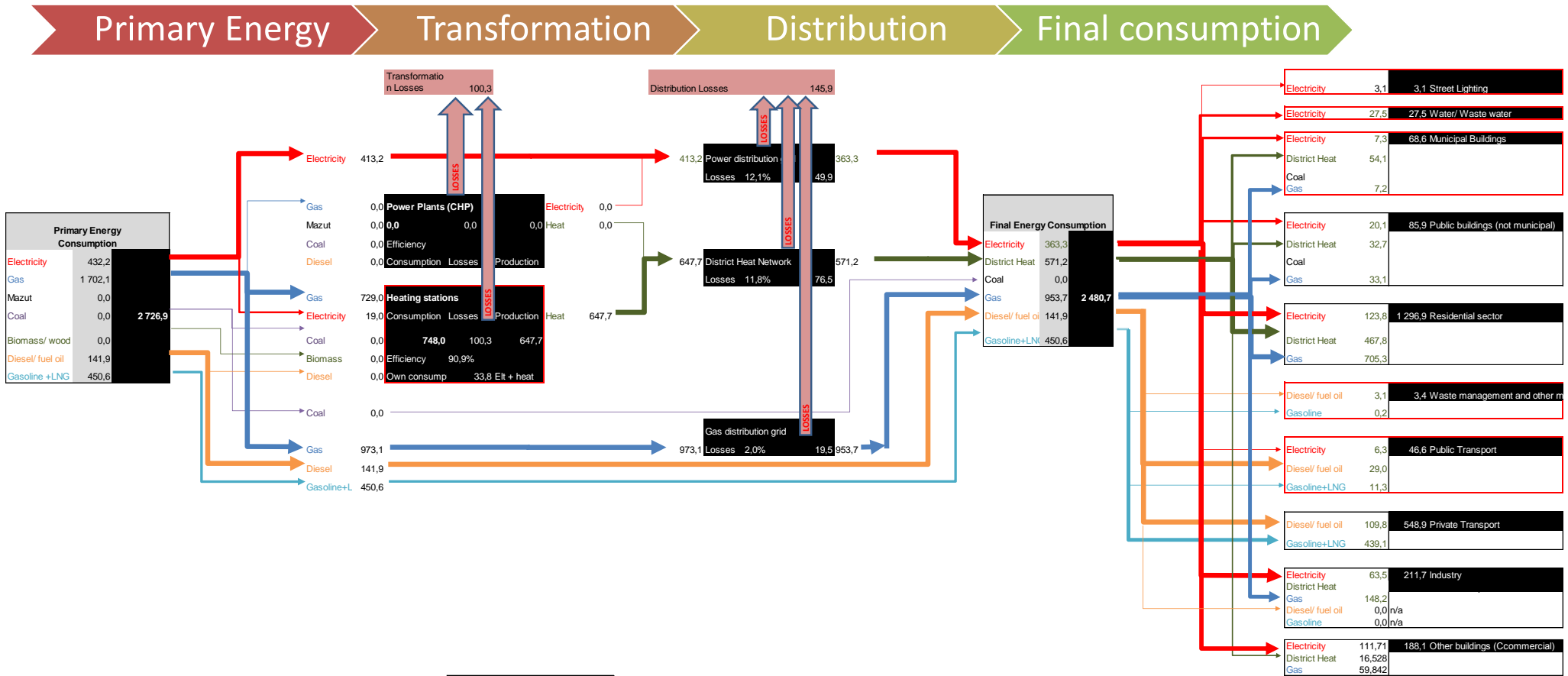
5 Brief Review of Sectors

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

5.1 City wide energy

The Energy balance of Ternopil has been analyzed for the year 2013 and is presented graphically in a Sankey type Energy flow chart. The city controlled areas are marked with a red box. The energy flow of the city follows the logic of supply: Primary Energy → Transformation of Energy → Distribution → Final consumption.

Figure 30: Energy balance and Energy flow chart of Ternopil, 2013 (in GWh)



Ternopil's primary energy consumption amounts to 2,727 GWh in 2013 with highest consumption of natural gas of almost two third. The majority of gas is utilized in boilers of the central heating system to generate district heat for various end consumers. There are no power generation or heat and power cogeneration facilities operated in the city of Ternopil.

Figure 31: Primary energy consumption by energy carrier

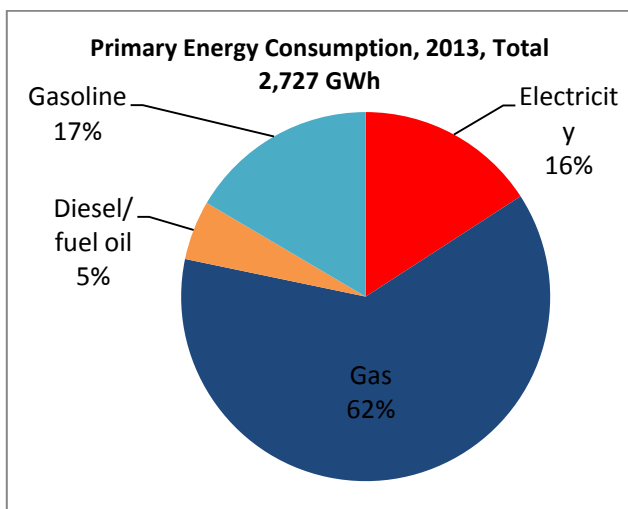
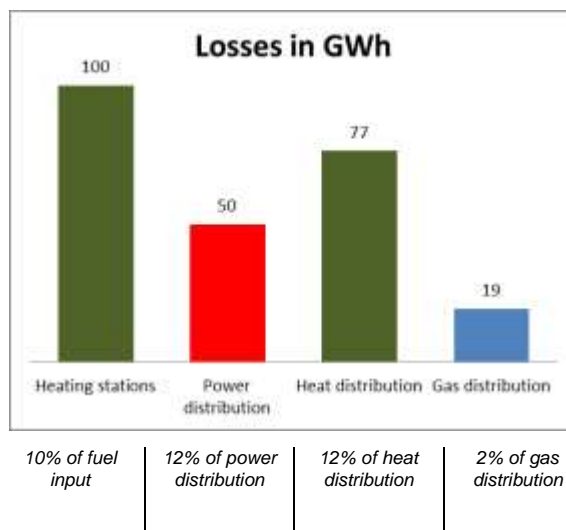


Figure 32: Losses in the energy transformation and distribution



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

Figure 33: Final energy consumption by sector

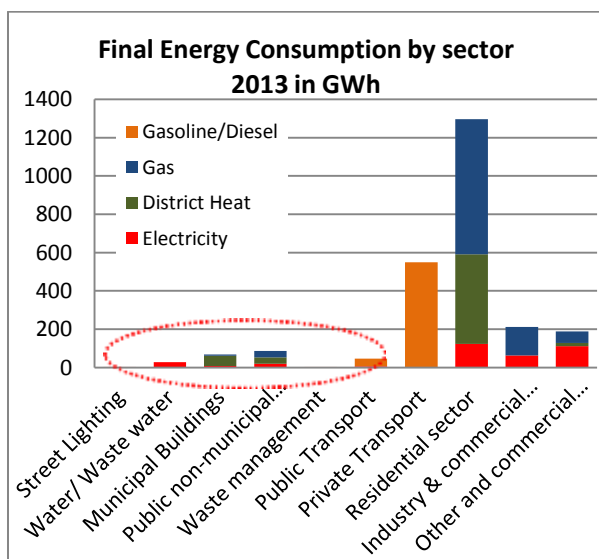
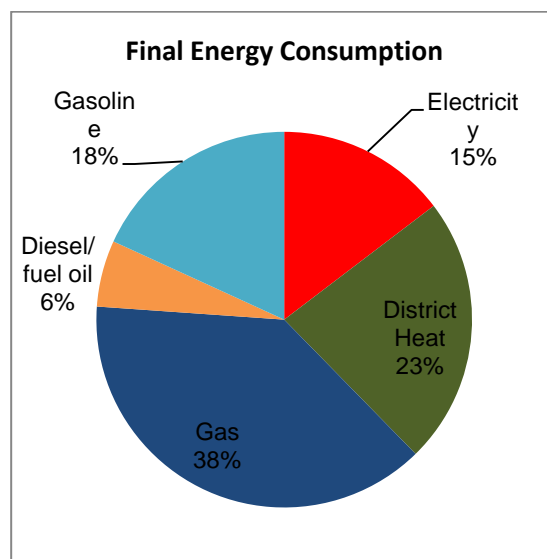


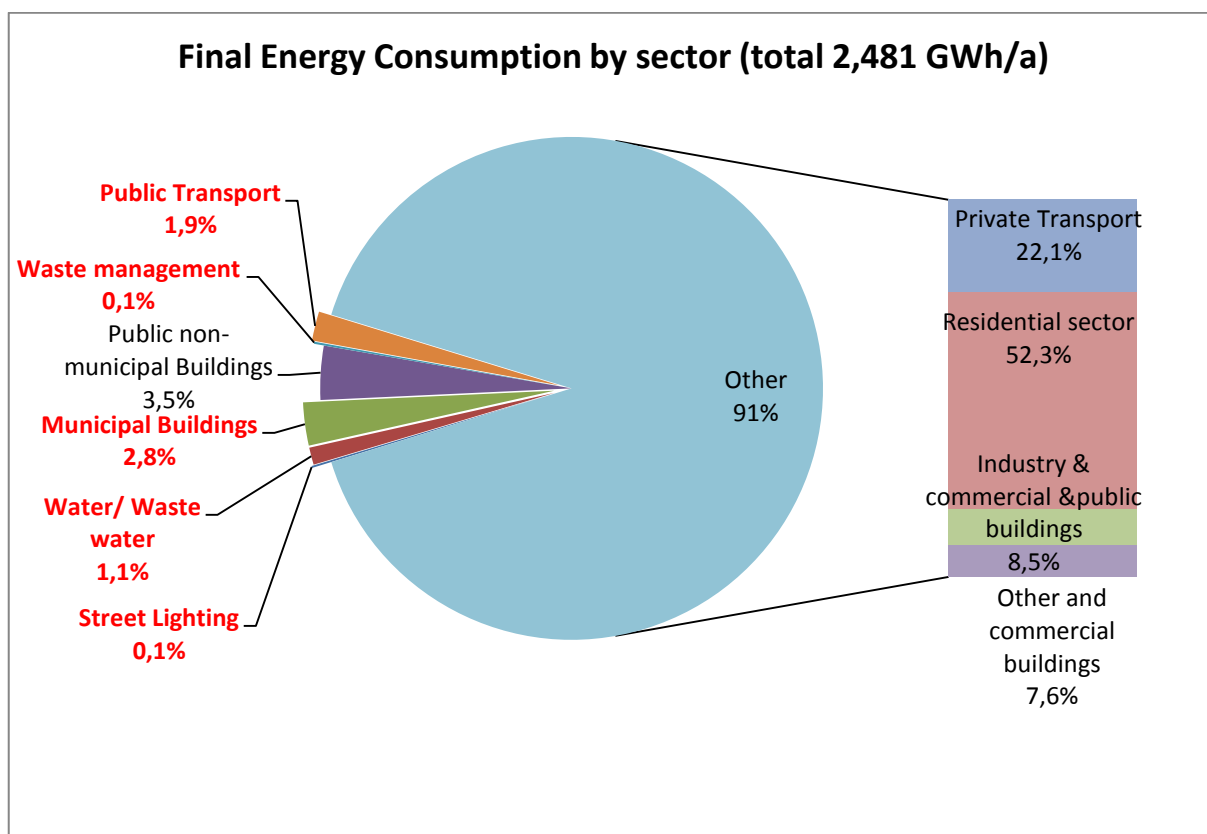
Figure 34: Final energy consumption by energy carrier



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

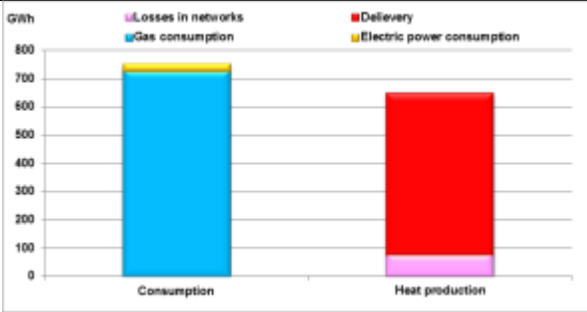
The final energy consumption of the sectors under control and influence by the city administration amounted in 2013 to 149.2 GWh which represents 6% of the overall city final energy consumption.

Figure 35: Final energy consumption by sector, 2013 in %



5.2 Heat generation and distribution - city wide

| | |
|-------------------------------------|--|
| Operators of facilities/ utilities: | The communal enterprises “Ternopilmiskteplokomunenergo” 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 “Ternopilmiskteplokomunenergo” and maintains influence on operation, performance and financing. |
| City energy spent and energy use: | <p>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.</p> <p>The DH company operates 38 boiler-houses, with a total installed capacity of 646.278 Gcal/h (751.6 MW). Much of boilers are outdated and physically worn out which leads to the reduction to an operational capacity to one third, at a level of 215 Gcal/h. Approximately 85% of the boilers have exceeded their operation life time.</p> <p>The production capacity of the heating company amounts for space heat delivery at 191.359 Gcal/h and for hot water supply 22.703 Gcal/h.</p> <p>The heat networks length is 148.5 km. The heat losses in the DH network amount to 12%, caused by hydraulic losses, network water loses and heat losses in the pipelines</p> <p>Figure 36: Comparison of fuel consumption and heat energy production</p> |

| | |
|--|--|
| |  <p>The energy input / gas consumption for the heat production is with the amount of 139 m³/Gcal. The electricity consumption for heat production and distribution is high (37.5 kWh/Gcal). The main reasons for the high specific electricity consumption are: disconnection of consumers from the centralized heating system with 34% customers already lost; technically outdated equipment; lack of hydraulic balancing at the consumer sites.</p> |
| <p>Condition of main equipment and EE potential:</p> | <p>The DH network was constructed in the 1970–80 years; today 62% of the DH network components are older than 15 years. The majority of the heat networks are laid in reinforced concrete troughs which are impassable channels. Thermal insulation of pipes made mainly by mineral wool and glass wool mats and is partly damaged.</p> <p>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".</p> <p>Gas tariffs for heating companies that produce heat for households shall increase during 2014-2017 in steps by 34%, 40%, 20% and 20%.</p> |

5.3 Power distribution - city wide

| | |
|--|---|
| <p>Operators of facilities/ utilities:</p> | <p>Electric power supply is carried out by JSC "Ternopiloblenergo" whose activities comprise electricity purchase, transmission and distribution to consumers in the region.</p> |
| <p>Level of CA control or influence:</p> | <p>The power distribution system is not subject of municipal control or the municipal budget. Energy efficiency measures are under the responsibility of JSC "Ternopiloblenergo".</p> <p>The electricity tariffs are regulated by the National Commission for State Energy and Public Utilities Regulation of Ukraine.</p> |
| <p>City energy spent and energy use:</p> | <p>In 2013 city electricity consumption in Ternopil was 363.2 GWh, including population consumption - 33%, other consumers - 25%, industry - 18%, municipal utilities - 17% and public buildings -7%.</p> <p>All households are connected and supplied by the power utility.</p> <p>Figure 37: Structure of city electricity consumption by consumers groups</p> |

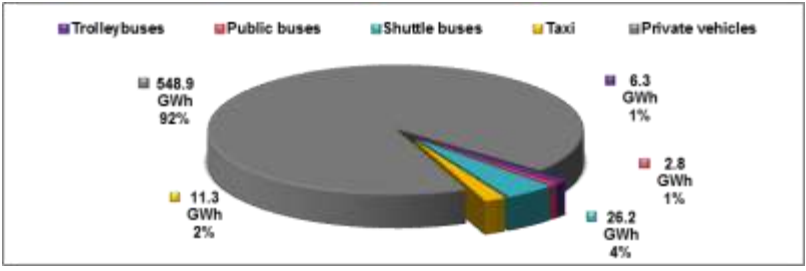
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| | |
| <p>Condition of main equipment and EE potential:</p> | <p>Ternopil power supply is operated through 6 substations at 110/10 kV with a total capacity of 197 MVA. The length of the power electric networks is as follows: cables 10 kV and 0.4 kV – 643 km, Overhead lines 10 kV and 0,4 kV - 158 km. For the power distribution 320 closed-transformer substations with a total capacity 174 MVA exist. Consumer network has 168 closed-transformer substations with total capacity – 114 MVA.</p> <p>The technical transmission and distribution losses amount of 49 GWh which represents 12% of transmission energy.</p> <p>During the period 2009-2014 the power utility has undertaken a number of investments to up-grade the system performance: cable and sub-station replacement, improvement of metering.</p> |

5.4 Gas distribution - city wide

| | |
|--|---|
| <p>Operators of facilities/ utilities:</p> | <p>The gas supply in Ternopil is operated by “Ternopilmiskgas”. As of 1st January 2011 76,005 apartments in Ternopil have been 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.</p> |
| <p>Level of CA control or influence:</p> | <p>The gas distribution system is not subject of municipal control or the municipal budget. Energy efficiency measures are under the responsibility of JSC " Ternopilmiskgas".</p> <p>The gas distribution tariffs are regulated by the National Commission for State Energy and Public Utilities Regulation of Ukraine.</p> |
| <p>City energy spent and energy use:</p> | <p>In 2013, the city gas consumption amounted to 179.5 million m³ (1,702 GWh). The structure of gas consumers is: district heating company 44%, residential sector 42%, industry 9%, public buildings 2% and other consumers 3%.</p> <p>Figure 38: Structure of city gas consumption by consumers groups</p> |
| <p>Condition of main equipment and EE potential:</p> | <p>“Ternopilmiskgas” operates 1,390 km of gas pipelines. Based on expert estimation, the technical losses in the gas distribution network amount to 2%.</p> |

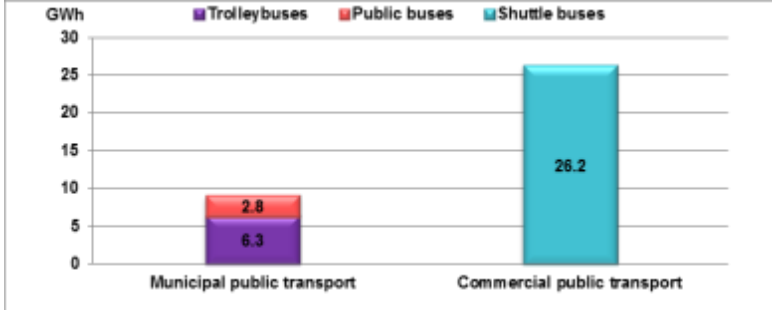
| | |
|--|---|
| | During the period 2009-2014 the gas utility has undertaken a number of investments to up-grade the system performance: reduction of leakages and losses, improvement of metering. |
|--|---|

5.5 Private Transport - city wide

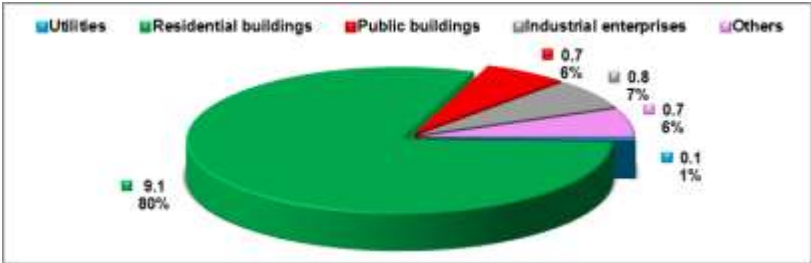
| Operators of facilities/ utilities: | The transport energy consumption is dominated by private, individual vehicles. While the transport mode split referring to passenger-kilometers is estimated with 50–60% urban public transport, 5-10 % walk and cycling, 30-40 % individual, private cars. | | | | | | | | | | | | | | | | | | |
|-------------------------------------|---|--------------------------|-----------|--------------------------|------------------|-----|-------|------|----|------|---------------|----|------|--------------|----|-----|--------------|----|-----|
| 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: | <p>Private vehicles of individual motorized transport are with 92% the largest consumer of fuel and energy in city transport sector in 2013 .</p> <p>The overall passenger turnover amounts to 1,317.6 million passenger km per year. With a total energy consumption of 595 GWh per year. The split of energy consumption for all transport is: 1% electricity, 24% diesel, 74% gasoline and 1% LPG.</p> <p>Figure 39: Share of energy consumption of transport sector</p>  <table border="1"> <caption>Data for Figure 39: Share of energy consumption of transport sector</caption> <thead> <tr> <th>Mode</th> <th>Share (%)</th> <th>Energy Consumption (GWh)</th> </tr> </thead> <tbody> <tr> <td>Private vehicles</td> <td>92%</td> <td>548.9</td> </tr> <tr> <td>Taxi</td> <td>2%</td> <td>11.3</td> </tr> <tr> <td>Shuttle buses</td> <td>4%</td> <td>26.2</td> </tr> <tr> <td>Public buses</td> <td>1%</td> <td>6.3</td> </tr> <tr> <td>Trolleybuses</td> <td>1%</td> <td>2.8</td> </tr> </tbody> </table> | Mode | Share (%) | Energy Consumption (GWh) | Private vehicles | 92% | 548.9 | Taxi | 2% | 11.3 | Shuttle buses | 4% | 26.2 | Public buses | 1% | 6.3 | Trolleybuses | 1% | 2.8 |
| Mode | Share (%) | Energy Consumption (GWh) | | | | | | | | | | | | | | | | | |
| Private vehicles | 92% | 548.9 | | | | | | | | | | | | | | | | | |
| Taxi | 2% | 11.3 | | | | | | | | | | | | | | | | | |
| Shuttle buses | 4% | 26.2 | | | | | | | | | | | | | | | | | |
| Public buses | 1% | 6.3 | | | | | | | | | | | | | | | | | |
| Trolleybuses | 1% | 2.8 | | | | | | | | | | | | | | | | | |

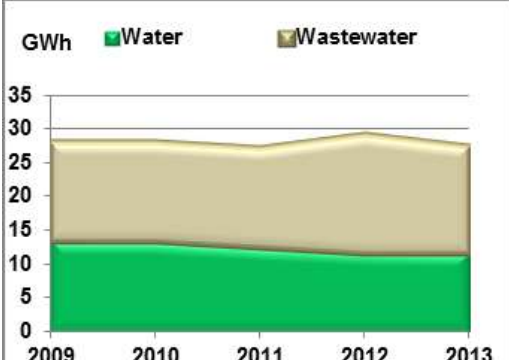
5.6 Public Transport Sector - City wide and City Authority

| | |
|-------------------------------------|---|
| Operators of facilities/ utilities: | <p>The city public transport service is operated by:</p> <ul style="list-style-type: none"> • Transport companies with the CA as the main shareholder: "Ternopilelektrotrans", company with additional liability "Taxopark", OJSC TOP "Ternopilavtotrans-16100", which are operating 42 vehicles (9 trolleybus and 33 bus). • Commercial transport companies: MC "Miskavtotrans", PJSC "Ternopil ATP - 16 127", LLC "Mens - Auto", LLC "ATK" Etalon ", LLC" Nazar - Trans ", LLC "Mega - Service", PE "Ternvoyazh" |
| Level of CA control or influence: | <p>The CA maintains budget control and influence on the 3 municipal public transport companies.</p> <p>Commercial and private transportation services providers and taxi operators must register their vehicles in accordance with Ukrainian laws, to have relevant license and license card for each vehicle equipped according to established specifications.</p> <p>The local authority has full regulatory influence on the transport carriers of municipal ownership but also to a certain extend to commercial transport companies.</p> |
| City energy spent and energy use: | In Ternopil 45 million people (rides) were served by public transport services in 2013 including: trolleybuses - 37% municipal buses - 6%, minibuses - 57%. Preferential transportation is provided by all city |

| | <p>trolleybuses.</p> <p>The total number of inner-urban public transport vehicles comprise 268 units, comprising: 49 trolleybuses, 21 municipal buses, 198 shuttle buses).</p> <p>Figure 40: City transport fuel and energy consumption (excluding taxi and private transport) in 2013</p>  <table border="1"> <caption>Data for Figure 40: City transport fuel and energy consumption (excluding taxi and private transport) in 2013</caption> <thead> <tr> <th>Transport Type</th> <th>Vehicle Type</th> <th>Energy Consumption (GWh)</th> </tr> </thead> <tbody> <tr> <td rowspan="2">Municipal public transport</td> <td>Trolleybuses</td> <td>6.3</td> </tr> <tr> <td>Public buses</td> <td>2.8</td> </tr> <tr> <td>Commercial public transport</td> <td>Shuttle buses</td> <td>26.2</td> </tr> </tbody> </table> | Transport Type | Vehicle Type | Energy Consumption (GWh) | Municipal public transport | Trolleybuses | 6.3 | Public buses | 2.8 | Commercial public transport | Shuttle buses | 26.2 |
|--|---|--------------------------|--------------|--------------------------|----------------------------|--------------|-----|--------------|-----|-----------------------------|---------------|------|
| Transport Type | Vehicle Type | Energy Consumption (GWh) | | | | | | | | | | |
| Municipal public transport | Trolleybuses | 6.3 | | | | | | | | | | |
| | Public buses | 2.8 | | | | | | | | | | |
| Commercial public transport | Shuttle buses | 26.2 | | | | | | | | | | |
| <p>Condition of main equipment and EE potential:</p> | <p>There is the opportunity to introduce higher vehicle emission standards in the process of providing new or the extension of licenses for public transportation.</p> <p>The energy consumption of the private, individual transport can be influenced by the CA to a certain extent only, for example by attracting passengers to shift to public transport mode of mobility and by smoothing inner-city traffic flow.</p> | | | | | | | | | | | |

5.7 Potable Water and Wastewater– city wide

| <p>Operators of facilities/ utilities:</p> | <p>Water supply and waste water services are provided by the municipal utility "Ternopilvodokanal". It is a city wide service to all customer groups.</p> <p>The number of users of potable water (residential, public and commercial) is 80,759 of which 96% are connected to the waste water collection and treatment system.</p> | | | | | | | | | | | | | | | | | | |
|--|---|------------|----------------------------------|------------|-----------------------|-----|-----|------------------|-----|----|------------------------|-----|----|--------|-----|----|-----------|-----|----|
| <p>Level of CA control or influence:</p> | <p>The CA as a key shareholder has control over MU "Ternopilvodokanal" and maintains influence on operation, performance and financing.</p> | | | | | | | | | | | | | | | | | | |
| <p>City energy spent and energy use:</p> | <p>Annual water consumption in the city is 11.4 million m³.</p> <p>Figure 41: . The water consumption Structure in the city, million m³</p>  <table border="1"> <caption>Data for Figure 41: The water consumption Structure in the city, million m³</caption> <thead> <tr> <th>Category</th> <th>Volume (million m³)</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Residential buildings</td> <td>9.1</td> <td>80%</td> </tr> <tr> <td>Public buildings</td> <td>0.7</td> <td>6%</td> </tr> <tr> <td>Industrial enterprises</td> <td>0.8</td> <td>7%</td> </tr> <tr> <td>Others</td> <td>0.7</td> <td>6%</td> </tr> <tr> <td>Utilities</td> <td>0.1</td> <td>1%</td> </tr> </tbody> </table> <p>The annual volume of sewage to be treated (including waste water from other sources and collected rain water) is 18,4 million m³.</p> <p>For the operation purposes of the water supply and wastewater system 27.5 GWh of electricity have been consumed in 2013, of which 43% for water supply and 57% for wastewater.</p> <p>Average specific electricity consumption for water supply is 0.675 kWh / m³ and for wastewater – 0.857 kWh / m³.</p> | Category | Volume (million m ³) | Percentage | Residential buildings | 9.1 | 80% | Public buildings | 0.7 | 6% | Industrial enterprises | 0.8 | 7% | Others | 0.7 | 6% | Utilities | 0.1 | 1% |
| Category | Volume (million m ³) | Percentage | | | | | | | | | | | | | | | | | |
| Residential buildings | 9.1 | 80% | | | | | | | | | | | | | | | | | |
| Public buildings | 0.7 | 6% | | | | | | | | | | | | | | | | | |
| Industrial enterprises | 0.8 | 7% | | | | | | | | | | | | | | | | | |
| Others | 0.7 | 6% | | | | | | | | | | | | | | | | | |
| Utilities | 0.1 | 1% | | | | | | | | | | | | | | | | | |

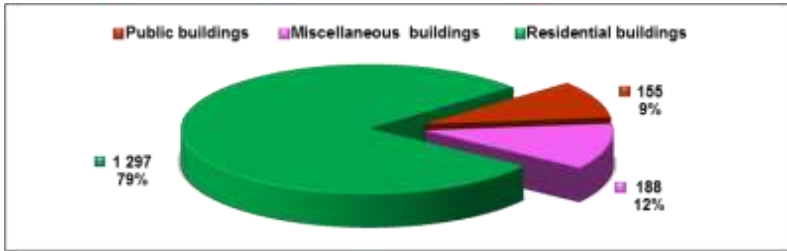
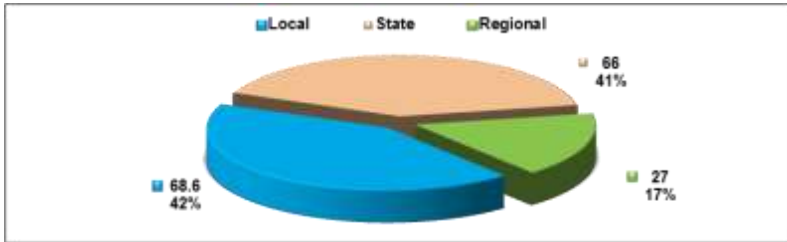
| | <p>Figure 42: Electricity consumption of MU "Ternopilvodokanal" on water and wastewater service</p>  <table border="1"> <caption>Data for Figure 42: Electricity consumption (GWh)</caption> <thead> <tr> <th>Year</th> <th>Water (GWh)</th> <th>Wastewater (GWh)</th> </tr> </thead> <tbody> <tr> <td>2009</td> <td>~12</td> <td>~16</td> </tr> <tr> <td>2010</td> <td>~11</td> <td>~16</td> </tr> <tr> <td>2011</td> <td>~11</td> <td>~17</td> </tr> <tr> <td>2012</td> <td>~11</td> <td>~18</td> </tr> <tr> <td>2013</td> <td>~10</td> <td>~18</td> </tr> </tbody> </table> | Year | Water (GWh) | Wastewater (GWh) | 2009 | ~12 | ~16 | 2010 | ~11 | ~16 | 2011 | ~11 | ~17 | 2012 | ~11 | ~18 | 2013 | ~10 | ~18 |
|--|---|------------------|-------------|------------------|------|-----|-----|------|-----|-----|------|-----|-----|------|-----|-----|------|-----|-----|
| Year | Water (GWh) | Wastewater (GWh) | | | | | | | | | | | | | | | | | |
| 2009 | ~12 | ~16 | | | | | | | | | | | | | | | | | |
| 2010 | ~11 | ~16 | | | | | | | | | | | | | | | | | |
| 2011 | ~11 | ~17 | | | | | | | | | | | | | | | | | |
| 2012 | ~11 | ~18 | | | | | | | | | | | | | | | | | |
| 2013 | ~10 | ~18 | | | | | | | | | | | | | | | | | |
| <p>Condition of main equipment and EE potential:</p> | <p>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 water supply network that need to be replaced is 183.6 km, which is 54% of the total water supply pipeline length. The length of waste water treatment network that need to be replaced is 135 km, which is 54% of the total waste water treatment pipeline length. Demand for energy saving by:</p> <ul style="list-style-type: none"> • Implementation of energy efficient pumps and fans • improved metering of water consumption at residential sector | | | | | | | | | | | | | | | | | | |

5.8 Waste management – city wide

| | |
|--|---|
| <p>Operators of facilities/ utilities:</p> | <p>Solid waste collecting services are determined on a competitive commercial basis according to the Law of Ukraine. In 2013 services collection, transportation and disposal of solid waste in the city has been provided by companies "Altfater-Ternopil", PE "Ekotern", PE "Quarter-L".</p> |
| <p>Level of CA control or influence:</p> | <p>The CA as has limited control over the commercial waste collection companies, but maintains full responsibility on the landfill.</p> |
| <p>City energy spent and energy use:</p> | <p>In Ternopil there are 86,891 households and approximately 2,000 companies and organizations which generate solid municipal waste. Total solid waste annual collection in Ternopil in 2013 is 485,900 m³. Recyclable fragments of the waste volume amount to 342,600 m³, i.e. 71 % of the total, of which paper 25 %, metal 5 %, plastic 6 % and biomass 35 %. Currently less than 1% of the waste annual volume is recycled. 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 300,040 liters of fuel in 2013</p> |
| <p>Condition of main equipment and EE potential:</p> | <p>According to the waste management programs of the city the following energy performance improvements are necessary: :</p> <ul style="list-style-type: none"> • 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 |

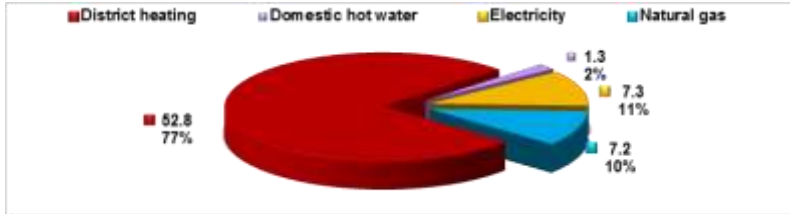
| | |
|--|--|
| | <p>driver training;</p> <ul style="list-style-type: none"> • awareness campaigns for reduction and separation of waste. |
|--|--|

5.9 Building sector – City wide and City Authority

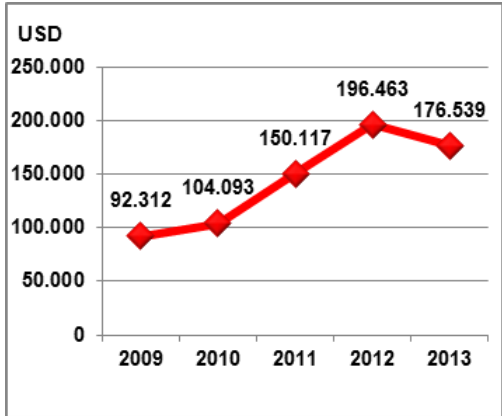
| Operators of facilities/ utilities: | The total energy consumption of all buildings in Ternopil of various types of usage and ownership amounted to 1,640 GWh in 2013, representing 66% of the total city consumption. | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|----------------|-------------------|------------|-----------------------|------|-----|-------------------------|-----|-----|------------------|-----|----|----------------|-------------------|------------|-------|------|-----|-------|----|-----|----------|----|-----|
| Level of CA control or influence: | The buildings of the city are the largest final energy consumers, of which almost 80% 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: | <p>Figure 43: Energy consumption structure of overall buildings of different ownership, GWh</p>  <table border="1"> <caption>Data for Figure 43</caption> <thead> <tr> <th>Ownership Type</th> <th>Consumption (GWh)</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Residential buildings</td> <td>1297</td> <td>79%</td> </tr> <tr> <td>Miscellaneous buildings</td> <td>188</td> <td>12%</td> </tr> <tr> <td>Public buildings</td> <td>155</td> <td>9%</td> </tr> </tbody> </table> <p>Figure 44: Structure of energy consumption of public buildings according to their ownership, GWh</p>  <table border="1"> <caption>Data for Figure 44</caption> <thead> <tr> <th>Ownership Type</th> <th>Consumption (GWh)</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Local</td> <td>68.6</td> <td>42%</td> </tr> <tr> <td>State</td> <td>66</td> <td>41%</td> </tr> <tr> <td>Regional</td> <td>27</td> <td>17%</td> </tr> </tbody> </table> | Ownership Type | Consumption (GWh) | Percentage | Residential buildings | 1297 | 79% | Miscellaneous buildings | 188 | 12% | Public buildings | 155 | 9% | Ownership Type | Consumption (GWh) | Percentage | Local | 68.6 | 42% | State | 66 | 41% | Regional | 27 | 17% |
| Ownership Type | Consumption (GWh) | Percentage | | | | | | | | | | | | | | | | | | | | | | | |
| Residential buildings | 1297 | 79% | | | | | | | | | | | | | | | | | | | | | | | |
| Miscellaneous buildings | 188 | 12% | | | | | | | | | | | | | | | | | | | | | | | |
| Public buildings | 155 | 9% | | | | | | | | | | | | | | | | | | | | | | | |
| Ownership Type | Consumption (GWh) | Percentage | | | | | | | | | | | | | | | | | | | | | | | |
| Local | 68.6 | 42% | | | | | | | | | | | | | | | | | | | | | | | |
| State | 66 | 41% | | | | | | | | | | | | | | | | | | | | | | | |
| Regional | 27 | 17% | | | | | | | | | | | | | | | | | | | | | | | |
| Condition of main equipment and EE potential: | Through the installation of Individual Heating Stations (IHS) overheating of apartments can be reduced and better hydraulic balancing can be achieved. EE investments in improvement of the building performance and a decrease of the heat demand, e.g. building shell measures, remain challenging due to the ownership structure. | | | | | | | | | | | | | | | | | | | | | | | | |

5.10 Municipal Buildings - city authority

| | |
|-------------------------------------|--|
| Operators of facilities/ utilities: | The operator of the municipal public buildings are the departments of the CA: Department of Health and medical care, Department of Education and Science, Department of Culture and the Arts, Social Policy Management Department, Department of Family, Youth, Sports and Tourism; |
| Level of CA control or influence: | |
| City energy spent and energy use: | <p>In Ternopil there are 122 public municipal buildings with local budget funding with a total area is 375,900 m².</p> <p>Municipal budget buildings can be divided into three types of budget funding: central government, regional and municipal buildings.</p> <p>Municipal budget buildings' fuel and energy consumption occupies approx. 4% among the total city buildings consumption</p> <p>The total amount of heat energy consumed in 2013 by municipal public</p> |

| | <p>buildings was 425,00 Gcal. Consumption of electricity is high at 11% of the total energy consumption. In 2013 7.3 GWh of electric energy was consumed by municipal public buildings.</p> <p>There is almost no supply of hot water from the district heating network for municipal public buildings.</p> <p>The gas consumption for heating and hot water preparation by individual boilers in municipal public building boilers amounted to 33 GWh per annum.</p> <p>Figure 45: The structure of fuel and energy consumption, GWh</p>  <table border="1"> <caption>Data for Figure 45: The structure of fuel and energy consumption, GWh</caption> <thead> <tr> <th>Category</th> <th>Value (GWh)</th> <th>Percentage (%)</th> </tr> </thead> <tbody> <tr> <td>District heating</td> <td>52.8</td> <td>77%</td> </tr> <tr> <td>Domestic hot water</td> <td>1.3</td> <td>2%</td> </tr> <tr> <td>Electricity</td> <td>7.3</td> <td>11%</td> </tr> <tr> <td>Natural gas</td> <td>7.2</td> <td>10%</td> </tr> </tbody> </table> <p>The specific heating energy consumption is in the range of 150-170 kWh / m².</p> | Category | Value (GWh) | Percentage (%) | District heating | 52.8 | 77% | Domestic hot water | 1.3 | 2% | Electricity | 7.3 | 11% | Natural gas | 7.2 | 10% |
|--|---|----------------|-------------|----------------|------------------|------|-----|--------------------|-----|----|-------------|-----|-----|-------------|-----|-----|
| Category | Value (GWh) | Percentage (%) | | | | | | | | | | | | | | |
| District heating | 52.8 | 77% | | | | | | | | | | | | | | |
| Domestic hot water | 1.3 | 2% | | | | | | | | | | | | | | |
| Electricity | 7.3 | 11% | | | | | | | | | | | | | | |
| Natural gas | 7.2 | 10% | | | | | | | | | | | | | | |
| <p>Condition of main equipment and EE potential:</p> | <p>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.</p> | | | | | | | | | | | | | | | |

5.11 Public Lighting – City Authority

| <p>Operators of facilities/ utilities:</p> | <p>Operation, and maintenance of outside city lighting is carried out by municipal communal enterprise "TernopilmiskSvitlo"</p> | | | | | | | | | | | | |
|--|--|------|------------|------|--------|------|---------|------|---------|------|---------|------|---------|
| <p>Level of CA control or influence:</p> | <p>CE "Ternopilmisksvitlo" is a legal entity in 100% ownership of the municipality. Thus the CA maintains full control and influence for the public lighting sector.</p> | | | | | | | | | | | | |
| <p>City energy spent and energy use:</p> | <p>The total amount of electric energy consumption in 2013 was 3.126 GWh.</p> <p>The electricity consumption for street lighting during 2009 -2013 has been quite stable, while the costs for energy in the same period has almost doubled.</p> <p>Figure 46: Annual costs for street lighting</p>  <table border="1"> <caption>Data for Figure 46: Annual costs for street lighting</caption> <thead> <tr> <th>Year</th> <th>Cost (USD)</th> </tr> </thead> <tbody> <tr> <td>2009</td> <td>92.312</td> </tr> <tr> <td>2010</td> <td>104.093</td> </tr> <tr> <td>2011</td> <td>150.117</td> </tr> <tr> <td>2012</td> <td>196.463</td> </tr> <tr> <td>2013</td> <td>176.539</td> </tr> </tbody> </table> | Year | Cost (USD) | 2009 | 92.312 | 2010 | 104.093 | 2011 | 150.117 | 2012 | 196.463 | 2013 | 176.539 |
| Year | Cost (USD) | | | | | | | | | | | | |
| 2009 | 92.312 | | | | | | | | | | | | |
| 2010 | 104.093 | | | | | | | | | | | | |
| 2011 | 150.117 | | | | | | | | | | | | |
| 2012 | 196.463 | | | | | | | | | | | | |
| 2013 | 176.539 | | | | | | | | | | | | |
| <p>Condition of main equipment and EE potential:</p> | <p>For street lighting mainly incandescent lamps, arc mercury fluorescent lamps, and sodium-vapor tube lamps are used. Currently 73% of installed bulbs are efficient high-pressure sodium-vapor bulbs at a</p> | | | | | | | | | | | | |

| | | | | |
|--|--|------|-------------------------------------|------------------------|
| | capacity of 150 W. | | | |
| | The operation hours of the street lighting are 3.743 h/year. | | | |
| | Figure 47: 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 | DNaT | 150 | 6,050 |
| | Arc mercury fluorescent lamps | DRL | 250 | 2,138 |
| | Incandescent lamps | IL | 100 | 56 |
| LED lamps | LED | | 4 | |
| Total | | | 8,248 | |
| 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 39.200. | | | | |

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 Ternopil
- recommended EE measures which have been identified during **interviews with city administration and local stakeholders, utilities**
- **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, EBRD) 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 74 EE recommendations has been identified and preliminarily evaluated on their appropriateness. Those include also EE recommendations in the sectors with have been recommended as ‘low priority’, i.e. the power sector and private transport.

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

- a) Degree of **control and influence** of the Municipal Authority on the sector
- b) Degree of **competencies of the CA** or the stakeholder responsible for the implementation. Competencies of the CA comprise: Capacities of the utility or municipal staff to operate and maintain the project, equipment/ facility; Capacity to undertake project assessment, public procurement and implementation supervision; Experiences with similar previous projects; Available methods/equipment to verify energy savings. The assessment of the competencies follows the initial appraisal of the TRACE model
- c) **Ease** of Implementation
- d) Availability of the **local market** for the EE measure and maturity of the Ukrainian and local market for application, mainly related to absorption capacity for the technology and its operation
- e) Availability of a **supporting framework**, in terms of regulatory, legal and municipal policy
- f) Ability to achieve the **Economic Sustainability**; to establish and maintain the economic benefit in terms of revenues from the EE measure for the investor in the EE measure.

If one or more of the criteria b) to f) have been evaluated negatively, such as low or not guaranteed, the respective EE recommendation has been dropped for further consideration.

The Recommended EE measures are of **different type**, nature:

- **Type I: investment** measures, which comprise the investment and installation of EE technology and equipment and generate physical energy savings
- **Type P: preparation** measures which are non-investment but preparing the framework or conditions for the smooth implementation of investment measures, such as feasibility studies, regulation, implementation mechanisms. It is recommended to link and combine those type P measures with investment measures.
- **Type A: Accompanying** measures, which are non-investment or low investment, which 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 | 258,402 sqm including building shell, piping (no EE on electricity consumption) |
| PB-02 | Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals) | I-Investment | Biomass (woodchips/pellets) and heat pumps |
| PB-03 | Municipal medical facilities Audit and Retrofit Program (hospitals, polyclinics, etc.) | I-Investment | 73,660 sqm including building shell, piping (no EE on electricity consumption) |
| PB-04 | Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.) | I-Investment | 30,162 sqm including building shell, piping (no EE on electricity consumption) |
| PB-05 | Municipal administrative buildings Audit and Retrofit Program | I-Investment | 13,688 sqm including building shell, piping (no EE on electricity consumption) |
| PB-06 | Replacement of indoor lighting for all municipal public buildings | I-Investment | (T5 with reflector of LED), all buildings 10 kWh/m2 for lighting |
| PB-07 | Municipal Building Inventory and Benchmarking and Monitoring Program | P-Preparation | |
| PB-08 | Mandatory Building Energy Efficiency Codes for Existing and New Buildings | 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

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:

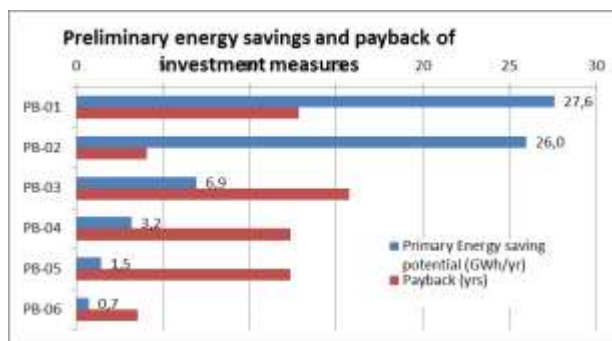
- Municipal Building Energy Efficiency Task Force, as it shall be included in the Energy Management sector
- Municipal Residential building Audit and Retrofit Program; as there are no considerable municipally owned residential buildings
- Computer PowerSave Project
- Solar Hot Water Program
- Green Building Guidelines for New Municipal Buildings, due to limited number of new construction expected
- Installation of IHS at schools and kindergartens, as this has been realized already for 90% of the related buildings (74 buildings)
- Green Building Guidelines for New Municipal Buildings, included in PB-06

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.

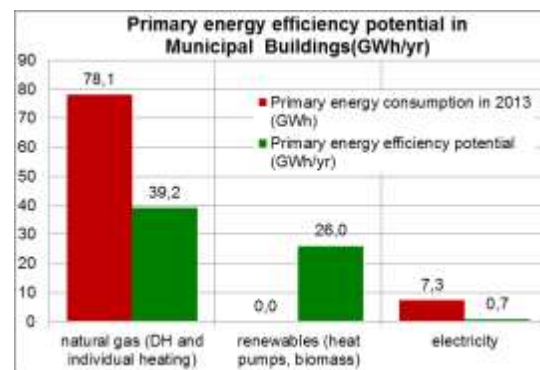
| Code | Title of EE recommendation | Investment costs (M USD) | Primary EE (GWh/a) | Saving of energy carrier | Emission saving (kt CO2/a) | Preliminary payback time (years) ⁸ |
|-------|--|--------------------------|--------------------|--------------------------------|----------------------------|---|
| PB-01 | Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.) | 28,55 | 27,61 | Primary-gas | 5,6 | 12,87 |
| PB-02 | Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals) | 5,30 | 26,00 | Primary-gas | 5,3 | 4,08 |
| PB-03 | Municipal medical facilities Audit and Retrofit Program (hospitals, polyclinics, etc.) | 8,62 | 6,94 | Primary-gas | 1,4 | 15,78 |
| PB-04 | Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.) | 3,14 | 3,22 | Primary-gas | 0,7 | 12,37 |
| PB-05 | Municipal administrative buildings Audit and Retrofit Program | 1,42 | 1,46 | Primary-gas | 0,3 | 12,37 |
| PB-06 | Replacement of indoor lighting for all municipal public buildings | 0,59 | 0,73 | Primary-electricity | 0,8 | 3,55 |
| PB-07 | Municipal Building Inventory and Benchmarking and Monitoring Program | 0,01 | 0,34 | all Final energy of the sector | 0,2 | 0,23 |
| PB-08 | Mandatory Building Energy Efficiency Codes for Existing and New Buildings | 0,01 | 0,00 | all Final energy of the sector | 0,0 | n/a |

Figure 48: 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

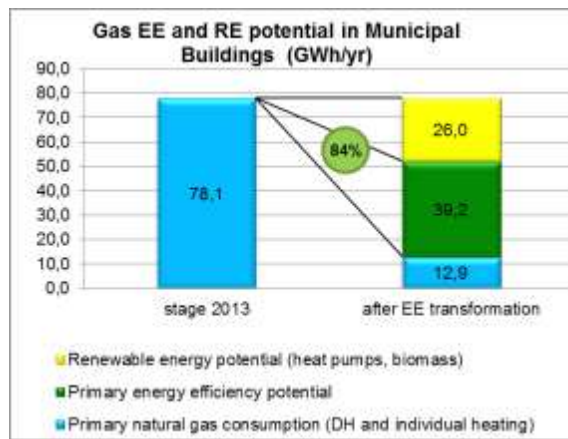


Primary energy savings by type of energy and RE

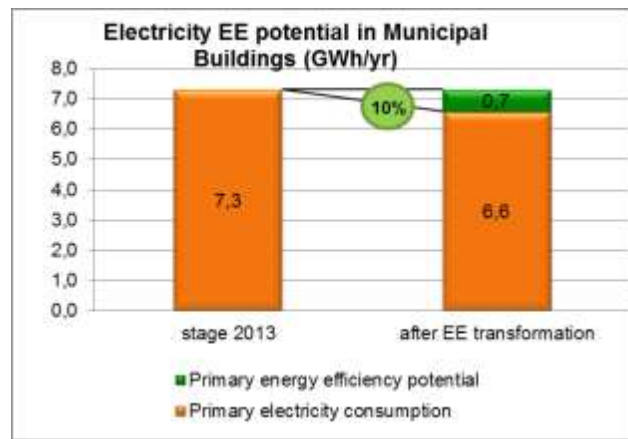


⁸ The PBT is based on a rough estimate of the investment and it doesn't consider operation costs.

Potential gas savings



Potential electricity savings



The reduction of energy demand of municipal public kindergartens and various types of schools bears the largest potential to save district heating energy at a level of 26 GWh per year. The same level of savings of district heat can be achieved by the installation of individual heat generation units using renewable energy sources (such as heat pumps and biomass boilers).

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

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

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

| Title of EE recommendation | Implementation perspective | Possible start in | Implementation Speed (years) |
|--|----------------------------|-------------------|------------------------------|
| Renewable energy individual heat generation for municipal education and medical facilities (schools, kindergartens, hospitals) | short-term | 2017 | 2 years |
| Replacement of indoor lighting for all municipal public buildings | short-term | 2016 | 1 year |
| Municipal Building Inventory and Benchmarking and Monitoring Program | short-term | | 2 years |
| Municipal educational facilities Audit and Retrofit Program (schools, kindergartens, etc.) | long-term | 2016 | 3 years |
| Municipal medical facilities Audit and Retrofit Program (hospitals, polyclinics, etc.) | long-term | 2017 | 3 years |
| Other municipal Building Audit and Retrofit Program (culture facilities, libraries, etc.) | long-term | 2017 | 2 years |
| Municipal administrative buildings Audit and Retrofit Program | long-term | 2016 | 2 years |
| 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

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 | I-Investment | Replacement of Mercury bulbs with LEDs, (approx. 2,100 mercury-vapour lamps of 566 kW), including replacement at public space lighting on demand |
| SL-02 | Street Lighting timing, dimming and management | I-Investment | Combination of dimming and timing device for light points which will be replaced. |

| Code | Title of measure | Type | Comment/ additional information |
|-------|---|---------------|--|
| | Program | | |
| SL-03 | Traffic Signal Audit and Retrofit Program | I-Investment | Replacement at 40 intersections |
| SL-04 | Procurement Guide for New Street Lights | P-Preparation | Implementation of life cycle cost assessment |

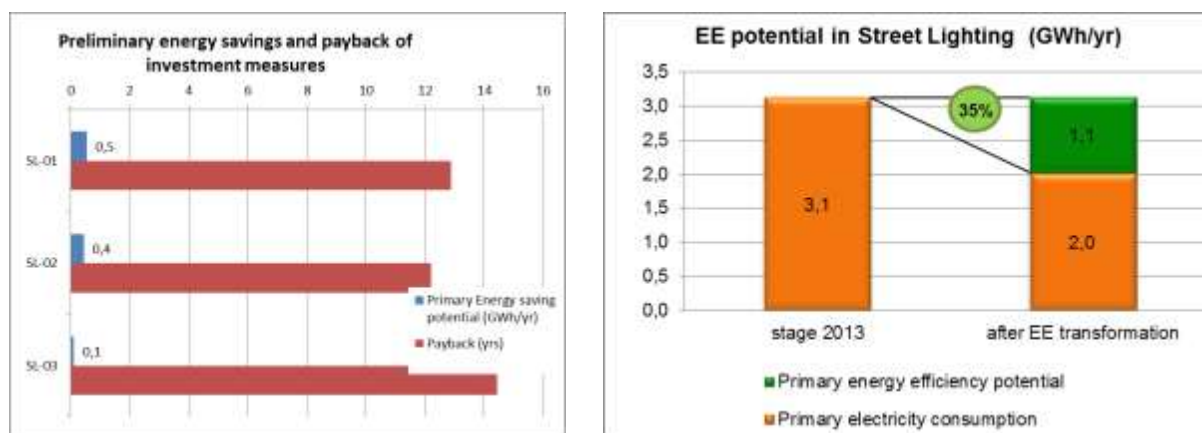
Presently there are no considerable EE investment programs in the sector.

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.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. 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) ¹⁰ | 0,69 | 0,55 | 0,6 | 10-12,87 |
| SL-02 | Street Lighting timing, dimming and management Program | 0,54 | 0,45 | 0,5 | 12,19 |
| SL-03 | Traffic Signal Audit and Retrofit Program | 0,16 | 0,11 | 0,1 | 14,45 |
| SL-04 | Procurement Guide for New Street Lights | 0,00 | 0,00 | 0,0 | 0,00 |

Figure 49: Preliminarily calculated Primary energy saving potential of recommended EE measures and payback time



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

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:

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

¹⁰ Investments include replacement of electric network and poles Lighting Timing, dimming and management Program. It will be analyzed in more detail in the EE program/ profile.

| Code | Title of EE recommendation | Implementation perspective | Possible start in | Speed of Implementation, years |
|-------|--|----------------------------|-------------------|--------------------------------|
| SL-01 | Street Lighting Audit and Retrofit Program | short-term | 2016 | 1 year |
| SL-02 | Street Lighting timing, dimming and management Program | short-term | 2016 | 2 years |
| SL-03 | Traffic Signal Audit and Retrofit Program | short-term | 2016 | 1 year |
| SL-04 | 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 Street lighting company
- Cooperation with the power utility Ternopilenergo 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 | Performance increase of boiler-houses by rehabilitation | I-Investment | change of burners, economizers, replacements, reduction of own consumption |
| DH-02 | Fuel switch for heat generation - gas to biomass | I-Investment | one biomass boiler of 8 MW |
| DH-03 | District heating network rehabilitation, pipeline replacement | I-Investment | emergency replacement of 25% of distribution and transmission pipeline system |
| DH-04 | Solar heating plant | I-Investment | assumed 2 MW for the DHW |
| DH-05 | Hydraulic balancing of the DH system | I-Investment | |
| DH-06 | Installation of cogeneration plant for coverage of own demand | I-Investment | 2 small units (0.3-0.5 MW) |
| DH-07 | Implementation of SCADA system | I-Investment | |
| DH-08 | Replacement of circuit pumps and equipment with VSD | I-Investment | |

On-going EE investment programs in the sector are as follows:

- EBRD project and IBRD project covering DH 02, DH – 03, DH-04, 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.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.

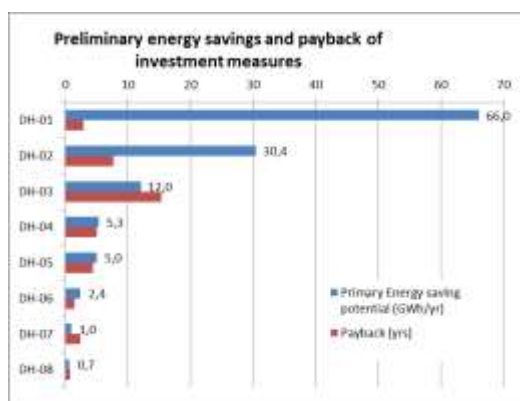
¹¹ TRACE model EE activities in this sector which have been rejected due to their low appropriateness (technology, framework, economic sustainability, capacities, and ease of implementation) are:

- District heating network rehabilitation, pipeline insulation and maintenance, as the remaining pipeline system of 75% of distribution and transmission is presumed to be in good performance.

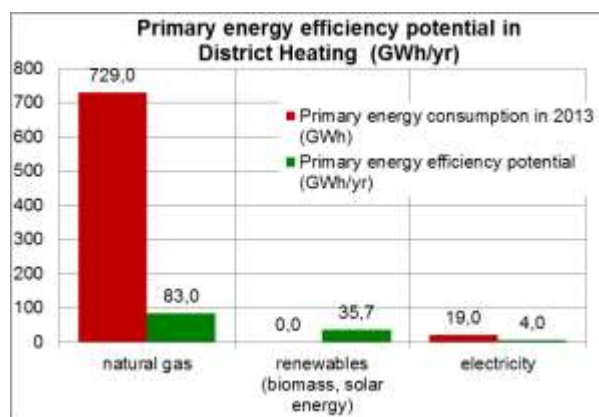
| Code | Title of EE recommendation | Investment costs (M USD) | Primary EE (GWh/a) | Saving of energy carrier | Emission saving (t CO2/a) | Preliminary payback time (years) |
|-------|---|--------------------------|--------------------|--------------------------|---------------------------|----------------------------------|
| DH-01 | Performance increase of boiler-houses by rehabilitation | 11,25 | 66,00 | Primary-gas | 24,0 | 2,91 |
| DH-02 | Fuel switch for heat generation - gas to biomass | 7,00 | 30,40 | Primary-gas | 6,1 | 7,68 |
| DH-03 | District heating network rehabilitation, pipeline replacement | 6,88 | 12,03 | Primary-gas | 2,4 | 15,34 |
| DH-04 | Solar heating plant | 1,56 | 5,33 | Primary-gas | 1,1 | 4,99 |
| DH-05 | Hydraulic balancing of the DH system | 1,00 | 5,01 | Primary-gas | 5,5 | 4,46 |
| DH-06 | Installation of cogeneration plant for coverage of own demand | 0,78 | 2,40 | Primary-electricity | 2,6 | 1,44 |
| DH-07 | Implementation of SCADA system | 0,50 | 0,95 | Primary-electricity | 1,0 | 2,33 |
| DH-08 | Replacement of circuit pumps and equipment with VSD | 0,10 | 0,67 | Primary-electricity | 0,7 | 0,69 |

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

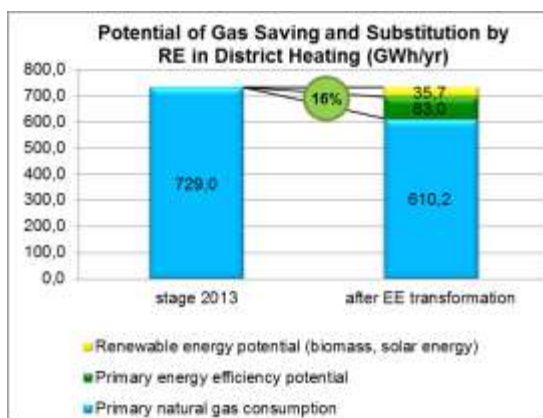
Primary energy savings and payback time by EE measures



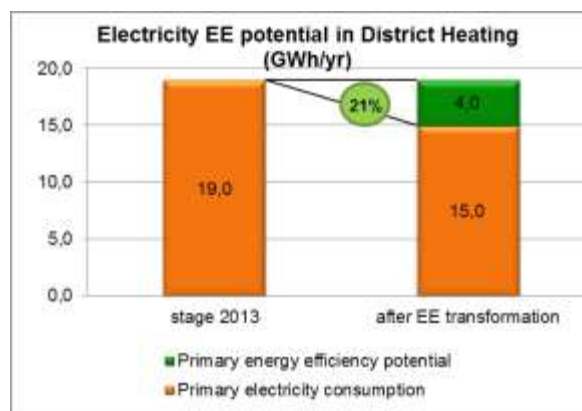
Primary energy savings by type of energy and RE



Potential gas savings



Potential electricity savings



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

| Code | Title of EE recommendation | Implementation perspective | Possible start in | Speed of Implementation, years |
|-------|---|----------------------------|-------------------|--------------------------------|
| DH-01 | Performance increase of boiler-houses by rehabilitation | short-term | 2016 | 2 years |
| DH-02 | Fuel switch for heat generation - gas to biomass | short-term | 2016 | 1 year |
| DH-03 | District heating network rehabilitation, pipeline replacement | short-term | 2016 | 2 years |
| DH-04 | Solar heating plant | long-term | 2018 | 1 year |
| DH-05 | Hydraulic balancing of the DH system | short-term | 2017 | 2 years |
| DH-06 | Installation of cogeneration plant for coverage of own demand | short-term | 2017 | 2 years |
| DH-07 | Implementation of SCADA system | short-term | 2016 | 2 years |
| DH-08 | Replacement of circuit pumps and equipment with VSD | short-term | 2016 | 1 year |

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

- The municipal enterprise “Ternopilmiskteplokomunenergo”

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 | Promotion of Public Transport, improvement of attractiveness | I-Investment | making the public transport more attractive (information system, clean, punctual, new bus stops) |
| TM-02 | Public Transportation Development for new district with innovative vehicles | I-Investment | (e.g. electric buses, bio CNG), for connection of new micro district K. (considering fast track lane) |
| TM-03 | Fuel switch of municipal bus fleet from diesel to electric (trolley busses) | I-Investment | need to include the extension of electric overhead infrastructure |
| TM-04 | Replacement of municipal diesel bus fleet to hybrid (diesel/electric) | I-Investment | all remaining |
| TM-05 | Reconstruction of existing trolley bus overhead lines | I-Investment | including SCADA and system optimization |
| TM-06 | Vehicle Emission 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.¹²

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

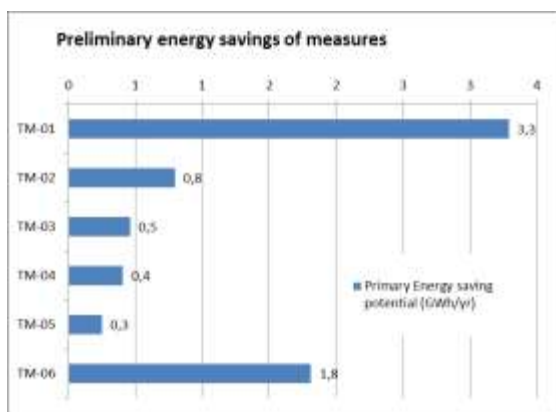
- Municipal Vehicle Fleet Efficiency Program, as there is the very low number of such very specialized vehicles
- Car parking Management
- Traffic Flow Optimization
- Traffic Restraint Measures
- Travel Planning

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.

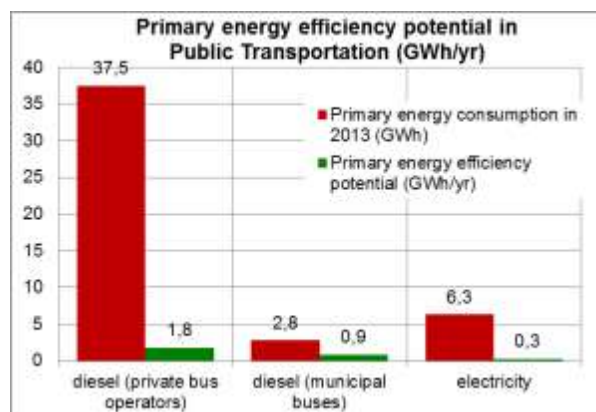
| Code | Title of EE recommendation | Investment costs (M USD) | Primary EE (GWh/a) | Saving of energy carrier | Emission saving (t CO2/a) | Preliminary payback time (years) |
|-------|---|--------------------------|--------------------|--------------------------|---------------------------|----------------------------------|
| TM-01 | Promotion of Public Transport, improvement of attractiveness | 0,30 | 3,29 | Gasoline | 0,8 | |
| TM-02 | Public Transportation Development for new district with innovative vehicles | 6,50 | 0,80 | Gasoline | 0,2 | |
| TM-03 | Fuel switch of municipal bus fleet from diesel to electric (trolley busses) | 0,84 | 0,46 | Diesel | 0,1 | 22,64 |
| TM-04 | Replacement of municipal diesel bus fleet to hybrid (diesel/electric) | 1,68 | 0,41 | Diesel | 0,1 | 20,34 |
| TM-05 | Reconstruction of existing trolley bus overhead lines | 0,98 | 0,25 | Primary-electricity | 0,3 | 17,15 |
| TM-06 | Vehicle Emissions Standards for private bus operators | 0,08 | 1,81 | Diesel | 0,5 | 0,22 |

Figure 51: Preliminarily calculated energy saving potential (primary energy, final energy gas and electricity) and payback time of recommended EE measures

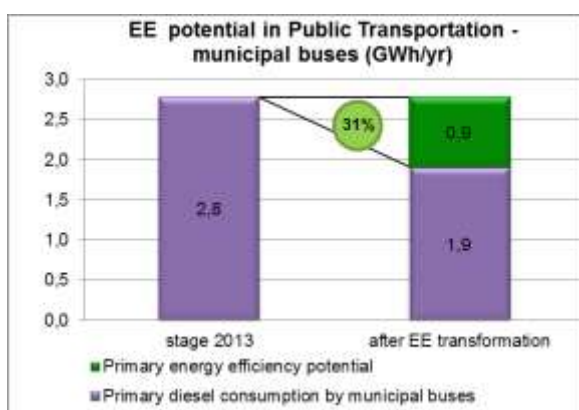
Primary energy savings and payback time by EE measures



Primary energy savings by type of energy and RE



Potential diesel savings



Potential electricity savings

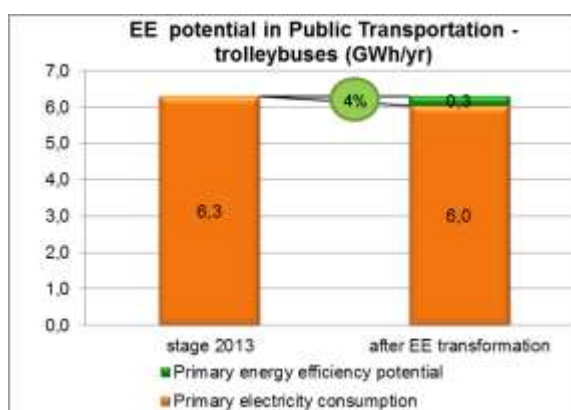
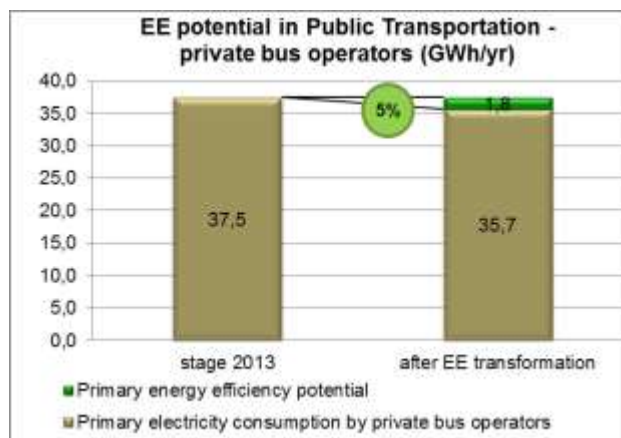


Figure 52: EE potential by measures for commercial public transport companies



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 | Promotion of Public Transport, improvement of attractiveness | Long-term | 2018 | > 4 years |
| TM-02 | Public Transportation Development for new district with innovative vehicles | long-term | 2019 | > 4 years |
| TM-03 | Fuel switch of municipal bus fleet from diesel to electric (trolley busses) | short-term | 2017 | 2 years |
| TM-04 | Replacement of municipal diesel bus fleet to hybrid (diesel/electric) | long-term | 2020 | 2 year |
| TM-05 | Reconstruction of existing trolley bus overhead lines | short-term | 2016 | 2 years |
| TM-06 | Vehicle Emissions Standards for private bus operators | long-term | 2018 | 3 year |

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

- a) Transport companies with the CA as main shareholder:
 - "Ternopilelektrotrans"
 - A company with additional liability named "Taxopark",
 - OJSC TOP "Ternopilavtotrans-16100", which are operating 42 vehicles (9 trolleybuses and 33 buses).
- b) Commercial transport companies: MC "Miskavtotrans", PJSC "Ternopil ATP - 16 127", LLC "Mens - Auto", LLC "ATK" Etalon ", LLC" Nazar - Trans ", LLC "Mega - Service", PE "Ternvoyazh",

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 Pumps and Motors in water supply and WWTP (elements of the IBRD project), upgrading of WWTP and pumping stations of sewer system, improvement of performance of water supply network | I-Investment |
| WW-02 | Active Leak Detection and Pressure Management Program for potable water system | I-Investment |

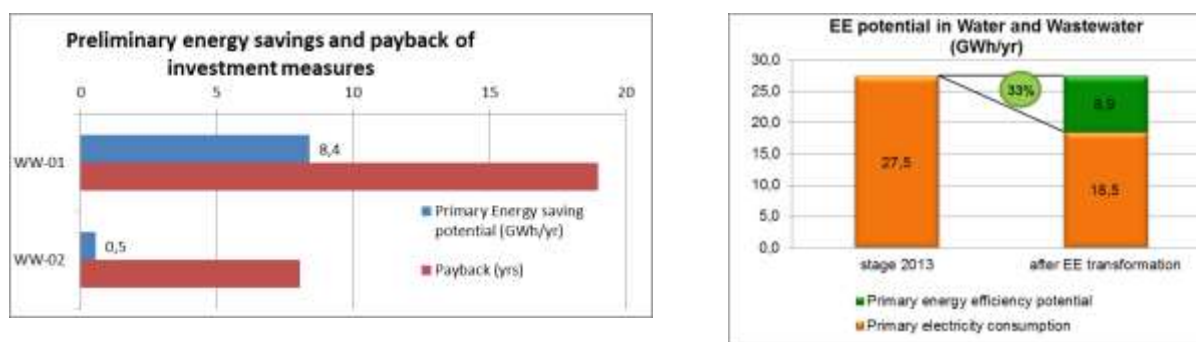
The above measure WW-01 is covered by the IBRD Ternopil Vodokanal project «Rehabilitation and Upgrade Water and Wastewater Facilities - 2014».

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.¹³

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 Pumps and Motors in water supply and WWTP | 36,00 | 8,40 | Primary-electricity | 9,2 | 18,99 |
| WW-02 | Active Leak Detection and Pressure Management Program for potable water system | 1,00 | 0,55 | Primary-electricity | 0,6 | 8,06 |

Figure 53: Preliminarily calculated Primary energy saving potential of recommended EE measures and payback time



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

| Code | Title of EE recommendation | Implementation perspective | Possible start in | Speed of Implementation, years |
|-------|--|----------------------------|-------------------|--------------------------------|
| WW-01 | Improve Efficiency of Pumps and Motors in water supply and WWTP | short-term | 2016 | 2-3 years |
| WW-02 | Active Leak Detection and Pressure Management Program for potable water system | long-term | 2017 | 3 years |

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

¹³ 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
- Water Efficient Fixtures and Fittings
- Water Meter Program (individual at end consumer side)
- Improve Performance of System Networks
- Formation of Ring Main

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 | Intermediate Transfer Station including sorting, recycling line and composting station | I-Investment | |
| WS-02 | Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program | I-Investment | 20 units |
| WS-03 | Fuel Efficient Waste Vehicle Operations | A-Accompanying | includes non-investment measures, training etc. |
| WS-04 | Waste Infrastructure Planning (connected to landfill site, containers) | P-Preparation | |

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.¹⁴

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

| Code | Title of EE recommendation | Investment costs (M USD) | Primary EE (GWh/a) | Emission saving (t CO ₂ /a) | Preliminary payback time (years) |
|-------|--|--------------------------|--------------------|--|----------------------------------|
| WS-01 | Intermediate Transfer Station including sorting, recycling line and composting station | 9,00 | 0,84 | 0,2 | 52,76 |
| WS-02 | Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program | 0,85 | 0,76 | 0,2 | 5,56 |
| WS-03 | Fuel Efficient Waste Vehicle Operations | 0,01 | 0,02 | 0,0 | 2,90 |
| WS-04 | Waste Infrastructure Planning (connected to landfill site, containers) | 0,40 | 0,00 | 0,0 | |

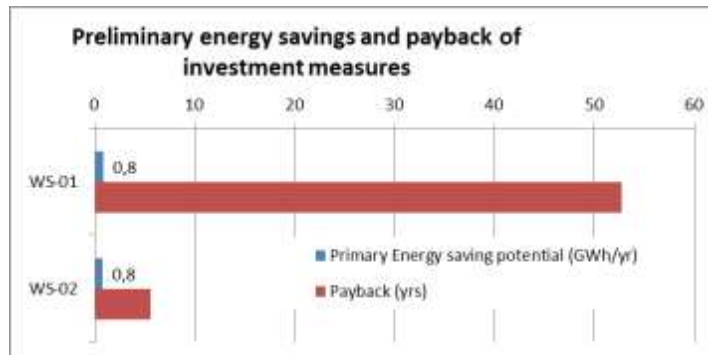
Energy savings will mainly be realized on diesel fuel.

¹⁴ 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:

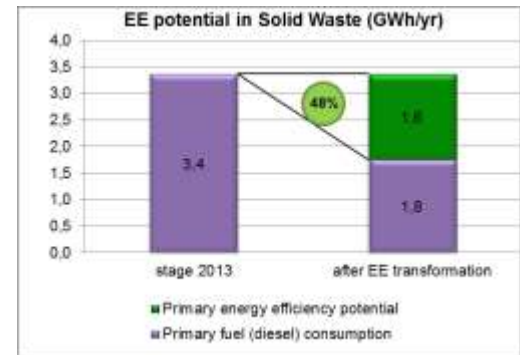
- Waste Composting Program, as this can be combined with the transfer station
- Landfill Gas Capture Program, due to low gas production potential
- EE in existing sorting and transfer facilities, not existing
- Waste to Energy Program, not appropriate
- Waste Collection Route Optimization shall be included in infrastructure planning

Figure 54: Preliminary calculated Primary energy saving potential of recommended EE measures and payback time

Primary energy savings and payback time by EE measures



Primary energy savings , diesel



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

| Code | Title of EE recommendation | Implementation perspective | Possible start in | Speed of Implementation, years |
|-------|--|----------------------------|-------------------|--------------------------------|
| WS-01 | Intermediate Transfer Station including sorting, recycling line and composting station | short-term | 2016 | 2 years |
| WS-02 | Waste Vehicle Fleet Maintenance Audit and Retrofit or replacement Program | short-term | 2017 | 2 years |
| WS-03 | Fuel Efficient Waste Vehicle Operations | short-term | 2016 | 1 year |
| WS-04 | 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
- Waste services collection, transportation companies "Altfater-Ternopil", PE "Ekotern", PE "Quarter-L".

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) | Primary EE (GWh/a) | Emission saving (t CO2/a) |
|-------|---|--------------------------|--------------------|---------------------------|
| EM-01 | Awareness raising and EE promotion programs for all sectors | 0,08 | to be analysed | n/a |
| EM-02 | Capacity building programs | 0,10 | 3,53 | 0,9 |

| Code | Title of EE recommendation | Investment costs (M USD) | Primary EE (GWh/a) | Emission saving (t CO2/a) |
|-------|----------------------------------|--------------------------|--------------------|---------------------------|
| EM-03 | EE Municipal task force | 0,12 | 0,10 | 0,0 |
| 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 | | |

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 |

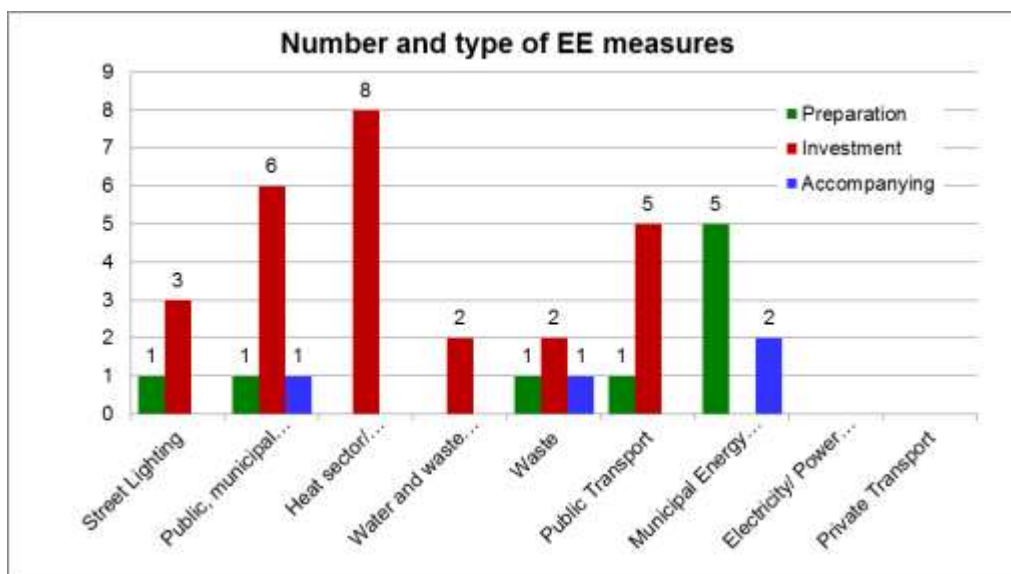
The key stakeholders for implementation of the recommended EE measures in this sector are:

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

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

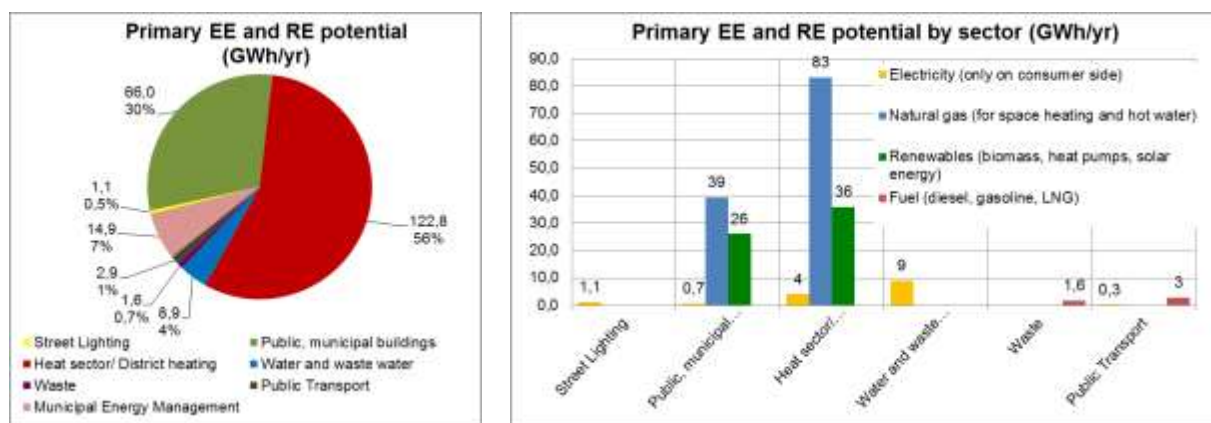
From the above analysis it is recommended to consider 39 EE measures, of which 26 are investment type; 9 preparation and 4 accompanying measures.

Figure 55: Number and type of EE measures recommended by sector



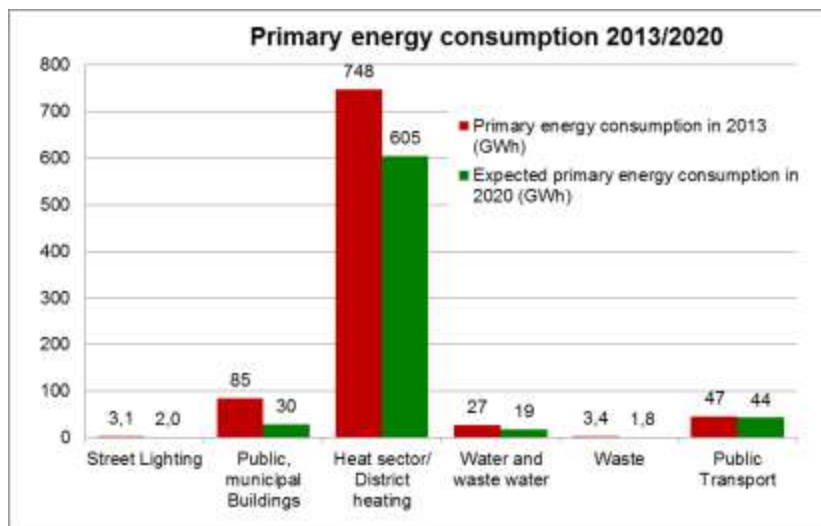
The overall primary energy savings by implementation of the 39 recommended measures will amount to annually in the range between 200 to 215 GWh of which energy saving in energy consumption amounts to 75% and the substitution of conventional primary energy by renewable energy at 25%.

Figure 56: Primary energy saving potential by sector and type of energy



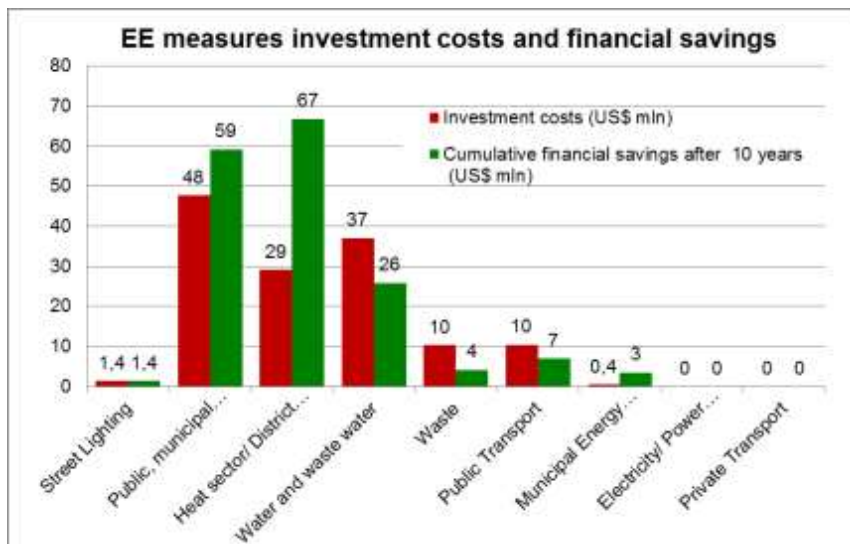
The implementation of the recommended EE measures until the year 2020 can reduce the primary energy consumption in the considered sectors by up to 20% (from 843 GWh in 2013 to approx. 680 GWh in 2020). This savings potential would represent only 8% of the overall city’s primary energy consumption (including industry, commercial, residential sector, which are not considered in the analysis).

Figure 57: 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 39 measures would be in the range between 120 to 140 million USD, which can generate a 10-years cumulative saving of energy costs (considering a projection of energy tariffs) of up-to 170 million USD.

Figure 58: Investment costs for EE recommendations and cumulative 10-years energy cost saving achievements (in million USD)



The largest savings (90%) of primary energy can be achieved in natural gas by up to 180 GWh which represents a level of 19.5 million m³ gas of annual savings.

Figure 59: Primary energy saving and substitution by renewable energy potential (in GWh/year)

