Kazakhstan: Energy Efficiency Transformation in Astana and Almaty

Supported by

Energy Sector Management Assistance Program

Municipal Energy Efficiency Plan for the City of ASTANA

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Exchange rate US$ 1 = KZT 222 (as of 2015)

Energy consumption and expenditure in the report is for the baseline year 2015.

Content

List of Abbreviations

AES	Astana Energy Service (holding)	IT	Individual Private Transport
AOA	Apartment Owners Association	KEGOC	Kazakhstan Electricity Grid Operating Company
BEMS	Building Energy Management Systems	KPI	Key Performance Indicator
CA	City Administration (Akimat)	KZT	Kazakh Tenge
CB	Commercial Buildings/Industry Sector	LED	Light Emitting Diode
CFL	Compact Fluorescent Light	LPG	Liquid Pressed Gas
CHP	Combined Heat and Power Plant (cogeneration)	LRT	Light Rail Transport
CNG	Compressed Natural Gas	MEA	Municipal Energy Agency
DH	District Heating	MoF	Ministry of Finance
DHW	Domestic Hot Water	MoID	Ministry of Investments and Development
EBRD	European Bank for Reconstruction and Development	MSW	Municipal Solid Waste
EE	Energy Efficiency	MW	Megawatt
EEDI	Institute of the Electricity and Energy Efficiency Development	PB	Public (municipal) Buildings
EERF	Energy Efficiency Revolving Fund	PBP (T)	Payback Period (time)
EL	Electricity sector - Power supply	PEC	Primary Energy Consumption
EM	Energy Management	PPP	Public Private Partnership
EPC	Energy Performance Contracting	PT	Public Transport
ESA	Energy Service Agreements	PV	Photovoltaic - Solar power generation
ESCO	Energy Service Company	RE (S)	Renewable Energy (Sources)
ESMAP	Energy Sector Management Assistance Program	REI	Relative Energy Intensity
FEC	Final Energy Consumption	SCADA	Supervisory Control And Data Acquisition System
GDP	Gross Domestic Product = GRP	SL	Street Lighting Sector
GRP	Gross Regional Product	SPV	Special Purpose Vehicle
GHG	greenhouse gas emissions	TA	Technical Assistance
GoK	Government of Kazakhstan	TRACE	Tool for Rapid Assessment of City Energy
GWh	Giga Watt Hours = Million Kilo Watt Hours	TWh	Terra Watthour - billion kWh
HDI	Human Development Index	VAT	Value Added Tax
HFO	(heavy) Heating fuel oil (mazut)	VSD	Variable speed drive
HPS	High Pressure Sodium	WB	The World Bank
IBRD	International Bank for Reconstruction and Development	WS	Water & Wastewater
IFI	International Financial Institution	WWTP	Wastewater Treatment Plant
		yr	year

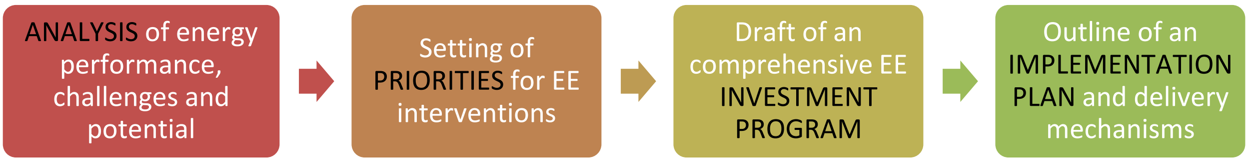
1 Executive Summary

This report outlines the results and key findings of an energy efficiency (EE) study - "Energy Efficiency Transformation in Astana and Almaty" - conducted by the World Bank between November 2016 and November 2017 in Astana, using the Tool for Rapid Assessment of City Energy (TRACE 2.0). The objective of this study is to outline an urban EE strategy for the next 12 years for the city of Astana, up to 2030, by assessing the energy performance of the municipal service sectors and identifying and prioritizing EE opportunities along with a sound implementation plan.

The overarching objectives of the municipal EE plan are to reduce energy consumption, diminish related expenditures from the municipal budget, and improve municipal service delivery for the city residents. The plan includes a host of qualitative targets, from reducing the Greenhouse Gas (GHG) emissions and Primary Energy Consumption (PEC), avoiding an increase in the energy bills to improving performance of local public service providers and enabling the environment to attract private investments for EE interventions.

The methodology used comprises four steps, namely assessment of the energy performance, prioritization of sectors having the highest energy savings potential, and drafting and implementation of the EE plan

Figure 1. Steps for preparing the EE plan



The assessment was made by benchmarking Astana against other cities with similar features (like human development index by country, climate etc.), thus allowing for a comparison of energy related key performance indicators (KPIs), and then drawing certain performance targets by sector. The team conducted interviews with the City Administration (CA) of Astana, municipal service providers and other relevant stakeholders, in addition to organizing a couple of technical workshops, to identify the sector challenges and discuss about the EE investment program and potential delivery mechanisms for the implementation of the plan.

Energy Efficiency Context

This EE plan is very timely and in line with the strategies and targets set at the national and local level in Kazakhstan to reduce energy consumption and improve performance in most sectors, including public services. Under the Green Economy Concept (GEC) adopted in 2013, Kazakhstan has embarked on an ambitious path to transition from an energy-driven economy to a green and more diversified, competitive economy by 2050, a plan that should add more than half million new jobs. Some of the key GECs' long-term goals suggest that Kazakhstan should rely more on renewable energy sources (RES) and reduce the energy intensity of the GDP by 25% by 2020 and by 50% by 2050.

The endorsement of the EE matter by the top leadership in the country in recent years has created a great momentum for cites to commit to energy and climate related targets at the local level, thus sending the right signals to municipal authorities to acknowledge the importance and benefits of EE, and making them think seriously about how to reduce energy and related expenses by taking ownership of EE projects. EE investments in municipal urban infrastructure - such as district heating, street lighting and public transport - can improve the city's capacity to deliver good quality services and meet the demand in the near future, reduce specific energy consumption and make a better use of municipal finances. Such interventions are not only conducive to improving overall living condition for the city residents in a clean healthy environment, but also to significantly reducing the energy related spending from the local budget, hence allowing the money to be directed to other local priorities.

Energy Performance Challenges

Astana faces a constant population and economic growth which requires an expansion of the energy and municipal service delivery. Most of the city's infrastructures, such as central heat supply network, water pipes or the residential and public buildings stock are old, with high energy intensity and incur losses. In addition to recent initiatives to improve the capacity and performance in public transport and some retrofit programs for central heating and potable water sector, there is still a huge demand to modernize the infrastructure and meet the future needs with regard to energy and municipal services.

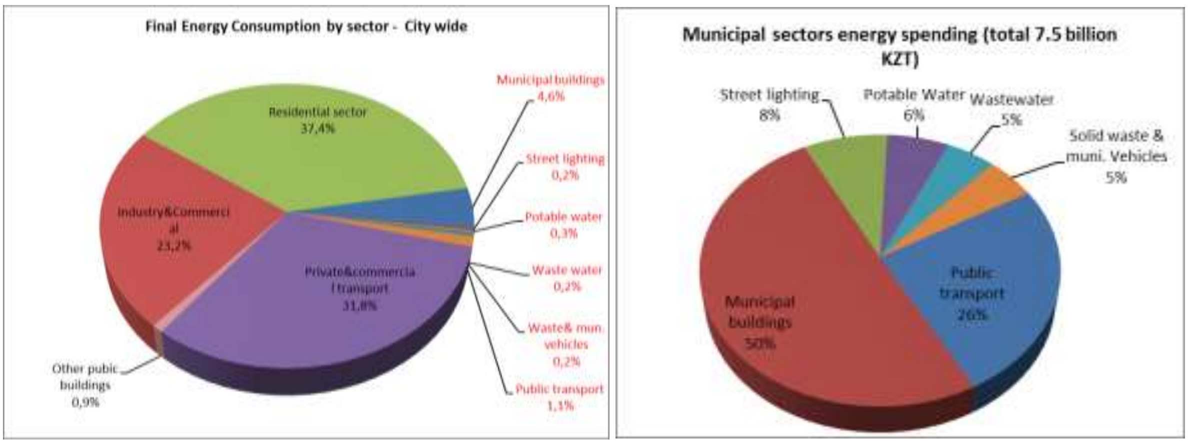
As of now, Astana incurs high energy losses for district heat and electricity generation, as well as in the energy distribution for the end-users, mainly in the residential sector. In 2015, the baseline year for this study, the PEC in Astana amounted to 22 billion kWh, of which 30% are losses in the energy transformation and distribution system for final district heat and power users. Losses are more than 15% of the final energy consumption (FEC) for the entire residential sector in the city. Due to the increase in the mobility of the city residents, private and commercial transport has reached critical levels in terms of density, congestion and GHG emissions.

The increasing costs for energy and for maintenance of municipal service facilities put an additional challenge on the CA of Astana, especially regarding street lighting and public buildings. Despite some high savings potential of 40-60% in these sectors, the financial incentives necessary to pursue complex EE investments are limited because of budget regulations and low profitability of the respective interventions. Moreover, the lack of funding and delivery financing mechanisms to implement these EE measures, together with some poor implementation capacity, are additional big obstacles.

The energy flow of the city of Astana in the year 2015 (presented as a Sankey diagram in Annex 1), illustrates the primary energy consumption in all municipal sectors, with a city-wide FEC of 15,389 GWh. The residential sector is the largest energy consumer, using approximately 37% (5.6 billion kWh) of the final energy in the form of district heat, power and coal. The private and commercial transport consumes approximately 5 billion kWh per year in the form of gasoline and diesel, accounting for one third of the city-wide FEC. The final energy use in all municipal service sectors amounts to 1,030 GWh, which accounts for 7% of Astana's FEC. Among these, the largest user are the municipal public buildings (70%), followed by public transport, potable water and street lighting.

In 2015, the annual energy expenditure for all sectors in Astana was around KZT 165 billion (US$ 746 million), which is about 3.4% of the city's GDP. Of this, the energy bill for all the six sectors under the CA control (i.e., public transport, municipal buildings, street lighting, waste, water & wastewater) was KZT 7.5 billion (US$ 34 million), which is 2% of the overall municipal budget. (see Figure 2 below)

Figure 2. City-wide energy consumption in Astana by sector (left) and by type of energy (right)



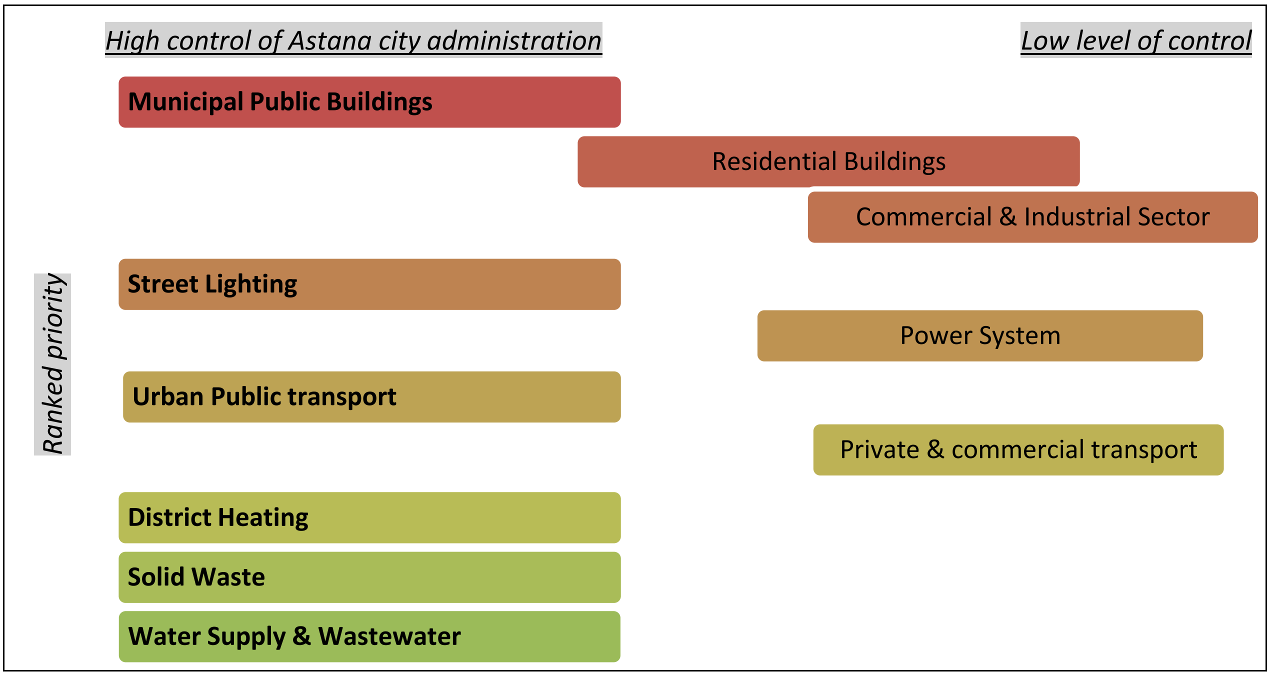
Priority Areas of Intervention

The TRACE methodology is based primarily on benchmarking of the city against other peer cities, identifying sectors with most EE potential based on which most appropriate EE measures are recommended. Details about the TRACE 2.0 Methodology are provided in Section 2 of this report. The TRACE analysis uses three key factors to prioritize sectors for the EE interventions, namely energy spending, energy intensity, and the level of control of the CA over the sector.

Figure 3. Key factors for the TRACE analysis

The TRACE study has identified six priority sectors in Astana with significant energy potential savings. Specific demand driven factors, like increasing efficiency of energy production and distribution, in parallel with reducing energy intensity for FEC, diminishing primary coal consumption and traffic density to lower the inner-city GHGs level, were taken into consideration. Overall, ten sectors were identified for EE interventions in Astana. The top priority sectors with large energy savings potential and significant influence from the CA are municipal public buildings, street lighting, urban transport, district heating, waste and water & wastewater. Four more sectors with some limited municipal control are also included, i.e., residential buildings, commercial & industrial sector, power system, and private transport.

Figure 4. Sectors and level of city control



Energy Efficiency Strategy

The overall EE strategy should be based on two types of interventions, namely the EE investment program and a set of non-investment interventions. The *investments measures* comprise a pipeline of direct EE investment projects that could generate physical final energy savings, help reduce energy losses and use more renewable energy (RE). They can also bring some co-benefits in the form of better quality of services and comfort for end-users, in addition to reducing the operation and maintenance (O&M) costs.

Additional non-investment interventions should complement the core solutions by enabling an appropriate environment to carry out the EE plan, such as project preparation, development of adequate financing and delivery mechanisms, in addition to local policies that should set up the necessary regulatory framework and help build local institutional capacity.

Box 1. Pillars for the EE Strategy

Pillars for the EE strategy

Increase in Quality of Municipal Services & Living Conditions
Increase the quality of public services (e.g., heating, public transport)
Increase comfort and/or meet the demands
Reduction of GHG emissions
Increase attractiveness of the city to residents and tourists
Meet the challenges and energy needs in the future as a consequence of the city growth

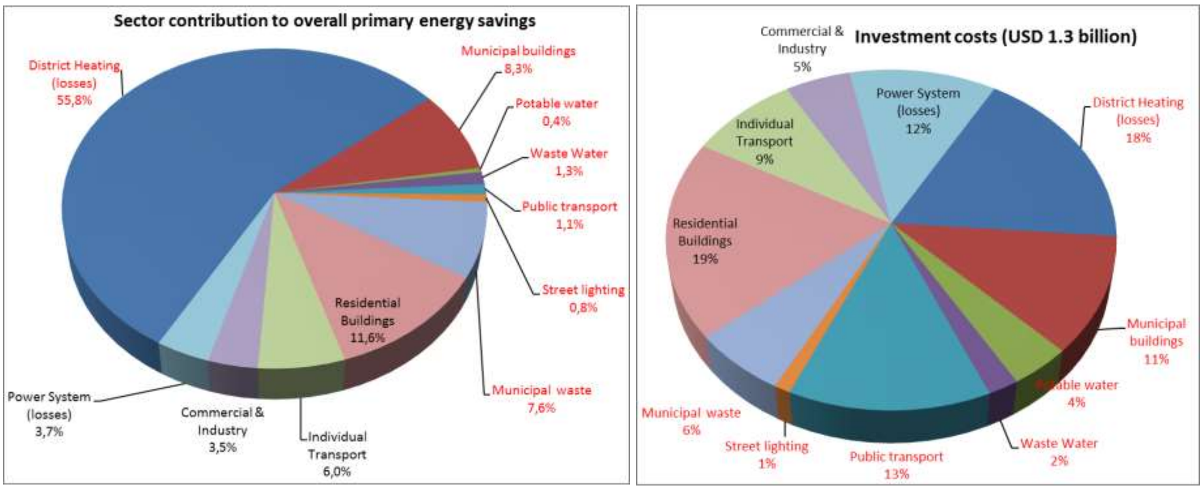
Resource Savings
Lower the city-wide energy demand (energy intensity)
Reduction of PEC
Increase the use of RES
Avoid escalation of energy bills and limit budget spending
Use of additional revenue source

Sustainable Development
Improvement of the performance of municipal public service operators
Implementation of energy management in all sectors, an activity led by the CA
Change in consumer's behavior towards EE
Setting up the environment to attract private investment in EE
Increase and develop capacities for program implementation
Development of financing delivery mechanisms and bring in private partners for energy performance contracting (EPC) within the frame of Public-Private Partnership (PPP).

Energy efficiency Investment Program

Overall, the EE investment plan for Astana consists of 50 EE measures split into ten sector investment packages in short, medium-, and long-term spanning over the next 12 years until 2030, with total investments of US$ 1.34 billion.[1] The table at the end of this executive summary provides a brief overview of these measures - including initial capital investment, estimated energy savings and cost benefits, responsible parties for implementation, and a proposed schedule for implementation.

Figure 5. Primary energy consumption by sectors in Astana (left) and investments costs (right)



This complex EE plan to be implemented between 2018 and 2030 could reduce the PEC in Astana by

[1] Initial costs estimates on the basis of 2017; including material, equipment, installation and VAT

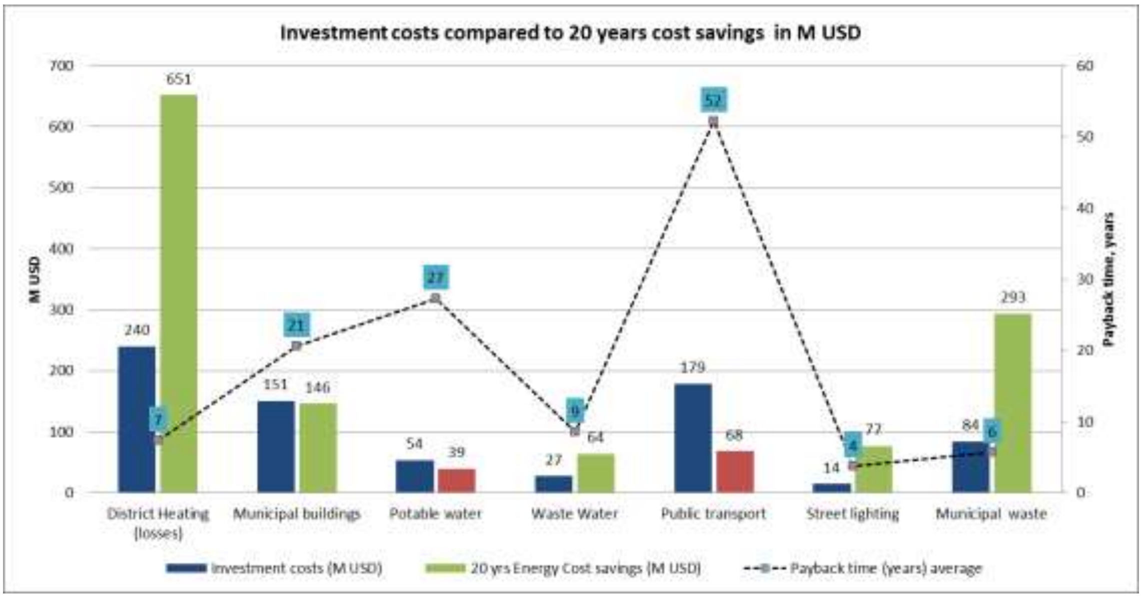
23% (compared to 2015), hence achieve annual primary energy savings of 5 billion kWh by 2030. This could be translated into city-wide energy cost savings of US$ 140 million per year.[2] Most of the primary energy savings (94%) can be obtained by cutting about one 1 million tons of coal per year, which is around one-third of the amount of coal used to generate power and heat. Other major savings could be achieved in form of fuel for cars, up to 28 million liters per year.

The reduction of coal consumption is particularly important to diminish the GHG emissions in order to improve the air quality in the city. The EE program can deliver annually reduction of 1.7 million tons of CO_2 emission equivalent, which represents one quarter of the emissions in 2015. Considering a phased implementation over a 12-year period, the achievable total cumulative energy savings can sum up to 75.7 billion kWh, resulting in a specific investment demand of US$ 0.02 per each kWh of energy saved. This saving per invested amount ratio is in the range of average energy costs for public and residential customers (at the level of 2015).

Of all 50 EE measures, 38 interventions target the municipal service sectors that are under the CA control, and they require US$ 750 million capital investment. These investments could save 43% of the overall energy consumption in these sectors. The savings are equivalent of 2.3 billion kWh per year which would translate into US$ 67 million annual savings. For example, ten measures aim to improve energy performance in municipal public buildings (US$ 150 million), eight to curb losses in the district heating sector (US$ 240 million), eight to reduce fuel consumption and increase attractiveness of the public transport system (US$ 294 million), while eight interventions seek to diminish losses in the water pipes and improve overall performance of the water & wastewater sector (US$ 81 million).

A preliminary cost-benefit analysis has been performed for these EE measures.[3,4] A rough comparison between the investment costs and achievable energy cost savings over a 20-year period shows that the accumulated savings in most sectors exceed the investments costs, which indicate a positive ratio over the lifecycle of the intervention (except for those in the public transport and water supply sector).

Figure 6. Investment costs compared to energy savings

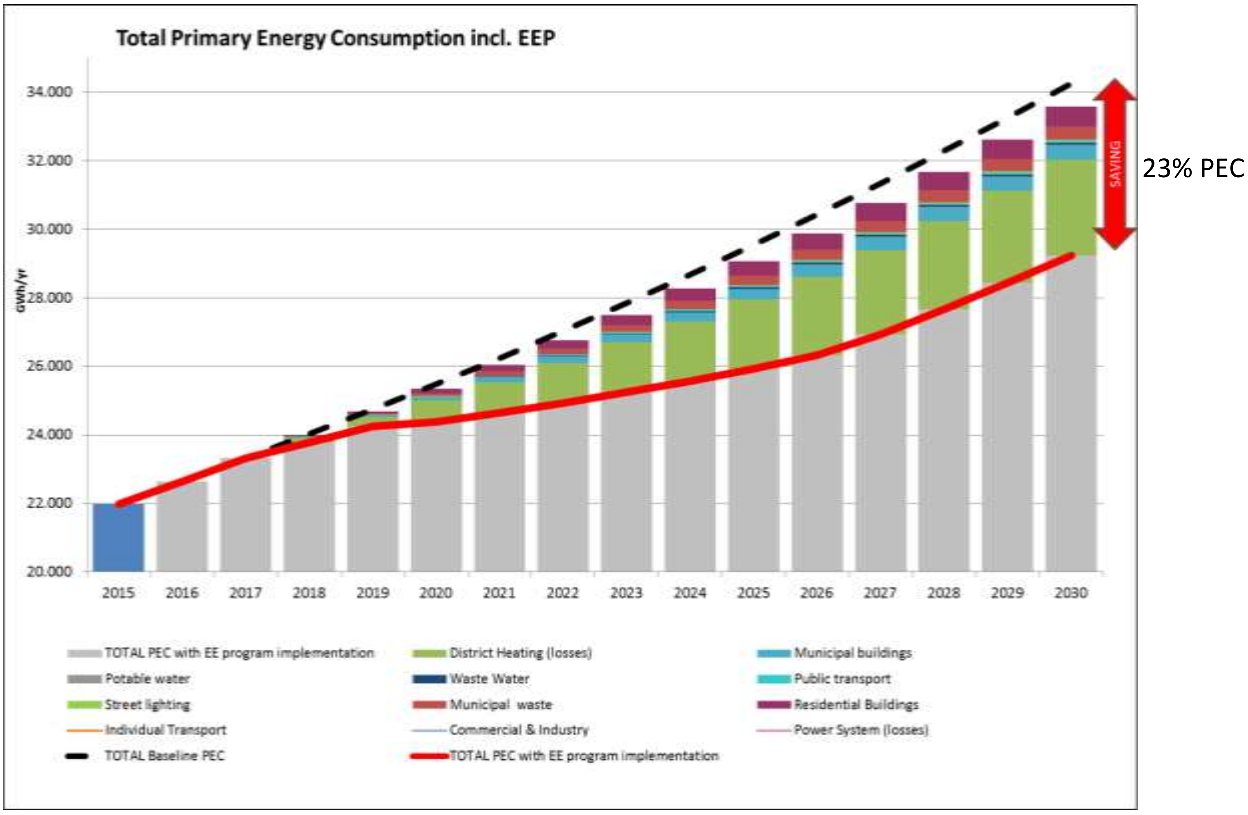


2 This is calculated considering a scenario of energy cost increase by 1.5-2% per year for the period 2018 - 2030.
3 The preliminary assessment of the economic analysis considers the energy cost savings. Investments into non-energy infrastructure, such as waste, water & wastewater, building retrofit and transport deliver additional economic benefits of improved service/infrastructure and extended lifetime which reduce the payback time. A more detailed socio-economic analysis is needed to monetarize such co-benefits.
4 All assumptions made for this assessment are available in Annex 2 of this report.

The payback time for each measure varies, depending on investment and its financial benefits, between four to more than 50 years, with an average of 10 years. EE investments that aim to reduce losses in the power and central heat generation and distribution are more profitable, with less than eight years of payback time. Similar acceptable level of profitability is indicated for interventions focusing on RE generation, such as biogas, landfill gas, waste-to-energy, and photovoltaic panels. These projects have great potential for PPPs and could attract private partners/investors. Large-scale projects above US$ 50 million in public transport, water infrastructure or public and residential building retrofit are long-term investments since they have long payback time spanning from 25 to more than 50 years. The additional comfort, social and environmental benefits pertained to these interventions could justify carrying them out in the short- and medium run. Usually, such investments are paid back throughout the lifetime of the facility.

A scenario considering an average 3% annual increase in local population and economy in Astana over the next decade would significantly impact the demand for municipal services and energy supply. For example, the PEC in Astana is expected to go up by 55% - to 34,250 GWh by 2030 (see Figure 7 below). The projected energy savings could help slow down this energy trend up to 33% by 2030, provided the EE plan would be implemented starting with 2018. From this forecast, one must understand how important is to undertake the EE interventions under a comprehensive EE investment program.

Figure 7. Primary energy consumption by 2030 and potential savings



Setting Energy Efficiency Targets

Based on the above energy savings projections, the expected city-wide targets for the EE program were calculated, and some are presented in Table 1 below.

Table 1. EE targets for Astana by 2030

Indicator	Value in 2015	Targets to be achieved by implementation of the recommended EE program by 2030
City-wide Primary Energy Consumption (PEC)	22 TWh	reduction by 23%; target savings of 5 TWh/year
Primary energy coal consumption (all sectors)	15.5 TWh coal = 3.3 million tons of coal	reduction by 30%, target saving of 1 million tons of coal compared to baseline 2015
Use of renewable energy	almost 0 (zero)	417 GWh/year generated by RE = at least 2% of PEC
CO_2 emissions (city-wide)	7 million tons of CO_2 equivalent	24% reduction; equivalent to 1.7 million tons of CO_2 per year
Energy consumption of municipal sectors [5]	5 TWh	43% reduction; target savings of 2.3 TWh
Municipal public buildings	711 GWh	35% reduction; target savings of 250 GWh/year

These figures can be achieved through some energy saving targets for the key sectors (see Table 2 below).

Table 2. Energy savings by sectors

MUNICIPAL BUILDINGS	DISTRICT HEATING	STREET LIGHTING
Minimum 30% energy savings of heat energy for all facilities (schools, kindergartens) by building retrofit 50% energy savings for lighting by replacement of indoor lighting	Reduction of energy losses for district heat generation and distribution - from 38% to 22%	Minimum 60% energy savings for the entire public lighting system
PUBLIC TRANSPORTATION	**POTABLE WATER**	**SOLID WASTE**
Increase of urban mobility by improving capacity, service and attractiveness of public transport 5-10% reduction of individual motorized transport by increasing the attractiveness of public transport as alternative to individual cars	Minimum 40% reduction of water losses 25% electricity savings at pumping stations for water supply and wastewater treatment	Minimum of 80% of the waste to be sorted and prepared for recycling or composting 30% reduction of the fuel consumption for waste collection vehicles

Implementation Strategy and Roadmap

There are some important prerequisites to set the ground for the implementation of this EE plan. To this end, the CA of Astana should undertake immediate actions in three key areas to enable the adequate environment for a successful execution of the plan.

- *First*, the city council of Astana should **adopt a short- and medium-term EE plan** in order to politically commit to straightforward EE targets.

[5] In 2015, the final energy consumption of the sectors under city administration's control (including district heating losses) amounted to 5,474 GWh (25% of the overall city energy consumption). Under a "business as usual development" scenario with population increase (without the Energy Efficiency Plan in place), this part of the municipal sector energy consumption is expected to go up to 8,528 GWh/year in 2030.

- *Second*, the CA should **strengthen the EE delivery capacity** by establishing a municipal EE agency that should draft and oversee the implementation of the EE plan. The key elements for such dedicated administrative EE unit/EE agency are a clear mandate to undertake certain responsibilities and deliver upon them, adequate number of qualified staff and an appropriate budget.
- *Finally*, the Astana CA should undertake quick steps to **develop and promote sustainable EE financing mechanisms** (by using government programs, loans, commercial sector financing and PPP schemes) that should take into account multi-year energy savings to repay EE investments.

Achieving the EE targets and energy savings envisioned in this EE plan would require an integrated transformation approach to allow scaling-up the investments (e.g., sound energy audits, good feasibility studies), sustainable delivery and financing mechanisms in the form of EPC, ESCO etc., and good local delivery capacity (e.g. by an EE Agency).

The comprehensive package of the EE interventions needs a clear roadmap to adequately plan and implement these measures. While investment measures are only one component of this roadmap, the other element is the non-investment activities that should provide support the CA in setting up the framework and delivery capacity for these interventions. A general roadmap for scaling-up EE in municipal sectors with straightforward activities for the next six, 12, 18, and 24 months was designed. For example, one of the actions the CA should undertake in the next period of time is to give more powers and responsibilities to the existing energy management division. During the first year the city should draft the business plan for the ESCO/PPP and pilot the EPC model in street lighting and in a few public buildings, while in the next year it should deal with procurement of works and services, work implementation & supervision, benchmarking and energy performance monitoring program etc. (More details are available in Table 3 below).

Table 3. Short- and mid-term actions for the EE program

6 months	Enhance and Empower the **Municipal Energy Management Division**	Development of a Municipal **Building Inventory**	Development of **energy audits** and project proposals for funding
12 months	**Business planning** municipal ESCO and PPP	**Feasibility studies** for sub-projects with fesible funding	**Piloting** of EPC for public buildings and LED street lighting
18 months	Set-up the Program Implementation Unit **(PIU)**	**Tender** and procurement of services, equipment and works	**Implementation** supervision, completion and commissioning
24 months	Extension of the **pipeline for EE investment** projects	Raising cross-sector **information and awareness on** EE	Benchmarking and Energy Performance **Monitoring Program**

Sustainable Energy Efficiency Financing

Finally, in order to translate the activities from paper into some real actions, every strategy and plan needs a key element: funds. This goes the same for the Astana EE plan. The execution of this EE program requires significant amount of money that could come from different sources. A combination of three types of funding sources is necessary to pull off the US$ 1.34 billion estimated to cover all 50 EE interventions in Astana. These could be i) grants from the municipal budget or government programs, ii) debt loan financing form government programs or commercial financial institutions, with soft-loan conditions (if possible), and iii) commercial funding in the form of PPP, service or operation contracts.

A suitable financing structure should be designed, based on the financial viability and project features, to meet the loan or private co-financing requirements. In general, a successful approach for structuring the project financing involves three steps. The first step is to design the project or make some adjustments to it as to become attractive to commercial/PPP funding. The second step should focus on getting the external debt loans or grant funding from different sources. Finally, the last stage is about covering the remaining financing demand from the municipal budget. Currently, there are a few on-going programs with attractive financing conditions targeting modernization of public, urban and social infrastructure (such as DAMU or Nurly Zhol) that could be potential funding sources for the EE program. The CA of Astana should prepare feasible applications for such funds.

Most of the measures in the EE plan must be implemented under specific financing and delivery framework. Service contracts for energy performance can be developed with private suppliers, based on the existing PPP legislative framework. Such service contracts would be best suited for straightforward, profitable, low risk projects, like the replacement of street lights or changing the public building indoor lighting with LEDs. For more complex EE investments (e.g., public buildings retrofit or heat supply) where the city has high long-term benefits, an institutional PPP model as a Service Purpose Vehicle in the form of ESCO could work. The EPC delivery mechanism could enjoy the financial compensation revenues under the PPP legislative framework. This ESCO could implement different types of EE projects under the EPC delivery mechanism by enjoying the financial compensation revenues under the PPP regulation. If proven successful, the ESCO could have a great chance to evolve, on the medium-run, into an Energy Efficiency Revolving Fund, and use the revenues obtained from the EPC to fund new EE projects.

In the next period of time, Astana should pilot the EPC-PPP model for some interventions, such as LED in street lighting or replacement of the indoor lighting with LED in public buildings. Depending on the results, some well-designed projects should be promoted to potential private partners to get them involved into this new business area. The PPP Center of the Astana is expected to play a crucial role in designing the project as such as to make it attractive to private partners. The lessons learnt from these EE pilot interventions should ultimately enable tuning and restructuring this financing and delivering scheme in order to meet the expectations and requirements by potential interested partners, funders or donors.

A separate concept note on EPC-PPP has been developed by the WB team, detailing how this scheme could actually work in the local context in Kazakhstan. It outlines the legal framework on the PPP, the key requirements for EE interventions, as well as the three business models that could be considered by local authorities for implementing EE measures – namely, service contracts PPP, operation (concession) contracts, and a joint venture under a Special Purpose Vehicle in the form of ESCO.

Summary of Energy Efficiency Investment Measures of the EE plan

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results: Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]	Timeline	Responsible party for implementation
1	2	3	4	5	6	7	8	9
Priority 1: SECTOR - Municipal Public Buildings (PB)								
EE Retrofit Program of municipal schools including: a) Retrofit of building envelop: replacements of windows and insulation; b) Modernization of heating and hot water system: replacement of heat pipes, radiators, thermostat valves, hydraulic balancing, automated heating sub-station, temperature and consumption control, metering, frequency control (VSD) pumps	– 654,000 m² in 88 schools & higher education buildings (60% of the municipal building stock)	52	141	EE 45% district heat	33	1.6	2018-2022	Astana City Administration, Division of Education
EE Retrofit Program of municipal kindergartens including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 284,811 m² in 127 pre-schools (70% of the building stock)	28	68	EE 50% district heat	37	0.8	2018-2022	Astana City Administration, Division of Education
EE Retrofit Program of municipal medical facilities (hospitals, healthcare clinics etc.) including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 396,496 m² in 28 public health buildings (80% of the building stock)	36	95	50% district heat	34	1.1	2018-2022	Astana City Administration, Division of Health
EE Retrofit Program of other municipal facilities (administrative, cultural facilities, libraries, etc.) including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 116,640 m² in 5 public admin buildings (90% of the building stock)	8	18	40% district heat	41	0.2	2018-2022	Astana City Administration, Division
Replacement of indoor lighting for all municipal public buildings, including advanced control	– 1,909,884 m² in 330 public buildings (90% of the building stock)	17	53	50% power use	6	3.0	2018-2020	Astana City Administration, Division of Education

[6] Initial costs estimates at the level of 2017, including material, equipment, installation (plus VAT).
[7] Primary energy savings considering the primary energy factor, e.g. for power 1.9, for district heat 1.7, other energy carriers 1.0.
[8] Assumption of energy cost increase by 1.5-2% per year.
[9] Considering energy cost savings only.

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results				Timeline	Responsible party for implementation
			Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]		
1	2	3	4	5	6	7	8	9
Solar Hot Water Program for education and medical facilities	– 120 solar systems 40 m² collector	1	5	RE – heat 70%	22	0.1	2020-2028	Astana City Administration
Building Energy Management Systems (BEMS) for large buildings (> 20,000 m²)	– 200,000 m² for BEMS in 20 buildings	1	7	20% district heat and power	13	0.1	2020-2025	Astana City Administration
Program on efficient water-saving faucets (cold and hot water) with motion sensors	– 36,000 water users in 360 public buildings (90% of the building stock)	1	9	10% of hot & cold water use	7	0.1	2020-2022	Astana City Administration
Program on energy saving entrance doors: automatic closers or air curtains	– 3,600 outside doors in 360 public buildings (90% of the building stock)	1	15	30% heat losses through doors	7	0.2	2018-2022	Astana City Administration
Program on energy-efficient electric appliances: computers, kitchen equipment, etc.	– 10,000 appliances in 200 public buildings (50% of the building stock)	5	6	15% power	16	0.3	2018-2025	Astana City Administration, Division of Education
Priority 2: SECTOR - Street Lighting (SL)								
Street + Public Space LED Lighting Program, including replacement and adjustment of power supply network for advanced LED street lighting: retrofit, voltage stabilization, wiring, time management, diming, and remote control	– 30,869 light points – 737 km of SL power supply network (approx. 50% of the network)	14	38	55% power	4-5	2.1-3.8	2017-2020	Astana City Administration, Division for Housing and Communal Service, Astana Kalalyk Zharyk
Priority 3: SECTOR - Public Transport (PT)								
Conversion of public diesel buses fleet to EURO 6 or hybrid busses/compressed natural gas (CNG)	– 250 urban diesel buses (25% of all buses)	78	15	25% diesel	137	0.6	2020-2025	Astana Transport Authority
Rail and bus connection “Left bank to the airport”	– 50 km new route	10	8	60% fuel of taxis and cars	20	0.5	- 2023	Astana Transport Authority
Development of Bike Sharing Program -	– 20 bike share hubs	4	5	100%	11	0.3	- 2020	Astana City

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results				Timeline	Responsible party for implementation
			Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]		
1	2	3	4	5	6	7	8	9
Establishment and extension of infrastructure for non-motorized transport (bikes)	for 50 bikes + 200 km of bike lanes			replacement of car fuel			in progress	Administration
Traffic Flow Optimization, "Intelligent Transportation System of Astana", dispatching system, priority bus lanes	– For 40 bus routes	8	7	5% gasoline/ diesel	18	0.5	2017 - 2022	Astana City Administration, Division of Planning
Construction of light-rail train (LRT)	– 22 km rail + 16 trains + 10 stations	79	24	0.5% gasoline of individual cars	50	1.6	- 2022 In progress	Astana Transport Authority
Priority 4: SECTOR - District Heating (DH)								
DH distribution: Automation of DH distribution flow management; Implementation of SCADA	– 6,846 DH supplied buildings (80% of the building stock)	3	148	EE 2% of distributed heat	2	1.5	2018-2025	Astana City Administration Division of Energy, Astana Energo Service, Astana Teplo Transit
DH distribution: Rehabilitation DH Pumping stations; Replacement of pumps (with variable speed drives, reactive power compensation)	– 32 DH pump stations (80% of all)	0.5	1	EE 40% of power for DH water pumping	14	0.03	2018-2021	
DH distribution: Automated heat substations with improved heat metering (including hydraulic balancing, efficient circulation pumps)	– 6,441 DH supplied buildings (90% of the building stock) – under a building service PPP	161	2.159	EE 26% DH distribution losses	8	21.3	2018-2023	
DH distribution: DH network rehabilitation, pipe replacement	– 58 km of DH network (10% of network)	23	175	EE 60% DH distribution losses	13	1.7	2018-2026	
DH distribution: Increase DH supply, storage and balancing capacity by construction of DH transmission pipeline between CHP 1, 2 and new CHP3	– 8 km of DH main pipeline	24	146	EE 10% of DH losses and DH supply	17	1.4	2020-2025	
Reduction of own consumption on heat and power generation plants	– 10 CHP & HOB units	10	100	EE 10% power use at facilities	2	5.6	2018-2022	

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results: Annual energy saving [7](million kWh/year)	Expected Results: Energy savings (%)	Expected Results: Annual energy cost savings (million US$/yr)[8]	Expected Results: Payback time (years)[9]	Timeline	Responsible party for implementation
1	2	3	4	5	6	7	8	9
DH generation: district boiler houses reconstruction and rehabilitation	– 16 boiler houses (80% of the facilities)	16	49	EE 50% of DH losses at individual networks	22	0.7	2018-2023	
Steam condensate return from industry steam consumers of CHP 1	– 10 steam users industry	2	21	EE 10% of DH losses at steam networks	7	0.3	2018-2013	
Priority 5: SECTOR – Municipal Solid Waste (SW)								
Fuel-Efficient Waste Vehicle Operations, vehicle replacement: Conversion of waste collection vehicles to CNG + fueling infrastructure	– 113 waste collection trucks (90% of the rolling stock)	7	4	20% diesel	30	0.2	2019-2022	Astana City Administration Division for Natural Resources, Astana Tazalyk
Waste Collection Route Optimization, GPS tracking and hauling management, central dispatch center	– For all 126 waste collection trucks	1	2	10% diesel	8	0.1	2018-2022	
Construction of modern waste sorting complex and transfer station near to CHP plant: including sorting, recycling, composting station “Taldykol” + Increase sorting and recycling: new waste container sites and containers enabling sorting	– Covering 70% of waste - 247,100 tons of municipal waste to landfill – 4,000 waste bins	6	5	25% diesel for waste delivery to landfill + revenues from recycling	10	0.6	2020-2023	
Bio waste to energy: biogas plant	– biogas plant + CHP (approx. 5 MW)	14	94	RE 100%	3	5.3	2022-2028	
Landfill Gas Capture Program	– Landfill gas capture plant + CHP (approx. 6 MW)	21	56	RE 100% heat and power	7	3.2	2022-2028	
Waste-to-Energy Program - Construction of a waste incineration plant for waste that cannot be recycled	– capacity of 40 MW	35	219	RE 90% (heat and power. 3:1)	7	5.3	2022-2030	Astana City Administration, Division for Energy, Astana Energo Service
Priority 6: SECTOR - Potable Water & Wastewater (PW/WW)								

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results				Timeline	Responsible party for implementation
			Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]		
1	2	3	4	5	6	7	8	9
Increase performance of the water distribution network; Replacement of outworn pipelines and valves	– 303 km of water distribution pipes (25% of the network)	30	3	80% power for pumping of water losses	178	0.2	2018-2025	Astana City Administration, Division of housing and Communal service, Astana Su Arnasy
Improve Efficiency of Pumps and Motors in the water supply system	– 2 pumping stations (5% of all)	0.2	0	10% power for pumping	8	0.0	2017-2020	
Active Leak Detection and Pressure Management Program	– 60 control points	0.2	1	5% power for pumping of water losses	6	0.0	2021-2025	
Improve water metering and remote metering	– 221,826 metering points (80% of all)	22	7	12% power for pumping of water losses	18	1.2	2018-2022	
Support program for residential users for Water Efficient Fixtures and Fittings	– 443,652 customers (80% of all)	1	9	15% power for pumping	2	0.5	2022-2028	
Improve Performance of the sewage network, new mainline collectors; replacement of obsolete pipes	– 141 km of sewage pipes (20% of network)	7	7	60% power for pumping of WW losses	93	0.1	2020-2025	
Improve Efficiency of Pumps and Motors, Modernization of WW pumping stations	– 100 pumping stations (70% of all)	8	9	40% power for pumping of WW losses	16	0.5	2027-2020	
Biogas production from sludge	– 1 biogas plant + CHP (approx. 5 MW)	13	47	RE power 100%	5	2.6	2023-2026	
Priority 7: SECTOR - Residential Buildings (RB)								
Installation of individual heat meters in all apartments and introducing consumption-based billing	– 4,446 multi-floor residential buildings (70% of the building stock)	11	175	5% DH in multi-floor residential buildings	8	1.3	2018-2030	Astana city administration, Division of Housing and Communal Service
Efficient lighting in public spaces of multi-store residential buildings (staircases & outside	– 5,082 multi-floor residential buildings	6	14	50% power	7	0.8	2018-2025	

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results				Timeline	Responsible party for implementation
			Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]		
1	2	3	4	5	6	7	8	9
equipped with LEDs & sensors)	(80% of the building stock							
Retrofit of residential multi-store buildings (15-year program)	– 1,681,995 m² multi-floor residential buildings (10% of the building stock)	118	250	50% DH in multi-floor residential buildings	65	1.8	2020-2030	Apartment Owners Associations
Solar Rooftop in Residential Buildings	– 381,120 m² roof area on multi-floor residential buildings (20% of the building stock)	119	143	RE power 100%	6	19.1	2025-2030	City Administration - Division of Energy, Astana Energo Service
Priority 8: SECTOR - Commercial Buildings/Industry (CB)								
Development of EE credit line for SME, commercial and industry with special incentives for Astana (grant or tax benefits)	– 137 relevant commercial entities (10% of all)	27	124	40% share of energy use in energy intensive industry	5	5.2	2029-2025	City Administration, Division of Economy and Budget Planning
Information and support program for solar rooftops for industrial and commercial buildings	– 134,280 m² roof area on large industry buildings (20% of the building stock)	42	50	RE power 100%	6	6.7	2020-2027	City Administration, Division of Energy
Priority 9: SECTOR – Private Transport / Vehicles (IT)								
Enforcement of Vehicle Emissions Standards, empower technical inspectors, service stations, penalty system for non-compliance	– 134,500 individual and commercial vehicles (50% of the fleet)	101	244	10% fuel use of individual and commercial cars	6	15.8	2020-2024	Astana City Administration, Division of Natural Resources
Increase attractiveness of low-emission vehicles: Development of Vehicle Charging Infrastructure Electric, LPG and CNG vehicles (20+20 stations)	– 40 individual fueling stations and commercial vehicles (5% of the fleet)	12	37	15% fuel use of individual and commercial cars	5	2.4	2023-2030	Astana Transport Authority

Energy Saving Investment Measures	Details about implementation	Estimated investment costs[6] (million US$)	Expected Results				Timeline	Responsible party for implementation
			Annual energy saving [7](million kWh/year)	Energy savings (%)	Annual energy cost savings (million US$/yr)[8]	Payback time (years)[9]		
1	2	3	4	5	6	7	8	9
Car parking management and restraint measures in the city center + inspection service	– Applied to 30 km of roads (2% of the fleet)	3	20	20% fuel use of individual & commercial cars	2	1.3	2020-2030	Astana City Administration, Division of Planning
Priority 10: SECTOR - Power System (EL- Electricity)								
Solar Photovoltaic (PV) plant; 40-50 MWp	– 300,000 m² PV area RE power – capacity 0,04 GWp generation	94	113	RE power 100%	6	15.0	2022-2027	City Administration, Division of Energy, Astana Energo Service
SMART metering program: automated electricity metering for commercial entities	– 5,475 commercial entities	2	5	2% power	3	0.6	2018-2025	Astana Energy Sales Company + Astana Energosbyt
Construction and modernization of the substations and replacement of some of the 110 kV lines by 10 kV lines (nearby CHP)		60	70	30% of power losses in the related network	15	3.9	2019-2025	Astana REK

2 Energy Performance Assessment of the City of Astana

2.1 Objectives of the Study

The study assesses the energy performance of the municipal service sectors in Astana and identifies and prioritizes EE opportunities in order to outline an urban EE strategy for the next 12 years - from 2018 to 2030 - along with a sound implementation plan.

The Energy Efficiency Plan for the City of Almaty was developed in connection to the World Bank's (WB) Kazakhstan Energy Efficiency Project (KEEP) with support from the Energy Sector Management Assistance Program – ESMAP, a multi-donor technical assistance fund managed by the WB.

The plan was prepared by using the **Tool for Rapid Assessment of City Energy (TRACE**), a tool developed by the WB through ESMAP, which aims to assess the EE potential of the city, identify sectors with the most improvement potential, and recommend a set of EE measures (including timeline, costs and savings). The TRACE assessment is done through:

- Benchmarking the city EE performance in comparison with peer cities around the world;
- Prioritizing sectors based on energy-saving potential, expenditure and city authority control, and identifying appropriate EE interventions; and
- Prioritizing actions based on the city's implementation capacity and planning horizon.

2.2 Process of Energy Efficiency Diagnostics

This TRACE EE assessment began in February 2017 with the data collection and compilation, a process that benefited of support from the CA of Astana, as well as from different utility and municipal services divisions.

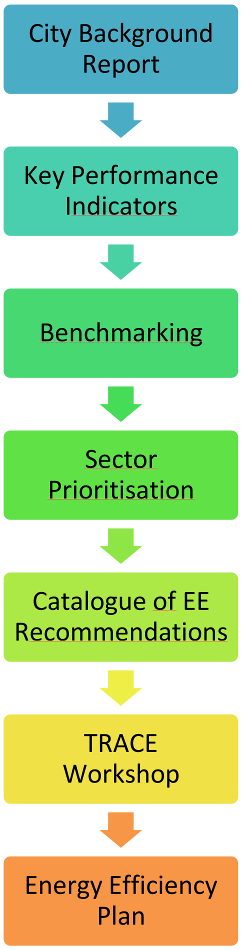
Based on this data, a number of Key Performance Indicators (KPI) for Astana were calculated and aggregated into TRACE.

The Sector prioritization pointing to those municipal service areas with highest energy savings potential took into consideration a few elements, namely a) the municipal energy spending, b) potential energy savings related to the relative energy intensity, and c) the level of control of the CA over the respective sectors, including budget, regulation and enforcement in implementing EE measures.

Based on data collected and interviews with city authorities and municipal service providers, a long list of potential EE recommendations was compiled, based on the city's needs. The proposed EE interventions were presented and discussed with local authorities during a decision review workshop organized in May 2017 in Astana.

During the workshop, city authorities, utility companies and other local stakeholders have agreed over the intervention areas for the city energy efficiency plan, under an integrated approach.

The Astana Energy Efficiency Plan is in line with the decisions taken in the workshop focusing on certain priorities, interventions and targets. The plan looks into the EE potentials and benefits of a refined list of EE investment measures, and finally, outlines an implementation strategy for the plan.



2.3 Country Background

Kazakhstan has 14 regions (oblasts), namely Akmola, Aktobe, Almaty, Atyrau, East Kazakhstan, Karaganda, Kostanay, Kyzylorda, Mangystau, North Kazakhstan, Pavlodar, South Kazakhstan, West Kazakhstan, and Zhambyl. There are 86 cities, including 41 cities of republican and regional subordination, 175 districts, 35 settlements and 2,468 "aul" (rural) administrations. Astana and Almaty, the current and the former capital city, respectively, have special status (called “important status”), and they do not belong to any region. Oblasts are divided into districts and cities/municipalities. Cities/municipalities are further split into municipality districts (rayons). Oblasts, municipalities and districts are managed by akims (governors). The President of the country appoints the governors for the oblasts and the mayors of Astana and Almaty. Regional governors appoint the municipal governors, who further pick the rayon/district governors.

Kazakhstan is the largest economy in Central Asia, due to its vast natural resources of hydrocarbon and minerals. Oil and gas reserves are concentrated in the western regions. The country has the ninth largest proven oil reserves and the 15th largest proven natural gas reserves in the world, with hydrocarbons making the equivalent of nearly 18% of GDP and 60% of exports (as of 2015).[10] Energy sector is the backbone of the economy. Around 60% of the assets belong to the state, mostly grouped under Samruk Kazyna, a wealth funds and a joint stock company that owns entirely or in part many important companies from the energy, transport and financial sectors. The main entities under Samruk include KazMunaiGas – the state oil and gas entity, KazTransGas – the state gas company, KEGOC – the national energy grid operator, and KazAtomProm – the national importer of uranium, rare metals, and nuclear fuel components for power plants, Samruk Energy –the state generation company, in addition to several others, such as the postal service and the national air transport operator. Between 17-20% of value added to GDP is made by state enterprises

With a Human Development Index of 0.788 (as of 2014), Kazakhstan is among top 60 countries in the world in terms of life expectancy, education and per capita income.[11] The energy driven economy had helped this Central Asian nation transition from lower-middle-income to upper-middle-income status in less than two decades, making to the upper-middle-income group in 2006. Since 2002, GDP per capita has risen six-fold while the poverty rate has fallen sharply. In 2015, the GDP was US$ 184.4 billion, with the GDP per capita US$ 10,501 (as per current exchange rate). In 2015, the average income in Kazakhstan was US$ 364 per month, and only 0.04% of the population lived below poverty line on less than US$ 1.9/day (as per poverty headcount nations at poverty line).[12] The life expectancy also indicated good figures, i.e., 69.6 years.

The service sector employs approximately 62% of the labor force in the country, with almost 12% working in industry and the rest in agriculture. Agricultural development and production sector are on the top of the government agenda. Grain and industrial crops such as wheat, barley, and millet occupy up to 70% of farm lands in the northern Kazakhstan, while rice, cotton, and tobacco are grown in the south. Energy and extractives products, like oil & oil products, natural gas, ferrous metals, chemicals, machinery, grain, wool, meat, and coal comprise Kazakhstan’s main exports. The country ranks 15th for crude oil producer and 10th for crude oil exports. Main imports consist of machinery and equipment, metal products and food. Russia and China are the key trading partners, in addition to a few European countries like Germany, France, and Italy. As a landlocked country, Kazakhstan relies on Russia for its oil export to Europe. In 2010, Kazakhstan joined Russia and Belarus to establish a Customs Union to boost foreign investment and improve trade, an entity that later evolved into the Single Economic Space in 2012 and into the Eurasian Economic Union in 2015.

Kazakhstan’s economy is still adjusting after the decline of domestic and external demand trade due to the recent international oil crises. The drop-in oil price since 2014 brought some negative

[10] World Bank Country overviews available at: http://www.worldbank.org/en/country/kazakhstan/overview
[11] HDI for 2014 – report available at http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf
[12] World Bank PovCalNethttp://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx

consequences for both domestic consumption and investor confidence. Kazakhstan suffered from the collapse of global oil prices, with the GDP growth slowing from 4.1% (year-on-year) to only 1 (one) percent during the following year.[13] The drop-in oil price by more than 50% triggered cuts in export revenues by almost half, along with decline of foreign direct investments and deterioration of the local currency (tenge or KZT). To counter the oil crisis repercussion, the Government of Kazakhstan (GoK) implemented some rapid fiscal changes together with monetary and exchange-rate policy adjustments. In August 2015, the country moved to a floating exchange rate and shifted its monetary policy to an inflation-targeting regime; by the end of 2014, the local currency had lost about a third of its value against the US dollar.

On the long run, the main challenge on the longer-run for Kazakhstan is to shift from an economic development model based on natural resource extraction to a more diversified, competitive economy. In recent years, the country has embarked on an ambitious program to diversity its economy, with a specific target on sectors like transport, pharmaceuticals, telecommunications, petrochemicals and food processing. But despite of these efforts, economic diversification has proven quite difficult to achieve, especially until 2014, when oil prices were still high. Despite of significant steps has taken toward a more transparent, less-regulated, and market-driven business environment, the country is still facing challenges and constraints related to governance, infrastructure, institutions, investment climate, rule of law, and there are little incentives for investments in physical capital and new technologies. The government has set a target to transition to a green economy by 2050, a move which is expected to increase the GDP by 3% and create more than half million new jobs.

2.4 Astana City Background and Context

The capital city of Kazakhstan since 1997, Astana is located in the north of the country, within Akmola region, lying on the banks of the Ishim River in a flat semi-arid steppe. A city of 872,700 inhabitants which makes it the second largest in the country after Almaty, Astana is spread over 722 km² with a population density of more than 950 people per km². Astana and Almaty are cities with a special status (in addition to Baikonur town), and administratively they are not part to any of the country's 14 regions. A planned city, like Brasilia or Canberra, Astana was designed by Kisho Kurokawa, a Japanese architect who is combing mega-structures organic biological architecture, well-known for his eco-friendly and sustainable projects and who has built the Kuala Lumpur International Airport, among others.

The world's second coldest capital city, after Ulan Bator of Mongolia, Astana has extreme continental climate with cold with long winters and warm summers. The temperatures have great variations, from as low as -35 Celsius in the winter to 30-35 Celsius in the summer. The city is usually frozen from November till April, a period during which it gets hit by high winds, especially in the left side of the river. Two-thirds of population is made of Kazakhs, with Russians accounting for nearly a quarter, in addition to 2.8% Ukrainians, 1.7% Tatars, and 1.5% Germans.

The city has three districts, namely Almaty, Yesil, and Saryarka. Astana is home to the state sovereign welfare fund Samruk-Kazyna comprising most of the state-owned companies, as well as to other state-owned entities. The local economy relies on trade, transport, construction, communications, and industrial production, such as mechanical engineering, foodstuff and construction materials. The rapid development of the city had attracted many investors. Investments went up by more than 30 times, while the gross regional product (GRP) by 90 times in the past two decades since the city has become the capital of the country. The local administration promotes actively the development of small and medium enterprises (SMEs). The number of SMEs has increased by 13% in the past years, to nearly 100,000 units. By 2015, around 235,000 people were employed by the SME sector. In 2013,

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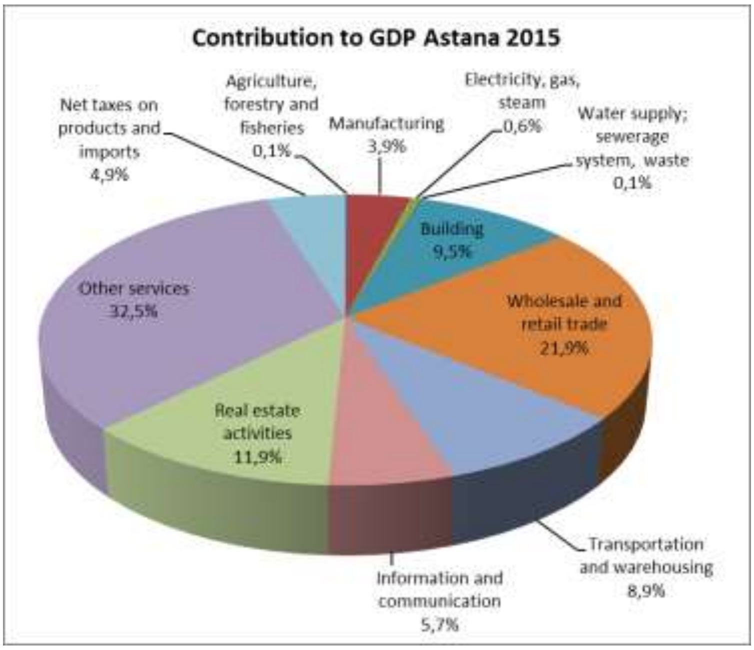
[13] Kazakhstan – Economic Update no.2 Fall 2015 -- Adjusting to lower oil prices; Challenges ahead available at https://openknowledge.worldbank.org/bitstream/handle/10986/23236/101506.pdf?sequence=5

77% of the local working population was active in the service sector. This sector also employs annually 60% of the new jobs.

The GRP of Astana accounts for around 8.5% of the country's GDP. The city makes 9.9% of the GDP - which is 15% of the state budget and around 9% of the total investments in Kazakhstan.[14] Astana, in addition to Almaty and Mangistay and Atyrai Oblasts, are donors to the state budget. In 2015, the city's GDP was US$ 21.6 billion, with US$ 24,820 GDP/capita.

Figure 8: Sector contribution to GDP of Astana in 2015



The rapid growth the city's GRP is mainly a result of the development of the service sector – an increase from 72.6% in 2013 to more than 87% in 2013.[15] The service sector began to dominate the GRP starting with year 2010 – especially in finance, logistics, health, education, and transport. The local economy relies on services, which is estimated at KZT 834,000 per person. From 2008 to 2013, the shares of investments went up and reached KZT 2.9 trillion, of which less than half (KZT 1.29 trillion) were public investments. The local revenues increased by 22%, while the money from the national budget diminished by 29% (from 77% to 58%).

One of the key priorities of the CA is Smart Astana, a project that should turn Astana into a world class city characterized by using information and communication technologies and innovative solutions in six areas – i.e., economy, management, life, mobility, people and environment.

Like many other cities in the world, Astana is challenged by rapid population growth and internal migration. Despite of that, Astana has the highest housing provision in Kazakhstan, with 27.7 m^2/capita as of 2013), which is 25% increase as compared to less than 20 m^2 a decade ago. Astana has one-fifth of the total housing in the country. 13% of construction companies are registered in the city. Around KZT 500 billion was spent in the housing sector between 2008 and 2013 on building 7.7 million m^2 – comprising almost 74,000 apartments of which around 10,000 are state-owned.

2.5 Energy Efficiency - Legal and Institutional Framework

For many years, energy efficiency (EE) has not been a priority for the GoK. The *Law on Energy Saving* was adopted in 1997, but it remained mainly declarative in nature due to lack of specific national

[14] Concept of entering the capital Astana in the top 10 best cities in the world until 2050 –Document approved by Resolution # 1394 of the Government of Republic of Kazakhstan on December 29, 2014

[15] Concept of entering the capital Astana in the top 10 best cities in the world until 2050.

goals about EE, action plans, legislation and methodology to support EE. In recent years, EE has become more of a policy priority to the government in the attempt to prevent serious growth-slowing energy shortages, improve industrial competitiveness, and mitigate consequences of the recently rapid rise in domestic energy price.

The President's speech "New Decade - New Upturn in the Economy - New Opportunities for Kazakhstan" delivered on January 29, 2010 set the path to advance and strengthen the EE topic. A few months later, the leadership of the country set publicly the goal to reduce energy intensity of the national economy by 10% by 2015 and by 25% by 2020, hence making EE a top policy priority.

A new *Law on Energy Saving and Energy Efficiency* was approved in 2012, and amended in 2015. The country has approved the State program "Energy Efficiency-2020" and Strategic Development Plan until 2020. In early 2010s, the Complex Plan on EE for the period 2012-2015 was prepared.

Kazakhstan ratified the Paris Agreement in November 2016 and committed itself to fulfillment of the proposed target as its first intended Nationally Determine Contributions (NDC). In its NDC, Kazakhstan pledges to an economy wide absolute reduction of GHG emissions of 15% from 1990 emissions levels by 2030. Kazakhstan has also stated in its NDC that it is interested in increasing the ambition of its climate change mitigation target to 25% from the 1990 emissions levels, should there be additional international support and finance, access to international carbon markets and low carbon technology transfer. Kazakhstan plans on updating the GEP in the coming months and revising the indicative targets for key sector based on the updated projection on the economic growth. The key entity at the national level overseeing all activities on EE is the Ministry of Investments and Development (MoID). The MoID has a dedicated unit - the Committee on Industrial Development and Industrial Safety that is responsible for EE policy, ensuring that the EE legislation follows the primary and secondary legislation. The MoID supervises the State Energy Registry (SER) according to article 5 of the Energy Efficiency Law. Companies enrolled in the SER are mandated to provide the energy audits and then implement the audit's recommendations.

Public or private entities with energy consumption exceeding 1,500 toe/year must report to the registry. They should conduct energy audits (for the period until up to year 2016), prepare an EE plan, apply EE retrofit measures, and implement an energy management system. There are approximately 7,500 entities listed under SER, of which 765 private enterprises, 2,505 public companies, and 4,284 government organizations.

By November 15 each year, local authorities must send to SER information about all entities registered with SER. By March 1st, companies must provide information on issues, like energy and water production, consumption, transmission and losses of energy during a calendar year; EE and savings plan developed based on energy audits; results following implementation of the EE plan; actual energy consumption per unit of production and/or spending of energy for heating per unit area of buildings and structures. They also must submit a copy of the conclusions of the energy audit and fill in information about metering equipment, if any. Before August 15, SER must prepare an assessment that should be submitted to the MoID.

According to the EE legislation, municipalities (akimats) are the institutional players at the local level in the field of EE. Local authorities must include EE activities in the local development programs, implement the state policy on EE and monitor compliance with normative energy consumption of public facilities. Moreover, they are responsible to develop the regional EE Complex Plan, and update the MoID on the implementation process. Local governments should also execute the EE and conservation measures mentioned in the EE program, monitor compliance with energy standards in the public sector, and organize energy audits in public institutions. Cities are also in charge for the thermal insulation of public buildings. Also, they must buy and install metering and automated heat control systems in public institutions, introduce energy savings measures in the street lighting sector, and organize recycling of mercury lamps from the city residents.

2.6 Key Strategies with Relevance to Energy and Energy Efficiency

2.6.1 National Level

The "Kazakhstan 2030" Strategy for Development was made public in 1997, and outlines a long-term development plan directed at transforming the country into a stable and ecologically sustained and developing economy.[16] One of the seven priority areas focuses on power resources. By 2030, Kazakhstan should accelerate the development of the domestic energy infrastructure, settle the self-sufficiency and competitive independence issue, on one hand, and use wisely its strategic resources to make savings for future generations, on the other hand.

The main areas of interventions with regard to EE target new energy-saving technologies, equipment, heat substations, metering systems, and increase in the fuel and energy balance of renewable and alternative energy sources. New legislation and regulation is necessary to establish the right mechanisms to encourage companies to implement EE measures. New financial instruments are needed, such as urban revolving financial mechanism to help accumulate funds based on the budgetary framework, and identify a corresponding body at the city level.

The "Kazakhstan 2020" Strategic Development Plan is adopted as a short-term phase plan to support implementation of Strategy "Kazakhstan – 2030". The document aims to address a few issues after the recent oil crisis, such as economic diversification through industrialization and infrastructure development, high quality housing and communal services. The mid-term indicative targets in key sectors have been set to support the green economy development and diversification, thus improving the business environment and social services in the country. The plan also aims to reduce the energy intensity of GDP to 25% as compared to 2008 baseline.

Kazakhstan Strategy 2050 is a long-term plan consisting of 100 concrete steps that should implement an institutional reform to place the country among top 30 advanced nations in the world by 2050, from its currently ranking position of 51st.[17] The program was made public by the president in May 2015, and targets the power sector reform, among other issues. In the future, Kazakhstan wants to introduce the single buyer model which will allow reduce the differentiate tariffs in the region, expand the regional electricity companies and reduce the cost of power transmission to end-users, and introduce a new tariff policy to stimulate investment in the energy sector (the tariff should have one component to finance the capital cost and another one to cover the variable cost of electricity generation). Step #59 of the strategy refers to energy savings companies (ESCOs) by attracting strategic investors to the energy saving industry. Priority should be given to the development of companies in the private sector to provide energy saving services with the return of their expenditures and financial profit obtained from the reduction of energy costs.

The *Green Economy Policy* was approved in 2013 and its main target is to diversity Kazakhstan's economy through careful use of resource, in parallel with development of renewable energy sources.[18] Closely connected to *Kazakhstan Strategy 2050*, the document is the country's new economic policy under which "green economy" should increase the GDP by 3% and create more than half million new jobs. By 2020 3% of power should be generated from renewable energy sources (solar and wind) and the clean energy share should increase by 30% by 2030 and by 50% until 2050. A third of the total waste should produce green energy by 2050.

On the long-term, Kazakhstan aims to reduce greenhouse gas (GHG) emissions by 40% by 2050 (as compared to 2012 levels) and increase the share of natural gas-based power plants to 30% by 2050.

[16] Strategy Kazakhstan 2030 available at http://www.akorda.kz/en/official_documents/strategies_and_programs
[17] Strategy Kazakhstan 2050 available at: http://strategy2050.kz/en/page/message_text2014/ and http://strategy2050.kz/en/
[18] Green Economy Policy was approved by the Decree of the President on May 30, 2013 (#577)

In the field of EE, the GoK is determined to reduce the intensity of the GDP by 30% by 2030 and by 50% by 2050 (compared to the levels of 2008). Municipal waste coverage should achieve 100% by 2050, while recycling waste should be 40% by 2030 and 50% by 2050. The law on renewable energy (RE) and ecology was amended in 2016 to further encourage the newly developing green industry in the country.

The Feed-in-Tariff policy was established in 2013 for the next 15 years, in an attempt to increase power generation from RES, which currently makes less than 1% of the energy mix in Kazakhstan, as well as help the GoK to carry out the GEP. Other provisions regarding RE include mandatory purchase of electricity generated using RES by the single off-taker Financial Settlement Center under KEGOC[19] and mandatory connection of RES facilities to transmission or distribution networks by the grid operating company. There are no licensing requirements for RE generation.

Nurly Zhol (the Bright Path to the Future) is a US$ 9 billion domestic stimulus plan launched in 2014 with the main target to improve the critical infrastructure and priority sectors, and drive economic growth by state and foreign direct investments.[20] The program provides very attractive loans with a small interest rate and six-year grace period. The program should be able to shift productivity from the oil sector towards other areas, like agribusiness, manufacturing, trade and logistics, tourism, information technology and finance. The main target of the program is to bring about development in seven areas, namely infrastructure development in transportation and logistics, industrial energy, public utilities, housing, social, and SMEs. In addition to building high-voltage transmission lines and balancing energy access to rural areas through a balanced energy supply, the program pledges annually US$ 450 million to modernize heat & water infrastructure and develop social housing, in addition to KZT 20 billion for new kindergartens. The program focuses on development and modernization of hard infrastructure, like roads and ports, and should create 4,500 new jobs in the SME sector, with overall 200,000 new jobs in the country.

2.6.2 Local Strategies for Astana

Astana Development Plan for 2016-2020 provides a picture of where Astana should be in the next period of time and the development targets. The document mentions that the city should reduce the energy intensity of the GRP by 10% by 2020 as compared to the 2013 baseline by using energy savings technologies in housing, transport, communal services, and improve EE in all main public utility sectors, including street lighting, transport, heat and water.

Astana Among Top 10 Capital Cities by 2050 is a document approved by the GoK in December 2014 that sets up an ambitious goal of placing Astana among the world's most important and developed cities by 2050. The document assessed the challenges and opportunities for Astana in order to achieve its goals in the next two decades. Some of the key issues are related to expanding the basic infrastructure and providing good quality services to people.

Integrated Energy-Savings and Energy Efficiency Plan for Astana 2016-2020 is a document designed by the JSC Institute of the Electricity and Energy Efficiency Development for Energy Efficiency (EEDI) that sets the EE priorities for the city for the next few years. The document presents a comprehensive program highlighting EE measures in all major sectors. It should also help establish a set of legal and institutional measures, such as ESCOs, and bring together the public and private sectors under a PPP mechanism to implement the EE interventions. The main target is to reduce energy consumption in Astana by 10% by 2018 and by 15% by 2020 as compared to 2015. Another ambitious goal is to reduce energy intensity of GDP by 25% by 2020. The document is listing over 100 measures – most of them targeting public utility services, such as water, district heating or solid

[19] KEGOC – Kazakhstan Electricity Grid Operating Company

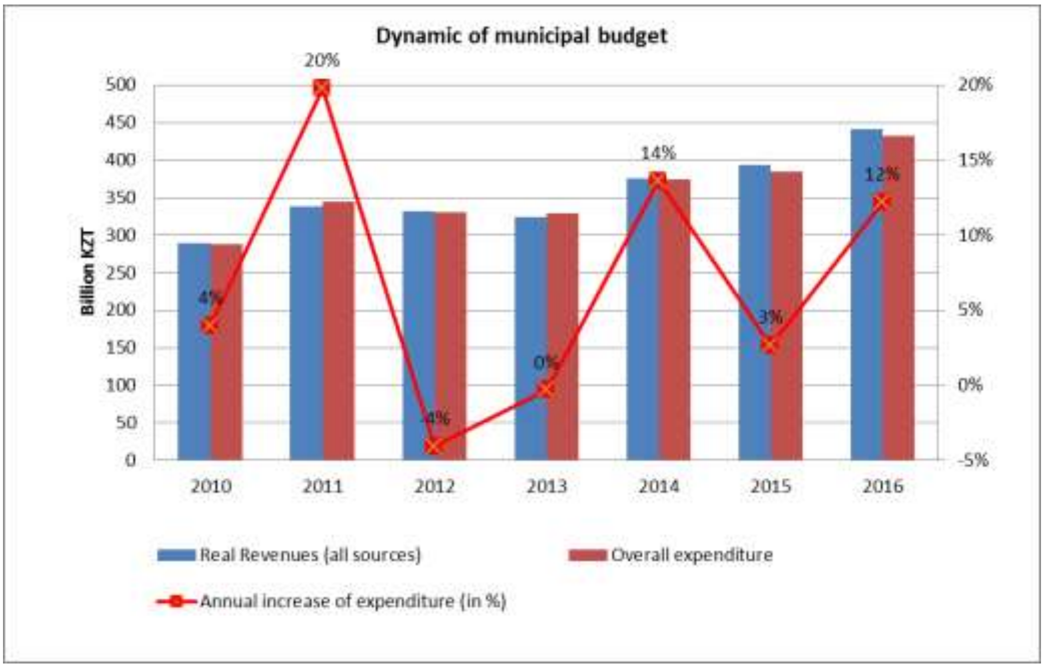
[20] Nurly Zhol – more details about this program are available at: http://www.kazakhembus.com/content/nurly-zhol-0

waste – and mentions the funds that would be necessary to implement these interventions, but without providing any information to back-up these figures. The document should be approved by the Astana local council in 2017.

2.7 The Local Budget Framework of Astana

In Kazakhstan, the national and local budgets are regulated by the Budget Code. Astana, Almaty and two regions are donors to the national budget. The local budget is drafted and managed by the Budget Division of the CA. The budgetary cycle has three years. The local budget has two funding sources, namely local revenues and the national budget. 40% of the local budget is made of local revenues in the form of tax collection, while 60% is earmarked transfers from the national budget for investments and specific expenditures. This share split is in place since 2000, although local expenditures have considerably gone up in recent years by approximately 10% per year, mainly due to increased municipal services and operation costs for salaries and utilities (including energy expenditure). This budget trend indicates a future annual increase of 2-3% for energy costs.

Figure 9.Dynamic of Astana municipal budget 2010 to 2016



The spending is split into two types of expenditures, i.e., for operations and investments. About 80% of the earmarked funds go for investments, and the rest of 20% covers some specific expenditures. Overall, 55% of the budget covers operations costs, including salaries and public sector services, while 45% is used for investments. Most of the money collected from local taxes and revenues fund the operation costs of the public sector areas, including schools, street lighting, waste collection and road cleaning. The city budget also covers expenditures related to street lighting operation in municipal districts. The kindergartens receive from the city budget a monthly lump sum of KZT 20,000 per child. This money are used for operation costs of the facilities and salaries. There are no subsidies from the national budget to municipal services.

40% of the money for investments finances the ongoing projects. If earmarked funds for investments are not spent by the end of the fiscal year, cities must return the money to the Ministry of Finance (MoF) or ask for an extension. Sometimes transfers from the national budget are delayed, triggering delays for tenders for the service providers.

The budget projection for the next period is made based on some 10% increase of the current budget. Annually, there are three budget adjustments. There are three restrictions for debt limits -- (i) up to maximum 75% of revenues (excluding liabilities), (ii) cannot exceed 10% of the total budget, and (iii) accumulated debts should be less than 75% of the total budget. It is important to note that the city cannot borrow money to cover the daily operation expenditures. A special provision under article 210 of the Budget Code allows Astana and Almaty to issue bonds if they have budget surplus.

The Budget Division of the CA receives investment proposals from all divisions. Since local money is never enough, the city must ask for more funds from the national budget. The local investment plan is prepared by the line ministries and sent for approval to the MoF, and further to the Committee of the Financing of Kazakhstan. If money is not allocated in the respective fiscal year, projects could be considered for the next fiscal years. When city managers are able to generate some additional revenues from local taxes, the local council (maslikat) decides on how the money should be spent.

If there is some budget surplus in a public sector area, it is for the local government to decide how the money should be spent, based on recommendations from the respective city division. For example, the school drafts a proposal on how to alternatively use the funds in the next fiscal year, which is sent to the Division of Education, which is responsible for overseeing the schools in the city. The Division of Education sends the proposal to the Financial Planning Unit and from here it goes further to the specific working group in the local council. After getting the green light from the working group, the proposal must be approved by the local assembly.

2.7.1 Economic Indicators

Table 4: City key statistics of 2015[21]

№	Indicator	Value in 2015	Unit
1	Population	872,700	people
3	Municipal Area	700	km^2
2	Population Density	1,250	people/km^2
4	Primary Energy Consumption	21,985	GWh
5	Employment Rate	Above 95%	
6	Human Development Index (HDI)[22]	0.79	
7	Total Annual Municipal Budget	1,774 394	US$ million KZT billion
8	Energy Spending (for municipal sectors: public transport, municipal buildings, street lighting, waste, water and astewater services)	34,025 equal to 1.9%	US$ million of municipal budget
9	Municipality Expenditures for Energy in Public Buildings	17,125 equal to 1%	US$ million of municipality budget
10	GDP (2015)	21,666 4,810	US$ million KZT billion

[21] It was agreed with the City Administration and the World Bank team to apply data of the year 2015 as baseline data for the TRACE assessment and the following EE assessment.
[22] UN Human Development Reports available at https://hdr.undp.org/en/data; Value for Kazakhstan,2015

3 Municipal Energy Consumption and Sector Analysis

3.1 City-Wide Energy Consumption and Key Performance Indicators

In 2015, the total primary energy consumption (PEC) in Astana was 22 TWh (22 billion kWh), of which 70% was coal, primarily used for heat generation or heat& power cogeneration (CHP) facilities. 80% of the power used in the city is generated by the local CHPs, while 20% is supplied by KECOG, the national transmission grid operator in Kazakhstan. The city has some limited supply of natural gas.

Figure 10: Share of Primary energy consumption

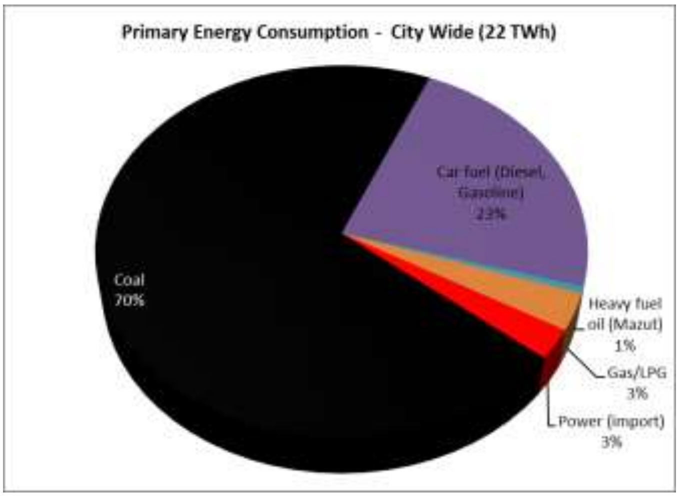
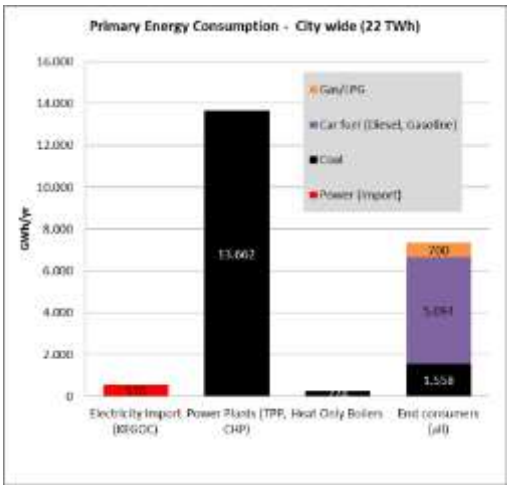


Figure 11: Use of Primary energy



The losses in the energy transformation and distribution system incurred by final energy carriers of district heat and electricity were 6,600 GWh in 2015, which accounts for 30% of PEC in 2015. The figure exceeds the final energy consumption (FEC) of the entire residential sector in Astana. Based on the generation and distribution losses, the primary energy factor for electricity is 1.9 - meaning that 1 kWh of power delivered to the final consumer requires 1.9 KWh of primary energy (mainly coal). For district heat the primary energy factor is at 1.7.

The energy flow of Astana in the baseline year 2015 is presented in Annex 1 as a Sankey diagram. This illustrates the consumption of primary energy carriers for the energy in all municipal sectors, and it sums up city-wide FEC. In 2015, the final energy consumption of the city amounted to 15.400 GWh, with main consumption of car fuel and district heat comprising one third each.

Figure 12: City-wide final energy consumption

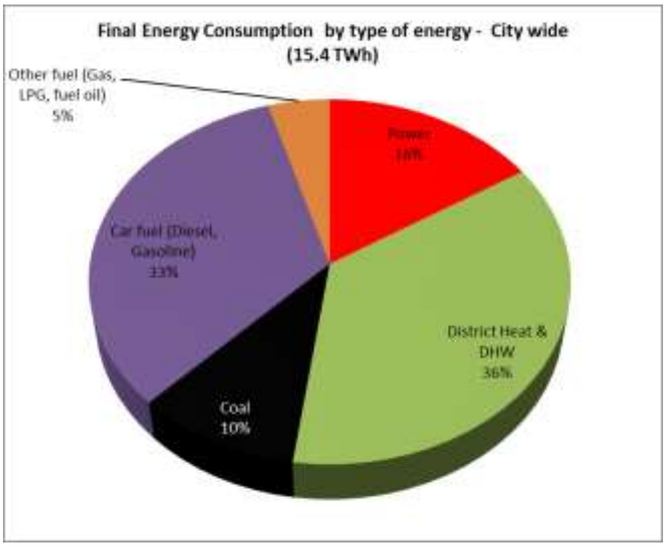
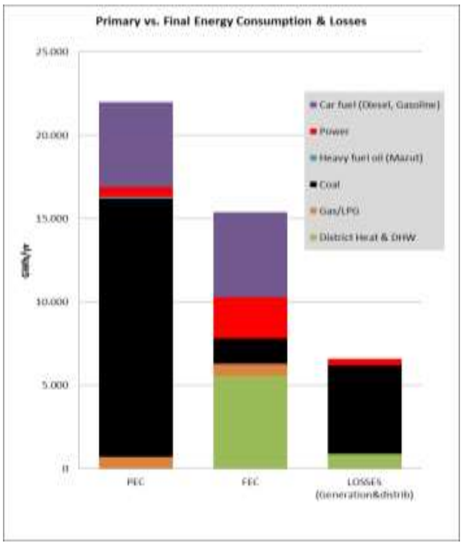
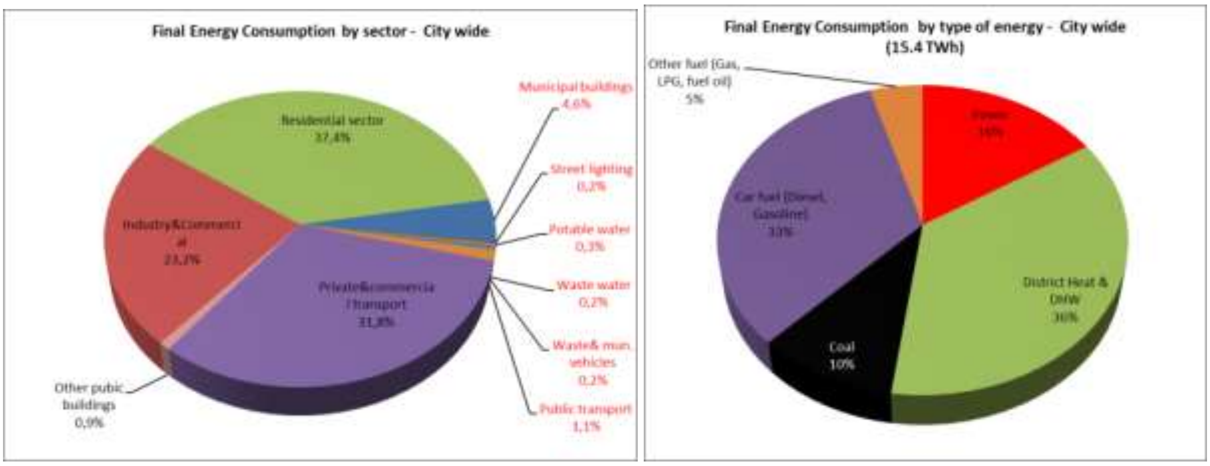


Figure 13: Primary and FEC



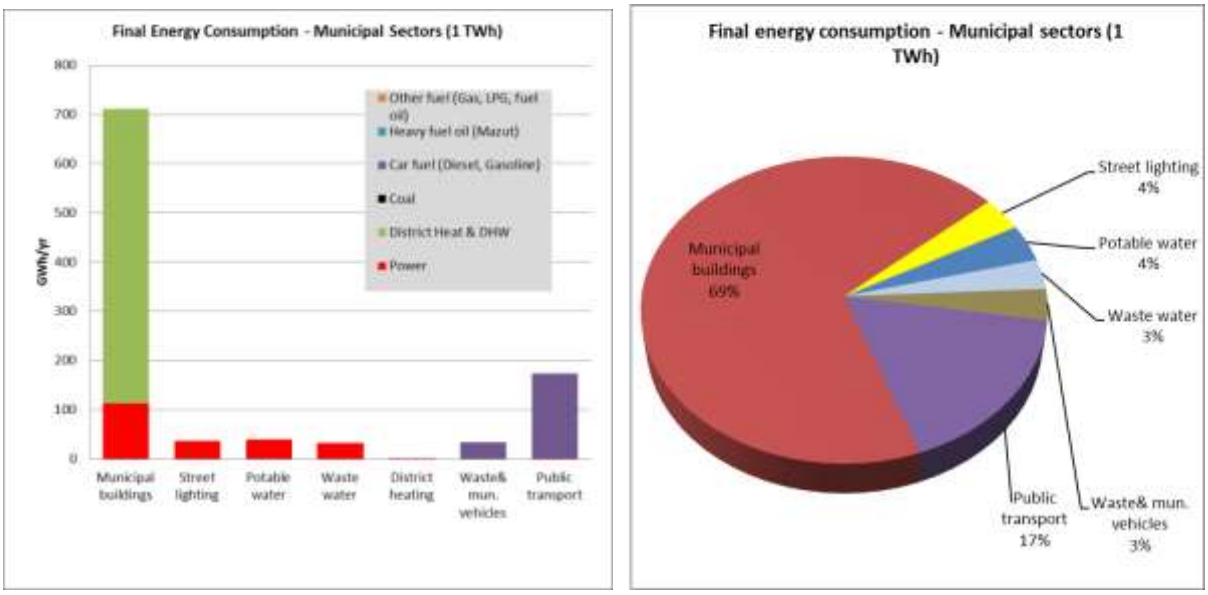
The residential sector is the largest energy consumer in Astana, using approximately 38% of the total FEC, an adequate percentage for cities in Kazakhstan. This is followed by the private transport sector (32% of FEC) and industry and commercial sector (23% of FEC).

Figure 14: Share of city-wide final energy consumption by sector and energy carrier



Most of the energy used in Astana is used to generate heat (36%), followed by car fuel and electricity. The residential sector is the main consumer of district heat (57% of total heat). The main consumer of electricity is the local industry (58%). The final energy consumption of municipal service sectors amount to 1,030 GWh in 2015, which represents 7% of Astana's FEC. Largest consumer are the municipal public buildings with 711 GWh (69% of municipal sector consumption), followed by public transport energy consumption.

Figure 15: Share of municipal wide final energy consumption by energy carrier



3.2 CO_2 Emission Balance

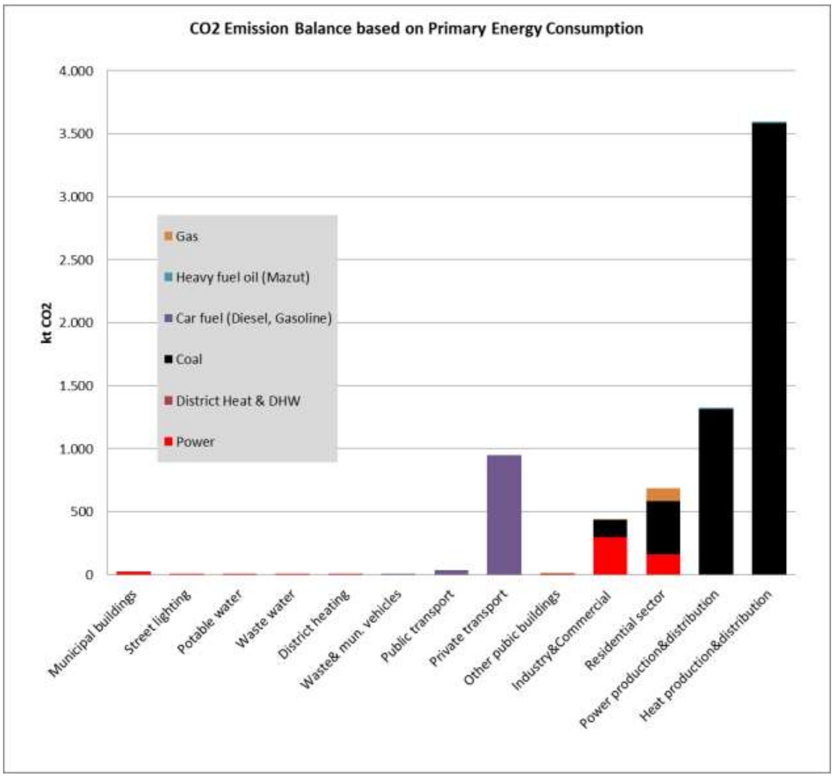
Due to extensive use of coal for power and heat generation CO_2 emissions have reached 7.1 million tons in 2015[23], representing a high value of 0.32 kg CO_2 per kWh primary energy use. Highest emissions factors are calculated for heat and power generation - approximately 0.6 kg CO_2/kWh.

The emission factor for electricity produced in cogeneration plants in Astana (0.6 kg CO_2/kWh) is

[23] Source: Expert calculation based in the primary energy balance 2015.

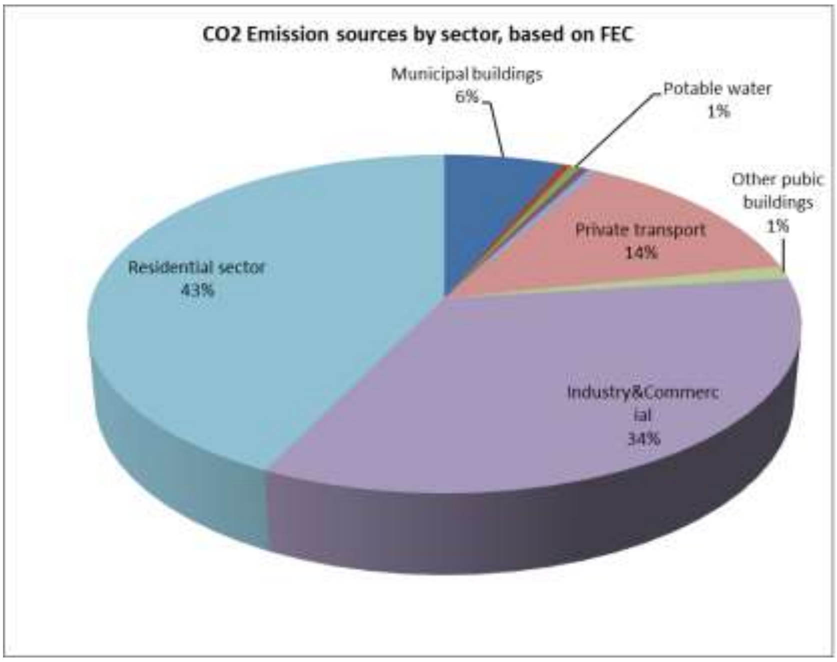
one third less than the country-wide power **emission factor of 0.9 kg CO_2/kWh. Thus, the locally produced electricity** in **CHP is cleaner than the** power imported by **KEGOC.** 70% of emissions come from heat & power production and distribution, 13% from private transport and 10% from the residential sector.

Figure 16: CO_2 emission sources by sector



Based on FEC, the residential sector is the largest producer of GHG emissions reaching annually to 3 million tons of CO_2, (43%) followed by emissions from the industry and private transport.

Figure 17: Emission sources by final energy consumption sectors



3.3 Energy Performance Benchmarking

The benchmarking component of the TRACE tool is intended to assess the energy performance of Astana compared to other peer cities. For this exercise, the city-wide and sectoral Key Performance Indicators (KPI) of Astana are compared with KPIs of other cities through the built-in peer city data. For an illustrative comparison with Astana a number of large size peer cities of similar HDI and climate have been chosen from the TRACE database, such as Bucharest/Romania, Almaty/Kazakhstan, Belgrade/Serbia, Baku/Azerbaijan, Banja Luka/Bosnia and Herzegovina, Sarajevo/Croatia, Sofia/ Bulgaria, Teheran/Iran, Tallinn/Estonia, Tbilisi/Georgia, Kiev/Ukraine, and Urumqi/China.

A summary of some of the KPIs is presented in Table 5 below.

Table 5. City-wide energy KPIs for Astana

Key Performance Indicators (TRACE)		
Primary energy consumption per capita	25,192	kWh/capita/annum
Primary electricity consumption per capita	3,289	kWh_e/capita/annum
Thermal energy consumption per capita	5,705	kWh_T/capita/annum
Primary energy consumption per GDP	1,01	kWh/US$
Energy supply coverage	100	%

The implementation of TRACE delivers 27 KPIs for the city of Astana. The complete list of municipal energy data of the baseline year 2016 is available in Annex 5.

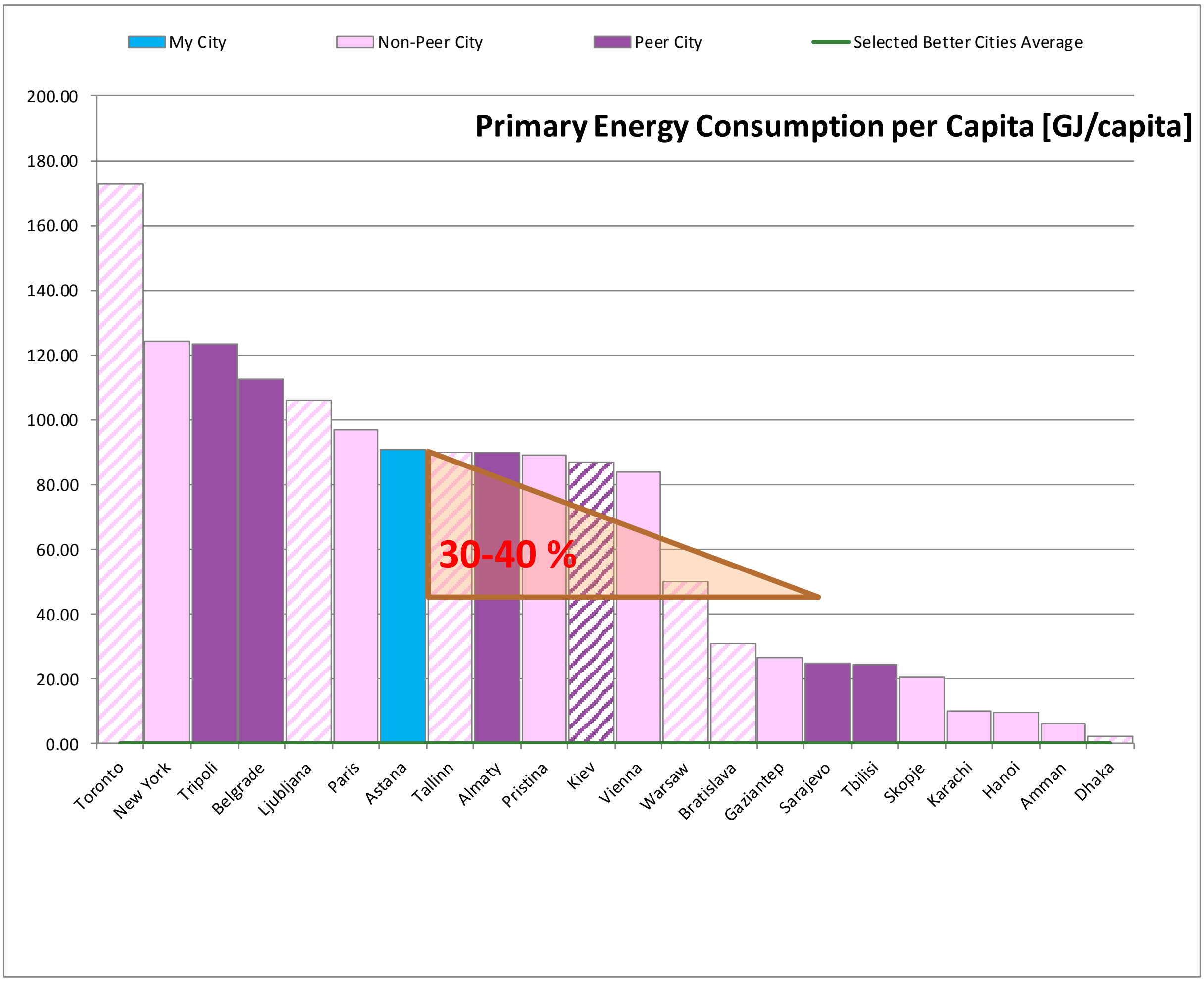
Table 6. Benchmarking summary of KPIs for Astana

Sector	Selected KPI		Comparison with better performing cities	Energy savings potential
Municipal-wide energy	Annual primary energy consumption per capita	91 GJ/capita	Low performance	20-30%
	Annual primary energy consumption per GDP	3.7 MJ/US$ GDP	Medium performance	n/a
Solid Waste	Annual waste generation	404 Approx. kg/capita	Medium performance	25-30%
	Solid waste recycled	6 %	Low performance	100%
Water Supply and Wastewater	Energy density of potable water production	0.57 kWh_e/m^3	Low performance	20-30%
	Percentage of non-revenue water	25 %	Low performance	50%
	Energy density of Wastewater processing and cleaning	0.63 kWh_e/m^3	Low performance	20-30%
Street Lighting	Annual electricity consumed per light point (LP)	1,200 kWh_e/LP	low performance	50-60%
Municipal Public Buildings	Annual energy consumption	244 kWh_{th}/m^2 46 kWh_{el}/m^2	Low performance Low performance	30-50%
District Heating	Losses in DH network	13,6 %	Medium performance	20-30%
Municipal public transport	Public transport energy consumption	0.04 MJ/pass km	Medium performance	20-35%
	Public transport mode split	58%	High performance	10%

The PEC per capita in Astana in 2015 of 91 GJ/capita (25,200 kWh/capita) is high among peer cities. Astana ranks medium-to-low for PEC per capita in comparison with other peer cities. The high PEC per capita in Astana is primarily caused by four factors: (i) harsh climate; (ii) availability of primary energy carriers (mainly coal, with very limited natural gas), and (iii) high losses for production of final energy, as well as high inefficient energy consumption at end-users.

Astana has 30-40% theoretical energy saving potential to achieve the level of the better performing peer cities. A benchmarking of the KPIs for relevant sectors is undertaken in the sector analysis below.

Figure 18: Benchmark of primary energy consumption of Astana



The PEC per GDP for Astana is 1.0 kWh/GDP. This is a moderate performance due to the moderate GDP of the city – i.e., 25,000 US$ per capita/ per year (this is 70% of GDP/capita ratio of Western European cities[24]) compared to the high annual primary energy consumption of 22,000 GWh.

3.4 Sector Analysis - Municipal Public Buildings

3.4.1 Institutional Framework

Municipal buildings are managed by different divisions of the CA. For example, the Division of Education is in charge with schools, healthcare units are under the Division of Health, while the Division of Culture is managing local buildings hosting cultural and religious activities. Kindergartens are under the education divisions of the district administrations (rayon akimats). The Astana CA's divisions approve the budget for each facility. Part of the money comes from the respective line ministries– for example, the Ministry of Education allocates some money for schools, while some funds comes from the local budget.

The Division of Communal Properties of the CA is responsible for monitoring all municipal assets in the city. However, 30% of the local assets are not documented, since these are old buildings that

[24] Eurostat database available at: http://ec.europa.eu/eurostat/web/metropolitan-regions/data/database

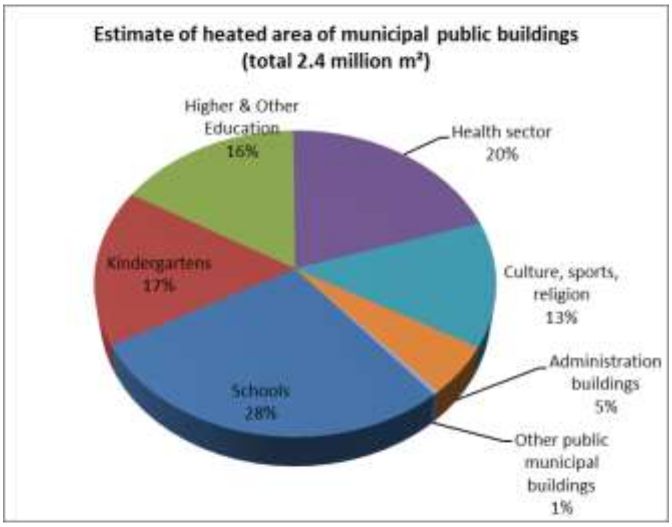
have been inherited from the Soviet Union. Approximately 10% of the municipal properties make revenues. EEDI, a non-profit entity preparing the Astana EE plan, is responsible to collect data on public buildings with over 100 ton of oil equivalent (toe) consumption. Large facilities with more than 100 toe consumption must report the data to the State Energy Registry under the MoID.

Municipal entities, like schools, hospitals, request money for building renovation and major investments from the city divisions. Money is allocated based on priorities and availability of funds. Schools have different budget setting than kindergartens. Funds for schools are allocated through a line in the local budget. The money comes from the national budget through the Ministry of Education, then to the city's Division of Education, and from here it goes further to the school. Schools get around KZT 1 million per year for urgent repair. Financial savings cannot be used for other projects, as the money goes either back to the local budget or is distributed in the form of financial bonuses to employees. As a result, there are budget cuts for the next year budget. Kindergartens are managed by the districts, and they get a lump sum of KZT 20,000 per month per child that should cover operation costs, including utilities and salaries. The facilities receive an annual amount per child for current repairs which can be accumulated and used in the next years. Money for energy related expenditures are allocated based on previous year's bills.

3.4.2 Infrastructure and Facilities

Municipal buildings in Astana account for 7% of the building stock in the city, as compared to 64% residential apartment buildings and 28% commercial and industrial facilities. Astana is host to 400 municipal buildings spread over 2,456,019 m². Most of them (300+ buildings) are education facilities comprising 96 schools, 181 kindergartens, and 50 higher education units. Nearly 169,000 children are enrolled in schools. The number of pupils enrolled went up by 10% between 2012 and 2014 because of population growth. There are 50 healthcare buildings (including 14 municipal hospitals and 14 primary care units), 29 cultural, sports and religious facilities, six local administration offices, and three other types of public buildings. 12 new healthcare units, including seven hospitals, were built in recent years. Education facilities account for nearly two-thirds of public buildings, healthcare units for 20%, and cultural & religious buildings for 13%. Public offices make only for 5% of the municipal building stock. As capital city, Astana has several government buildings that are managed by the State Property Division under the Ministry of Finance.

Figure 19: Heated area of municipal buildings in Astana



Astana is currently building seven new schools with funds from the Ministry of Education. The constant rise in population, birth rate and influx of migrants from other cities put a serious burden on city authorities to find solutions to address the shortage of education and healthcare facilities. The city plans to commission 80 new kindergartens between 2014 and 2020, and built a number of so-called "parallel" medical units. However, since money from the local budget is not enough, the CA must find ways to bring in the private sector and develop public sector facilities under PPP.

Most schools were built in former Soviet times. They are old and have issues with the building structures. Except for 17 units that are equipped with autonomous heating systems, all other schools in Astana are connected to the centralized heating system. Each school has a caretaker who is responsible with building maintenance, including the heating point. Under an EE program between 2014 and 2015 around 15-20 schools changed their lighting system to LEDs. For example, school #25 has switched to efficient bulbs and also upgraded its heating system through funds from DAMU, a program in cooperation with the United Nations Development Program (UNDP). Each school can get annually from the local budget KZT 1 million per year for "light" repairs (excluding EE measure/thermal insulation). The Ministry of Education can provide funds to retrofit only two-three schools each year.

Most schools in Astana are overcrowded, exceeding the norm of 2.5 m² per student. It is the case of school #27, a building from 1986 spread over 7,402 m². The school accommodates 2,500 pupils up to grade 11, which is by 1,000 more students than the norm. Pupils study in two shifts six days a week from 8 AM to 9 PM. The school is equipped with sports hall, labs, a cultural hall, and a canteen. The building has concrete panels, some poor envelope with cracks, and low quality wooden windows. In 2016, the school budget was KZT 313 million of which KZT 9.3 million was spend on energy bills. An energy audit was supposed to take place, but it never happened. The school has a KZT 400 million investment plan to buy new windows, pain and replace the walls, among others. The wiring system should also be replaced, but this is not included in the plan. Some of the windows are expected to be changed in 2017.

Figure 20: School # 27 in Astana

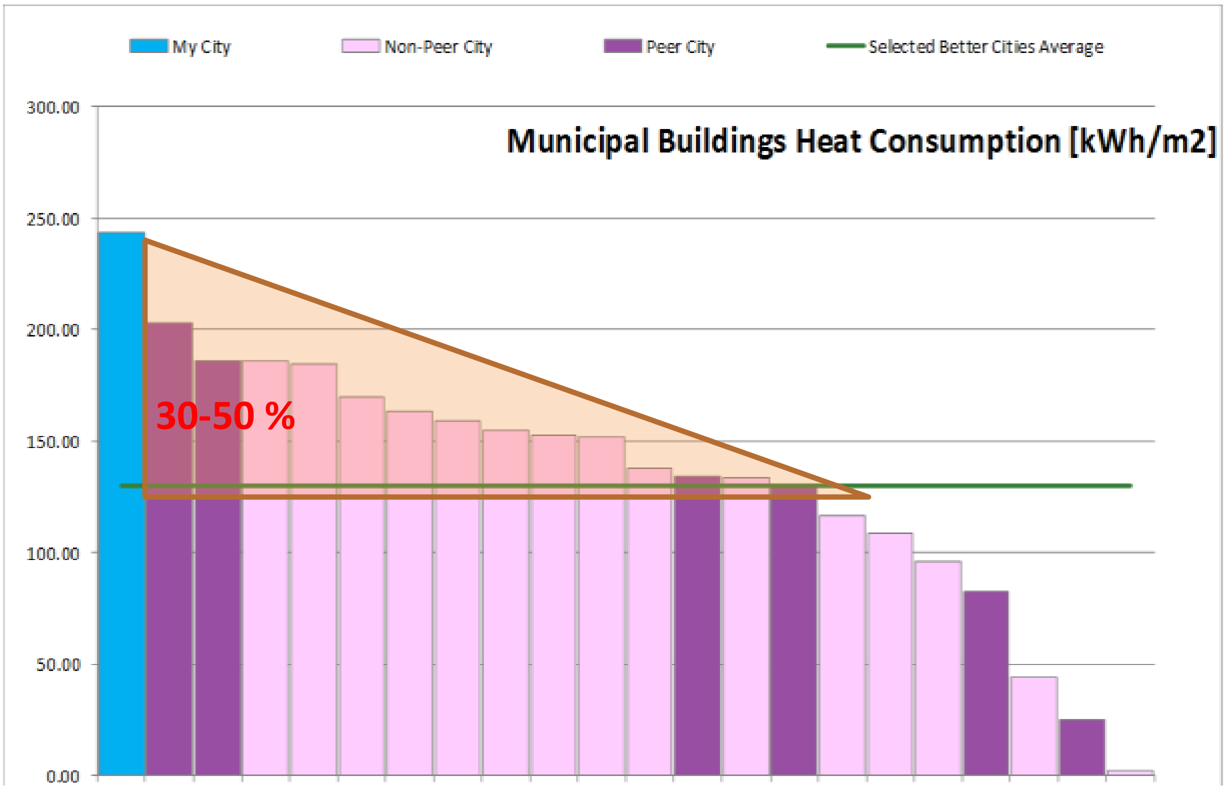
Source: Manuela Mot/World Bank

Astana has 81 kindergartens with 30,000 kids of three to six years old. Education units are required to get a safety monitoring audit every three years. However, this does not include energy performance, nor does recommend EE measures. Kindergarten #1 Baitarek, a two-storey 30 years old building spread over 2,056 m² with 420 kids enrolled has such an energy monitoring that comprises limited energy data. The kindergarten is overheated because the temperature cannot be controlled at building or room level. The facility has no thermal insulation, and the roof is leaking in a few places. Last major repair on the building was performed ten years ago. Lighting is done by incandescent bulbs in addition to a few new lights. The walls were painted a few years ago, and the façade is expected to be redone in 2017. Like most pre-school facilities in Astana, the kindergarten has new kitchen and laundry appliances. The heating boiler in the basement is equipped with a well-functioning meter. A new substation was installed in 2016 which includes a heat exchange without automatic control. The heat pipes are insulated only up to the sub-station and the electronic meter. The annual energy bill accounts for 12% of the kindergarten's KZT 84 million budget.

3.4.3 Energy Performance

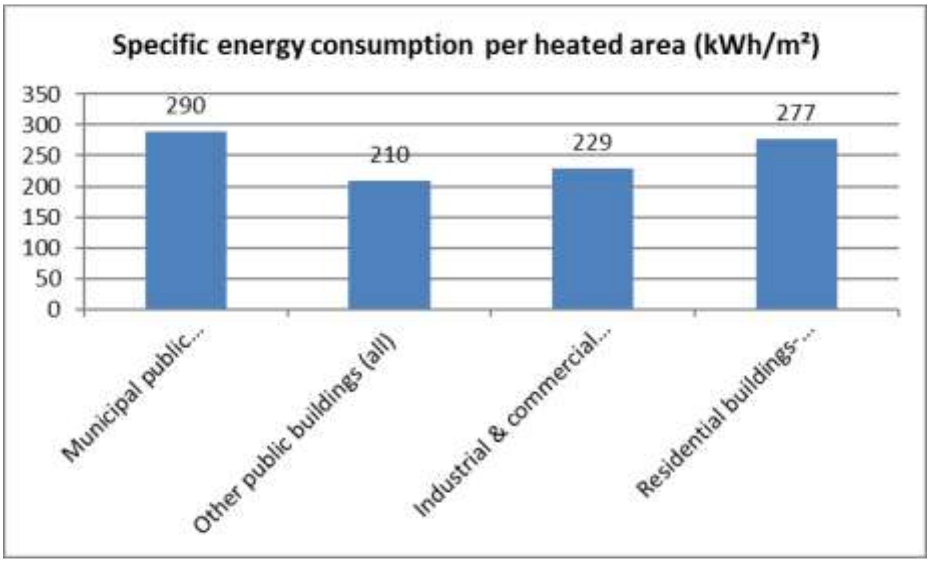
The TRACE 2.0 analysis shows that Astana has one of the highest energy consumption in municipal buildings among cities with similar HDI, with almost 250 kWh/ m² - twice more than the public facilities in Belgrade, for example. This high consumption can be explained by long, cold winters with temperatures dropping as low as minus 30-35 Celsius, in addition to no heat temperature control at room level.

Figure 21: Heat consumption in municipal buildings in Astana



Municipal buildings use the largest amount of energy per square meter among the entire building stock in the city - 290 kWh/m² - which is 20% higher than in industrial facilities, for example (see Figure 22). 84% of the energy consumed in public buildings is heat, while power makes for 16%. All public buildings are connected to the centralized heating network.

Figure 22. Energy consumption per heated area



Public offices also have the highest energy expenditure - KZT 129/month per m², which is almost twice more than industrial/commercial facilities and nearly 90% more than residential buildings. The annual energy bill for municipal buildings in Astana was estimated at US$ 17.1 million.

3.4.4 Main Challenges in the Public Buildings Sector

Based on a comparison with peer cities and considering the local authority control over the sector as well as the energy expenditure, the TRACE analysis indicates that public buildings in Astana have some good 50% energy savings potential. There is a considerable demand for building retrofit and EE rehabilitation that could save money from the local budget. Some interventions have been identified from the existing city EE program and the few energy audits performed. For example, the energy audit for high-school # 21, a three-storey construction built in 1988 with an area of 3,800 m², reveals that the outer walls of small sports hall leaking considerable amount of heat are the key challenge in achieving EE. Although the heat distribution pipes are in good shape, there is no constant heat adjustment. The school also uses low EE class equipment. EE interventions, such as replacement of carpentry, switching to efficient lighting, internal heat distribution with temperature control at building substation and rooms, as well as heat pipe insulation in the basement, would lead to some 30-40% energy savings.

- *Building codes with no EE standards*: As of now, Kazakhstan uses the ex-Soviet building codes. Although the codes have been updated, they do not include any EE requirements.
- *Lack of financial mechanism to retain EE savings:* Any financial savings made by education facilities must be returned to the city budget. Kindergartens get a lump sum of KZT 20,000 per child per month that should cover operation costs, including staff salaries, utility bills, investments, services etc. However, money obtained from energy savings must go back to the city budget.
- *Lack of adequate energy audit*s: The building assessment includes some basic technical information about building infrastructure, but not much about energy consumption, let alone EE recommendations. Such limited information is not enough to produce an adequate energy audit. Moreover, there is no follow-up on the energy monitoring neither by the school or the local government (Division of Education). Only a few genuine energy audits have been performed in Astana so far.
- *Limited trained staff for maintenance*: The CA has only a small number of qualified staff to ensure maintenance of the district heating points in public buildings.
- *Lack of good quality contractors*: There are only a few companies in Astana that could carry out good quality retrofit and construction works.
- *Lack of funds*: The limited availability of funds is a major challenge to perform any significant rehabilitation of public buildings. Most schools need repair or rehabilitation. Schools must submit to the Division of Education the list of major repair in schools (e.g., replacement of the lighting system with LEDs), and funds should be disbursed based on prioritization and availability. Anyway, the city has no leverage to influence quality of the materials used for new constructions.
- *Limited awareness on EE*: Finally, like in many cities in the world, local knowledge on EE and its benefits is quite limited in Astana, and not many are aware about how energy savings could be actually achieved. In public buildings less energy consumed would mean less money spent from the city budget.

Other Types of Buildings

There are a number of **public buildings** in Astana that belong to the central government. Based on expert estimates and very limited data available from local energy utilities, the overall area for the 35-45 government buildings was estimated at around 0.65 million m². An annual consumption of 134 GWh in these facilities was considered for the energy balance. Specific consumption was estimated at some 50 kWh/m² for power and 160 kWh/m² for heat. The city has no authority over these buildings, nor regarding their energy consumption.

The TRACE analysis looked into the residential and commercial & industrial buildings in Astana that are not under the CA control. The **residential sector** comprises 36,828 residential buildings with almost 300,000 apartments spread over more than 20 million m². Nearly one-third of the residential buildings are old, while the rest were developed in the past 10 years or so. 80% of the buildings are connected to the centralized heating system. Residential sector is the largest energy user in Astana, especially when it comes to heat. Due to cold weather, but also poor insulation and waste of energy because rooms are overheated and people open the windows, Astana has the highest heat consumption per square meter in the TRACE database. There are more than 27,000 commercial & industrial facilities in the city with a total floor area of 9.1 m². Both power and heat consumption in the commercial and industrial sector is quite high. More details about these sectors are provided in Annex 3.

3.5 Sector analysis - Street Lighting

3.5.1 Institutional Framework

The street lighting (SL) sector in Astana is operated by the CA through its own company, Astana Kalalyk Zharyk. The sector is supervised by the House and Communal Service Division of the CA. The SL operator has one-year contract with the local administration that must be renewed every year. The SL sector is entirely financed from the city budget. The CA allocates annually KZT 5 million to the three district administrations (Almaty, Saryarka, and Yesil) to cover part of SL operation expenditures in their communities. The annual costs to operate the SL system in Astana from city budget is around KZT 1 billion, and covers the energy costs, O&M expenditures and salaries.

3.5.2 Infrastructure

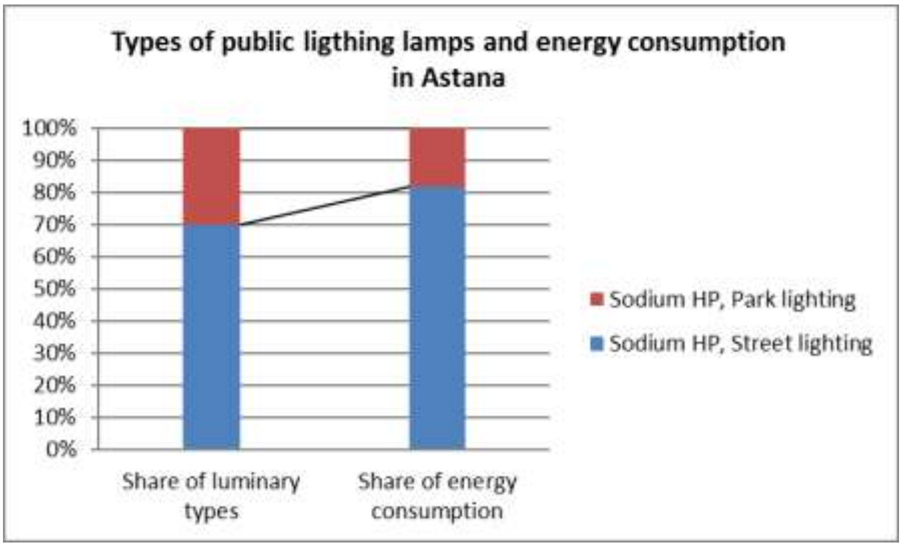
Around 98% of the roads in Astana comprising 1,505 km are covered by street lights. There are 30,869 light points in the city, with a total of 36,783 lamps. Most poles are in good shape. 84% of the poles have one luminary each, 13% two luminaries each, and 3% have four luminaries each. Of the total number of street lamps, 23,137 are placed on roads, while the remaining lights are located in parks. All street lights are high-pressure sodium (HPS), with a few pilot LEDs. The lamps on the city roads are of 250W, while the bulbs placed in the parks have smaller intensity i.e., 130W.

Figure 23: LED par luminaries and High-pressure sodium street lamps in Astana

Source: Manuela Mot/World Bank

Street lamps are less efficient than the luminaries spread in the parks. Street lights accounting for 70% of the luminaries requires 82% of the total power for the SL system, while the lamps in the parks making for 30% of the public lights in the city require only 18% of electricity.

Figure 24. Types of lamps and related energy consumption in Astana



A big burden for the SL operator is the maintenance of the public lighting network. Since there is no automatic switch control system, the monitoring of the luminaries is done manually and by site inspection. The integration of an automated, remotely controlled system combining operation, malfunction, time-switch and dimming function will increase the quality of illumination and reduce the maintenance costs.

The cost to replace one HPS lamp is KZT 1,780 (10% of the overall cost), while changing one lighting pole would be five times more expensive, i.e., KZT 10,822 (35% of the total cost). Like everywhere else in Kazakhstan, the public illumination standard in Astana is based on the ex-Soviet SNIP norms. There is no dimming system in place, although the SNIP norms would allow reducing the light from midnight to 5 am. Failure rate due to technical problems is 3%.

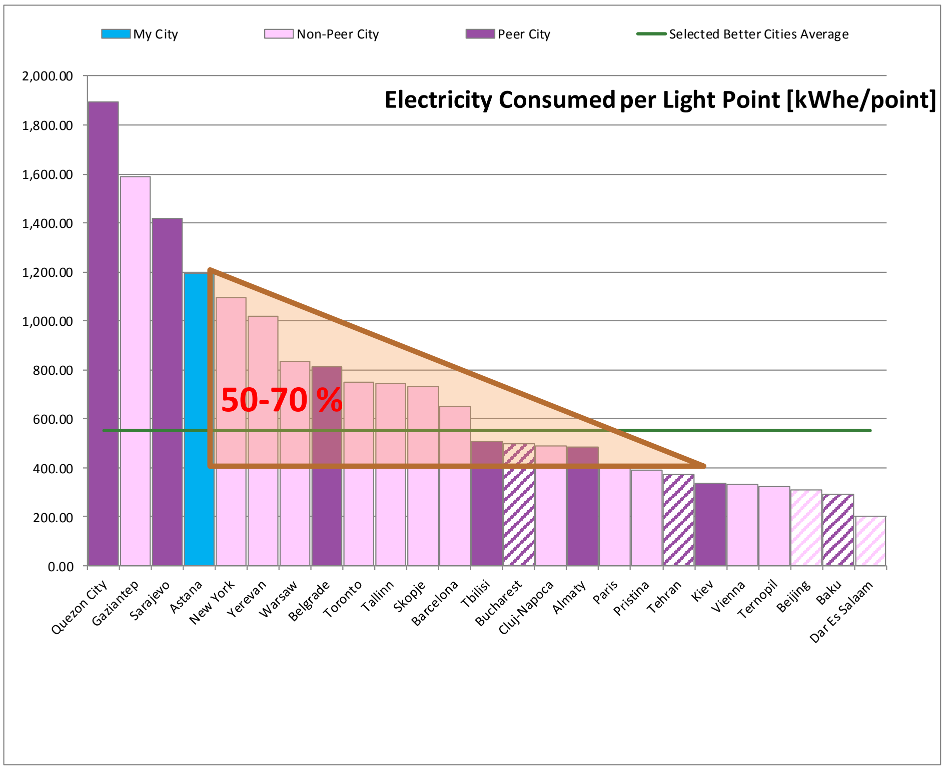
The city authorities make efforts to introduce smart street lighting, as part of Smart Astana, a project that should make Astana one of the smartest cities in the world by 2050. A smart lighting pole with regulatory capacity was implemented on one street by Astana Innovations, a city-owned company. 60% savings was achieved in six months from June to December 2015, as compared to the same period in 2014. CA has ambitious plans to introduce high-efficient lamps throughout the city. The local government city is quite advanced in moving towards street lighting LEDs. The upcoming LED program is expected to cost KZT 6.2 billion and should be managed by Astana Innovations under a PPP.[25] The tender to select the company to execute the program was scheduled to take place in July 2017. At the beginning, around 11,000 lamps in Yesil district on the left bank of the Ishim River - approximately one-third of the street lights in the city - should be replaced with LEDs equipped with dimming control.

3.5.3 Energy Performance

The TRACE 2.0 analysis based on benchmarking against peer cities with similar HDI shows that Astana needs almost 1,200 kWh of power per lighting point. This is among the highest consumption in the TRACE database compared to peer cities. Astana needs 15% less electricity than in Sarajevo, but a third more than in Belgrade and twice as much as Tbilisi. (see Figure 25 below)

[25] Astana Innovations was established by Astana city government in 2011 to implement the state program for accelerated industrial-innovative development of Kazakhstan for the 2010-2014 period. Currently, the company is developing the plans for "smart city" infrastructure, hence place Astana among one of the 50 smartest cities of the world.

Figure 25. Energy consumption per light pole in Astana



Annually, Astana requires 36,814,321 kWh of electricity to operate the SL network. With KZT 17.03/ kWh of power (US$ 0.076), the annual energy bill comes to US$ 2.82 million, which is almost two-third of the total budget for the SL sector.

3.5.4 Main Challenges in the Street Lighting Sector

The TRACE assessment has identified a little over 50% theoretical energy savings potential for SL in Astana, a figure which had been reviewed to a more realistic 40%. Due to low electricity tariffs, the savings from the lighting retrofit measures would lead to less operational and administrative costs.

- *Use of domestic products*: The existing legislation is encouraging domestic producers. The public procurement legislation requires public entities to use 70% local content for the equipment they purchase. There are five domestic companies in Kazakhstan that manufacture LED equipment about few times cheaper than international providers. For example, LED poles are available for KZT 120,000-KZT 150,000/pole, as compared to KZT 800,000/pole bought from international providers. Also, a local LED luminary (fixture) is available for US$ 350-US$ 400, twice cheaper than the luminary purchased from international manufacturers. Although Kazakh products are a whole lot cheaper, their technical performance and quality of lamps does not always meet international standards. Domestic LEDs have lower quality in terms of efficiency and lifetime, in addition to limited warranty.

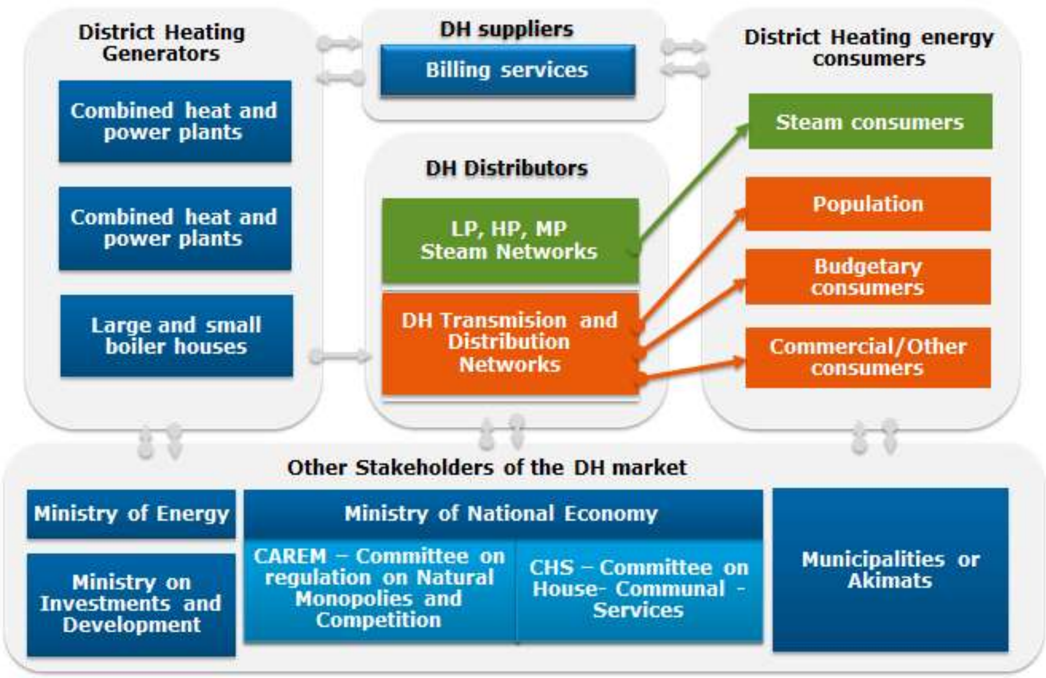
3.6 Sector Analysis - Power and District Heating

3.6.1 Institutional Framework and Ownership Structure

The energy sector reform in Kazakhstan began in 1996 with the privatization of district heating (DH) and power plants, after they underwent what was known as "corporatization", a process under which state-owned companies were converted into joint stock companies (JSC) with the state as the single shareholder. At that time, some facilities were privatized, while others, like sub-divisions, were transferred to municipalities. Combined heat and power (CHP) facilities and heat transmission pipelines received administrative and legal independence, whereas local heat supply facilities were transferred to communal properties. The second wave of privatization in 2013 opened the energy sector to the private sector in order to attract investments under public-private partnerships.

Today, out of 316 companies active in the DH system in the country, 178 are entities with limited liability, 91 are state-owned enterprises (utility companies), 27 are JSCs, and 20 are cooperatives. It is quite difficult to draw a line between private and public ownership structure since the shares of JSCs (with limited liability) are owned by the state. 67.4% of the DH network has private ownership, while 32.6% belongs to municipalities. The distribution networks are operated by specific service providers whose activities are regulated by city authorities. Main stakeholders in the DH sector are generation companies, supplier/distribution entities, and final users. At the legal/administrative level the key players are the Ministry of Energy, the Ministry of National Economy, the Ministry of Investment and Development, and municipalities (see Figure 26 below).

Figure 26: Structure and stakeholders of DH market [26]



Established in 1999, Astana Energo Service (AES) is the power and heat holding in Astana in which the Astana CA is the only shareholder. The companies that are part of the AES holding include Astana Energia (power and heat generation), Astana Rek (physical distribution of electricity from power plants to end-users), Astana Teplo Transit (physical heat distribution from plants to end-users), and Astana Energy Sales Company (commercial delivery of energy). Astana Energosbyt, a private entity, totally independent from AES, is the power and heat billing company, responsible for commercial distribution of heat. Heat & power sector is regulated by the Agency on Regulation of Natural Monopolies (ARNM). Investments in the sector must be approved by the CA.

3.6.2 Infrastructure and Facilities

60% of the power used in Astana is produced by Astana Energia and 40% is purchased from imports from KECOG, the state electricity grid operating company in Kazakhstan. AES has two coal-fired heat

[26] Source: Kazakhstan Joint Economic Research Program, World BankTechnical Assistance Project "Modernization and Financing Mechanisms for DH Sector and Other Municipal Services", June, 2015

and power co-generation plants, and a few boiler houses for heat. The plants have a total installed capacity of 502 MW and 2,396 Gcal/hour. CHP-1 has 22 MW installed capacity; it can generate 862 Gcal/hour and is primarily used to produce thermal energy. CHP-2 has 480 MW installed capacity and 1,021 Gcal/hour generation capacity, and generates power. In addition, there is a water boiler with a capacity of 480 Gcal/hour and a district boiler with a capacity of 32.8 Gcal/hour. CHP-1 has 4.7% share of power and 42% of heat, whereas in case of CHP-2 the share of electricity is 95.3% and 58% for heat. CHP-1 is completely shut down during the summer when hot water is supplied only by CHP-2. The third CHP with an installed capacity of 560 MW and 480 Gcal/hour running on coal is under construction and should be commissioned in 2020; it is expected to start operating during the 2017-2018 heating season, and it should be used primarily to generate thermal energy.

Heat in Kazakhstan is dominated by Boiler Houses (BHs), which 90% of them belong to cities. Most of BHs are 50 years old, with a depreciation rate of 41%, while main equipment, such as boilers, turbines and generators has already reached the end of life-cycle. Astana has a few house-only boilers (HOB) systems. One HOB has three steam boilers running on coal, with an installed capacity of 65 tons/hours; it was built between 1999 and 2011 and has achieved between 20,000 to 60,000 operation hours. Another HOB comprises seven boilers with 100-110 Gcal/hour capacity, of which three run on oil and four on coal. One of the boilers was commissioned in 1967, and by now it has more than 152,000 hours of operation. The new boilers built in 2015 have less than 1,000 hours of operations. Finally, there is another HOB system consisting of coal-based four boilers with 120 Gcal/hour capacity, in operation since 2012. In addition, there are coal-based six power boilers (some from the 1970s), with 420 tons/hour capacity and 50,000 to 183,000 operation hours. Additional heat is generated by GKP Heat Kazakhstan, a state-owned entity, with a small capacity of 33 Gcal/hour. Only 1% of the heat in Astana is produced via individual boilers.

Astana Energia produces 60% of heat/hot water demand in Astana, while the rest of 33% is bought from KECOG. The city has 105 Gcal/hour heat deficits that must be covered from other sources. The centralized DH network does not cover the entire city. Heat pipes are not available in new communities, where people use individual gas tanks for cooking.[27]

3.6.3 Heat and Power Generation Facilities

In 2015, the power plants in Astana produced 2,869,957,772 kWh of electricity of which 2,212,897,315 kWh was distributed to 227,667 customers in the city. The largest power share went to residential consumers (782,927,121 kWh) and public sector (241,202,944 kWh - of which national government offices received 157,373,255 kWh, regional offices some 3.5 million kWh, and local administration buildings 80,302,999 kWh). Industrial sector used 221,699,947 kWh of power, while other sectors consumed 967,067,303 kWh. The average monthly consumption in summertime in Astana is 204,333,937 kWh, while in the winter is almost 30% higher, i.e., 282,010,970 kWh. In recent years, the city generated around 2.4 billion kWh of power per year. At the same time, heat production went up by 15.5% - from 5,404,000 Gcal to 6,243,000 Gcal. In 2015, the technical losses in the power and distribution network were 411,128,368 kWh.

Overall, 4,795,272 Gcal of heat was delivered in Astana in 2015. More than half went to the residential sector (2,714,312 Gcal), 598,545 Gcal to the public sector, while the rest of 1,482,906 Gcal to other clients including commercial sector. There are 197,824 apartments in the city of which 96.1% have heat meters. All 394 clients in the public sector and 95.4% of the 2,641 commercial buildings have heat meters. Only 52% of the 1,147 clients in the private sector have heat meters. Other heat users in Astana comprise 7,897 clients of which 95.8% are equipped with heat meter.

[27] These tanks are prohibited in multi-storey residential buildings.

According to the Housing Communal Center, as of June 1st, 2015, there were 36,280 buildings in Astana, of which 29,790 family house buildings and 6,489 residential apartment buildings. Heat meters were installed in 2,343 in residential buildings, which account to only 36% of the multi-storey apartment buildings stock in the city. Meters have been also placed in commercial and public facilities. Since one commercial building could host more than one company, the number of meters in commercial buildings is actually higher than the actual number of commercial facilities. Overall, 97% of heat supplied in the city is metered.

Overall, CHP plants have 66% fuel efficiency generation – 62% for power and 70% for heat. In 2015, the two CHPs produced 27% power (2,300 GWh) and 73% heat (6,266 GWh). The main fuel used was coal (2,593,000 tons), with little mazut (11,000 tons), with a total fuel input equivalent of 13,790 GWh. Most of the coal comes from Karaganda; it has an energy content of 4,630 kWh/ton and is available at KZT 2,000/ton. The HOBs have produced 191.9 GWh for which 59,000 tons of coal was used. The total amount of fuel used to produce energy by CHPs and HOBs altogether was the equivalent of 14,064 GWh. In 2015, AES spent US$ 54.88 million on fuel to produce power and US$ 49.26 million to produce heat. The power plants can meet the energy demand in Astana for now. However, there might be some issues after 2020, when the demand is expected to increase. CHP-3 and the awaited future gas supply should help solve the potential threat with regard to energy supply.

3.6.4 Heat Distribution

All city residents in Astana are connected to electricity network and most of the multi-storey residential buildings are linked to the centralized heating system. 90% of the power generated by AES holding is distributed by Astana Rek and 10% by Astana Energy Sales Company. Power coverage is good, and the city experiences only a few blackouts in a year. Astana REK exploits the outer ring of 220 kV and the city ring of 110 kV, while the 10-0.4 kV networks belong to the CA. The high voltage of kV 200 belongs to KEGOC. The total length of power network in Astana has 6,315 km of which 18% needs repair.[28] Astana Energosbyt is responsible for the commercial distribution of power and heat in Astana. It has the monopoly for heat, and holds 70% market share for electricity, supplying to residential, commercial and public customers. The company also issues the heat & power bills for the residential sector.

The physical distribution of heat is managed by Teplo Transit (TT), a JSC owned 99% by the city of Astana. TT is regulated by four laws, namely the law on natural monopoly, on energy, on district heating monopoly, and on JSCs. The company is responsible to deliver heat up to the multi-storey apartment buildings, while home owner associations (HOAs) are managing the boilers and heat points inside the buildings.

[28] City development Plan 2016-2020

Figure 27: Heating sub-station located in a school's basement in Astana

Source: Manuela Mot/World Bank

The heat distribution network has 1,250 km, and most of it is more than 50 years old. 57% of the heat pipes are in poor condition, with the average life time of 30-35 years. In addition, one-third of the fixed capital is also deteriorated. Around half of the heat pipes have been pre-insulated in 1999. Heat meters are installed at the building level, one per each facility. Heat meters are available only in multi-storey apartment buildings (not in public buildings or individual houses). 40% of the customers have automated heat transfer stations. 97% of the heat consumption is metered at the building level. There is some poor heat metering at the apartment level.

TT has contracted a service company to provide maintenance of the heat supply station at the apartment building level. The company reads the heat consumption via a remote reading system. Interestingly, although it owns the heat meters, TT is not granted access inside the buildings. TT is interested to transfer ownership and full responsibility of the heating points to the HOAs. A PPP service contract scheme between TT and a private company for a facility services is under discussion.

Annual investments in the heat network amount to KZT 1 billion (US$ 3.1 million. The money is mainly spent to upgrade the network and reduce heat losses.[29] All investments are included in the heat tariffs. In the past few years, efforts were undertaken to modernize the heat and power network. 28 km of heat pipes were rehabilitated in recent years. The company uses pre-insulated pipes for rehabilitation works. The CA is interested to get private funds to build and modernize the 110-200 kV network by 2030 (estimated at KZT 300 billion). The bulk of substations are owned by the CA. The first bidding documents for two new substations are under the preparation.

3.6.5 Heat and Power Tariffs

The cap rates tariffs considering mid-term and long-term investments were implemented in the power sector in Kazakhstan in the 2009-2015 period, and included a financial component for modernization & development, provided the utility can present an investment plan to be approved by a relevant authority. This tariff policy not only covers the key costs and provides for an investment component, but would also minimize the risks on the long run. In April 2015, the tariff scheme was extended to heat & power industry until 2020. Differentiated tariffs for customers with heat meters/no meters are enforced in eight regions in Kazakhstan since April 2015.[30] The new tariff

[29] Calculated for US$- KZT exchange rate as of 2017 - US$ 1 = KZT 320

[30] This policy does not apply to dilapidated houses that pay per the average scheme.

scheme applies to all heat generation, transmission, distribution and supply companies operating in Astana and cities of national and regional status. The small capacity boiler houses (≤20 Gcal/h) do not have to submit a tariff request, as they can operate on a notification basis. However, tariff policies for CHP plants are more complicated since power prices are market-defined, whereas the heat is controlled by ARNM, the energy regulator. The actual power and heat generation costs are quite difficult to separate since heat is a by-product of power production. CHPs can divide the costs for heat generation either by a *physical method* in which most costs are allocated to heat generation, or by the *exergy method* under which costs are allocated to power generation based on the operating condition of the plant.

Heat and power tariffs are regulated by the ARNM. Power tariffs are reviewed yearly, while heat tariffs once every five years. Astana Energosbyt adds some margins to cover operation costs related to energy distribution. The new heat tariffs for the 2017-2020 period have already been approved. Tariffs are differentiated by types of customers. Power billing for small properties and commercial sector is based on energy loads, whereas in the residential sector is done by m^2. Power loads are pre-assigned to public buildings. The EBRD and the GoK are considering options to increase power tariffs for certain groups and decrease tariffs for those with low income.

All power tariffs are costs covering and include the cost of generation, transmission & distribution, and the share of electricity from imports. In 2015, power tariffs in Astana varied between KZT 17 and KZT 18.6/kWh (US$ 0.07/kWh, and US$ 0.08/kWh, respectively). The heat tariffs include subsidies for steam production. Steam is sold for the same price as the heat, although its production is costly. Heat tariffs in Astana are quite low, and they are kept low artificially for social reasons. They are below the cost recovery level and are cross-subsidized by the CA. Without subsidies, the cost of heat for the end-user could increase even by five times. However, even with the cap rates, the upcoming slight increase in tariffs by 2020 would hardly be able to prompt some solid investments.

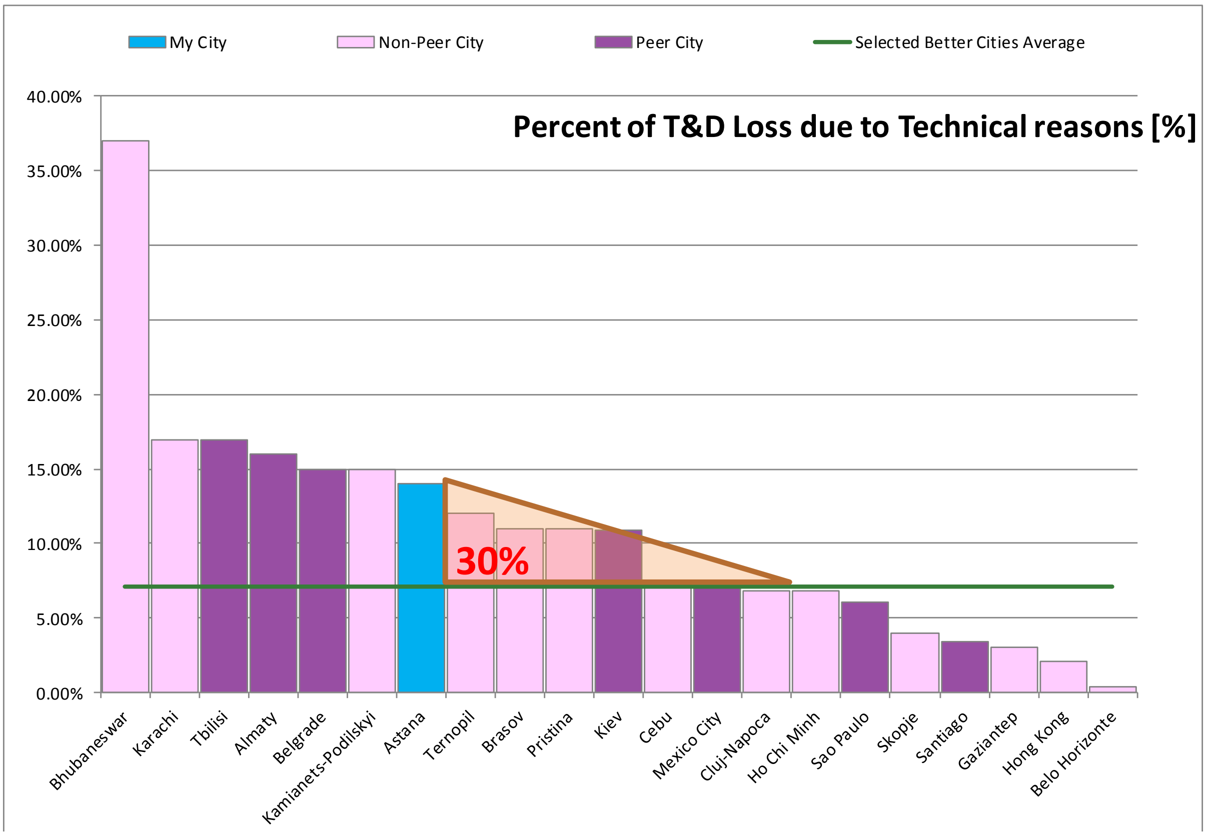
In 2015, residential customers who have heat meters paid KZT 4,600/Gcal (US$ 20/Gcal), and those without meters KZT 6,300/Gcal (US$ 28.3).[31] In 2016, the heat tariffs went slightly up, KZT 4,975/Gcal for clients with heat meters and KZT 6,803/Gcal without meter (in dollars the tariffs are lower as the local currency depreciated).[32] Other users with heat meters would pay KZT 5,177/Gcal in 2015 and KZT 5,582/Gcal in 2016.

3.6.6 Energy Performance

Losses in the power network in Astana are 12.3%. Losses were quite high in the 1990s, but they were reduced drastically following rehabilitation of part of generation facilities and distribution network. The level of losses in the electricity network in Astana is below Tbilisi, Almaty, or Belgrade, but higher than in Kiev. Power losses in 2015 are translated into US$ 147.8 million.

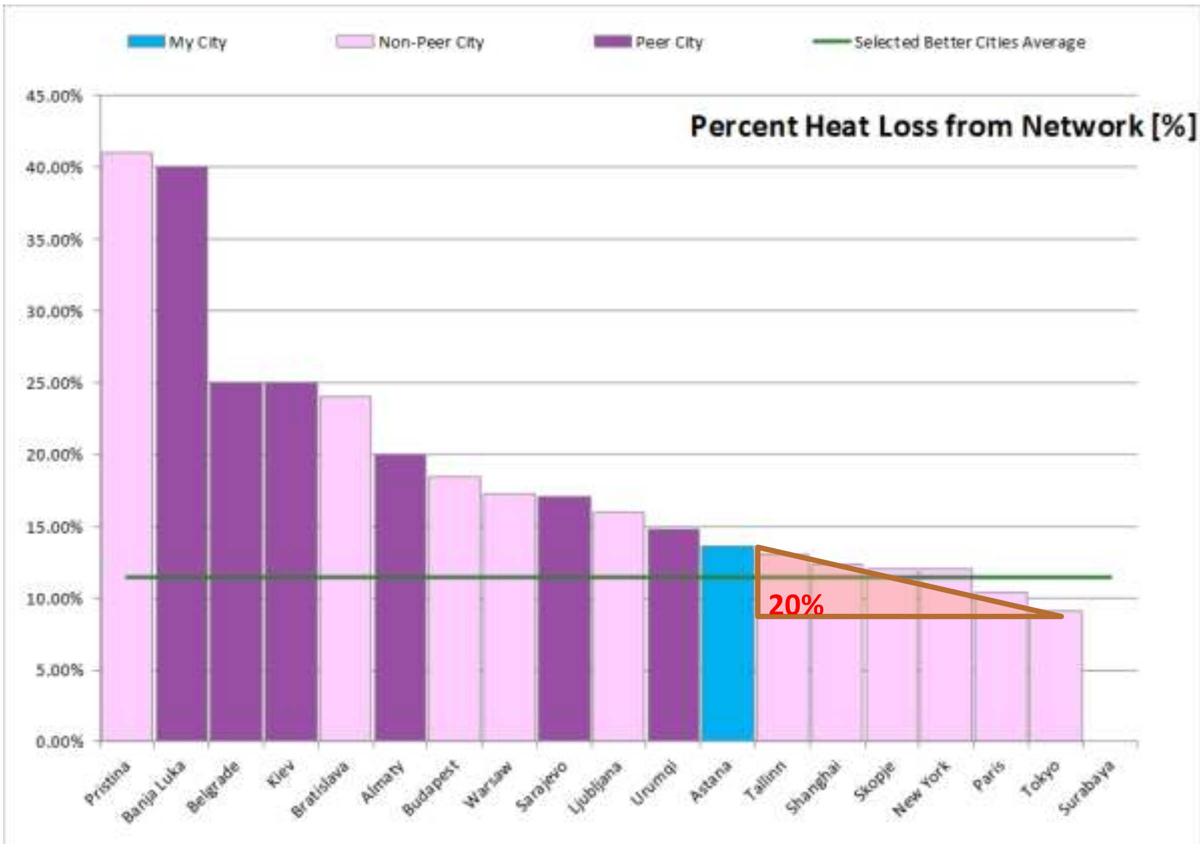
[31] In 2015, the average exchange rate was US$ 1 = KZT 222.
[32] Average exchange rate in 2016 was US$ 1= KZT 313

Figure 28: Power losses in the network in Astana



Losses in the heat distribution network in 2015 accounted for 13.6%. This figure places Astana in the middle of the TRACE benchmarking against cities with similar HDI, since losses are smaller than in Belgrade, Kiev or Almaty, but higher than in other cities (see Figure 29). Losses occur between generation and metering. They occur between the distribution point and customers, mainly due to obsolete network and poorly insulated pipes. Losses in the network are reflected in the heat metering as well. Heat losses in 2015 were the equivalent of US$ 63.7 million. Heat losses in the network are compensated by revenues obtained from power sales.

Figure 29: Heat losses in the network in Astana



3.6.7 Main Challenges in the Power & Heat Sector

The TRACE analysis has identified some 32% theoretical energy savings opportunities to improve efficiency of the power sector in Astana that subsequently was reviewed to a more realistic 15%. The DH sector has some 18% EE potential. The city already has some potential investment plants to modernize the generation facilities, like reconstruction of the fuel tanks at the CHPs, expansion of the power plants, reduction of losses in the generation & transmission of power& heat, new equipment to reduce energy consumption, or increase the life-cycle service of main equipment. In addition, other interventions tackle thermal insulation of multi-storey buildings, expanding heat metering to all customers, and introducing automated control system for remote metering of electricity for household and industrial customers. Such investments would improve efficiency of heat and power production decrease the level of GHG emissions in the city. However, there are a number of issues that could hinder or prevent the city to realize its potential in this sector.

- *No natural gas pipe*: The CA of Astana is preoccupied to bring the natural gas pipeline into the city from southern Kazakhstan. Power generation technology based on natural gas would increase efficiency of the power & heat sector. However, the pre-feasibility study performed in this respect indicates that only individual housing should get connected to the gas pipes, while residential buildings should continue rely on coal as it is cheaper.
- *Lack of legislation regarding heat distribution:* Although there are three players in the DH sector – the generation & distribution companies and customers - no one is responsible for maintenance of the heat network inside buildings. The DH operator is responsible for heat pipes only up to the building walls. Another issue is that individual heat meters are not specifically required by the legislation.
- *Limited funds*: The CA has limited money to invest in the heat & power generation and distribution network. Although there are several official local documents that all mention investments in the power & heat system, due to lack of money such plans are likely to remain on paper. Moreover, the city must find resources to expand the heat network to meet the future demand. Since the local energy holding, AES, does not make enough profit to invest in new

facilities or rehabilitate the worn-out heat pipes, they are forced to rather concentrate resources on maintenance issues. Currently, the local energy holding can spend KZT 1 billion annually for maintenance of the network. To embark on some large investments, AES must apply for specific government funds via the CA.

- *Poor quality of energy audits in the power & heart network*: Although some energy audits have been performed, the quality of such assessments is not so good.
- *Increasing energy demand*: The rapid population growth in Astana in recent years has led to significant new residential, administrative and public constructions. By the end of 2020 it is predicted that the demand for housing would go up from 14.7 million m² (as of in 2014) to 23.7 million m² by 2020 and further to 37 million m² by 2030. Commercial and industrial facilities would be on the rise as well, from 4.5 million m² to 5.4 million m² by 2030. Therefore, the local administration must expand both generation and distribution capacities to meet the demand. In addition, in line with the "green economy" concept, the city is considering to develop alternative energy sources and build a solar plant with a capacity of 50 MW to produce over 60 million kWh of power/year.[33] Currently, there are communities awaiting for the DH network to expand so they can connect to the centralized heating system.

3.7 Sector Analysis - Potable Water Supply

3.7.1 Institutional Framework

Astana Su Arnasi, a company owned 100% by the CA, is the water operator in Astana. The company supplies water and sewage services to city residents and other customers. The company also prepares the water bills for clients. A tender is organized every year to select the water operator although the contract is always awarded to the same company. The water sector is monitored by the Housing and Communal Service Division of the CA. All investments in the water & wastewater sector are subject to prior approval from the CA.

3.7.2 Infrastructure

The main water source for Astana is a reservoir located around 51 km far from the city. Water is brought to the city through three large 1,000 mm pipes, and is pumped by two pumping stations. One of them is a new pumping station that was modernized in 2010 under a JICA-funded program that reduced energy consumption by 40%.[34] Water is stored in three large tanks with a capacity of 20,000 m³, equipped with four large 300-400 KV pumps. The water pumps are being modernized by adding some modern variable speed drives. The water filter station is located in the city, and is currently under reconstruction.

There are around 277,000 water subscribers in Astana of which 95% are households. Overall, the city has 95% water coverage. Around 1.5% of residents use water from individual wells. The city has 1,261 km of potable water network of which 1,212 km are used for water distribution and remaining pipes for water transmission. The water supply network has expanded by 240 km following an investment program in 2014. Nearly 65 km of water pipes were replaced at that time. Currently, 400 km of pipes still needs to be replaced. But despite of recent investments, most of the water network in Astana is in poor condition and incurs leakages.

Astana Su is responsible for the water network up to the building level. Only 64% of residential customers have water meters. The CA is planning to expand the metering system to all customers and add remote reading system for water consumption in commercial buildings. However, due to financial issues the project has been put on hold for the time being.

[33] Astana City Development Program

[34] JICA – Japan International Cooperation Agency

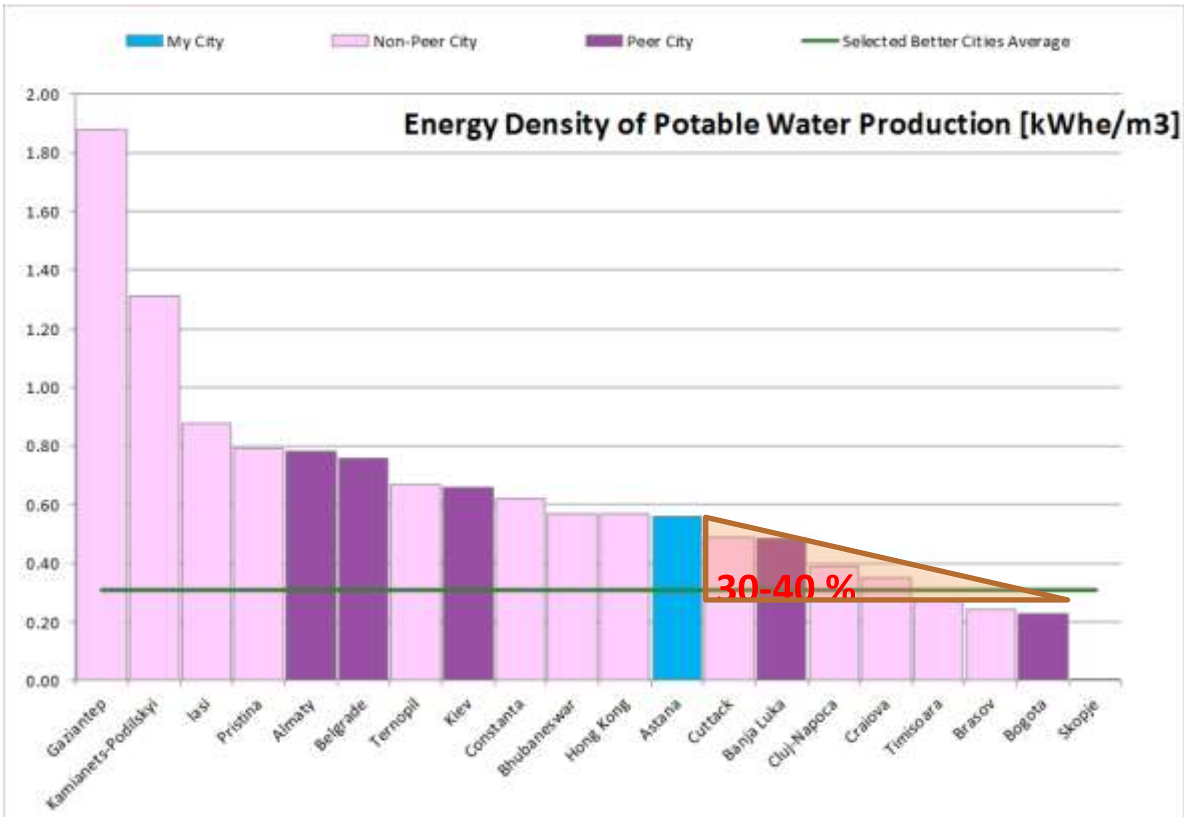
In 2015, around 70 million of m^3 of water was produced in Astana, but only 56 million m^3 was actually billed. Hence, the water sector incurs around 25% losses in the system, of which 5% are commercial losses as not all people pay the water bills in time. Water losses in Astana are twice lower than in Tbilisi, smaller than in Almaty, but much higher than in Kiev, according to the TRACE benchmarking against cities with similar HDI. Overall, in recent years the amount of water supplied to Astana has increased due to population growth and territorial expansion of the city.

Water tariffs must be approved by the energy regulator, ARNM, and they are differentiated by types of consumers. Water is billed based on a flat rate, and includes the water losses as well. As of December 2015, the average water and sanitation tariff in Astana is 61.7 per m^3. Residents pay the lowest tariff, i.e., KZ 24.8/m^3. Clients in the public sector pay more - KZT 102.2/m^3, while other entities pay KZT 107.8/m^3. The water operator is able to make some profit. The investment returns are possible primarily because of high tariffs applied to clients in the public, commercial and industrial sectors.

3.7.3 Energy Performance

In 2015, Astana needed 40.2 million kWh of power to produce, treat, and distribute 70 million m^3 of water. This would come to an energy consumption of 0.56 kWh/m³ of potable water. The figure is higher than in other peer cities like Banja Luka, but smaller than in Kiev, Belgrade or Almaty. Power is purchased on a wholesale market for KZT 11.4/kwh (single tariff), which is almost three times less than the regular tariff. The related energy expenditure was KZT 410.5 million, which would represent 8% of the annual total water utility cost (KZT 5.7 billion). Overall, the energy expenditure for both potable and wastewater is US$ 3.74 million, representing 11% of the annual operational budget of the water utility company.

Figure 30: Energy density to produce potable water in Astana



According to the city development plan, investments for the 2016-2020 period in the water sector in Astana are expected to rehabilitate some 20-25 km of water network per year. Overall, 225 km of pipes should be rehabilitated or replaced, which would reduce the wear and tear level of the network by 15% by 2018. The program includes reconstruction of pumping equipment and purchase of a few new efficient pumps.

3.8 Sector Analysis - Wastewater

3.8.1 Infrastructure

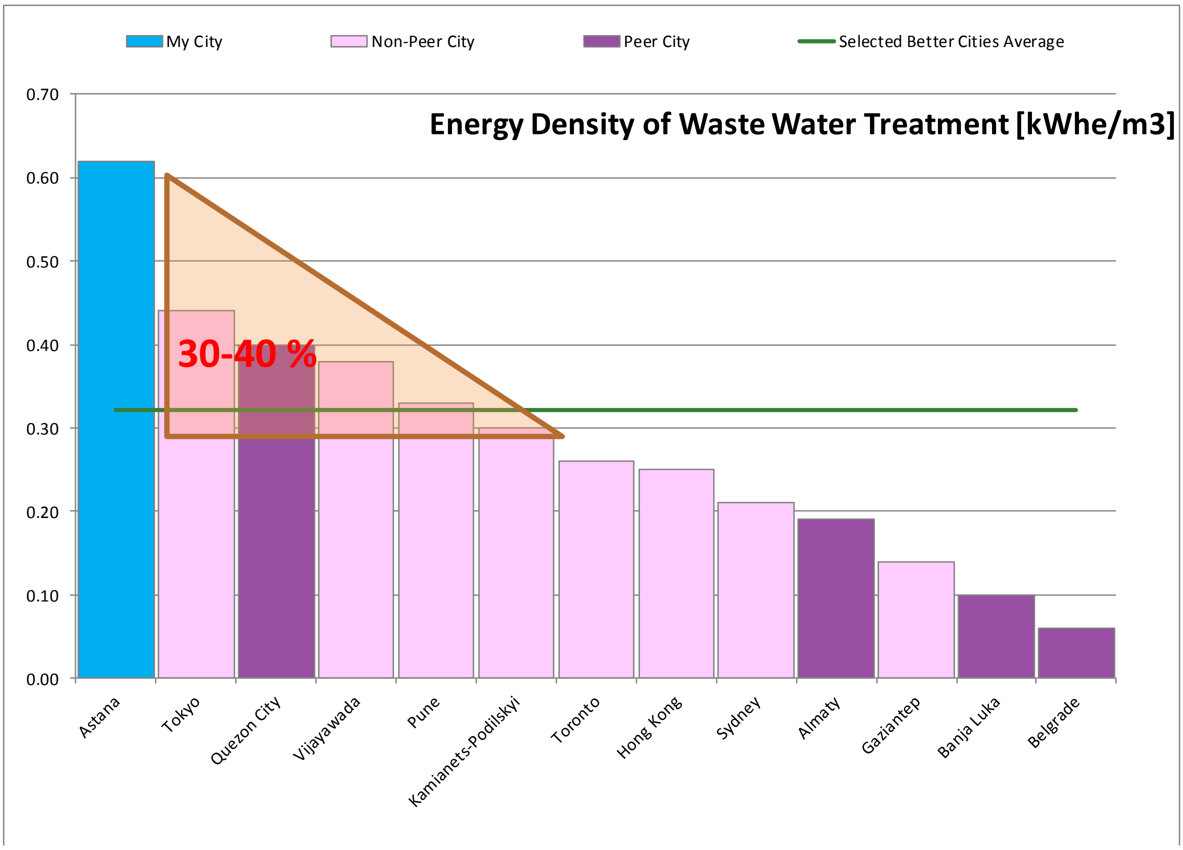
The sewage network in Astana has approximately 700 km that caters to 214,941 households. 90% of the potable water subscribers are also connected to the sewage network, while the remaining 10% use some individual sewage/sanitation systems. Some of the individual family housing units have individual sewage systems, like septic tanks. Around 30-35% of the wastewater network is worn out, and water pipes are leaking water. The investment program in the water sector is expected to improve 40 km of network every year. Hence, by 2018 the level of depreciation of the network in the city should reduce by 10%.

As of now, the city has only one wastewater (WW) treatment plant with an installed capacity to treat 189,000 m^3/daily. In addition, sewage is collected and pumped through 140 pumping stations. The increase in population (estimated at 30,000 people/year) and territorial growth require CA and the water operator to undertake efforts to expand the water/wastewater infrastructure in order to meet the future demands. A new WW treatment plant with a capacity of 150,000 m^3/daily should be completed in 2020. A third facility is under planning, and it should be ready by 2030. Until then, the existing WW treatment station should expand its daily treatment capacity to 200,000 m^3 of water by 2018. The modernization process also covers the network water supply and the storm-water infrastructure. On average, residents pay for sewage KZT 26 (US$ 0.11)/m^3, while clients from the public and commercial sectors pay KZT 47/m^3.

3.8.2 Energy Performance

In 2015, approximately 51.6 million m^3 of WW was treated for which 32,440,107 kWh of electricity was used. This required 0.62 kWh of power to treat one m^3 of wastewater. The TRACE analysis based on benchmarking against cities with similar HDI points out that Astana has the highest consumption, as it needs three times more power than Almaty, six times more than Banja Luka and 12 times more than Belgrade (see Figure 31 below). The water operator paid KZT 317 million (US$ 1.66 million) for the energy used to treat WW.

Figure 31. Energy used to treat one m³ of wastewater in Astana



It is important to note that the amount of treated water in Astana had increased by 12% between 2012 and 2014, from 52.8 million m^3 to 59.3 million m^3, and came down by 13% in 2015, to a little over 51 million m^3.

3.8.3 Main Challenges in the Water/Wastewater Sector

The TRACE analysis had identified some energys saving potential of 20% in the water& wastewater sector in Astana that could be achieved through EE interventions, such as active leakage detection program or rehabilitation or replacement of leaking water pipes. The city has plans to replace 30% of the distribution water pipes by 2020, which would be able to cut technical losses by half. The rehabilitation of 140 WW pumping stations by 2020 has already begun. The water metering system with remote meters must be expanded to all clients in the city to help diminish the commercial losses.

- *Old water & wastewater infrastructure:* One of the main issues in the water system in Astana is the old water network. One-third of the potable water distribution pipes and one-third of the sewage network is in critical condition. Obsolete, poorly insulated pipes are the main culprit for losing a quarter of the water produced.
- *Limited infrastructure to meet the future demand*: With a constant population growth estimated at 30,000/year, soon the current water and WW network will not be able to cater to future connections. The CA and the water operator must expand the network to ensure that new communities will have adequate access to water & WW infrastructure**.** Based on the estimated population growth, the water & WW network should expand by 5% year.
- *Limited funds and low tariffs*: For any investments the water operator should primarily rely on its own funds since there are no subsidies from the city budget. However, the water tariffs for residents - who are the largest share of clients - are artificially kept low for social reasons. Money for investments are very limited and rarely provided, and when so, funds gets often postponed. The lack of funds put quite a burden on the operator and it prevents the company to ensure appropriate maintenance of the water network.

- *Long implementation time*: Finally, another key challenge in achieving the EE potential in the water & WW sector in Astana is the long project implementation period. For example, the rehabilitation/recalibration of the water pumps by JICA was completed in seven years. Most interventions are very complex and lengthy, and this would be quite discouraging for city authorities to undertake significant investments in the sector.

3.9 Sector Analysis - Municipal Solid Waste

3.9.1 Institutional Framework

Solid waste management (SWM) in Astana is handled by both public and private sector. Collection of waste and street sanitation services are monitored by the CA through the Division of Natural Resource. The division must also draft local waste management policies. There are several players in the waste sector in the city. Astana Tazalyk, a company with 51% shares from the CA and Taza Alem Astana, a private entity, are among the key stakeholders with regard to waste collection. Astana Takalyk is responsible for street cleaning, Aktyn TET operates the sorting station, and Astana Eco Poligon manages the landfill. In addition, there are some 30 small waste transport companies dealing with collection activities. The costs for waste/street cleaning services are covered from the local budget. These services are provided by public and private contractors through public and privately-owned trucks. Private contractors have service agreements with the CA.

3.9.2 Infrastructure

Waste is collected from 12,455 trash bins located at households and legal entities throughout the city. Around 40% of the bins are old and should be replaced. Astana-Tazartu is the largest company in Astana dealing with waste collection and transportation, serving 23 out of the 24 sites in the city. The company caters to 95% of the households. It collects garbage from 11,155 bins of 0.75 and 1.1 m³, using 67 waste trucks equipped with GPS and 23 special vehicles. Salaries and the tipping fee paid at the landfill account for the largest share of expenditures. In 2014, the company collected and disposed to the landfill 246,800,000 kg of waste. Taza Alem Astana caters to the remaining 5% of residential household, collecting from 1,300 waste bins using 22 vehicles of which 10 waste trucks and 12 vehicles for waste disposal. In 2014, they collected overall 23,300,000 kg of wastes.

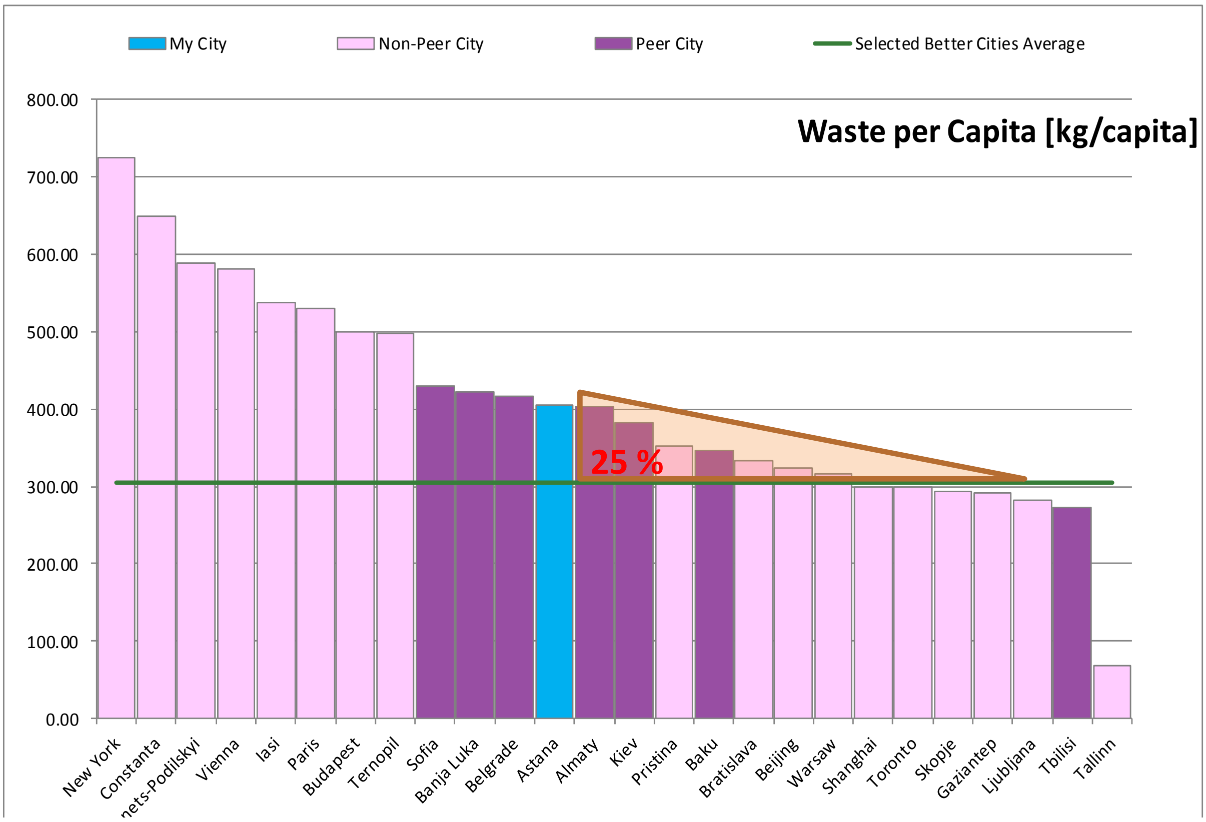
Astana Tazalyk, a company owned 100% by the CA is responsible for street cleaning activities and solid waste collection from non-residential clients. Another player involved in street cleaning, snow removal, tree planting, watering and irrigation is Astana-Zelenstroy, a public entity.

In 2015, Astana generated 404 kg of waste per capita, a figure just like in Belgrade and Almaty, hence placing Astana in the middle of the TRACE database with comparable cities having similar HDI (see Figure 32). Astana generates 969 tons/day of residential garbage, with a norm of 2.16 m³/per person. The amount of waste in Astana had increased by 20% between 2014 and 2015, from 289,000,000 kg to 353,000,000 kg. A quarter is organic waste, 10% plastic, 13% glass, 8% paper, 18% textile, 1% metal, less than 5% street garbage, and 4.3% sludge which is sent to the waste treatment facility. In addition, the city gets 207,000,000 kg of construction & demolition waste, and 45,000,000 kg of industrial waste and ashes. Nearly half of the organic waste is collected by Astana Tazarty, 8% by Taza Alem Astana, 16.5% by Altyn TET and 14.7% by Astana Tazalyk, while rest by other 30 small companies.[35]

Only 6% of waste in Astana comes from the new separate collection and recycling system. Home-based recycling at city residents was recently introduced in a few communities. In addition, public bins for separate collection have been placed all over the city. Separate containers where people can place old mercury lamps are also available.

[35] City Program on Waste Management in Astana

Figure 32. Waste generation per capita in Astana



About two kilometers far from Astana and spread over 12 hectares, the landfill is owned by the CA and managed by Astana Poligon. First cell of the facility has already reached its capacity of 2.8 million tons of waste, and the second cell is under construction. The landfill received 94% of waste collected in the city in 2015, which is an increase by a third as compared to the previous year.

The city has one sorting plant which was built in 2012, with a capacity of 250,000,000 tons per year where recyclable items such as paper, carton, plastic and metal are split and sorted. 6% of the waste in Astana is sorted at this facility, with cardboard & paper and plastic holding the largest share. From April 2013 to November 2015 the sorting station received 271,000,000 tons of garbage, with an average load of 53% per year.

Small waste collection companies servicing the commercial sector usually drop off the garbage at illegal dumping sites. Estimates made by district administrations indicate that between 2013 and 2015 the amount of waste took to illegal dumping facilities increased from 15,700 tons to 18,300 tons, a figure that accounts for 5.2% of the total waste disposed at the city landfill.[36]

People pay 260 KZT/person per month for waste collection and sanitation services. Collection rate is expected to improve to 92% as of 2016, to 96% by 2020 and reach 98% by 2030.[37] The waste sector does not get any subsidies from the city budget because SWM is perceived as a cost-recovery activity.

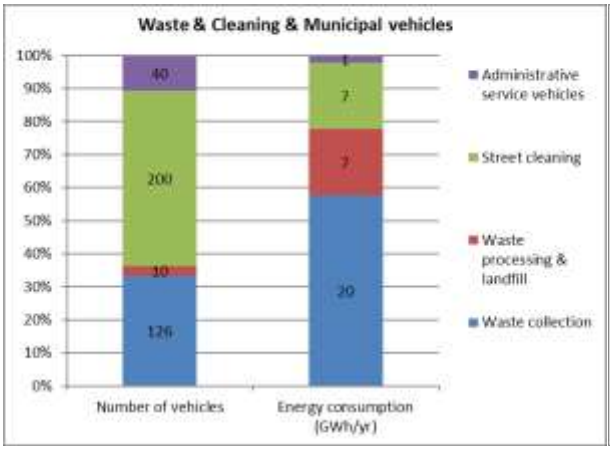
3.9.3 Energy Performance

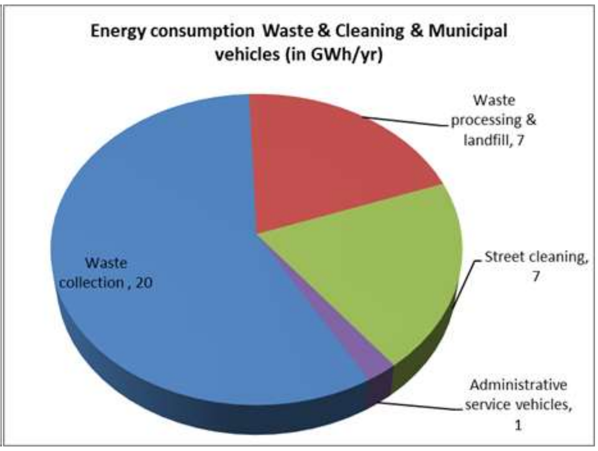
35 GWh of energy in the form of car fuel is annually required to cover waste collection and management activities in Astana. The city has 126 waste collection vehicles, in addition to 10 CNG vehicles that operate at the landfill. 200 trucks are used for street sanitation and snow removal in winter. Street sanitation vehicles are quite efficient as they use only 7 GWh per year. Waste

[36] City Program on Waste Management
[37] City Waste Program

collection vehicles make several daily trips to households and the landfill. They need overall 20 GWh, which is 60% of the total energy used in the sector. The annual fuel to operate the waste vehicle fleet cost KZT 375 million (US$ 1.69 million).

Figure 33. Energy consumption for waste collection and street sanitation in Astana





3.9.4 Main Challenges in the Solid Waste Sector

The TRACE analysis has identified some 25% good energy savings potential in the solid waste sector in Astana. The city government has already plans to improve SWM system in the short and medium term, which is in line with the draft State Program on the Development of the SWM 2020. The document set an ambitious 50% target for recycling, in addition to requiring placing all related activities (e.g., collection, transportation, disposal, and management) under one single operator. By 2017, the city should increase the share of recycling to 35%, develop a new sorting facility for 30,000 tons/year of plastic items (KZT 414 million), replace 11 waste trucks operating at the landfill and 30 large waste vehicles of 12 tons (KZT 762 million) and privatize 30% of the waste/sanitation vehicle fleet. In addition, they should replace 4,000 bins for separate collection (KZT 360 million), buy 370 bins for electronic waste items like bulbs, batteries (KZT 125 million), and develop an organic waste separation facility (KZT 40 million). On the medium-run, by 2020 the recycling rate should go up to 75%. The city is also planning to build a landfill gas extraction with 6 MW capacity for power generation and sell the energy produced to the power utility company.

A PricewaterhouseCoopers study approved by the city mayor in 2017 shows that local authorities plan to develop a treatment plant and a few recycling facilities near the existing landfill, and consider building a biogas plant for bio waste. The second landfill is under planning, with the feasibility study under way. While the city managers are committed to improve SWM through development of both policy and infrastructure, the sector is facing several challenges.

- *SWM system is not integrated*: There are too many players in the sector, with very little or no coordination among them. Overall, there are around 50 active waste collection companies. Also, Astana is struggling with inadequate quality of waste collection services, and both authorities and waste/cleaning operators make efforts to keep the city clean, in line with sanitary standards.
- *Limited funds and low tariff:* The tariffs for waste collection and disposal in Astana are low. A fee of KZT 260/month/person can hardly cover operation costs. Waste collection and management fees should increase since these are the only funding source of the sector. Additional revenues could be made from recycling waste and waste-to-power generation.
- *Limited recycling:* Astana does not have adequate recycling arrangements. Recycling is at its very early stage, with only few households taking part to the separate waste collection system. The city has ambitious plans to reduce the amount of waste sent to the landfill to 35% by 2020 and 20% by 2030, and increase by ten folds the share of recycling - to 65% by 2020 and to 80% by 2030.

- *Illegal dumpsites*: Most of the waste collected from the commercial sector goes to illegal dumping sites. In 2015, the amount of waste gathered in such illegal facilities accounted for over 5% of the overall garbage generated in the city. The cost to remove these illegal disposal sites is high - KZT 250 million per year.
- *Need for new infrastructur*e*:* Finally, with the population growth estimated at some 30,000 people/year, Astana is expected to generate a whole lot more waste which would require additional infrastructure. Between 2014 and 2015 the amount of waste per capita has increased by 15%, and is expected to further upsurge. Forecasts indicate that by 2020 Astana should generate 492,000,000 kg of garbage and 684,000,000 kg by 2030.

3.10 Sector Analysis - Public Transport

3.10.1 Institutional Framework

According to the Astana Development Strategy for 2016-2020, transport sector in the city accounts for 8% of the GRP. Public transport is managed by the Astana Transport Authority (ATA, former Astana LRT) with supervision from the Division for Public Transport Management of the CA. The public transport authority was established in 2011 by CA as Astana LRT and it later was rebranded as ATA. Besides coordination of bus routes and ticketing, ATA is also responsible for drafting local transport policies and plans, which are subject to approval by the CA.

3.10.2 Infrastructure

There are 81 bus routes covering 46 km, operated by nine operators of which eight are private and one is public, LRT. LRT belongs to the CA and holds 30% share of the market. LRT serves 14 routes with nearly 360 buses, most of them known as "social routes" since they are extensively used by specific social categories, such as school kids. The city owns the public transportation infrastructure, like routes, rolling stock, bus stops etc. Public transport fleet has 1,025 diesel vehicles of which only 850 are operational. There are different types of buses in Astana, such as Iveco, MAN, Diesel, Hyundai etc. 43% of the bus fleet is fairly new - less than 5 years old, 14% is between 10 and 15 years old, and a third is between 5 and 10 years old. Some of the old buses are not so efficient because they use diesel Euro 4. Most of the bus stops in Astana are equipped with electronic boards from where people can get information about routes and arrival time.

Approximately 814,000 people use public transport daily in Astana. In recent years, the number of annual commuters has increased by 24%, from 1.74 billion passengers in 2012 to 2.17 billion in 2014. However, the public transport share in Astana is not so high, as only a third of the daily trips are done by buses, a figure like in Teheran and Tbilisi, but smaller than in other cities, such as Bucharest, Baku or Sarajevo. This is primarily because 63% of the city residents rely on private transport, and 2% walk or bike for their daily trips. Bus tariffs are affordable (KZT 90/per trip), and the city subsidizes tariffs for low income groups, including retirees and students, which normally account for half of the passengers. No subsidies are provided to bus operators.

A large investment program to improve the quality of public transport in Astana is under way. The key measures include upgrading or replacing 90% the old buses. The program targets 738 buses of which 358 new IVECO buses were already purchased. 170 vehicles should be upgraded under Citybus 3, a program aimed at improving suburban and city center transport network. Around 200 new diesel 6 buses should be bought by 2017 with US$ 65 million loan from EBRD. 10% of the diesel 6 vehicles are hybrid, running on both diesel and electricity. City authorities are exploring options of compressed natural gas (CNG) buses, and a natural gas fuel station is under construction. However, the quality of public transport in Astana is quite low because the existing buses cannot meet the demand. Local authorities are considering expanding the fleet to enhance the quality of transport services. However, since the local budget does not have money to buy new rolling stock, ATA must get loans from International Financial Institutions (IFIs) or commercial banks.

The local government hopes that once it improves and gets more reliable, public transport would become more attractive to people, thus its share would increase from 33% to 45%. Under the government program Nurly Zhol, Astana is developing the transport infrastructure to become a major transport hub in the country. The program targets the rehabilitation of 140 km of local roads by 2020 and 50% increase in passenger turnover. ATA is installing new electronic dispatchers and e-ticketing to gradually move to an integrated transport system. Other interventions include dedicated bus lanes, optimization of bus routes, bus per km fuel consumption approach, school buses, development of closed, heated bus stops equipped with wireless internet, a new bus depot for parking and service for 150 buses, and a city taxi fleet.

An ambitious US$ 2 billion project to build 22 km of Light-Rail Train network from the airport to alleviate traffic on the left bank of the city is in its early stage. The city is also considering leasing buses to private operators. (However, private operators cannot be persuaded to improve efficiency since there are no EE performance requirements as such). According to the city strategy and in light of the Astana Energy Expo 2017, a new international airport terminal was commissioned and opened just a few days before the event. Other plans include building ten parking facilities under PPP with a capacity of 5,340 cars. Two new bus stops for 4,500 passengers daily were to be opened before the event. 100 km of new roads were planned to be built by 2015, with another 217 km in the city new communities by 2020.

Figure 34: Planned Astana Light-Rail Train station

Source: Astana LRT

3.10.3 Energy Performance

Public transport in Astana requires 0.041 MJ per passenger per kilometer. Although this figure is quite small, it does not necessarily mean that the public transport system is efficient, but rather it shows that is underdeveloped. And that is because public transport share is quite small and the bus fleet is struggling to meet the demand. Expert analyses indicate that among all vehicles, taxis are the most inefficient. There are 600 taxis in Astana operated by 14 companies; the taxi fleet has one percent share of the total passenger kilometer and use 18% of the overall fuel consumption (see Figure 35 below). Annually, the city spends US$ 8.64 million to cover the cost of fuel for the public transport sector.

Figure 35. Energy consumption per pass/km for public transport in Astana

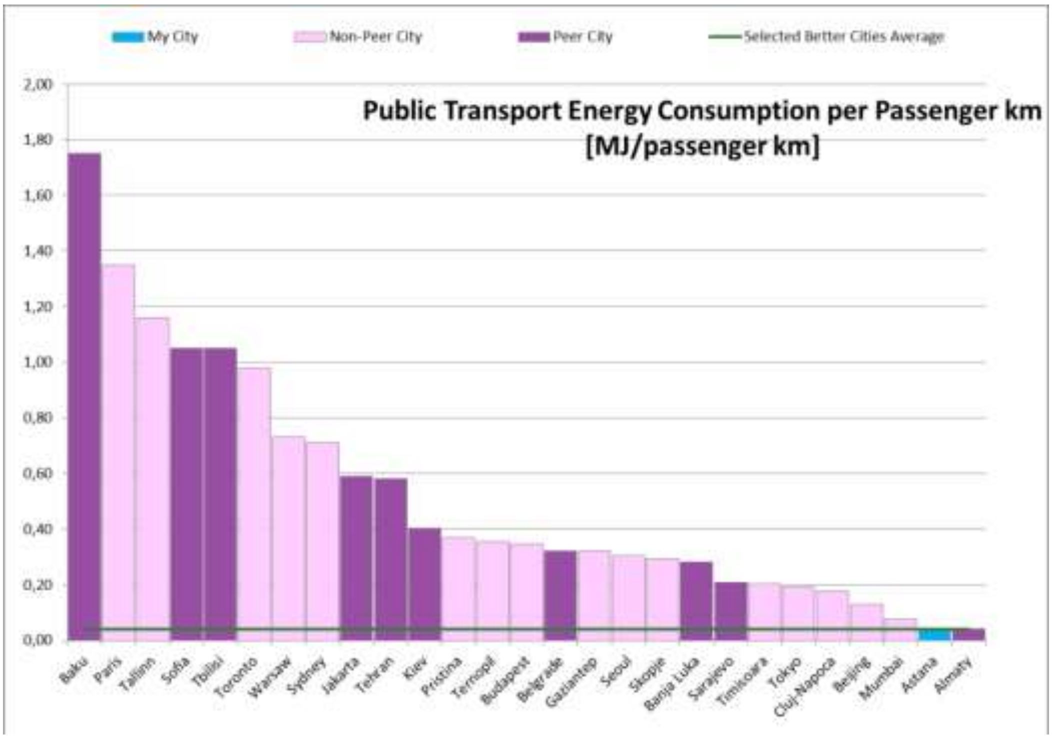
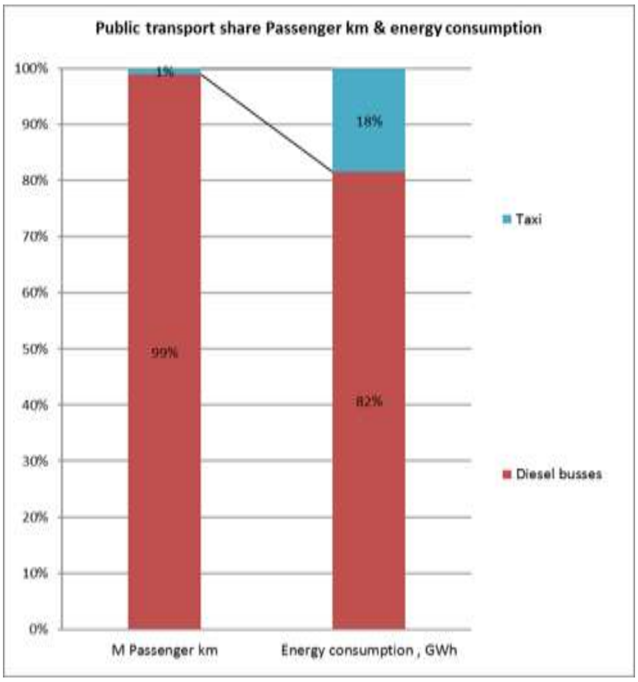


Figure 36. Public Transport share pass/km and fuel use



TRACE looked also into **private transport** in Astana, although this sector is not under the CA control. There are around 500,000 private vehicles in Astana, of which 270,000 are registered. In addition, approximately 80,000 vehicles drive in daily from other places. The city has a bike sharing system but no dedicated bike lanes. Private transport in Astana has the largest energy consumption among peer cities with similar HDI, with 6 MJ per passenger kilometer. The overall cost of fuel for private transport is almost US$ 250 million. Astana incurs high levels of congestion and bottlenecks in morning and evening rush hours, since almost two-thirds of the city residents use private cars for their daily commutes. More details about private transport sector in Astana are available in Annex 4.

3.10.4 Main Challenges in the Urban Transport Sector

Although the TRACE analysis indicates some limited energy savings potential in the urban transport in Astana (12%), the sector could improve by developing a modern public transport in addition to some measures targeting private transport. These could include e-ticketing, park and ride facilities in the city outskirts where people could leave their cars and take public transport to continue their travel, more parking facilities, an adequate traffic management system, and a genuine bike infrastructure. In addition, the development of the planned Light-Rail Train would not only diminish traffic on the left side of the river, but also reduce travel time. In line with the Comprehensive Action Plan for Improving the Air Quality in Astana, around 3,000 vehicles from the municipal fleet should switch to natural gas in the near future.

The local transport authority in Astana is assessing options to introduce electric transport in the city. The development of a few electric charging stations for hybrid buses is under day. With funds from KazMunaiGas, nine fuel stations should be equipped with charging electric devices, and three modern "green" fuel stations should be built for petrol, diesel, natural gas, and power using energy-efficient materials and alternative energy sources. However, the problems in the urban transport sector in Astana may hinder the local plans to provide an EE transport system in the city.

- *Low fuel efficiency of buses*: Some buses use low efficiency diesel Euro 4 that require significant amount of fuel. Until they get replaced, these buses will continue to be a burden on the city budget.
- *Lack of natural gas infrastructure:* Although the CA has ambitious plans to purchase more CNG buses, this requires adequate infrastructure, which is not only costly but also high maintenance. Since the city has only very limited funds which cannot cover new rolling stock, ATA must look at other funding options, including from external sources.
- *Lack of legislation to increase performance of transport operators*: Improving quality and efficiency of public transport could face a set back from a legislative perspective, as there is no legal regulation requiring operators to increase their performance.
- *Low cost of fuel*: The relative low cost of fuel – i.e., KZT 138/liter in 2015/2016 (equivalent of US$ 0.62/liter) - will continue to encourage people use their cars for their daily commutes.
- *Congestion and increasing number of private cars:* Traffic congestion during rush hours, with several bottlenecks, make people spend more time in traffic and, hence, use more fuel. With a higher standard of living as compared to other regions in the country, Astana will continue to attract more people, and they would buy cars, hence putting a lot of pressure on the road loads in the city. In addition, the number of cars transiting the city daily would increase the road load and aggravate traffic management. At the same time, the insufficient number of parking in residential areas and business centers has a negative impact on road capacity.

4 Prioritizing Sectors

TRACE helps rapidly assess the energy use in a city in order to identify and prioritize sectors and recommend specific EE interventions. For this purpose, sectors with the highest energy savings potential that are both achievable due to the control and impact by the municipality and financially viable will be highlighted and presented in table 7 below.

The process for identifying priority sectors considers three main issues:

- **relative spending on energy** in each sector, either at a municipal level or for the entire municipality (public and private);
- **Relative Energy Intensity** (REI) of the sector as theoretical energy savings potential based on the benchmarking exercise and the consultant's professional estimate after reviewing each sector; and
- **degree of control or influence** the CA has over each sector with the level of budgetary control being the most important factor.

The overall expenditure for energy within the municipality amounts to approximately US$ 746 million per year in 2015, which is about 3.5% of the GDP of the city.

Table 7: Summary of sectors by spending for energy, REI and energy efficiency potential

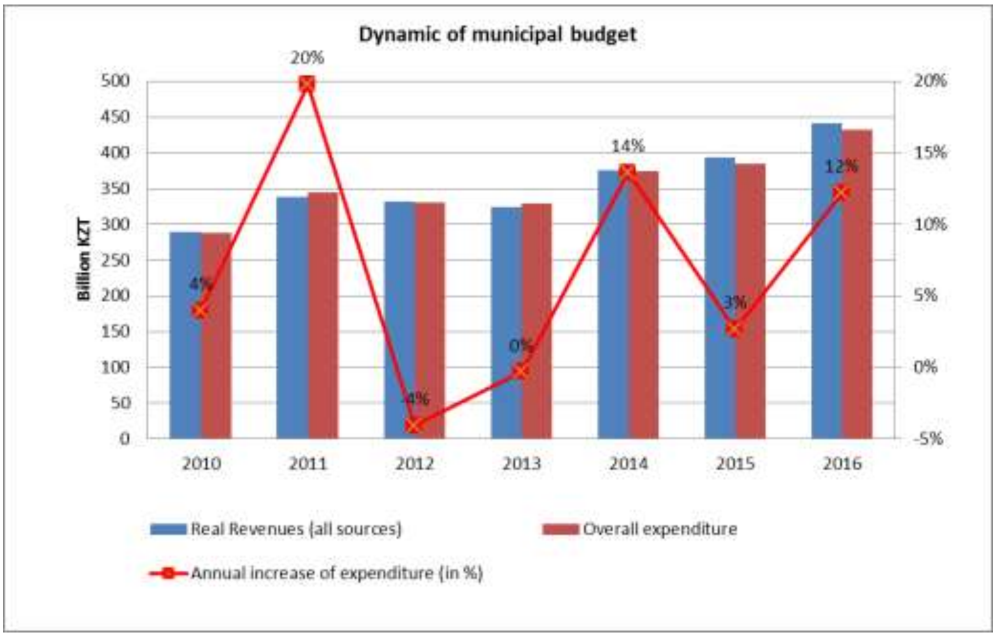
Sector	Energy spending (in million US$ including VAT) in 2015	Theoretical Energy Savings Potential = Relative Energy Intensity[38]	Municipal level of control
Public Transportation	8,6	20-35%	HIGH
Private Transport	244,1	10-15%	LOW
Municipal public buildings	17,1	30-50%	HIGH
Street Lighting	2,8	50-60%	HIGH
Power (losses)	147,9	10-15%	LOW
District Heating (losses)	63,7	20-30%	MEDIUM
Potable Water	2,1	20-30%	HIGH
Wastewater	1,7	20-30%	HIGH
Solid Waste & Municipal Vehicles	1,7	25-30%	HIGH
Other Public Buildings	4,0	30-40%	LOW
Residential Sector	111,2	30-40%	LOW
Commercial & Industrial sector	141,3	30-35%	LOW

4.1 Energy Expenditures as part of the Municipal Budget

The city budget had a positive trend over the past six years, with an average increase by 8% per year. The budget expenditure followed the similar trend with an annual increase of 7-8%, and with a tendency to reach over 10% in recent years, a situation caused by the increase in energy costs.

[38] The Relative Energy Intensity is the potential improvement in the given sector. It is calculated using the average of municipalities under similar conditions, performing better than Astana city. For example, if the specific heat consumption per area of municipal public buildings for a selected number of similar municipalities performing better than Astana is 130 kWh/m², and the buildings in Astana consume in average 244 kWh/m², then its relative energy intensity is (244-130)/244= 45%.

Figure 37: Dynamic of the municipal budget in Astana



Around 60% of the budget (KZT 219 billion) was transfers from the national budget and 40% came from local revenues.[39] Approximately 55% of the city budget covers operation costs, like education (14%), housing and communal services (26%), transport (27%), heat & power (8%), healthcare (7%), sport (6%), etc. District governments (rayon akimats) receive money to operate the street lighting network, whereas waste collection and street cleaning services are covered from the city budget.

The local government can decide on how should spend the surplus. For 2016, Astana managed to make a surplus of KZT 7.4 billion of which KZT 5 billion from local revenues. If transfers from the national (state) budget are not spent in the given fiscal year, money must be returned. Since 2013 onwards the city has accumulated KZT 62 billion from the state budget, money that should fund investments in affordable housing and expand the district heating network. Significant funds go to the housing sector, including for social housing units. In 2016, Astana was planning to build 1.7 million m² of new residential housing, with additional 2.25 million m² of new constructions in 2017.

Table 8: Municipal energy spending

Energy spending (public transport, municipal buildings, street lighting, waste, water and wastewater services) in 2015[40]	US$ 34 million (KZT 7.5 billion)
Energy spending for municipal services as percentage of annual budget	2%
Of which energy spending for municipal buildings	US$ 17.1 million (KZT 3.8 billion)
Energy spending for municipal buildings as percentage of annual budget	1%

The energy spending for municipal sector facilities (municipal buildings, street lighting, waste, water & WW services) amounts to US$ 34 million in 2015 (5% of city-wide energy spending) of which 50% covers the energy bill in municipal buildings.

[39] Average exchange rate for 2016 - US$ 1 = KZT 341
[40] Energy spending for heat and power supply are covered by the utilities and calculated within the energy tariff.

Figure 38: Share of city-wide energy spending (KZT 165 billion)

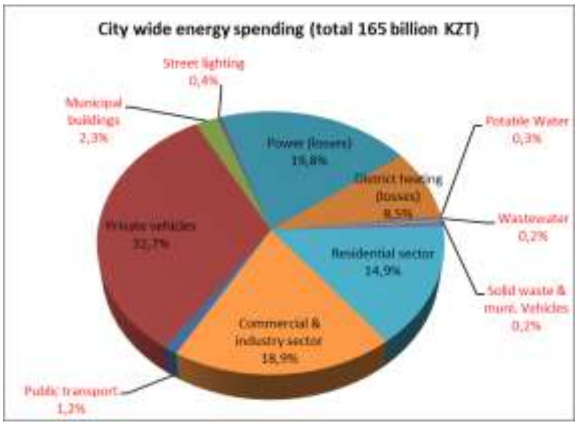
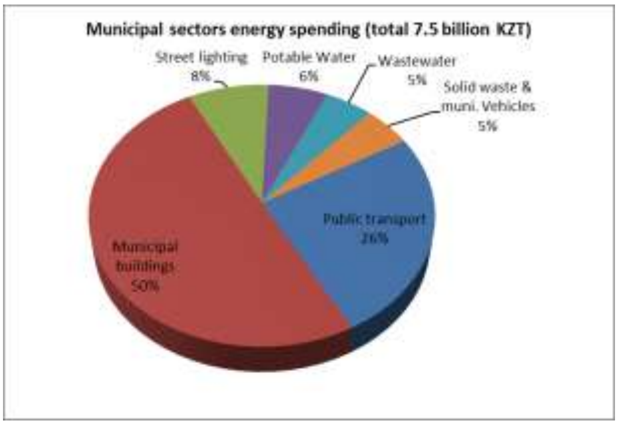
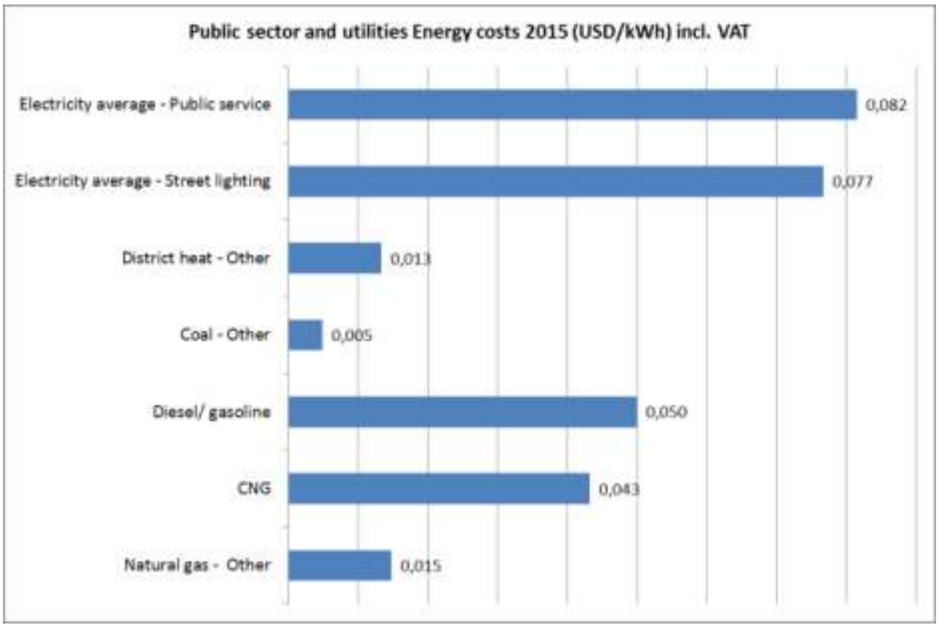


Figure 39: Share of energy spending in municipal sectors (KZT 7.5 billion)



The costs per unit of energy (kWh) for public entities vary depending on the type and quality of the energy used (e.g., 1 kWh of electricity is six times more expensive than 1 kWh of district heat). The high quality energy carriers such as gasoline and power are more expensive than gas and district heat.

Figure 40: Energy costs for public entities, 2015 (US$ per kWh)



Despite the fact that energy consumption in the sectors that are under the city control represents only 7% of total municipal-wide energy consumption, successful interventions in these areas are important to increase awareness of city residents about energy savings potential and EE benefits. Moreover, energy savings in these sectors will directly contribute to reducing the energy costs, as well as diminishing the municipal budget spending or the government subsidies.

4.2 Level of Municipal Control across Sectors

The city can have different levels of influence and control over municipal utilities and energy end-users. The various types of ownership of energy consuming facilities in different sectors can limit or strengthen the budget control and enforcement power of the city government. Hence, an inherent part of the urban energy diagnostic is to determine the degree of authority or control the municipality can exert on municipal/local energy stakeholders.

Figure 41: Key to the municipal authority control

	National Stakeholder	The city has virtually no control; decisions are taken at a national level.
	Local Stakeholder	This city is one of many stakeholders who take decisions at a local level
	Local Committee	The city is formally represented on a Committee that take decisions
	Multi-Agency	The city is one of several agencies with a formal decision-making role
	Policy Formulator	The city can directly set policy in the sector
	Regulator/Enforcer	The city can directly set policy in the sector and enforce compliance
	Budget Control	The city has direct control over expenditure in this Sector.

The examples below show the level of municipal influence and control for two sectors.

Sector example A: Municipal Buildings – HIGH level of control: When the CA is responsible for all building codes, regulations and permits, it means that the city has high regulatory control in this sector. Since all building operation related costs (including energy, maintenance) as well as investments are paid from the local budget, the city has high budgetary control and direct incentives to invest into high energy efficiency equipment. Finally, as owner of the building, this gives the city the necessary degree of influence to ask the building's user to implement certain energy savings measures.

Sector example B: Private Transport - LOW level of control: Since the city cannot control the fuel consumption of the private vehicles nor impose performance codes to them, the CA has low regulatory control over this sector. Since energy costs of individual transport are covered by individuals (private individuals) this means that the municipality has a low budgetary control over this sector. Finally, the city has limited influence on enforcement of EE in the private transport sector.

As shown in Table 9 below, the CA has full control over the following sectors - municipal buildings, street lighting, water supply & wastewater, and waste management, and they should be the primary focus for the municipal EE plan.

Table 9: City control over sectors – regulator, budgetary and enforcement

Sector	Level of municipality authority control		
	Regulatory	Budget control	Influence and enforcement
Public Transportation	HIGH	HIGH	HIGH
Private Vehicles	LOW	LOW	MEDIUM
Municipal Public Buildings	HIGH	HIGH	HIGH
Street Lighting	HIGH	HIGH	HIGH
Power (losses)	LOW	LOW	MEDIUM
District Heating (losses)	MEDIUM	MEDIUM	HIGH
Potable Water	HIGH	HIGH	HIGH
Wastewater	HIGH	HIGH	HIGH
Solid Waste & Municipal Vehicles	HIGH	HIGH	HIGH
Other Public Buildings	LOW	LOW	LOW
Residential Sector	LOW	LOW	MEDIUM
Commercial & Industry Sector	LOW	LOW	LOW

The city has low or no regulatory or budget control and EE enforcement power on the final energy consuming sectors power supply, private individual transport as well as residential, commercial and non-municipal public buildings, since they are controlled by the central government or are commercially/individually organized. The city could influence those sectors by involving stakeholders in the process of municipal energy planning, as well as by increasing awareness on EE benefits.

At this point, for sectors with low level control only a few EE interventions are recommended, and could be initiated by the CA within the municipal EE program in close cooperation with the relevant stakeholders. However, the financial involvement from the city budget shall be limited, since the facilities are commercially or privately owned, and soothe financial benefits of the EE investments will stay with these at private/commercial end-users.

4.3 Municipal Energy Challenges

Astana is facing three types of challenges regarding EE (see Table 10 below) that should be addressed in the municipal EE plan when outlining specific EE interventions and targets.

Table 10: Municipal Energy Challenges

<table>
<tr><th>Economic and demographic challenges</th><th>Overall municipal level energy challenges</th><th>Sector specific challenges</th></tr>
<tr><td rowspan="3">Increasing:
➢ Population
➢ Demand for energy
➢ Demand for municipal services
➢ Maintenance cost
➢ City budget spending
➢ GHGs, NOx and particle emissions</td><td rowspan="5">❖ High specific energy consumption of city public services (buildings, lighting)
❖ Increasing demand to provide service to new customers
❖ High costs for maintenance and repair
❖ High and escalating budget spending for energy supply due to increasing energy tariffs
❖ Limited investment funds for retrofit or extension of infrastructure
❖ Out-dated, inefficient and partly or worn-out equipment and facilities
❖ Decreasing availability of facilities and unreliable supply, such as electricity and water supply
❖ Limited capacities on preparation and implementation of energy saving and retrofit measures
❖ Limited capacities of human capital: municipal staff does not have the adequate instruments to enforce energy performance regulations
❖ Generally low awareness of EE opportunities and behavior due to low energy tariffs and lack of information</td><td>Municipal public buildings (PB)
- High specific energy consumption
- High and escalating budget spending for energy supply
- Requirement for in-depth analysis and energy audits</td></tr>
<tr><td>District heating (DH)
- High losses in heat generation and distribution</td></tr>
<tr><td>Street lighting (SL)
- High costs for replacement and maintenance
- Demand for improvement of illumination</td></tr>
<tr><td rowspan="2">Limitations in:
➢ Performance of facilities
➢ Funds for investments
➢ Incentives to invest in energy efficient technologies
➢ Awareness of energy efficiency

Other influences
➢ Weak energy efficiency policy implementation</td><td>Water and Wastewater (WWS)
- High water consumption patterns
- High energy intensity for water processing and supply</td></tr>
<tr><td>Solid Waste (WS)
- High and increasing fuel costs for waste fleet
- Low rate of recycling and energetic use</td></tr>
</table>

4.4 Sector Prioritization

The TRACE sector analysis indicates that the top three sectors with highest energy savings opportunities in Astana are municipal buildings, commercial buildings and residential buildings (see Figure 42).

Figure 42: Sector ranking from TRACE model

Figure 43: Sector ranking

Key sector features and challenges together with the analysis on the EE potential were presented and discussed during the TRACE workshop in Astana in May 2017. According to the prioritization of sectors, the EE interventions shall focus on 10 sectors and cross-sectoral measures. The interventions in the municipal EE plan must be structured as such as to address the key challenges of each sector and target to achieve specific benefits. The areas of intervention for each sector are justified by the potential EE benefits for the city, such as the reduction of the energy bills and increase in the level of comfort inside the facilities.

5 Energy Efficiency Program

5.1 Intervention Strategy and Types of Measures

The overall energy efficiency strategy should be based on two types of interventions:

A) **INVESTMENT MEASURES:** They comprise a pipeline of direct EE investment projects that can generate physical energy savings with co-benefits in the form of increased service and comfort for end-users, in addition to reducing the O&M costs. These investments should be prioritized based on:
   1) Reduction of energy demand and consumption at end consumer sectors, mainly in buildings;
   2) Reduction of energy losses for heat and power generation and distribution; and
   3) Use of renewable energy (RE) sources, whenever these are technically and economically feasible to substitute fossil fuels.

The next section of this report will outline the 50 EE investment measures, the necessary investments and benefits.[41]

B) **ADDITIONAL NON-INVESTMENT MEASURES AND POLICIES AT MUNICIPAL LEVEL**: These are essential requirements and prerequisites (i) to enable the investment program implementation by investment preparation, development of financing and delivery mechanisms, (ii) develop a local regulatory framework, (iii) develop local institutional capacity, and (iv) raise public awareness on EE.

The investment and non-investment measures of the EE plan has been developed during a complex process that included (i) interviews with relevant stakeholders of the city of Astana, (ii) available investment plans from utilities and service suppliers, (iii) analysis of existing and previous EE plans and urban development plans, (iv) recommendations from the TRACE model, and (v) expert recommendations on relevant EE measures, based on experience and best practices.

5.2 Overall Energy Saving Targets

The overarching objectives of the municipal EE plan are to reduce energy consumption, diminish related expenditures from the municipal budget, and improve municipal service delivery for city residents. The qualitative targets can be summarized in three pillars in table 11 below.

Table 11: Summary of qualitative targets of the EE program

Increase of municipal services & living quality	Resource savings	Sustainable development
- Increase the quality of the **service level** (e.g., heating, health conditions) - Increase comfort and /or meeting the demands - Reduction of **GHG emissions** - Increase the **attractiveness** of the city	- Lower the city-wide energy demand (**energy intensity**) - Reduction of primary energy consumption - Increase the use of **renewable energy** - Avoid escalation of energy bills and limit budget spending - Use of additional revenue	- Improve the **performance** of municipal service companies - Implementation of **energy management** in all sectors, an activity led by the CA - Change of **consumer's behavior** towards EE - Setting up the environment to attract **investment in EE** - Increase and develop **capacities**

[41] Investments for the extension of urban infrastructure and performance increase of utilities are not listed in the EE plan, since those measures will not have a direct saving effect compare to the baseline energy consumption of the year 2015, they are not an inherent part of the municipal energy savings plan.

Increase of municipal services & living quality	Resource savings	Sustainable development
- Meeting the challenges and energy demand in the view of the future city growth	sources	for program implementation - Development of financing delivery mechanisms (like EPC, PPP)

This municipal EE plan should be implemented between 2018 and 2030, and it would help achieve annual final energy savings of 3,139 GWh, which would be 35% less energy consumption in the respective municipal sectors. Considering the primary energy factors, the 50 city-wide investment measures could realize primary energy savings of up to 5,013 GWh, which would save up to 22% of the overall energy consumption in Astana, as compared to the baseline year 2015.

The CA has showed interest in learning more about the technical and economic energy saving potential of the sectors under the municipal control (see Table 12). The implementation of the EE opportunities in the municipal sector could save 65 million US$ in energy related costs annually, which is 4% of the current city budget. The overall energy saving targets in the EE plan for the municipal sectors are listed below.

Table 12: Summary of quantitative targets of the EE program in municipal sectors

Municipal Public Buildings
✓ Minimum 30% energy savings of heat for all facilities (schools, kindergartens) by building retrofit ✓ 50% energy savings for lighting by replacement of indoor lighting ✓ Use of renewable energy to cover minimum 10% of hot water demand
Street Lighting
✓ Minimum 60% energy savings for the entire public lighting system in the city
District Heating
✓ Reduction of energy losses for district heat generation and distribution - from 38% to 22%
Water Supply & Wastewater
✓ Minimum 40% reduction of water losses ✓ 25% electricity savings at pumping stations for water supply and wastewater treatment
Public Transport
✓ Increase urban mobility by improving capacity, service and attractiveness of public transport ✓ 5-10% reduction of individual motorized transport by increasing attractiveness of public transport as alternative to individual cars
Solid Waste Management
✓ Minimum of 80% of municipal waste is sorted and prepared for recycling or composting ✓ 30% reduction of fuel consumption for waste collection vehicles

In addition to cost savings for energy expenditures, the implementation of the EE measures has additional co-benefits that are often overlooked. These are summarized in table 13 below. Investments in sustainable and environmental friendly urban infrastructure could increase attractiveness of Astana to city residents, tourists and businesses, and raise awareness on modern energy saving technologies and practices. In addition to benefits, implementation of EE measures EE could support the city to expand energy savings interventions to other sectors, such as residential and commercial.

Table 13: Benefits of energy efficiency

Sector	Example of energy efficiency measures	Multiple benefits
Municipal Public Buildings	• **Retrofit** of public buildings such as schools, kindergartens and administrative offices • Improved building energy management • Automated heating sub-stations in buildings	• Increased room comfort and health • Improved learning/working environment • Increased **lifetime of** buildings
District Heating	• Increase **efficiency** of heat generation (boilers) • Reduction of **distribution losses** (pipelines)	• Better hydraulic **balancing** • Higher heat availability to connect new customers
Street Lighting	• Upgrade of street lamps to **LEDs** • **Extension** of the street lighting network including illumination of sidewalks, promenades, parks, etc.	• Increased traffic safety • Improved attractiveness of sites for city residents and tourists
Water Supply and Wastewater	• **Retrofit** of potable water supply network • Improved water **metering** for all consumers • Rehabilitation of water pumping stations • Active **leak detection** and pressure management	• Reduction of water **losses** • Increased sanitary comfort • Continuous **water supply** at adequate pressure • Higher water availability to connect new customers
Solid Waste	• Construction of **waste transfer sorting**, recycling and composting stations • Energetic **use of wastes** (biogas, landfill gas, incineration)	• Reduction of environmental **pollution and waste volume** • Additional **revenues from sale** of recycled products and renewable energy
Urban Transport (public & private)	• Upgrade of public busses **low emission vehicles** • Promotion of non-motorized mobility (**biking**) • Increase capacity, reliability and comfort of public transport	• Reduced local **air pollution** • Improvement of passenger comfort • Reduced individual motorized transport • **Better access** to sites for city residents and tourists
Residential Buildings	• **Retrofit** of multi-floor buildings • Program for efficient indoor lighting • Automated heating sub-stations • Apartment-based heat metering and consumption-based billing	• Improved room **comfort** • Increased **awareness** on EE • **Fair energy billing** based on actual consumption • Lowering the **energy bill**
Power System	• **Solar** power generation • SMART metering • **Retrofit** of sub-stations and power lines	• Reduction of power distribution losses • Load shifting and **capacity** to connect new customers
Commercial & Industrial Sector	• Dedicated **financing program** (credit + co-financing) for EE technologies	• Lower **energy intensity** of production/ service • Increased **awareness** for EE • Improvement of **competitiveness**

5.3 Energy Efficiency Investment Program

The preliminary list of 50 EE measures in 10 sectors was presented to the city government and relevant local stakeholders during a workshop in Astana in May 2017. A preliminary cost-benefit and financial assessment has been performed for these EE measures.[42]

5.3.1 Priority 1: Investments in Municipal Public Buildings

The 10 interventions in municipal public buildings in Astana would require total investments of US$ 151 million (see table below).

Code	Energy Saving Measures	Details of applications	Estimated investment costs[43]	
			(million US$)	Specific costs
PB-01	EE Retrofit Program of municipal schools including: a) Retrofit of building envelop: Replacement of windows, insulation, b) modernization of heating and hot water system: Replacement of heat pipes, radiators, thermostat valves, hydraulic balancing, automated heating sub-station, temperature and consumption control, metering, and frequency control (VFD) pumps	– 654,000 m² in 88 schools & higher education buildings (60% of the building stock)	52	US$ 80/m² floor area
PB-02	EE Retrofit Program of municipal kindergartens including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 284,811 m² in 127 pre-schools (70% of the building stock)	28	US$ 100 /m² floor area
PB-03	EE Retrofit Program of municipal medical facilities (hospitals, policlinics, etc.) including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 396,496 m² in 28 public health buildings (80% of building stock)	36	US$ 90/m² floor area
PB-04	EE Retrofit Program of other municipal facilities (administrative, cultural facilities, libraries, etc.) including: a) Retrofit of building envelop; b) Modernization of heating and hot water system	– 116,640 m² in 5 public admin buildings (90% of the building stock)	8	US$ 70/m² floor area
PB-05	Replacement of indoor lighting for all municipal buildings including advanced control	– 1,909,884 m² in 330 public buildings (90% of the building stock)	17	US$ 9/m² floor area
PB-06	Solar Hot Water Program for education and medical facilities	– 120 solar systems 40 m² collector	1	US$ 10,000 per unit
PB-07	Building Energy Management Systems for large buildings (>	– 200,000 m² for BEMS in 20 buildings	1	US$ 5/m² floor area

[42] All assumptions made for this assessment are available in Annex 2 of this report.
[43] Initial costs estimates on the basis of 2017; including material, equipment, installation and VAT

Code	Energy Saving Measures	Details of applications	Estimated investment costs[43]	
			(million US$)	Specific costs
	20,000 m²)			
PB-08	Program of efficient water-saving faucets (cold and hot water) with motion sensors	– 36,000 water users in 360 public buildings (90% of the building stock)	1	US$ 20per user
PB-09	Program on enrgy efficient entrance doors: automatic closers or air curtains	– 3,600 outside doors in 360 public buildings (90% of the building stock)	1	US$ 300/ door
PB-10	Program on energy-efficient electric appliances: computers, kitchen equipment, etc.	– 10,000 appliances in 200 public buildings (50% of the building stock)	5	US$ 500/device

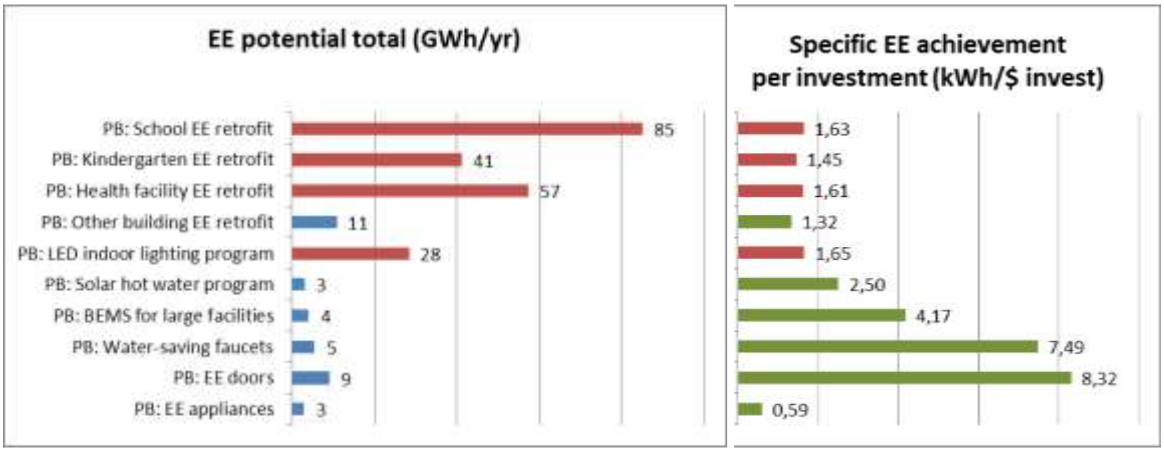
Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving[44] (million kWh/year)	Annual energy cost savings (million US$ /year)[45]	Simple Payback time (years)[46]
PB-01	PB: School EE retrofit	EE 45% district heat	141	1.6	33
PB-02	PB: Kindergarten EE retrofit	EE 50% district heat	68	0.8	37
PB-03	PB: Health care facility EE retrofit	50% district heat	95	1.1	34
PB-04	PB: Other building buildings EE retrofit	40% district heat	18	0.2	41
PB-05	PB: LED indoor lighting program	50% power use	53	3.0	6
PB-06	PB: Solar hot water program	RE – heat 70%	5	0.1	22
PB-07	PB: BEMS for large facilities	20% district heat and power	7	0.1	13
PB-08	PB: Water-saving faucets	10% of hot & cold water consumption	9	0.1	7
PB-09	PB: EE doors	30% heat losses through doors	15	0.2	7
PB-10	PB: EE appliances	15% power	6	0.3	16

[44] Primary energy savings considering the primary energy factor, e.g.,1.9 for power, 1.7 for district heat, 1.0 for other energy carriers.
[45] Assumption of energy cost increase of 1.5-2% per year
[46] Considering energy cost savings only

If this entire package would be implemented, Astana could save up to 247 GWh/year, which represents 35% of the consumption as compared to baseline year 2015. If the primary energy factor for heat and power is applied, Astana could save 416 GWh of primary energy. The specific annual primary energy savings per each dollar invested could reach 2.8 kWh per each US dollar, which is a good ratio for public building EE investments. Primary energy in the form of 87,000 tons of coal per year can be saved. Highest savings can be achieved by EE retrofit of education and health care facilities, with a good cost benefit ratio of 1.6 kWh annual saving per invested US dollar.

Figure 44: Public buildings EE measures: energy savings potential and specific annual savings per investment



The implementation of this package could avoid energy related costs of US$ 7 million per year. The average simple payback time[47] of the entire investment package is 21 years. Although it would save up to 60% of energy, a complete building retrofit is quite costly - up to 160 US$/m². Replacement of the lighting system in buildings is easy-to-implement and profitable, with only six-year payback time.

In addition to energy savings and lower energy bills, the EE measures in the municipal building offer multiple benefits, like improving comfort in the facilities and extending the overall life-time of the building. Since the building retrofit is a complex EE intervention, it is recommended to start with a set of easy-to-implement pilot projects in the facilities that are in need of repair. The approach can help the city to gain experience and build capacity for complex project planning and implementation.

Recommended implementation schedule

Ideally, this investment package should start off with a combination of PB-01, PB-02, PB-04 and PB-05 measures under a sub-program "Complex energy efficiency retrofit of municipal schools, kindergartens, hospitals" that could include thermal retrofit, EE lighting and RE heating for the buildings with highest energy consumption and saving potential. A combination of EE measures in public buildings can have less than 25 years of payback time, which is less than the project lifetime or extended lifetime of the building. In addition to economic benefits, these interventions help improve indoor comfort for children and teachers. Since the CA has limited funds to begin EE interventions to all buildings, a short- to medium-term two-phase implementation schedule is recommended, with 20-25 buildings per year.

The responsible entities for the implementation of this investment packages should be the Astana CA and the divisions of social development, education and health.

Additional non-investment measures could support the investments and help monitoring the results. These could include:

- A benchmark analysis for building energy consumption of all public buildings, together with

[47] Considering additional operation costs and cost savings.

an energy audit program for all buildings;
- The project preparation[48] could use some support for: a) feasibility studies and investment project design; b) technical specification, tendering and procurement; and c) qualified construction supervision along with capacity building and guidance of best practice installation;
- Energy consumption monitoring program;
- Capacity building program for the technical staff operating the facility; and
- Education and behavioral change training for employees/users of public buildings.

Accompanying measures at central government level could include:

- Introduction of green public procurement criteria for energy appliances in public buildings
- Minimum requirements for thermal quality of new buildings
- Certification scheme for buildings
- Leveraging commercial financing using energy service companies (ESCOs) under energy saving performance contracting (EPC) approach.

A couple of pilot projects in the public buildings are recommended below.

Retrofit of 3 hospitals with highest demand for improvement (from PB-03), approximately 110,000 m² heated area	US$ 10 million investment
LED indoor lighting for 200 public buildings	US$ 8 million investment

The opportunity for an Energy Performance Contracting (EPC) under the Public-Private-Partnership (PPP) scheme should be considered, and subsequently develop a business concept.

5.3.2 Priority 2: Investments in Street Lighting

Retrofitting public lights with light-emitting diode (LED) technology from mercury or HPS lamps can significantly increase the performance of the street lighting (SL) sector, lower O&M costs, and achieve significant energy saving, including for maintenance. An average 50% in energy and maintenance-related savings could be achieved, and up to 75% per year over the lifetime of the LED technology. Specific benefits of LEDs include reduced GHG emissions, improved nighttime visibility, better color rendering, less mercury, and uniform lighting distribution that could eliminate dark areas between poles. Typically, LEDs have a long operational lifetime ranging from 50,000 to 100,000 hours, which is roughly 25 years. For street light retrofit a number of factors should be considered based on cost and availability of fixtures, such as type of fixture and bulb wattage.

The EE interventions in the SL sector in Astana would require US$14.5 million investments.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
SL-01	Street + Public Space LED Lighting Program, including replacement and adjustment of power supply network for advanced LEDs: retrofit, voltage stabilization, wiring, time management, diming, remote control	– 30,869 light points – 737 km of SL power supply network (approx. 50% of network)	14	US$ 350 per light point, 5 per m

The EE measures could help the city save up to 20 GWh/year, which accounts for 55% of the energy

[48] The project preparation comprising a) feasibility studies and investment project design, b) technical specification, tendering and procurement, and c) qualified construction supervision along with capacity building and guidance for best practices for equipment installation – will be referred further in the report as **“support for project preparation”.**

consumption for the baseline year 2015. Around 38 GWh of primary energy can be saved. Preliminary estimates indicate that the specific annual primary energy savings per invested dollar is 2.6 kWh/US$. The savings will be mainly 6,500 tons coal per year. Subsequently, the energy savings could translate into 2.1 million US$ per year, while the overall cost savings (including less costs for maintenance and bulb replacement) could be up to US$ 3.8 million per year.[49] The simple payback time of the investment package in the SL sector is four to five years.

The CA of Astana, the division of communal services and Astana Kalalyk Zharyk, the SL operator, should implement these EE measures.

Around 95-98% of light poles in Astana (approximately 5% have already been replaced) and the environmentally sound disposal for the high-pressure mercury bulbs should be replaced. Automatic time control and night dimming shall be added.

The modernization of existing public lighting systems requires detailed information on new technologies and the condition of the SL network. A proper inventory that could be useful for monitoring and maintenance would require a database with the following information:

- Streets/roads: name, street width (lanes for traffic/pedestrians), street category (main road, secondary roads, local roads, etc.)
- Poles: height, distance between poles, type standing pole/wall), brackets, condition
- Luminaries/lamps: type (technical/historical/decorative), technology and capacity of lamps
- Operation: operation control (manually, astronomic clock, photo cells), operating hours, condition of the cabinets and cables, type of supply (public grid, separate grid).

Accompanying non-investment measures in the SL sector are useful in order to help with the investments and provide support for monitoring the results, and could include:

- City-wide integrated public lighting assessment program including energy audits;
- Benchmark analysis for SL energy consumption;
- Procurement guide for new street lighting systems;
- Support for project investments (see footnote 51)
- Energy consumption monitoring program;
- Capacity building program for technical operators of the facilities; and
- Leveraging commercial financing using ESCOs under the EPC approach.

The CA of Astana could focus initially on a short-term pilot project to replace approximately 10,000 lights with LED in Yesil district in the 2018-2019 period, which would require a financial effort of US$ 7.5 million. The **opportunities for an EPC under the PPP framework** should be assessed and, subsequently, a business concept for this delivery mechanism should be developed.

Other investment measures that could help urban development but with limited EE benefits are:

- Expansion of the SL network
- Extension of illumination on sidewalks, promenades, parks, etc.
- Installation of pedestrian street and rail crossing lights

5.3.3 Investments in Public Transport Sector

There are a number of EE interventions that could help extend and improve public transport services in Astana in order to increase the mobility in the city, save energy and GHGs. The five EE measures listed below require US$ 179 million investments.

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[49] Assumption of energy cost increase of 1.5-2% per year reduction of costs for maintenance and bulb change.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(US$ million)	Specific costs (million = M)
PT-01	Convert the diesel bus fleet into EURO 6 or hybrid busses or compressed natural gas (CNG)	– 250 urban diesel busses (25% of all)	78	US$ 300,000 per vehicle
PT-02	Rail and bus connection “Left bank to airport”	– 50 km new route + vehicles	10	US$ 200,000 /km
PT-03	Development of Bike Sharing Program - Establishment and extension of infrastructure for non-motorized transport (bikes)	– 20 bike share hubs at 50 bikes + 200 km bike lanes	4	US$ 18,000 /km
PT-04	Traffic Flow Optimization, "Intelligent Transportation System of Astana", dispatching system, priority bus lanes	– For 40 bus routes	8	US$ 200,000/ route
PT-05	Construction of Light-Rail Train (LRT)	– 22 km of rails + 16 trains + 10 stations	79	US$2 M/km, US$2 M/train, US$0.3 M /station

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$ /year)	Simple Payback time (years)[50]
PT-01	PT: Replacement of diesel busses by CNG or hybrid	25% diesel	15	0.6	137
PT-02	PT: Airport connection	60% fuel for taxis and cars	8	0.5	20
PT-03	PT: Extend the bike renting system	100% replacement of related car fuel	5	0.3	11
PT-04	PT: Traffic Flow Optimization	5% gasoline/ diesel	7	0.5	18
PT-05	PT: Light Rail Train	0.5% gasoline of individual cars	24	1.6	50

The implementation of this investment package should be able to save up to 53 GWh/year in the transport sector in Astana, which would be 30% less energy than in 2015. The primary energy saved could be the equivalent of 4.3 million liters of gasoline/diesel per year. The energy cost savings could sum up to US$ 3.4 million per year. The simple payback time varies from 10 to over 100 years. Modern, innovative technologies and high costs for associated infrastructure (e.g., tracks and stations) trigger long payback times. Only considering energy cost savings for the economic

[50] The preliminary assessment of the economic analysis is considering only the energy cost savings. Investments into non-energy infrastructure, such as transport generate economic values of improved service/infrastructure which reduce the payback time. A more detailed socio-economic analysis is needed to monetize such co-benefits.

assessment could be misleading since the additional financial and environmental benefits can also justify investing in a modern urban transport infrastructure. Energy cost savings will be achieved by transport operators when replacing diesel and gasoline with cheaper CNG (10-20% less) and by private individuals once they switch from their cars to public transport. This would require an attractive, affordable and reliable public transport.

Interventions in the public transport sector are medium-term measures that should closely coordinated with the transport operators and financially covered by commercial stakeholders. City authorities should facilitate and coordinate between different parties. **The responsible party** for these investments should be Astana Transport Authority.

A few **non-investment measures** that could help set the appropriate environment for the investments include:

- Procurement guide for energy (emission) performance of public vehicles (busses, cars, service truck vehicles)
- For investment projects for express bus:
    - feasibility study and investment project design
    - technical specification, tendering and procurement
    - ensure CNG fueling capacities
- Capacity building program for relevant technical people.

The city should carry out an integrated public transportation development study combining optimized bus routes, express bus-shuttle, and improved connections at public transport hubs.

5.3.4 Priority 4: Investments in District Heating Sector

Central heat is the key supply for space heating and hot water in Astana. The centralized heating system covers 70% of the public residential and industry heat demand in the city. The recommended investments in the DH sector in Astana target losses in the heat generation and improving the distribution facilities – totaling 4,445 GWh as of 2015. They also focus on energy savings at end-users in buildings and industry sector. In addition, investments in the DH infrastructure at end-users can improve the hydraulic balancing, which could allow new connections and consumption-based billing. The eight EE measures listed below would require total investments of US$ 240 million.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs (million =M)
DH-01	DH distribution: Automation of DH distribution flow management; Implementation of SCADA	– 6,846 DH supplied buildings (80% of the building stock)	3	US$ 500 / building
DH-02	DH distribution: Rehabilitation DH Pumping stations; Replacement of pumps (with VSD, reactive power compensation)	– 32 DH pump stations (80% of all)	0.5	US$ 15,000 /pumping station
DH-03	DH distribution: Automated heat substations with improved heat metering (including hydraulic balancing, efficient circulation pumps)	– 6,441 DH supplied buildings (90% of the building stock) – in the frame of a building service PPP	161	US$ 25,000 /IHS
DH-04	DH distribution: DH network rehabilitation, pipeline replacement	– 58 km DH network (10% of the network)	23	US$ 400,000 /km
DH-05	DH distribution: Increase DH supply, storage and balancing capacity by developing DH	– 8 km of DH main pipeline	24	US$ 3 M / km

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs (million =M)
	transmission pipeline between CHP 1, 2 and the new CHP3			
DH-06	Reduction of own consumption on heat and power generation plants	– 10 CHP & HOB units	10	US$ 1 M/unit
DH-07	DH generation: Reconstruction and rehabilitation of district Boiler Houses (BH)	– 16 boiler houses (80% of the facilities)	16	US$ 1 M /BH
DH-08	Steam condensate return from industry steam consumers of CHP 1	– 10 steam users industry	2	US$ 200,000 / connection

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)
DH-01	DH: Automated distribution	EE 2% of distributed heat	148	1.5	2
DH-02	DH: Retrofit of pumping stations	EE 40% of power for DH water pumping	1	0.03	14
DH-03	DH: IHS metering & service PPP	EE 26% DH distribution losses	2.159	21.3	8
DH-04	DH: Pipeline replacement	EE 60% DH distribution losses	175	1.7	13
DH-05	DH: CHP interconnection pipelines	EE 10% of DH losses and DH supply	146	1.4	17
DH-06	DH: Reduction of own consumption	EE 10% power consumption at facilities	100	5.6	2
DH-07	DH: district boiler house retrofit	EE 50% of DH losses at individual networks	49	0.7	22
DH-08	DH: steam condensate return	EE 10% of DH losses at steam networks	21	0.3	7

If all EE measures in the DH are implemented, they could save up to 1,687 GWh/year of energy and diminish by 36% the losses in the heat generation and distribution network. This could trigger 2,800 GWh of primary energy savings, which is equal to 605,000 tons per year. The annual energy cost savings were calculated at US$ 32.6 million. Considering the direct and associated indirect benefits, the EE investments in the DH system are economically viable, with average overall payback time of 8-10 years. These measures can reduce the GHG emissions (annually up to 950 ktons CO_2) and air pollution, since all district heat is coal-generated. It is recommended to begin with measures with rapid investment returns, especially at the heat delivery points, such as automated distribution and individual heating substations. The reduction of own energy consumption in HOBs and CHPs, as well as the replacement of heat pipes are long-term measures that should consider the technical depreciation of the network.

The parties responsible to implement the EE investments in the DH sector could the Astana CA and the division of energy, together with heat generation and distribution providers - Astana Energo Service holding/Astana Energia and Astana Teplo Transit. These pilot projects are part of the investment programs of the heat generation and distribution companies.

Additional non-investment measures may include support for project preparation (see footnote 51).

5.3.5 Priority 5: Investments in Municipal Solid Waste

The TRACE analysis has identified a few EE measures that could improve the solid waste sector in Astana. The six EE interventions listed below would require US$84 million investments.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
SW-01	Fuel-Efficient Waste Vehicle Operations, vehicle replacement: Convert waste collection vehicles to CNG + fueling infrastructure	– 113 waste collection trucks (90% of trucks)	7	US$ 60,000 /truck and share of infrastructure
SW-02	Waste Collection Route Optimization, GPS tracking and hauling management, central dispatch center	– For the entire fleet of 126 waste collection trucks	1	US$ 500/ vehicle
SW-03	Construction of modern waste sorting and transfer station near to CHP plant including sorting, recycling, composting station "Taldykol" + Increase sorting and recycling by placing new container sites and containers enabling sorting	– Covering 70% of waste - 247,100 tons of waste to landfill – 4,000 waste bins	6	US$ 5 M/ unit US$ 300/ per trash bin
SW-04	Bio waste-to-energy: biogas plant	– biogas plant + CHP (approx. 5 MW)	14	US$ 2,800 /kW capacity
SW-05	Landfill Gas Capture Program	– Landfill gas capture plant + CHP (approx. a 6 MW)	21	US$ 3,500 /kW capacity
SW-06	Waste-to-Energy Program - Construction of a waste incineration plant for waste that cannot be recycled	– capacity of 40 MW	35	US$ 700-1,000/kW capacity

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$ /year)	Simple Payback time (years)
SW-01	SW: Collection vehicle conversion to CNG	20% diesel	4	0.2	30
SW-02	SW: Collection route	10% diesel	2	0.1	8

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$ /year)	Simple Payback time (years)
	optimization system				
SW-03	SW: Waste sorting, transfer and recycling station	25% diesel for waste delivery to landfill + revenues from recycling	5	0.6	10
SW-05	SW: Biogas plant for bio-waste	Renewable energy 100%	94	5.3	3
SW-06	SW: Landfill Gas Capture and CHP	Renewable energy 100 % heat and power	56	3.2	7
SW-07	SW: Waste-to-Energy incineration plant	Renewable energy 90% (heat and power. 3:1)	219	5.3	7

The implementation of all these measures will save up to 10 GWh/year (mainly car fuel). Around 226 GWh of energy generated from renewable energy sources (RES) as by-product of municipal wastes (biogas, landfill gas and waste-to-energy) can be produced. The renewable energy produced could be sold and distributed via the heat and energy utilities. Astana can make US$ 14.7 million per year from cost-related savings and revenues obtained from clean energy RE (power and heat).The simple payback time for these investments is six years.

Recommended implementation schedule

Investments in intermediate transfer stations comprising of sorting, recycling and composting facilities (SW-03) need a comprehensive concept and feasibility study that should tackle the entire waste management cycle in Astana – from waste collection and transport, recycling and disposal to the landfill. The CA of Astana should also think about replacing the waste trucks with new vehicles.

Additional non-investment measures in the solid waste sector can help enable the appropriate environment for key investments and monitoring and evaluation (M&E) aspects. These could be:

- Elaboration of a complex study of municipal solid waste system for Astana including collection, transport, recycling, landfill and RE generation.
- Support for project preparation (see footnote 51)
- Waste collection monitoring program
- Education campaign for waste sorting and reduction
- Capacity building program for technical operators of the waste management facilities.

The CA of Astana and its Division of Natural Resources, the local waste collection companies (Astana-Tazartu and Taza Alem Astana) and the landfill operator (Astana Eco Poligon) should get involved in these investments.

5.3.6 Priority 6: Investments in Potable Water & Wastewater

Eight EE measures with a total cost of US$ 81 million have been identified to improve the water and wastewater sector in Astana, of which US$54 million for interventions in water supply and US$ 27 million in sewage/sanitation.

Code	Energy Saving Measures	Details of applications	Estimated investment costs

			(million US$)	Specific costs
PW-01	Increase performance of water distribution networks; Replacement of outworn pipelines and valves	– 303 km water distribution pipes (25% of network)	30	US$ 100,000 /km
PW-02	Improve Efficiency of Pumps and Motors in the water supply system	– 2 pumping stations (5% of all)	0.2	US$ 80,000 /station
PW-03	Active Leak Detection and Pressure Management Program	– 60 control points	0.2	US$ 4,000/point
PW-04	Improved Water Metering and Remote Metering	– 221,826 metering points (80% of all)	22	US$ 100 /meter
PW-05	Support program for residential users for Water Efficient Fixtures and Fittings	– 443,652 customers (80% of all)	1	US$ 2 /fixture
WW-01	Improve Performance of sewer/ canalization networks, new mainline collectors; replacement of the obsolete networks	– 141 km water sewage pipes (20% of the network)	7	US$ 50,000 /km
WW-02	Improve Efficiency of Pumps and Motors, Modernization of WW pumping stations	– 100 pumping stations (70% of all)	8	US$ 80,000 /station
WW-03	Biogas production from sludge at the wastewater treatment plant	– 1 biogas plant + CHP (approx. 5 MW)	13	US$ 2,500 /kW capacity

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)[51]
PW-01	PW: Retrofit water network	80% Power for pumping of water losses	3	0.2	178
PW-02	PW: Retrofit pumping stations	10% Power for pumping	0	0.0	8
PW-03	PW: Active leak detection	5% Power for pumping of water losses	1	0.0	6
PW-04	PW: Improved water metering program	12% Power for pumping of water losses	7	1.2	18
PW-05	PW: Water saving fitting program for residents	15% Power for pumping	9	0.5	2

[51] The preliminary assessment of the economic analysis is considering only the energy cost savings. Investments into non-energy infrastructure, such as water and waste water generate economic values of improved service/infrastructure which reduce the payback time. A more detailed socio-economic analysis is needed to assess such co-benefits.

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)[51]
WW-01	WW: Retrofit of sewage network	60% Power for pumping of WW losses	7	0.1	93
WW-02	WW: Retrofit of pumping stations	40% Power for pumping of WW losses	9	0.5	16
WW-03	WW: Biogas plant using sludge	Renewable energy power 100%	47	2.6	5

The implementation of this investment package in the water and WW sector in Astana will save up to 19 GWh/year (mainly electricity) and could produce annually 25 GWh of biogas. The clean energy produced could cover the electricity necessary water pumping or could be sold to the power utilities. Considering the primary energy coefficient for power (saved or substituted by RE power), the primary energy savings obtained are expected to 83 GWh per year or 14,400 tons of coal per year. The energy saving ratio for water and wastewater sector is at 27% of the energy consumed in 2015.

The savings and revenues obtained from the sale of RE produced or the costs-savings of the energy avoided could amount to US$ 5.2 million per year. The simple paybacks of these investments vary from five to more than 100 years. EE measures dealing with water supply and wastewater network have very long payback times. The network retrofit is a long-term investment program, based the on-going depreciation of the pipes. Straight forward EE measures, such as replacement of pumps and the biogas plant are financially viable in short payback periods. The biogas could be done under a PPP with private companies.

The responsible parties for water and WW EE interventions should be the CA of Astana and its Division of Housing and Communal Service, together with Astana Su Arnasi, the water operator.

Additional non-investment measures could include:

- Support for project preparation of (see footnote 51)
- Energy and water consumption monitoring program;
- Education program for water savings
- Capacity building program for technical operators of the water/wastewater facilities.

Although they have no or very little EE benefits, **there are other interventions** that could help with the water infrastructure development, like expanding the potable water distribution and wastewater collection networks to new city districts and building of a new WW treatment plant.

5.3.7 Priority 7: Investments in Residential Buildings

The EE measures in the residential sector in Astana target primarily the centralized heating system of multi-apartment residential buildings. They target to reliable and affordable heating service for residents, increase room comfort, health and living condition, expand the lifetime of buildings, metering and consumption-based billing to reduce non-technical losses and energy waste. The EE measures listed below would require investments of US$ 253 million.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
RB-01	Installation of individual heat meters in all apartments and consumption-	– 4,446 multi-floor residential buildings	11	US$ 20 / meter

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
	based billing	(70% of building stock)		
RB-02	Program for efficient lighting in public spaces of multi-storey residential buildings (staircases, LED & sensors)	– 5,082 multi-floor residential buildings (80% of the building stock	6	US$ 1,100/ building (5-10 light points/ staircase)
RB-03	Retrofit of residential multi-store buildings (15-year program), window replacement, insulation of building envelope	– 1,681,995 m² multi-floor residential buildings (10% of the building stock)	118	US$ 70/m²
RB-04	Solar Rooftop for Residential Buildings	– 381,120 m² roof area on multi-floor residential buildings (20% of the building stock)	119	US$ 2,500 per kWp of PV module

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)
RB-01	RB: Individual heat metering and billing program	5% heat to multi-floor residential buildings	175	1.3	8
RB-0	RB: Public space EE lighting	50% power	14	0.8	7
RB-03	RB: EE retrofit of buildings	50% heat to multi-floor residential buildings	250	1.8	65
RB-04	RB: Solar (PV) rooftop program	RE power 100%	143	19.1	6

The interventions could save up to 341 GWh/year. Measure RB-01& RB-02 targets around 70 to 80% of the multi-storey residential buildings stock in Astana. Measure RB-03 targets 635 multi-floor buildings (10% of the building stock) and could save up to 50%, as compared to 2015. The specific annual energy savings per invested dollar was calculated for 2.3 kWh/US$, which is a good ratio for residential building EE retrofit. Final energy savings will be heat (77%) and power generated from RE, plus total primary energy savings of 583 GWh, which is 161,000 tons of coal per year.

The simple payback time[52] for these investments varies from eight to more than 60 years. Metering and public space lighting have a relative short payback time of seven to eight years, while a complete building retrofit that could save up to 50% energy savings and increase the level of comfort is a costly long-term investment.

Recommendations for implementation

Solar rooftop energy (measure RB-04) can generate US$ 19 million under the current feed-in-tariff

[52] Considering additional operation costs and cost savings

(FiT) regulation. This intervention has six to seven years' payback time. It could be implemented by commercial, professional operators or could be part of a PPP.

Energy cost savings for residents (measures RB-01-RB-03) could get to US$ 4 million per year. Some of the energy cost-saving benefits will be at the DH operator and some at the end-users, with no direct returns to the municipal budget.

There are additional non-investment measures in the residential sector that could support implementation of main investments, as well as with the monitoring the results. There include:

- Introduction of energy efficient procurement criteria for new residential buildings;
- Development of a building code for new and existing buildings with minimum thermal quality requirements;
- Mandatory energy audits and certification scheme for buildings;
- Financing program for residential building rehabilitation (window change, thermal insulation, efficient boilers etc.) in cooperation with commercial banks in the form of credit lines with partly grant contribution from the government;
- Building inventory on all residential buildings
- Support for project preparation (see footnote 51)
- Energy consumption monitoring program
- Capacity building program for the technical staff operating the facility and home-owner associations.

Also, there are measures that could contribute to urban residential housing development, despite of having no or very limited EE benefits. One such intervention could be development of new residential buildings with high EE performance.

5.3.8 Priority 7: Investments in Private Transport

The shift of passengers from individual private vehicles to an attractive public transport can lower emissions and improve air quality in Astana. Since buses are owned by private operators, investments in new, more efficient vehicles is up them, with any say from city authorities. Hence, a number of soft infrastructure and regulatory measures could reduce the use of individual cars have instead people shift to public transport. The capital investment necessary for the three EE interventions outlined below is US$ 116 million.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
IT-01	Enforcement of Vehicle Emissions Standards, empower technical inspectors, service stations, penalty for non-compliance	– 134,500 individual and commercial vehicles (50% of the fleet)	101	US$ 100 per inspection
IT-02	Increase attractiveness of low-emission vehicles: Development of Vehicle Charging Infrastructure Electric, LPG and CNG vehicles (20+20 stations)	– 40 fueling stations for individual and commercial vehicles (5% of the fleet)	12	US$ 300,000 per charging/fueling station
IT-03	Car Parking Management and Restraint Measures in the city center + inspection service	– Applied to 30 km of roads (2% of the fleet)	3	US$ 3,000 /km + 15 parking-management

Preliminary energy saving benefits and economic analysis

Code	Short title of measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)
IT-01	IT: Enforcement of Vehicle Emission standards Program	10% fuel for individual and commercial cars	244	15.8	6
IT-02	IT: Fueling & charging stations for low-emission vehicles	15% fuel for individual and commercial cars	37	2.4	5
IT-03	IT: Traffic & Parking Restraint in the city center	20% fuel for individual and commercial cars	20	1.3	2

Of these three EE measures were implemented, they could save up to 301 GWh/year (equivalent to 28 million liters of car fuel). The payback time for these measures is between three to six years. Although municipal investments must achieve fuel savings, the fuel and fuel cost savings in this case will be at the individual (private or commercial) car operator, with no returns to the city budget.

5.3.9 Investment Package I: Commercial & Industry Sector

It must be mentioned upfront that investments in commercial and industrial buildings are totally up to the respective entities, according to their business strategy, EE potential and profitability of EE projects. In many cases, commercial entities lack information on EE/RE technologies and have limited access to finance. The table below outlines a couple of measures that should stimulate EE and RE generation in this sector from the local government's perspective, with US$ 69 million investments.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
CB-01	Development of EE credit lines for SME, commercial and industry with special incentives for Astana (grant or tax deduction component)	– 137 relevant commercial entities (10% of all)	27	200,000/ measure on average
CB-02	Information and support program for Solar Rooftops for industrial and commercial buildings	– 134,280 m² roof area on large industry buildings (20% of the building stock)	42	2,500 per kWp of PV module

Support programs can be in the form of credit lines (in cooperation with commercial banks or with the local agency focusing on industry), blended with grant incentives (5-10% as investment grant, loan repay, loan guarantee, or tax deduction/depreciation scheme). The estimated financial contribution from the city sources is between US$ 10 to US$ 15 million.

Preliminary energy saving benefits and economic analysis

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$ /year)	Simple Payback time (years)
CB-01	CB: EE credit line	40% share of energy use in	124	5.2	5

Code	Measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$ /year)	Simple Payback time (years)
		energy intensive industry			
CB-02	CB: Solar (PV) rooftop program	Renewable energy power 100%	50	6.7	6.5

These two measures could save 174 GWh/year of primary energy, with a theoretical payback time of five to seven years. The beneficiaries of the energy cost savings are the commercial facilities. The RE generated from the solar rooftops on the industrial facilities (measure CB-02) could make US$ 6.7 million/year in revenues under the current feed-in-tariff (FiT) policy. The RE produced could be sold to the power utility. The payback time is six to seven-years. This measure shall be implemented by commercial professional operators or under a PPP, but this should be decided by the respective commercial entity. The municipality of Astana could help develop the respective ESCO services.

5.3.10 Priority 10: Investments in Power Sector

The preliminary identified EE investments in the power sector aim to reduce losses in the distribution system also and generate RE. The total investments needed are around US$ million 156.

Code	Energy Saving Measures	Details of applications	Estimated investment costs	
			(million US$)	Specific costs
EL-01	Solar Photovoltaic plant; 40-50 MWp	– 300,000 m² PV area RE power – capacity 0,04 GWp) generation	94	US$ 2,500 per kWp of PV module
EL-02	SMART metering program: automated electricity metering for commercial entities	– 5,475 commercial entities	2	US$ 3,000/ meter
EL-03	Construction and modernization of substations and replacement of few 110 kV lines by 10 kV lines (nearby CHP)	– according to the defined program of AES	60	

Preliminary energy saving benefits and economic analysis

Code	Short title of measure	Energy saving (%)	Annual energy saving (million kWh/year)	Annual energy cost savings (million US$/year)	Simple Payback time (years)
EL-01	EL: PV plant	RE power 100%	113	15.0	6
EL-02	EL: Smart metering	2% power	5	0.6	3
EL-03	EL: Replacement sub-stations & transmission lines	30% of power losses in related network	70	3.9	15

The measures regarding power distribution (EL-02 and EL-03) could save primary energy up to 37

GWh/year. A new solar PV plant of 40-50 MW could produce 60 GWh/year of RE. Considering the primary energy factor for electricity in Astana, the primary energy savings could total up to 188 GWh per year (the equivalent of 33,000 tons of coal used for power generation). The RE generated by the solar PV plant (measure EL-01) should be implemented either by a subsidiary of AES, the power generation company, or it could be done under a PPP delivery mechanism. Operations contracts for RE are profitable for power generation projects under the FiT scheme. Under the attractive FiT scheme in place, this could enable some good revenues, up to US$ 15 million/year.

5.4 Projected Program Results and Benefits

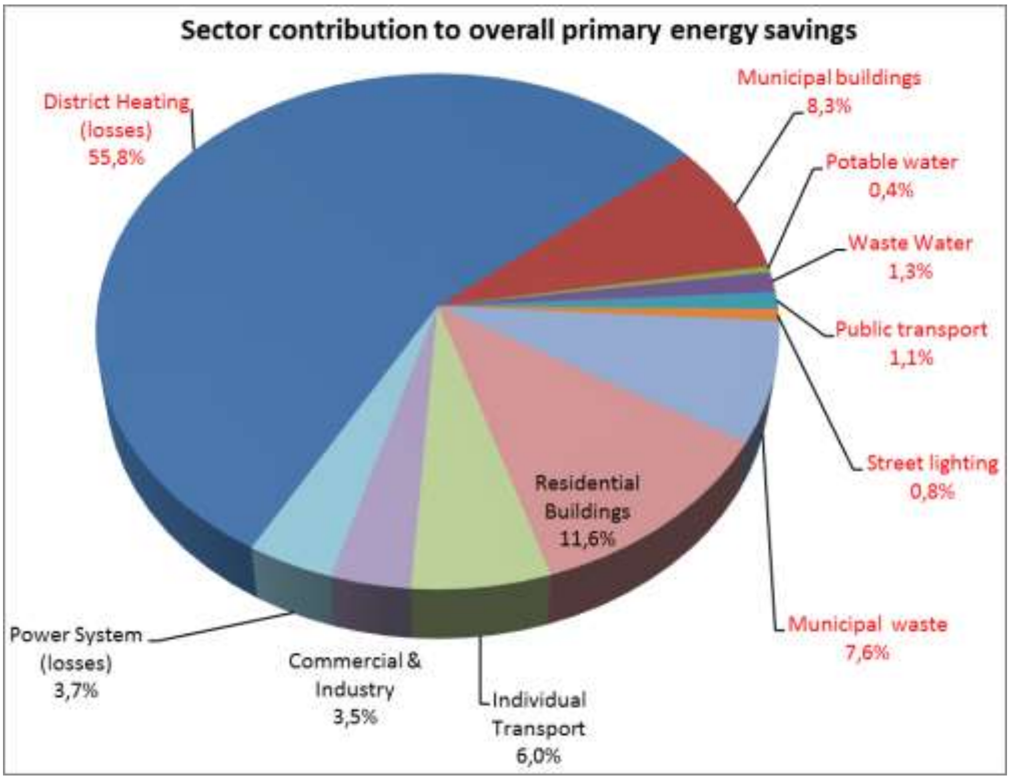
5.4.1 Energy Savings by Sector

The implementation of the municipal EE plan could save up to 5,013 GWh/year of primary energy in the target year of 2030, which is equivalent to 23% of the city-wide primary energy consumption of the baseline year 2015.

The primary energy savings in the seven municipal energy sectors that are the CA control local (street lighting, water/wastewater, municipal buildings, district heating, waste management, and public transport) amount to 3,767 GWh/year. This figure is 75% of achievable city-wide energy savings and for 17% of the city-wide primary energy consumption as of 2015.

The highest energy savings could be achieved in district heating by reducing losses related to heat generation and distribution - 2,800 GWh/year of primary energy. Medium energy savings potentials of some 7-8 GWh/year have been identified in public transport, power (losses) and water/wastewater sectors. Lower energy savings were estimated for street lighting and waste sectors.

Figure 45: Sector contribution to overall annual energy saving potential of 5,013 GWh/year



The total cumulative energy savings related to the EE program between 2018 and 2030 are 75,600 GWh, resulting in a specific investment demand of US$ 0.02 per saved kWh of energy, which is in the energy costs range for public and residential customers at the 2015 level.

The overall final energy savings of 3,139 GWh/year are projected to result in city-wide energy cost savings of US$ 125 million per year.[53] The final energy savings of 2,288 GWh/year that could be achieved in the seven sectors under the city control would translate into US$ 67 million per year. In addition there will be some financial benefits, such as less cost for O&M, extension of the lifetime of the facilities. The interim and final targets of the EE program for Astana are listed below in Table 15.

Table 14: Energy saving targets

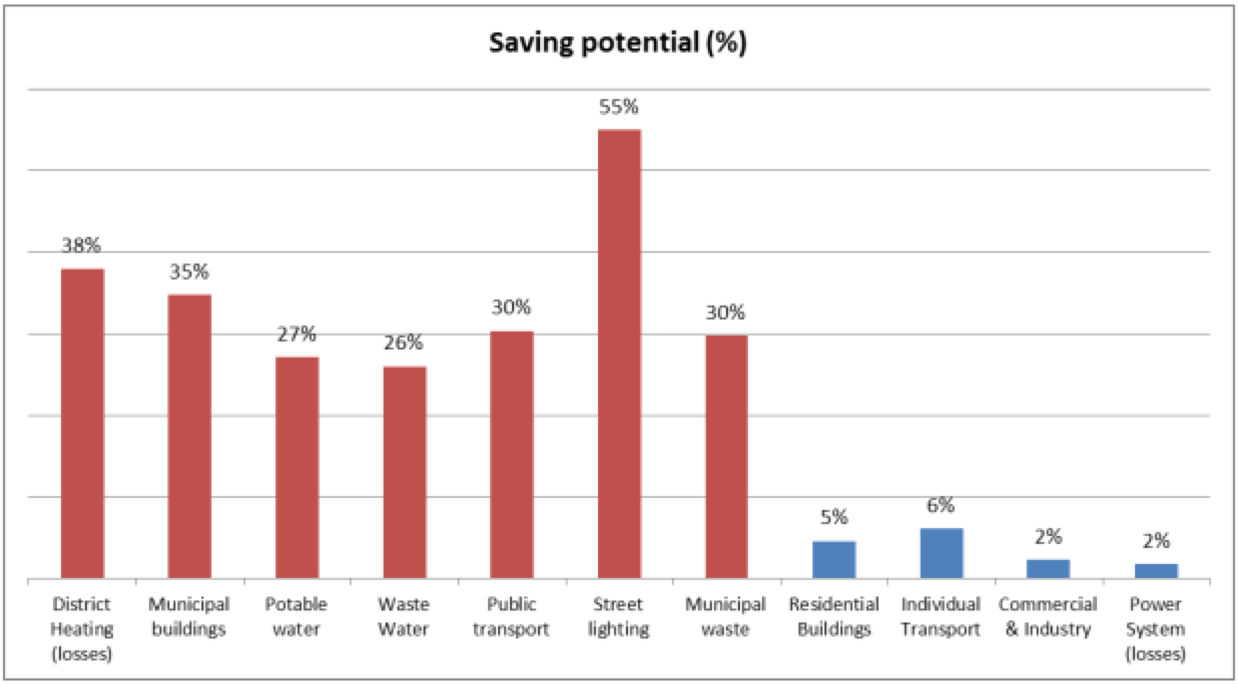
Years	2015 Value	2022 Target		2030 Target	
Municipal sub sectors	Primary energy consumption (GWh/year)	Primary Energy saving compared to 2015	Annual primary energy saving (GWh/year)	Primary Energy saving compared to 2015	Annual primary energy saving (GWh/year)
District Heating (losses)	4,445	26%	1,175	63%	2,798
Municipal Buildings	711	25%	175	59%	416
Potable Water	40	21%	9	51%	20
Wastewater	32	81%	26	194%	63
Public Transport	174	13%	22	30%	53
Street Lighting	37	43%	16	103%	38
Municipal Waste	34	471%	159	1120%	379
Residential Buildings	5,761	4%	245	10%	583
Individual Transport	4,887	3%	126	6%	301
Commercial & Industrial Sector	3,576	2%	73	5%	174
Power System (losses)	2,283	3%	79	8%	188
TOTAL	**21,985**	**10%**	**931,175**	**23%**	**2217,798**

Most of the primary energy savings (94%) can be achieved through coal savings of 1 million ton per year, which is about one-third of the amount used to produce power and heat in the city. Other major savings could come from car fuel, up to 28 million liters per year.

The relative energy saving ratio is high in all municipal sectors, between 25% and 55%. The TRACE study has identified lower saving ratios below 5% for non-municipal sectors (such as residential, commercial and private transport). This is primarily because the recommended EE measures in these sectors focusing on support programs or soft infrastructure and regulatory measures can target some of end-users only. Additional energy savings as a consequence of increasing urbanization, such as regulatory measures in the housing sector, are not considered at this stage.

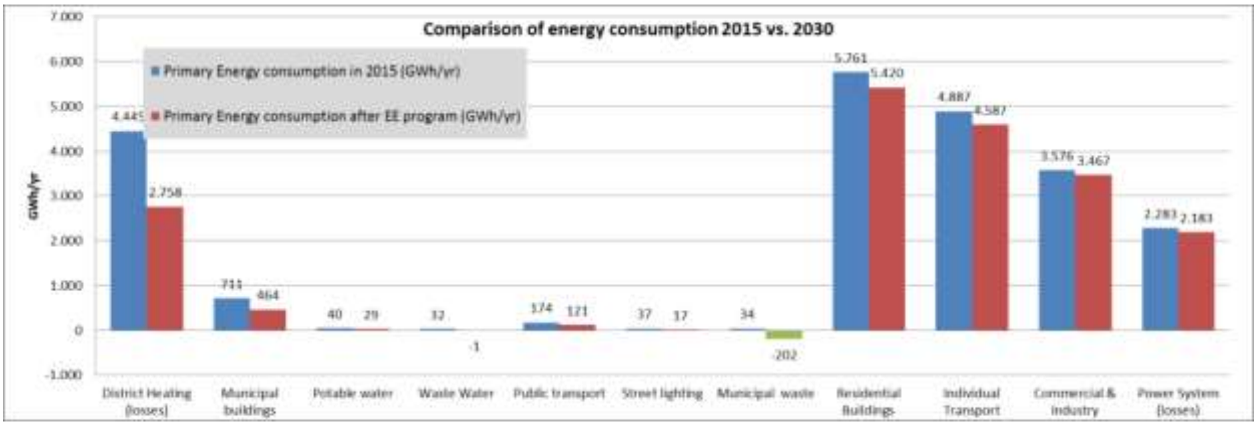
[53] This is calculated based on an annual energy cost escalation scenario of 2-3% for the period 2018 to 2030.

Figure 46: Achievable energy saving ratios by sector



A comparison between energy consumption in 2015 and estimated energy needed after the full implementation of the EE program in 2030 shows that the energy intensity of the sectors under municipal control could be substantially reduced by overall 37%. The municipal waste sector can even turn from an energy consumer (vehicle fuel) to a net energy producer (power & heat) by generating RE from waste.

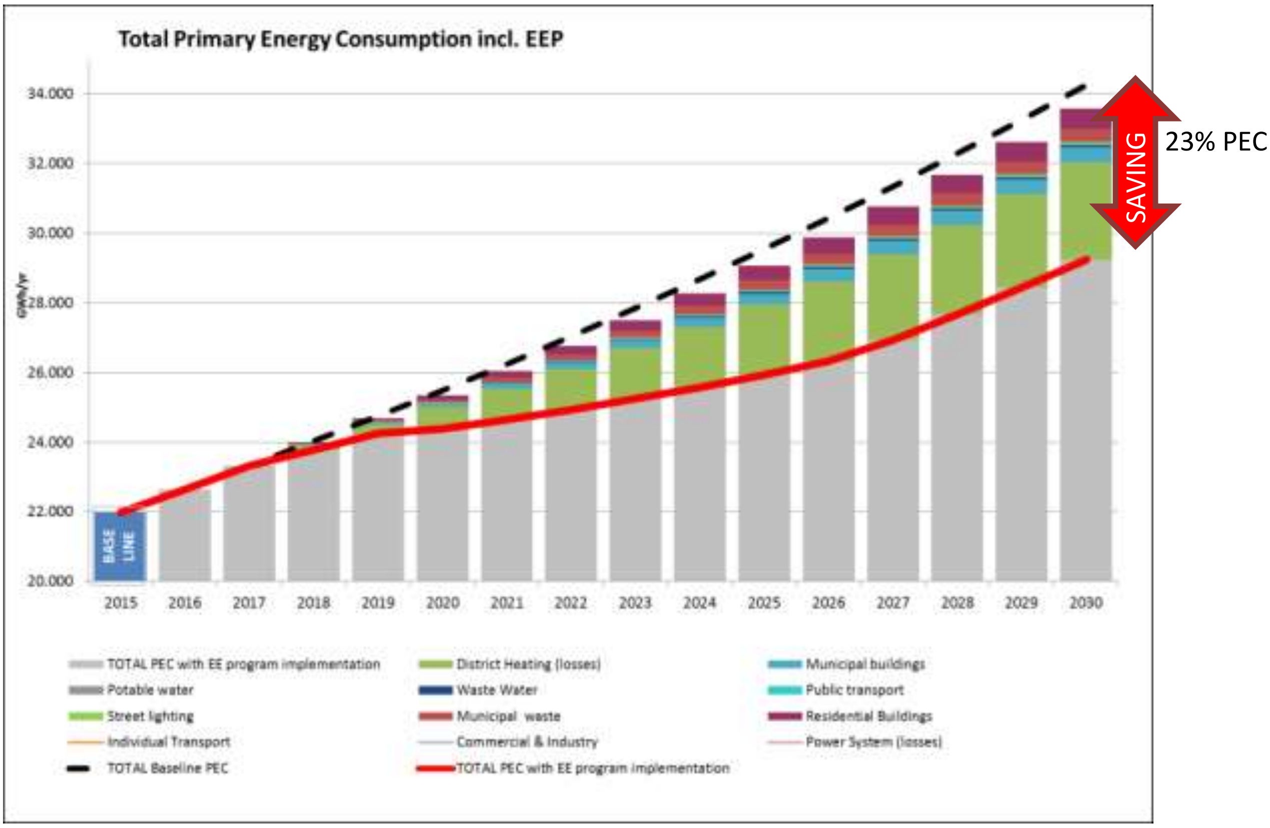
Figure 47: Comparison of energy consumption 2016 vs. 2030



5.4.2 Impacts on Primary Energy Balance

Assuming 3% annual increase in the city population would have a great impact on the local economy and municipal services, hence the Primary Energy Consumption (PEC) will rise by 55% by 2030 (to 34,250 GWh/year). If the EE program is going to be implemented starting 2018 could overturn this trend and help reduce energy consumption drastically. A projected increase in the PEC of 55% can be reduced by at least 33% (see Figure 58).

Figure 48: Projected annual primary energy saving achievements up to 2030



5.4.3 Emission Savings

The implementation of the EE program could lead to 1.7 million tons of CO_2 equivalent, which is 24% less when compared to the baseline year 2015 (7 million tons of emissions). Over the entire program implementation of 12 years up to 18 million tons of cumulative emission can be mitigated. There is some high potential to reduce particle emissions from the local CHPs and boilers that currently use coal with currently limited filter technology. Diminishing the use of coal by 1 million tons annually could substantially improve the air quality in Astana. The costs for the specific emission abatement are US$ 806 per ton CO_2 per year, which is almost three times higher than the global average for an EE investment.[54] However, the high specific decrease costs are because some costly measures in some sectors, like water, transport or waste have low energy/emission savings, but higher additional benefits, such as comfort and improving the quality of supply service.

[54] Climate Change 2014: Mitigation of Climate Change; Cambridge University Press; http://www.ipcc.ch

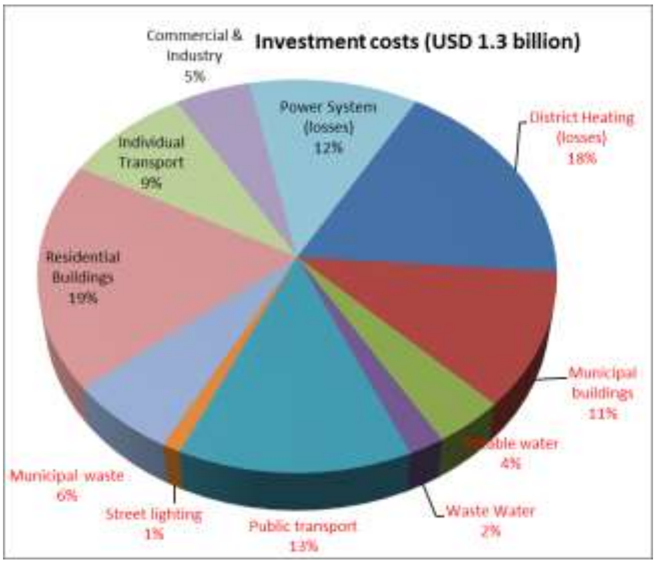
5.5 Economic and Financial Analysis of the Investment Measures

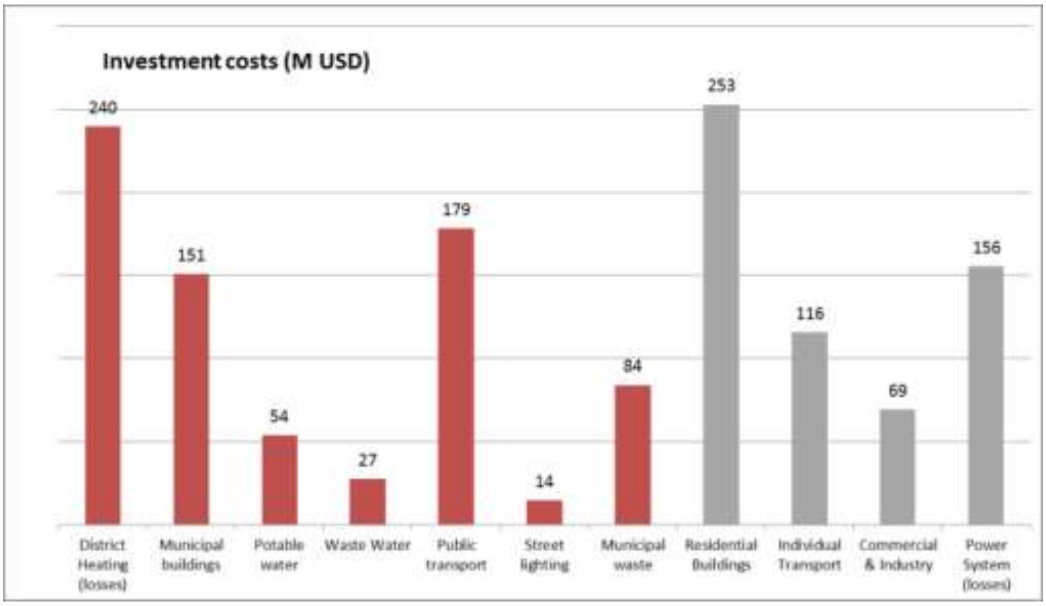
5.5.1 Initial Costs of EE Investment Measures

The total estimated costs for all 50 energy EE investment measures amount to US$ 1.34 million, of which:

- 30% for power & district heating;
- 22% for public and private transport
- 11% for municipal buildings
- 6% for potable water and wastewater
- 6% for waste sector
- 1% for street lighting
- 19% for residential buildings
- 5% for commercial & industry

Figure 49: Shares and costs of investment cost by sector





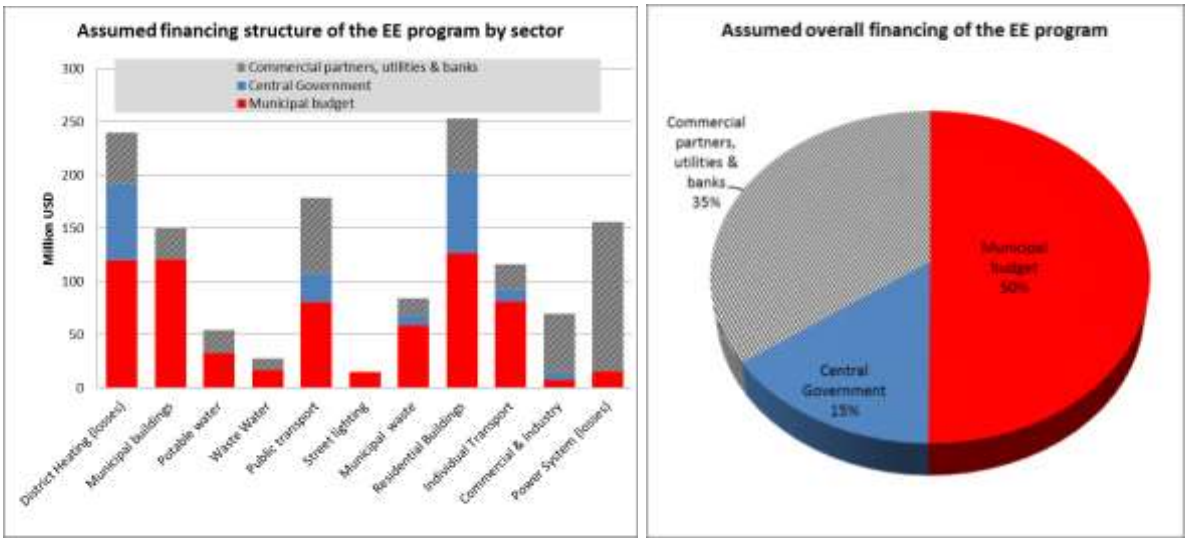
5.5.2 Preliminary Structure of Program Financing

As described in the Sector Analysis above, there is a wide range of ownerships of the facilities, responsibilities and control over the municipal sectors, and expected benefits. Thus, different stakeholders should take part and contribute to financing and implementing this municipal EE program. The table below outlines potential stakeholders and funding sources.

Stakeholder	Main related sectors or projects	Financing source and type	Total expected financing to the EE program
CA of Astana	Public Buildings, Street Lighting, Waste, Public Transport (partially) Residential Buildings and District Heating	Municipal budget (grants)	US$ 673 million - 50% of the total
Central government	• Utilities: gas, power, water	Government	US$ 201 million, 15% of

Stakeholder	Main related sectors or projects	Financing source and type	Total expected financing to the EE program
agencies/ministries	• Agencies: transport, waste • Partly residential buildings and District Heating	programs (grants or loans)	total
Commercial entities (service suppliers)	• Utilities: District Heating, power, water • ESCO: buildings, industry • Domestic commercial banks and IFIs: credits for street lighting, buildings, commercial	Commercial funding (equity or loans)	US$ 468 million, 35% of total

Figure 50: Assumed financing structure of the EE program by sector and funding source



The recommended investment packages need a phased implementation. This is justified by a number of issues, such as a) complexity and investment demand, b) different priorities due to investment profitability, c) time to prepare the feasibility studies and financial structuring, and d) available capacity and framework as key pre-requisites for a successful implementation. It is recommended to start with short-term measures between 2018 and 2022 to deliver immediate energy savings and benefits, and then continue with long-term measures for the 2023-2030 period.

The EE program could be implemented in four phases:

→ Phase I: start in 2018

→ Phase II: pilot and most profitable projects during 2018-2020 (5-8% of total costs)

→ Phase III: intensive implementation phase during 2020-2025 (10-11% of total costs)

→ Phase IV: completion of remaining long-term projects during 2026-2030 (4-6% of total costs).

The annual financing demand during the most intensive project implementation phase between 2019 and 2025 will be in the range of US$ 120 to US$ 140 million per year.

Figure 51: Speed of program implementation

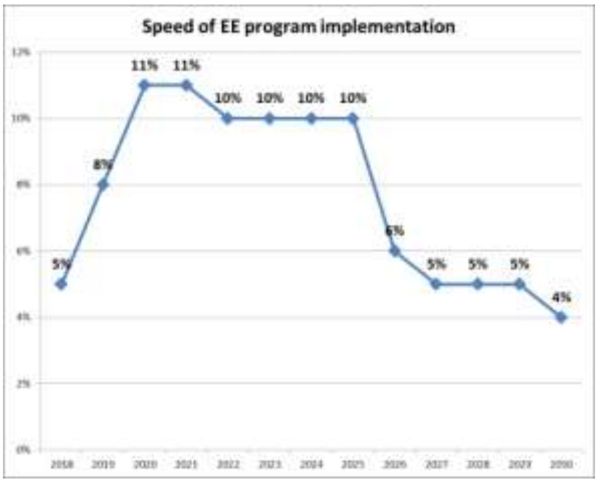
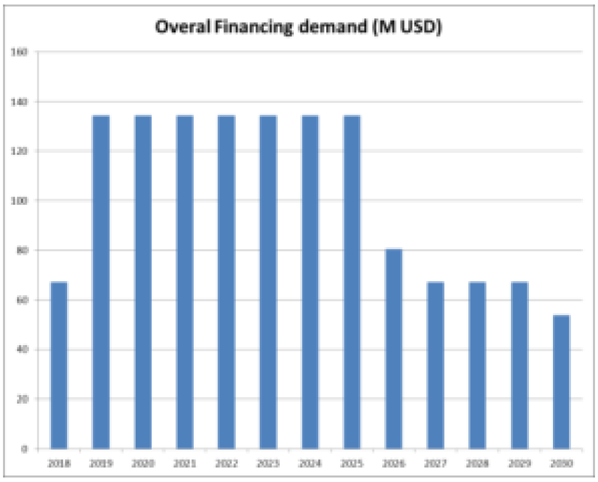
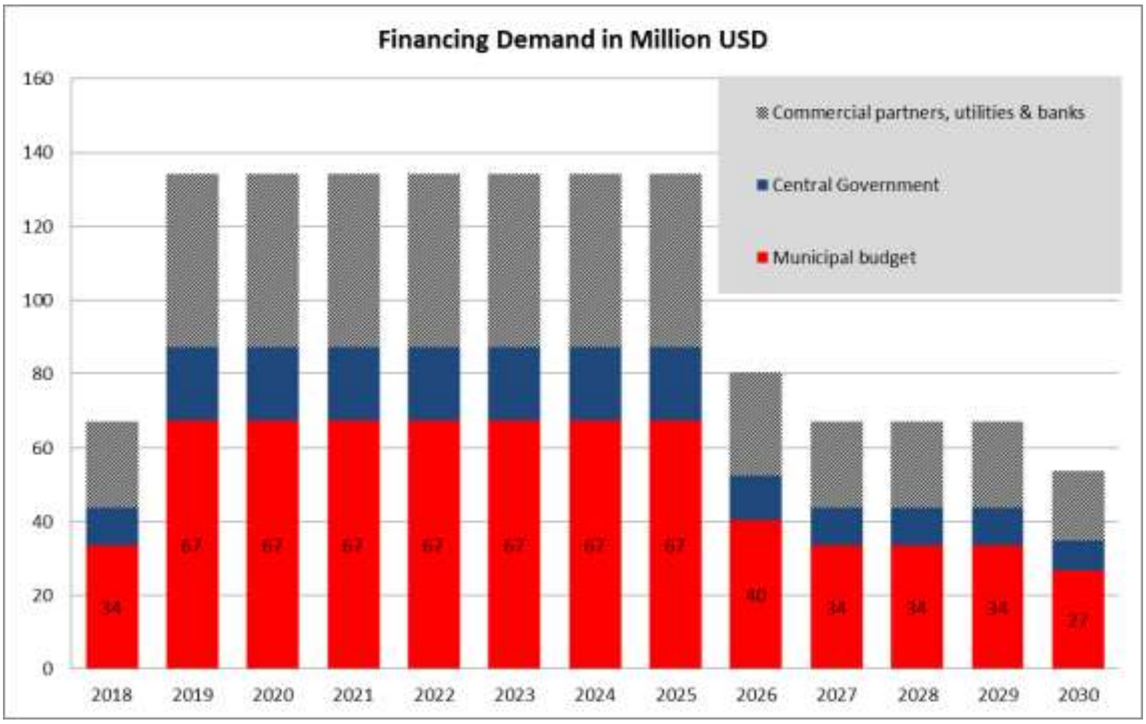


Figure 52: Annual financing needs (million US$)



The annual financing demand from the city budget (50% of the total) should be between 40 and US$ 67 million, which is 4% of the local budget. The maximum financing of US$ 67 million is at the same level as the projected annual energy cost savings by implementing the EE program.

Figure 53: Financial demand for implementation of the EE plan from different funding sources



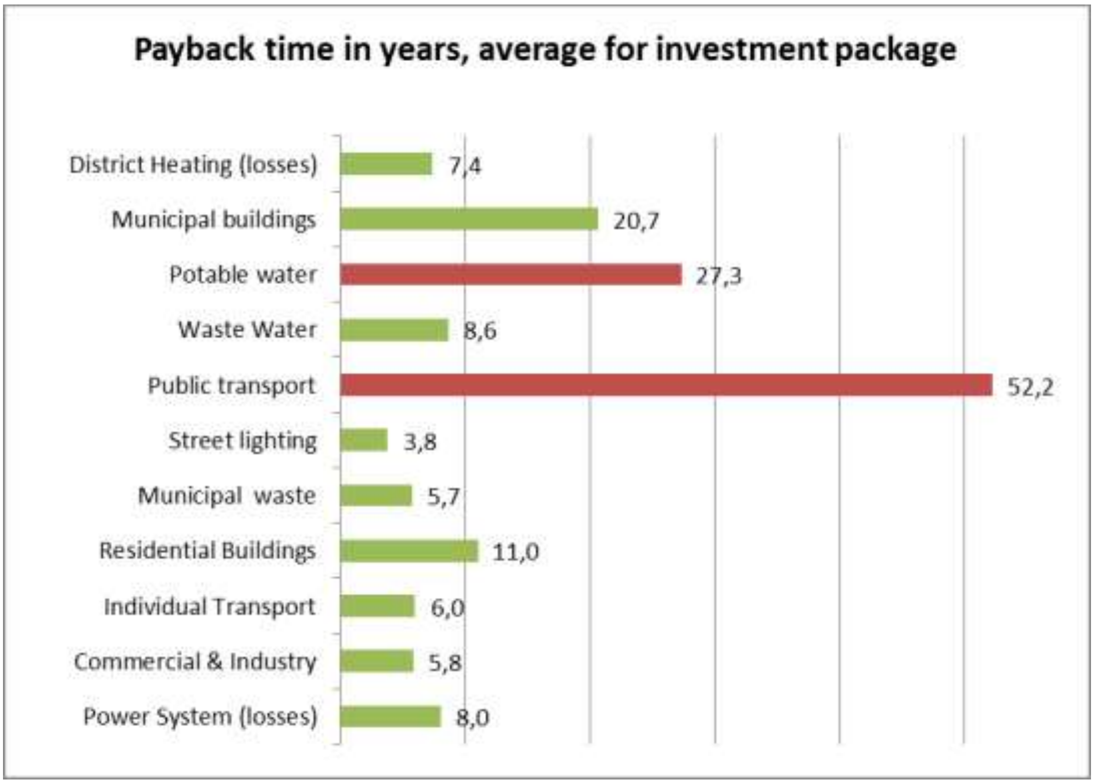
The CA should undertake some steps to facilitate co-financing from governmental programs (grants or loans), IFIs and commercial banks (loans), and also stimulate the utilities and commercial partners to take part in the EE program. This would include (i) preparation of concrete projects or sub-programs, (ii) development of appropriate delivery mechanisms and (iii) development of sound financing/project proposals.

5.6 Profitability of Investment Packages and Ranking for Implementation

The profitability analysis of the investments depends on a few elements. These are: a) the energy savings ratio compared to the baseline consumption of the facility and potentially avoided energy demand; b) saved energy costs[55]based on specific energy tariffs and forecasts, and c) the investment costs for the EE measures.

The assumption used to calculate the payback time is the energy cost reduction compared to the energy costs of the baseline year 2015. The payback time for each measure varies depending on the investment costs and financial benefits, between four to more than 30 years.

Figure 54: Average profitability of investment packages



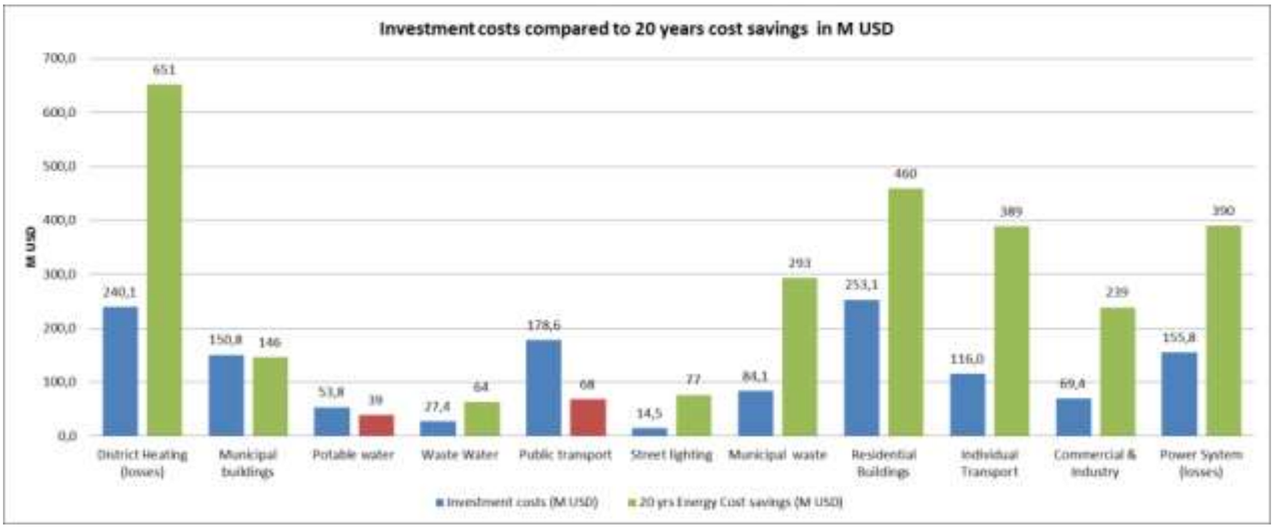
The overall specific primary energy savings is 3 kWh per year US$ dollar invested. In some sectors, such as potable water supply and public transport, the short-term socio-economic and environmental benefits must be taken into consideration in the cost-benefit analysis. Payback times between 20 to 30 years for EE buildings retrofit seem quite long, but these investments are paid back throughout the lifetime of the building, in addition to gaining comfort inside the facility.

A rough comparison between investment costs and achievable energy (and maintenance) cost savings over a 20-year period shows that in most sectors the **cost savings exceed the investments**, which is a positive ratio over the lifecycle. As mentioned above, energy savings investments in public buildings, water and wastewater sectors are long-term measures, while the decision to undertake EE interventions in these sectors should consider the comfort and environmental gains. The proposed investments in waste, wastewater, street lighting and transport are less costly and have high profitability due to additional, monetary and environmental benefits.

EE investments that target losses in the power and heat generation and distribution system are profitable with less than 10 years payback time. Similar level of profitability is indicated for investments in RE generation, such as biogas, landfill gas, waste-to-energy and solar PV. These projects have great potential for PPPs and to attract private investors.

[55] Including an assumption of additional non-energy costs benefits (maintenance) or additional operation costs

Figure 55: Investment costs compared to 20 years cost savings



Based on upfront investment capital and profitability by payback time, EE investments can be of three types, as shown in Table 16 below.

- Investments below US$ 5 million with relative **good** profitability in potable water, district heating, public building and waste sector and LEDs in street lighting should be implemented first.
- A few of medium-sized investment volume projects indicate **acceptable profitability** within the lifetime of the equipment. These projects are in the building, district heating and waste sectors and should be implemented in the short- and medium term.
- Large-scale investments above US$ 50 million, like public and residential building retrofit and public transport infrastructure development, are **long-term investments** with **long payback time**. The additional comfort, social and environmental benefits pertained to these interventions could make a case to implement them on the short- and medium run.

Table 15: Payback time of projects according to investment level

Investment range	Payback time < 10 years	10-20 years	Above 20 years
US$ 0-5 million	• DH: Automated distribution • DH: Steam condensate return • PB: Water-saving faucets • PB: EE doors • PW: Retrofit pumping stations • PW: Active leak detection • PW: Water saving fitting program for residents • SW: Waste collection truck route optimization system • IT: Traffic & parking restraint in center • EL: Smart metering	• DH: Retrofit of pumping stations • PB: BEMS for large facilities • PT: Extend of bike renting program • RB: Automated heating sub-stations	• PB: Solar hot water program
US$ 5 – 50 million	• DH: Reduction of own energy consumption • PB: LED indoor lighting program • WW: Biogas plant from sludge • SL: Street + Public Space LED Program • SW: Biogas plant for bio-waste • SW: Landfill Gas Capture and CHP • RB: Individual heat metering and billing program • RB: Public space EE lighting • IT: Fueling & charging stations for low-emission vehicles • CB: EE credit line • CB: Solar (PV) rooftop program	• DH: Pipeline replacement • DH: CHP interconnection pipelines • PB: Other building EE retrofit • PB: EE appliances • PW: Improved water metering program • WW: retrofit of pumping stations • PT: Traffic Flow Optimization • SW: Waste sorting, transfer and recycling station & new bins	• DH: District boiler houses retrofit • PB: Kindergarten EE retrofit • PB: Health facility EE retrofit • PW: Retrofit water network • WW: Retrofit sewage network • PT: Connection to the airport • SW: Waste collection vehicle conversion to CNG • SW: Waste-to-energy incineration plant
Above US$ 50 million	• DH: IHS metering & service PPP • RB: Solar (PV) rooftop program • IT: Enforcement of Vehicle Emission standards Program • EL: PV plant • EL: Replacement sub-stations, transmission lines		• PB: School EE retrofit • PT: Replacement of diesel busses by CNG or hybrid • PT: Light Rail • RB: EE retrofit of buildings

6 Implementation Plan

6.1 Implementation Strategy

A successful implementation of the municipal EE plan requires ownership and a great deal of commitment from municipal stakeholders. A structured sector analysis to define challenges and measures and understand the associated co-benefits should be developed. It is important to coordinate local policies in order to address the barriers across all sectors. The CA plays a crucial role in setting the cross-sectoral framework for EE. Local authorities can stimulate EE investments and accelerate implementation through a few strategies and policies. Once in place, monitoring, enforcement and evaluation of such strategies are crucial in identifying the gaps and achieving the targets. Also, by compiling the end-user data and reporting it to decision makers could help the stakeholders become more knowledgeable about EE policies.

Hence, the city should focus on the following three key areas:

(i) **Adoption of the EE plan** by the municipal council to set and endorse the EE targets (→ **stakeholder involvement**);

(ii) Development and promotion of **sustainable EE financing mechanisms** (e.g., apply for funds from central governmental programs, loans, commercial banks and PPP schemes) that takes into account multi-year energy savings to repay EE investments; and

(iii) Strengthening **EE delivery capacity** at the CA level by setting up a dedicated **EE unit** responsible for overseeing the implementation of the EE plan.

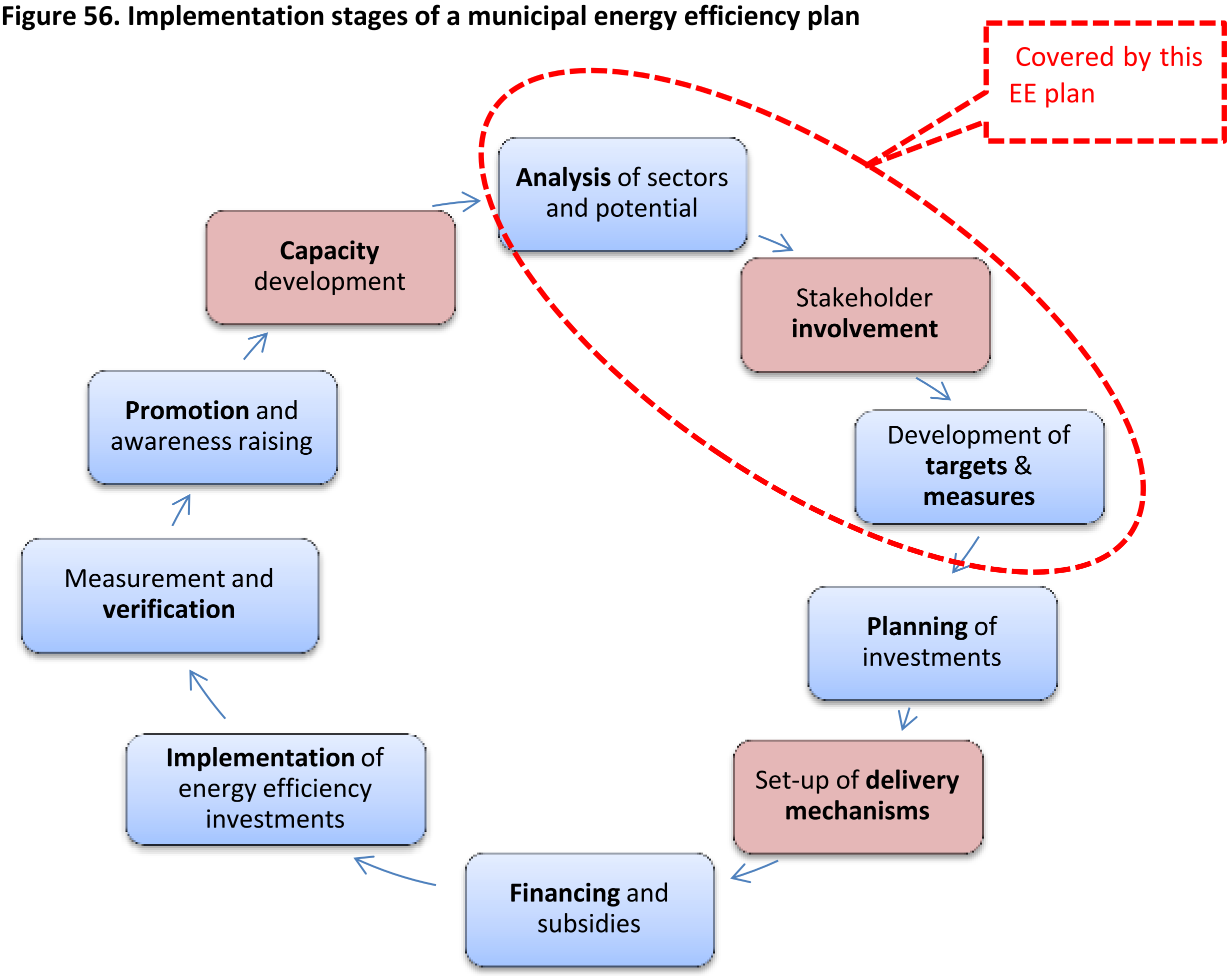
The three pillars necessary for the implementation strategy of the EE plan are summarized follow.

Table 16. Pillars for the EE program implementation strategy

Institutional and capacity development	Financing and delivery mechanisms	Support regulatory framework measures
❑ EE Strategy and Action Plan (in progress) ❑ Energy Efficiency Municipal Task Force ❑ Establishment of municipal energy management (EM) division, enhance and extend its powers, and enable cross-sector activities and communication ❑ Implementation of energy saving responsible in all CA divisions, including training and a certification ❑ Awareness raising and EE promotion programs for all sectors ❑ Capacity building programs ❑ Inventory of all public buildings ❑ Information program and guidelines for EE technologies, EE procurement and project preparation	❑ Feasibility studies and Capital Investment Planning ❑ Purchasing and Service Contracts ❑ Energy Performance contracting ❑ Establishment of a municipal energy service company (ESCO) ❑ Development of municipal EE revolving funds ❑ Preparation of EE project application to "Nurly Zhol" program ❑ Support program for public institutions EE investment projects	❑ Developing a set of regulations and methods for energy saving ❑ Establishment of test databases and laboratories for product certification ❑ Minimum EE performance indicators for equipment and material for new and retrofit ❑ Green Building Guidelines for New Building permits

Figure 56 below outlines the steps necessary for a successful implementation of a municipal EE plan. The first three steps are covered by this municipal EE program.’

Figure 56. Implementation stages of a municipal energy efficiency plan



The measures aimed at reducing energy consumption in the public sector should ultimately help curb the energy costs, hence create some fiscal space for other government expenditures (e.g., social services, social infrastructure investments, etc.). However, there are several constraints, even in developed countries, that can pose challenges for the implementation of EE programs, such as accounting rules, rigid public sector procurement rules and limited access to budget or project financing. For instance, the procurement criteria about the lowest price do not reflect the life-time benefits of the energy saving investments. High quality materials and equipment with good energy performance are more expensive, but they are able to achieve higher energy cost savings during their life-time cycle. A key element in achieving long-term benefits is to have a professional construction and equipment installation. The lowest cost for installation/construction works might not always benefit of experienced, professional workers. Consequently, public procurement procedures should be adjusted in order to select an offer that combines equipment and works performance together with most optimum cost and life-time benefits. For this purpose, the quality related requirements in the technical specification of the tender documents must be mentioned very clearly, and this should be reflected as such in the evaluation process.

Key factors for implementation of EE program are listed in Table 17 below.

Table 17. Key factors for implementation of EE programs

Commitment	Coordination	Capacities
✓ **Commitment and ownership** of an integrated program by top city managers ✓ Government level **defined targets** ✓ Established link of EE policy to the city development policies ✓ EE potential recognized as **key pillar** of sustainable development	✓ **Pool of stakeholders** and decision makers from the city and utilities to agree on the conceptual approach ✓ **Comprehensive analysis** of sector features and challenges, consumption and spending ✓ **Prioritized sectors** for EE intervention ✓ Investment plan prepared ✓ Preliminary projects identified and pilot projects under way ✓ Coordination of EE measures is integrated in the CA	✓ **Understanding** that EE investments could generate economic **returns** ✓ Turn technical proposals into an **investment plan** to approach financers ✓ **Cooperation** with IFIs & donor funding mechanisms ✓ **Mobilization** of international development assistance ✓ EPC as delivery mechanisms ✓ **Capacity** for project and program implementation

6.2 Strengthening Energy Efficiency Delivery Capacity

Building institutional capacity and establishing a focal point focusing on EE in the city is critical for any successful implementation for an EE program. This could be done by establishing a dedicated municipal division for energy EE within the CA.

The existing sub-division for Energy Efficiency within the Division of Energy of the CA of Almaty focuses on heat and electricity supply, and has limited cross sector outreach to other municipal service sectors, such as transport, waste or public buildings. The EE sub-division should undertake more responsibilities pertaining to EE in the public service areas, as well as coordinate and implement the recommended municipal EE program. However, the staffing, responsibilities, tools, project management skills and the capacity to perform adequate energy monitoring and investment planning of the EE sub-division are rather limited. The CA could use some support to build institutional capacity in order to be able to implement the EE program. Best practices in European Union countries illustrate that Municipal Energy Agency (MEA) is the most adequate entity that could help implement the EE program.

6.2.1 Recommendation 1: Establishment of a Municipal Energy Agency

6.2.1.1 Role and Mandate of the Municipal Energy Agency

The CA of Astana should establish a MEA, with its main role of managing implementation of the city EE program, as well as providing support throughout the execution of the EE interventions. As outlined above, the overall city transformation towards EE can be achieved only by applying a spectrum of investment and non-investment interventions, in addition to technical and non-technical measures. Some accompanying measures to enable the sound preparation and implementation of the EE investments, such as auditing, project structuring, development of tenders, financial structuring and fund raising, as well as monitoring and verification of EE results, are needed.

In order to improve the energy performance for all end consumer groups, including residential, commercial & industrial and public sectors, the city should have information and benefit of support in raising awareness and stimulating EE projects, initiatives and final investments.

6.2.1.2 Tasks of the Municipal Energy Agency

Some preliminary tasks of the MEA should comprise of general horizontal activities, in addition to specific strategies and measures in buildings, district heating and transport sectors.

A) General Horizontal Activities

- **EE data collection and indicators***:* Reliable, timely and detailed data on final energy use, technologies and opportunities in all sectors that could contribute to the development of EE strategies and policies.
- Establishment of a **Municipal EE task force**: This should involve regular meetings of stakeholders to inform and report on program implementation progress and develop EE solutions.
- Transforming EE technical proposals into a viable investment plan to approach financers/ donors.
- **Capital investment planning** for EE measures comprising preparation of pipeline of investments, financial structuring and fund raising.
- **Investment project support**: Organizing and supervising technical specifications, tendering and procurement, as well as qualified construction supervision along with capacity building and guidance to apply best practices.
- Preparation, purchasing and **supervision of energy audits** and feasibility studies for municipal educational and medical facilities (an audit program for up to 200 buildings).
- **Public relation implementation support**, dissemination of program results (information made available on relevant homepages, newspaper articles and newsletters).
- **Monitoring, enforcement and evaluation of EE measures:** Monitor, enforce, evaluate, and periodically update EE measures in all sectors. The program effectiveness should be evaluated during and after implementation, and the results should be used as inputs to for future decisions. Monitoring and evaluation with baseline assessments and periodic review and reporting should be established for new policies and measures.
- Setting up of an **energy consumption monitoring program**.
- **Awareness raising and EE promotion programs** for all sectors by organizing events, competitions and awards (e.g., in schools) and development and distribution of information materials on EE.
- Preparation and implementation of a scheme to integrate energy performance and **life-cycle cost assessment** for purchasing and service contracts, procurement guidelines for lighting[56], devices.
- **Preparation of Energy Performance Contracting (EPC)** by setting up the contracting frame, preparatory energy audits, tender documents and procurements of ESCO services.

B) Strategy and Measures in the Building Sector

Buildings hold great potential for cost-effective energy savings. Barriers such as split incentives between users/tenants and owners/landlords, lack of awareness about efficient technologies, absence of qualified technicians and initial high capital investments threaten market-driven energy savings measures. The CA can eliminate these barriers and achieve building sector energy savings by implementing a package of measures, such as:

- ➢ Mandatory building energy codes and minimum energy performance standards (MEPS):
  - All new buildings, as well as those undergoing renovation should meet the energy codes and minimum energy performance standards that tend to minimize life-cycle costs.
  - Support and encourage construction of buildings with higher energy performance standards.

[56] Besides quality requirements for materials/products such as lifetime and the fulfillment of standards, tender documents for street lighting should include certain criteria for the future lighting level in refurbished streets in the city. The shift to LED lamps has to be carefully prepared because the municipalities have very limited experience regarding the most appropriate capacity/luminous flux/light distribution. Simple replacement of lights is not enough. Due to new technologies, nowadays the luminous flux of LEDs can be much lower than those of conventional bulbs because LED lights have very focused lighting areas. In addition, the data provided by manufactures in the data sheets for LED luminaries is not yet standardized, hence this might allow some non-comparable bids.

- Implement policies to improve the EE of **existing buildings** with emphasis on significant improvements on building envelopes and systems during the renovation process. Measures should include:
  - An ambitious timeline and renovation rate for cost-effective reduction of energy consumption in existing buildings.
  - MEPS for the building as a whole during the renovation process, including key building-envelope components and energy-using systems.
  - Measures to help building owners and tenants to improve EE in existing facilities:
    - Energy audits, energy ratings and certification schemes.
    - Incentives encouraging investments in long-lasting building envelope and system improvements, and increased market penetration of new high-efficiency products.
    - Training to improve the quality and reliability of building retrofit services.
    - Information on financing opportunities.
    - A strong commitment from the CA to improve efficiency of public-sector buildings
- Require building **energy performance labels or certificates** with information from owners, buyers and renters.
- Establish policies to improve the EE **performance of critical building components** to improve the overall energy performance of new and existing buildings, such as advanced control of district heat supply at end-users.
- Repair/ refurbishment of buildings should include basic EE improvements.

Municipal Public Buildings	• Establishment of a municipal building inventory, benchmarking and energy performance monitoring • Energy audits, heat demand assessment and feasibility studies for retrofit • Capacity building program for technical staff operators of the facility • Education & behavior change of employees/users of the city-owned buildings
Residential Buildings	• Building inventory of all residential buildings • Energy audits, heat demand assessment • Capacity building program for technical staff operating the facility and apartment-owner associations • Energy consumption monitoring program for multi-apartment buildings

C) Strategy and activities in the District Heating Sector

- Heat energy consumption standards should encourage installation of meters and heat control devices close to actual heat consumption (for public/commercial buildings at building level, for residential buildings in apartments/rooms) to provide incentives to regulate temperature according to demand and limit waste of energy.
- Develop regulatory measures to ensure that energy utilities support cost-effective, verifiable end-user EE improvements.
- Ensure that verifiable EE options can compete directly with energy supply options in equipment procurement and wholesale markets.
- Compel appropriate energy sector entities (e.g., regulated utility, competitive retail supplier or third-party entity) to deliver cost-effective EE to end-users.
- Require that energy customers be provided with cost-reflective pricing, supporting information and technology necessary to better understand and manage the use of energy.
- Use energy tariffs as a funding mechanism for EE.

D) Strategy and activities in the Transport Sector

The transport sector remains one of the most challenging areas for improving EE. Several measures could tap energy-savings in this sector, notably:

- Enable policies to increase the overall EE of local transport systems, and promote shift to more efficient transport modes, e.g., increase capacity and attractiveness of public transport.
- Build the infrastructure for green and more efficient vehicles, such as electric or CNG cars.
- Implement and periodically strengthen mandatory fuel-efficiency standards for vehicles.

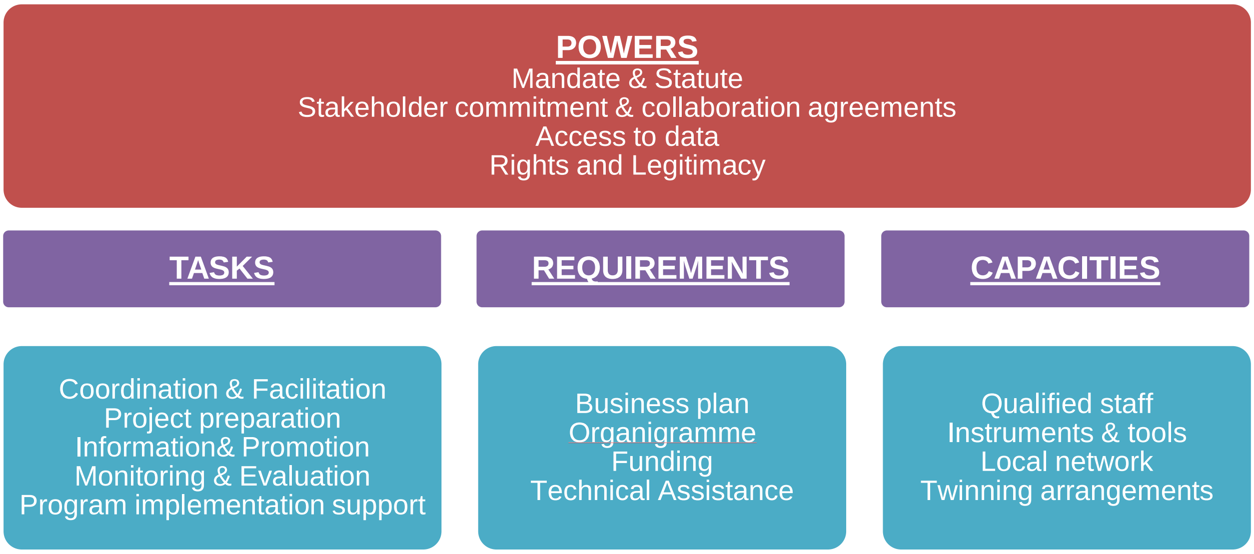
The CA should adopt policies to increase attractiveness of the urban transport, ensuring that

- Users pay the economic, environmental and energy security-related costs of the transport.
- The transport infrastructure is built and maintained to support the most energy and economically efficient and environmentally friendly transport modes.
- Urban and commercial development planning takes into account the likely implications for transport and energy demand.

6.2.1.3 Organization and institutional provisions

The organizational structure of the MEA could be a) commercial legal entity, b) subsidiary of a municipal utility (district heating company), or c) a dedicated administrative unit within the CA.

Figure 57. Key requirements and elements of a Municipal Energy Agency



For the beginning, the only viable option is for the CA to establish a sub-division (or an office) of the existing Energy Division that should act as the MEA. On one hand, the CA have some vetted interested in advancing the EE topic, as they know that successful implementation of EE interventions would help make considerably savings to the municipal budget. On the other hand, the market for business for EE consultancy (e.g., utilities and companies) is not yet mature. Nevertheless, on the medium-run, the MEA should transform into a semi-commercial service provider, once the demand for EE services would rise in other sectors than public sectors.

The key requirements for setting-up of the MEA are a clear mandate, qualified staff and adequate budget. The minimum staffing of the MEA shall be of 10-12 people, including: a director, sector specialists and engineers with expertise in engineering, economists (investment project related), a legal expert and a public relations specialist (for promotion/information tasks). In order to expand the Energy Division of the City of Astana, a capacity building program shall be planned right from the beginning. International donors can be approached to provide technical assistance for business planning and capacity building of the new agency.

Box 2.Municipal Energy Agency Frankfurt (Main), Germany STADT FRANKFURT AM MAIN Energiereferat > Municipal Energy Agency

The Energy Agency (Energiereferat) was founded in 1990 as a part of Frankfurt's environmental department to develop and implement the energy and climate protection plan for the city. In 2008 the city council agreed on a concept of 50 energy savings and climate protection measures. This concept has concrete steps on how Frankfurt can meet its obligations of reducing CO_2 emissions by 10% every 5 years.

The Agency concentrates on four main areas, namely 1) electricity savings, 2) energy planning and combined heat and power supply, 3) reduction of energy consumption and use of renewable energies for buildings, and 4) Masterplan 100% Climate Protection - combining activities in the mentioned areas above

The Agency is developing a concept on how the city can be supplied only by renewable energies by 2050. City residents, architects, urban planners and businesses will be involved in this process.

The Agency's main task is to implement measures for climate protection by bringing together various partners. It sets up feasibility studies and deals and manages with project implementation. The Agency is not a competitor to consultants, planners or investors, but manages projects carried out by different partners. Thus, EE and climate protection can be combined altogether with economic development and job creation.

The City of Frankfurt is member of several European alliances, such as Climate Alliance, Energy Cities and Euro Cities. Frankfurt also signed the Covenant of Mayors in 2008. The Energy Agency is involved in different EU-Projects, such as CHP goes Green (IEE), CASH (URBACT) and PRO EE (IEE).

Source: http://www.frankfurt.de

The Managenergy Network (*http://www.managenergy.net*), established by initiative of the European Union in 2002 aims to assist actors from the public sector working on EE and RE actions at the local and regional levels.

6.3 Promoting Sustainable Energy Efficiency Financing

There are a number of barriers to the implementation of EE programs, including inflexible public procurement procedures for equipment and services and one-year budget appropriations limiting funding of capital upgrades. Financing municipal EE projects can be challenging since cities are often locked into some vicious budget-cycle constraints, while the old infrastructure forces them to use inefficiently use costly energy resources.

EE financing is different from other forms of investment financing. While investment projects are often financed against the underlying asset – a tangible good – EE interventions generate most of their values by future cash-flows obtained from energy savings. Some issues should be sort it out before embarking on the EE plan, such as bundling/pooling of public procurement, multi-year public accounting practices, budget capture and savings retention – benefit sharing schemes.

6.3.1 Financing Mechanisms for Energy Efficiency in Municipalities

The financing mechanisms used typically by cities have an increasing dependence on commercial as opposed to public sources of funding, and they are broadly grouped into four categories.

- **Budget financing with capital recovery.** This includes direct financing from municipal budgets, use of external grants and of budget-capture mechanisms, e.g., fund from the Ministry of Finance (MoF) or a parent budgeting agency using donor funds, with repayments in the form of reduced future budgetary outlays.
- **Dedicated funds developed to address EE**. This requires revolving funds that after being established from the national budget or donor funds to become self-sustaining. The World Bank outlined the design for an EE fund in Kazakhstan in 2016.
- **Direct lending by International Financial Institutions (IFIs) to municipal utilities**. This comprises a public-sector financing mechanisms - provided by donors and/or national or regional governments to municipalities - that can help leverage commercial financing.

- **Leveraging commercial financing using** ESCOs under the energy saving performance contracting (ESPC) approach.

With the exception of budget financing, other funding sources for municipal EE investments require specific mechanisms to ensure repayments of funds, typically through cash-flows generated by reduced energy costs resulting from EE projects implementation. Such repayments need well-defined procedures for determining project baselines, assessment and verification of energy and cost savings, and retention of budgetary savings. Access to non-budgetary financing is linked to the creditworthiness of the municipality, its borrowing capacity, and the delivery mechanisms used for its EE projects. Energy Service Agreements (ESAs) are being used lately to access such financing.

6.3.2 Capital Budgeting in City Governments

The capital budgeting is a tool used for expenditure planning that often includes a multiyear capital improvement plan and preparation of annual capital budget. The capital improvement plan is important because for the purchase, development, expansion or rehabilitation of physical assets, (such as public buildings) requires large money outlays, often beyond the limits of the annual budget. Dedicated long-term planning should ensure that projects are evaluated in a systematic manner, from both technical and financial perspective, thus help the CA select feasible projects that can fit in the municipality's operating and financial capabilities.

Under this approach, financing is provided by a government agency at municipal or central level, such as the MOF, by combining government budget allocations and IFIs or donor funds. This type of funding covers EE investments in public buildings and facilities belonging to the city government. The funding recipient "repays" the funds through savings generated by the investment project in the form of reduced budgets for energy bills in future years ("budget financing"). The energy expenditure is usually based on the energy cost savings. The fund flow to pay for EE improvements follows the same pattern as the regular appropriations from the MOF. The repayment to the MOF could be complete or partial; the partial approach encourages municipal utilities and public agencies to participate in the program because they can retain a share of the savings.

Table 18. The logical flow of a capital planning and budgeting process

Phases	Steps	Results
Planning	Update inventory and assess asset condition; Identify projects; Project evaluation	Infrastructure inventory and analysis of the condition and adequacy of energy and maintenance spending; project list with rough cost estimates (capital improvement plan); detailed construction costs and operation costs; estimation of revenues, comparison with strategic plans, and cost-benefit analysis to identify priorities.
Budgeting	Project ranking	Ranking of projects using capital budgeting methods.
	Financing	Financing arrangements for projects to be included in the budget.
	Budget	Expenditures included in budget proposals of the respective city divisions and placing them in the budget lines; including project operating costs in the long-term budget forecasts for the time when the project is completed and operational.
Execution	Procurement Monitoring	Selection of project contractors; review of physical and financial progress of the project; coordination of spending with revenue flow.
Auditing	External audit	Ex-post review of financial records upon project completion.

The capital budget should have cost estimates for all proposed projects including investment costs and their financial implication on the operating budget. Capital budget preparation requires ranking the project proposals based on the capital budgeting methods, such as payback period, the net present value method, internal rate of return, or profitability index. Box 3 below presents an example of capital budgeting financed by the WB in the Former Yugoslav Republic of Macedonia.

Box 3. Example of Budget Financing: Macedonia

The WB provided a US$ 25 million loan (later expanded to US$ 75 million) to Macedonia to fund the Municipal Services Improvement Project which sought to improve the transparency, financial sustainability and delivery of municipal services in the participating municipalities through a focus on revenue-generating public services and investment projects with cost-saving potential. The loan funds were managed by the Ministry of Finance (MOF) and were on-lent to eligible municipalities through sub-loan and grant agreements on the same terms as the WB loan. The loan repayments were in the form of reduced budget outlays to the municipalities for energy.

Eligible borrowers were creditworthy municipalities that had received MOF approval to borrow, with publicly announced budgets and audit reports. The loan program was supplemented by technical assistance funds for capacity building and institutional reform, and by a performance-based investment grant fund that provided incentives and rewards to cities for implementing initiatives to improve service delivery performance.

Source: World Bank (2009 and 2012b).

6.3.3 Commercial Financing - Provisions and Limitations for Debt Financing

If the city is unable to raise investment funds, it can consider borrowing money from commercial banks and repaying the debt from the cost savings. The city's ability to access external financing is influenced by the national legislation. The city's limited power in raising revenues does restrict its ability to borrow commercial funds for EE projects. Lenders, who are generally more concerned about the city's capacity to service the debt by increasing taxes or user charges, require appropriate collateral/additional resources. Based on banking regulations and commercial lending practices and guidelines, the assets purchased under an EE project are unlikely to be accepted as collateral/additional resources in the case of commercial loans. Many such assets cannot be liquidated to be used elsewhere if the borrower defaults on the loan. Hence, lenders tend to look for either security over municipal assets or for recourse.[57]

The constraints the cities have regarding their own revenues, dependence on transfers and limitations on getting additional resources, in addition to offering recourse to revenue flows – make the local administrations, especially small cities, to be perceived non-creditworthy by lenders. As such, cities may have to rely on new lenders who are likely to need more time to conduct due diligence. Local administrations with bigger and more stable revenues and good borrowing capacity may be able to get money from commercial banks for EE projects.

Also, EE projects generate cost savings, instead of new revenues, relative to a baseline (the costs of energy use in the absence of the EE project). Banks may have issues in defining a baseline, measuring and verifying the savings compared to the baseline, and assuring that EE savings are dedicated to debt service. These challenges can make many banks be reluctant in lending for EE projects. Transaction costs can be another constraint, especially for small cities. Unless lenders are confident that they can develop a portfolio of EE projects with standardized due diligence and processing methodology, they are likely to reluctant to fund EE projects, especially if they know not much about EE investments.

6.3.4 Direct Lending from IFIs to Municipal Utilities

Improving EE in municipal utilities (such as water or district heat supply) often entails large infrastructure investments. Hence, an IFI may provide a loan directly to a municipal utility, with a sovereign guarantee from the national government. Such option has some advantages, as following:

[57] Recourse is used in this respect as: A type of loan that allows a lender to seek financial damages if the borrower fails to pay the liability, and if the value of the underlying asset is not enough to cover it. A recourse loan allows the lender to go after the debtor's assets that were not used as loan collateral in case of default.

- While the municipal utility could repay the loan with low risk, it may not meet the creditworthiness requirements of commercial banks, and therefore, would not get the money without the IFI loan.
- Incentives are aligned between the lender and borrower to seek approval for the economically justified tariffs from the national regulator.
- The IFI and the utility can work together during project preparation and implementation, including on customized capacity building for feasibility analysis, procurement and financial management.

However, one of the disadvantages of this approach is that the IFI should appraise each loan, which would be quite unfeasible for small and medium-sized municipal utilities or projects.
A scheme showing the fund flow for IFIs loans to municipal utilities in presented in Annex

6.3.5 Leveraging Commercial Financing with Private ESCOs

One way to overcome hurdles for financing EE investments could be by introducing the energy performing contracts (EPCs). However, this remains quite challenging for EE financing due to the limitations in municipal borrowing and the early stage for private energy service companies (ESCOs).

The EPC can be a promising delivery mechanism under which an ESCO finances EE investments and, subsequently, gets paid through the full or partial annual energy savings achieved throughout the contract period. Under an EPC, the revenues obtained from energy savings should be used to refinance obligations and also fund other EE interventions. Hence, the EPC could establish a corridor to enable EE savings cash flow from one project to another. The EPC is in line with policies promoted at the highest level in Kazakhstan. The concept of ESCO was outlined during the president's speech on the Kazakhstan 2050 Strategy and its Step #59 referring to attracting investments in EE through ESCOs, as well as during a parliamentary meeting in February 2017 with the MoID.[58]

EE investments under the EPC scheme would first need embarking on a few steps to set an adequate ground for project implementation, including development of the EPC framework, setting up guarantees, and outlining expected results following execution of EE measures.

Private ESCOs can help overcome barriers in scaling-up implementation of EE projects in the public sector. They can (a) offer a range of services throughout energy services value chain and (b) provide the technical skills and resources to identify and implement EE opportunities, execute services using performance based contracts (reducing the risks to the municipal utilities and public agencies), facilitate access from commercial banks, and enable energy users to pay for services out of the cost savings.

Box 4: Energy Service Agreements (ESA)

Under an ESA, EE Revolving Fund, ESCO or other EE agreements, the service provider covers a full package of services to identify, finance, implement and monitor EE projects. The client is usually required to pay in full or partially for their baseline energy bill, and to cover the investment cost and associated fees until the end of the contract. ESA payments can also be bundled with the client's energy bills.

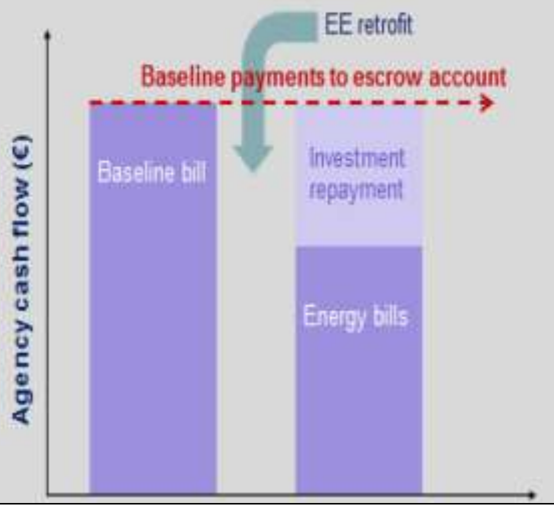
In this case, the figure on the right illustrates how a client's cash flows under the ESA looks like, with payments that are equal to their baseline energy bill. In some cases, the contract duration has a fixed term; in other cases, the contract can be terminated after an agreed level of payment has been made, which can encourage the client to save more energy.

[58] The meeting was held under "Advisory board on economy policy under Nur Otan", with the Ministry of Investment and Development.

For municipal clients, ESAs are generally not viewed by MOFs as municipal debt, since they can be long-term contractual commitments or a form of utility service. If both the client and the Fund are public, public procurement rules may not be required, henc making the financing approach a whole lot simpler. This also provides a dual advantage to the client of having relatively simple agreement and allowing carrying very little risk.

Sources: Authors; Kim et al., 2013. Innovations and Opportunities in Energy Efficiency Finance. New York: Wilson Sonsini Goodrich & Rosati, May 2013

Source: The World Bank; Western Balkans: Scaling Up Energy Efficiency in Buildings, June 2014.



To implement the EPC, a set of legislative, regulatory and policy initiatives are necessary, such as:

- Creating a large and stable demand for energy services projects in the public sector;
- Removing barriers to public procurement of EE services and establishing clear regulations and procedures for public agencies to work with private ESCOs (budget regulation, procurement regulation); and
- Facilitating adequate and affordable financing of private ESCO projects.

For example, the budgets in the public sector are often submitted and approved on a single-year basis rather than an extended (e.g., five years) period. This makes multi-year planning for facility upgrades quite difficult and, in general, can impede the multi-year contracting. The time span of an annual budget is too short for adjusting expenditure priorities. This is particularly problematic for EPCs, since such contracts require several years of energy savings in order to allow recover the investments. Multi-year budgeting could ensure that commitments made by governments are consistent with the medium-term fiscal outlook. Multi-year budgeting would also allow for better connections between policies, planning and budgeting.

6.3.6 Recommendation 2: Establishment of a Municipal Public ESCO

As outlined above, the most appropriate delivery scheme for EE measures should be an EPC operated by a municipal ESCO. A municipal ESCO is the most appropriate entity for developing, financing and implementing EE projects in municipal buildings and street lighting.

The existing legislation on public procurement and budgeting does not allow public entities to sign EPC contracts. Since there is no legislation on ESCO and developing such legal framework would be a long, complicated process, the EPC scheme could be set and implemented under the existing public-private partnership (PPP) legislation. The legal framework for PPP could enable the environment for EPC, help design the EPC contracts (e.g., PPP-EPC), and streamline the revenues for the EE interventions. The maximum duration of a PPP could be 30 years, while a PPP contract could be executed through a Special Purpose Vehicle (SPV) in the form of ESCO.

To attract the private sector, the EPC-PPP scheme should be designed based on a PPP in-built model that would partner a public (super) ESCO with companies from the private sector. The EPC-PPP scheme could take the shape of a public ESCO designed in the structure of a Joint-Venture PPP between the public and private sector. Essentially, two types of stakeholders are involved in the EPC-PPP structure playing a direct/indirect role, namely public and private actors.

The ESCO could be responsible for project development and implementation, and partial project financing. Preparation and monitoring shall be undertaken by an independent or the city affiliated energy agency, while the implementation by a commercial entity, namely the ESCO. This independent ESCO could be a commercial entity with shares from the city CA or a municipal utility. If all EPC-related steps would be implemented by one entity, some bias situations and conflicts of interest would be inevitable, and so the ESCO business would not be commercially sustainable. The disadvantage of this approach is the participation of commercial partners and having standardized procedures for tendering of services. The CA, as beneficiary of the project and of energy savings, could provide loan guarantees or partly contribute to initial costs and return on investments to the ESCO from energy savings.

A separate concept note on EPC-PPP has been developed by the WB team, detailing how this scheme could actually work in the local legislation and policy context in Kazakhstan. It outlines three business models that could be considered by the local authorities, namely service contracts PPP, operation (concession) contracts, and a joint venture under a Special Purpose Vehicle (SPV) in the form of ESCO.

Getting started

To turn the EE program into practice a practical pilot scheme of delivery mechanism needs to be established for the most viable pilot projects, with acceptable capital investment. The CA of Astana could develop feasibility studies for pilot projects and raise funds for the start-up capital for the EPC-PPP scheme in the form of SPV. The EPC-PPP scheme should be tested in municipal public buildings, such as schools/kindergartens and/or street lighting. There could be three types of interventions, as presented below.

a) ***Complex thermal retrofit program of public buildings:*** An EE retrofit investment program in municipal buildings is in line with the suggested measures PB-01/02/03 of the Astana EE program. For the beginning, a pilot scheme could target a pool of buildings with the highest energy consumption and demand for retrofit. **Two options could be considered:** a) 20 schools comprising an overall area of 133,000 m² with average 40% energy savings and investment needs of US$ 9 million, and b) three hospitals with total floor of area 110,000 m² and average 45% EE savings would require US$ 9 million investments.
b) ***Indoor LED lighting program for schools:*** The pilot project could cover 80 large schools, with investments of US$ 5 million that could prompt 50% in energy savings.

If proven successful, these pilot projects could be scaled-up to other buildings (like kindergartens).

c) ***Street lighting by LEDs:*** A pilot program for street and public space LED lighting program could focus on one city district and approximately 10,000 light points. The investment costs are in the range of US$ 7-8 million. Average energy savings of 65% and reduced maintenance costs could save US$ 0.8 million/year, with a payback period of seven-eight years.

Box 5: Municipal Energy Service Company and Municipal Energy Efficiency Revolving Fund in Ternopil

Ternopil, a medium-sized city in the West of Ukraine, has received technical assistance from the WB's ESMAP program to deploy TRACE and develop a municipal Energy Efficiency Transformation Program in 2015. The plan was adopted by the City Council in early 2016. The investment program recommended retrofitting of 46 municipal buildings, mainly schools and kindergartens, for total investments of US$ 11.4, with heat energy saving potential of 60-75% - up to 16 GWh per year. Limited funds from the local budget, on the one hand, and high commitments by the CA, on the other hand, led to a delivery mechanism based on the EPC scheme.

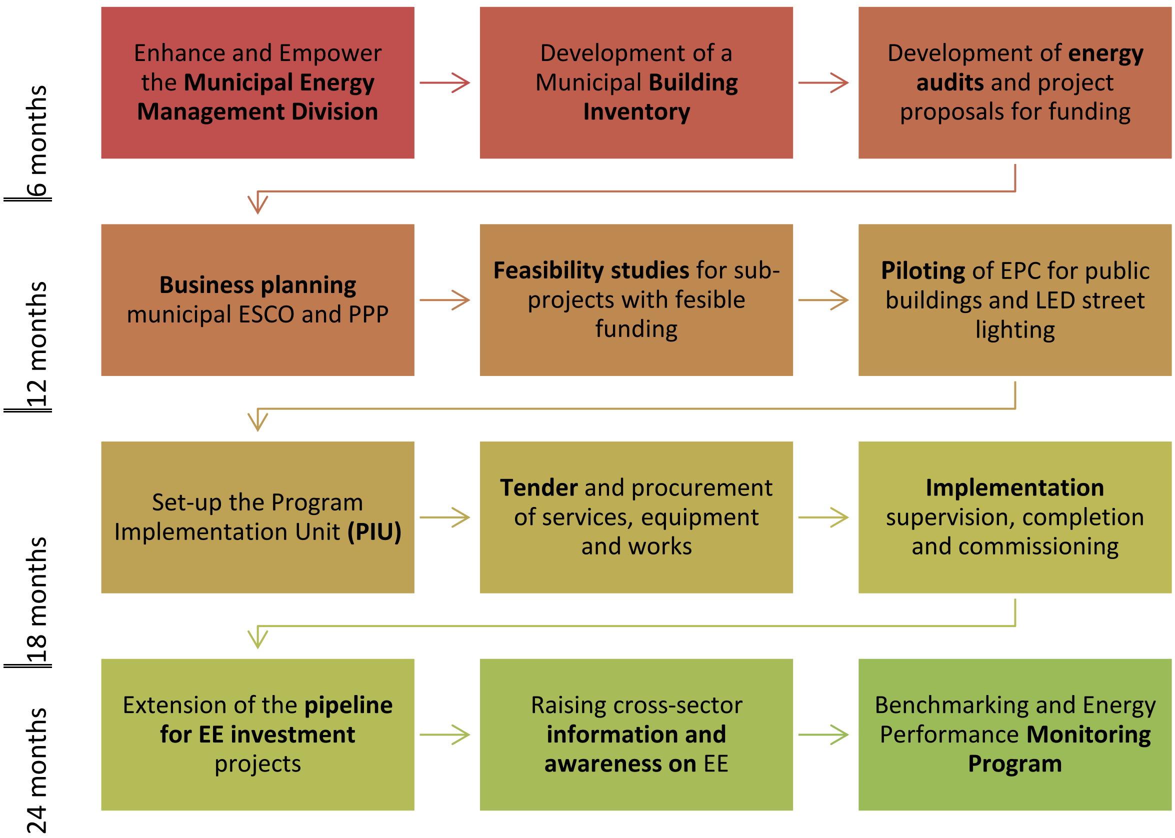
International consultants developed business plan for a municipal ESCO and strategy to the set-up of municipal Energy Efficiency Revolving Fund (EERF) under the city's financial department. The business model is based on a revolving fund that will finance energy saving investments carried out by the municipal ESCO starting with selected and most economically viable buildings. The municipal ESCO will be a subsidiary company of the city owned district heating company, while the EERF will be a separate, fenced account in the city budget, which should help arrange investment contributions for the EE projects identified by the Energy Office of the city. This institutional setting will ensure transparent procedures along with a reduction of transaction and operational costs. This model will use up-front funding from the city budget to retrofit 5 public buildings. The financial benefits are expected to flow back to the EERF, hence provide new capital for EE investment for the next buildings. The EERF provides funds for energy facilities in municipal entities and for investment preparation. The EERF has applied for funds from the Ukrainian Municipal Infrastructure Facility (funded by the European Investment Bank and administrated by the Ministry of Regional Development) for scaling-up EE measures. The implementation based on funds available from energy cost savings revenues will enable 10-15 building retrofits over a 10-years period, while ensuring the financial self-sustainability of the scheme.

Source: World Bank (2016), City Administration of Ternopil (2016)

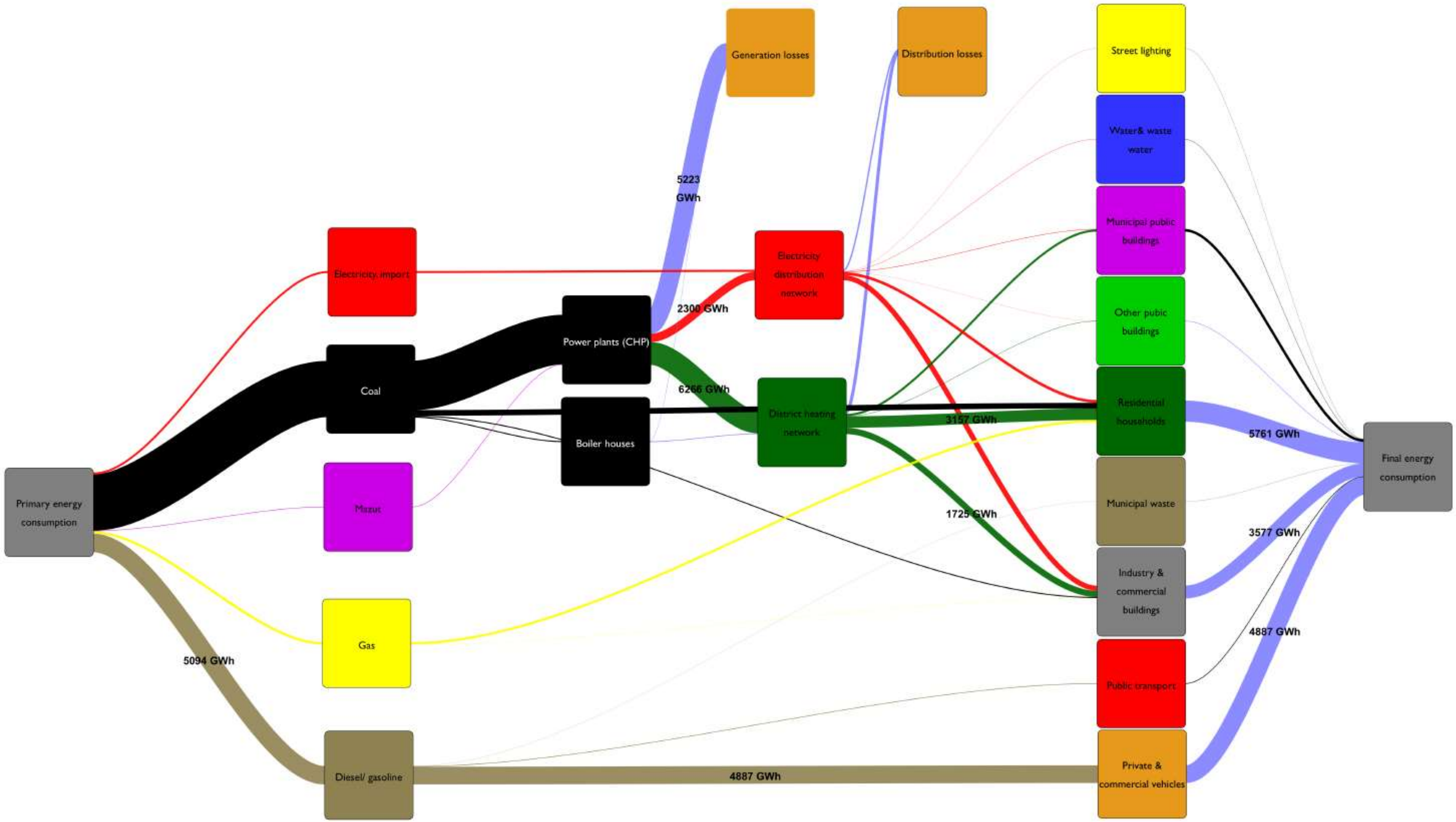
6.4 Program Implementation Roadmap

The city needs a comprehensive package of measures to address the challenges in the municipal sectors. Astana should have a clear roadmap to implement the EE measures. Non-investment activities should help establish the framework and delivery capacity for investments. Table 19 below presents a general roadmap for scaling-up EE in municipal sectors for the next two years.

Table 19. Recommended short to mid-term actions to begin implementation of the EE Program



7 Annex 1: Sankey energy flow diagram for Astana city in 2015 in GWh/year



8 Annex 2: City-Wide Energy Consumption and Emissions

Figure 58.Final energy consumption in Astana (2015)

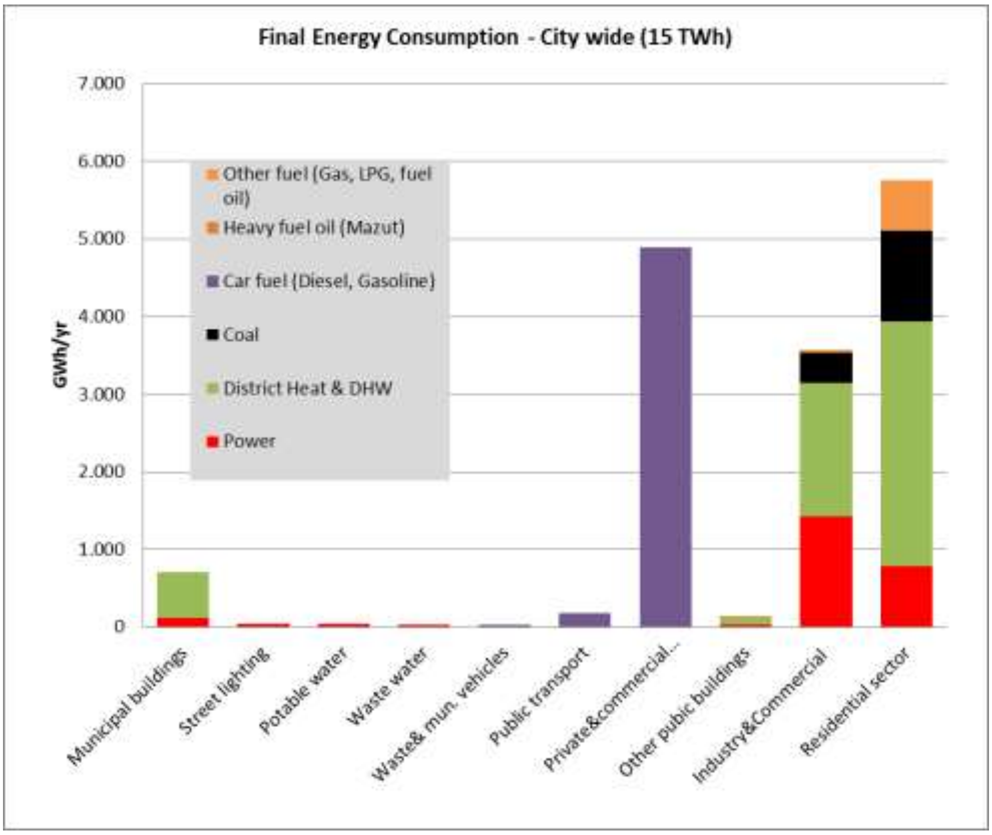


Figure 59.CO emission factors

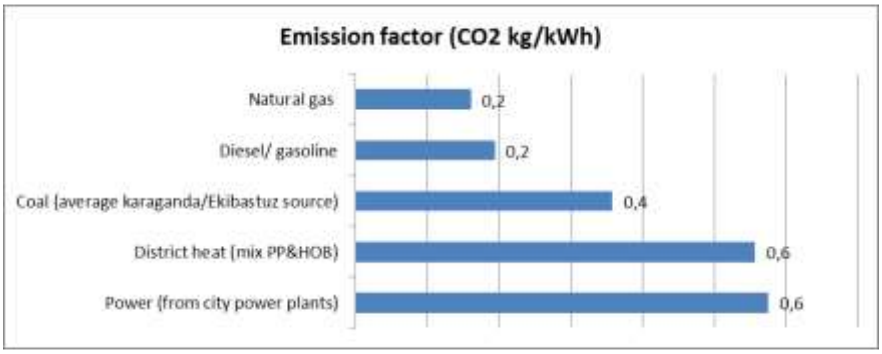
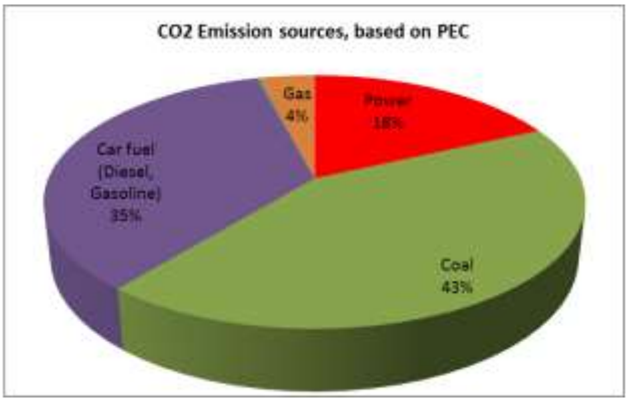
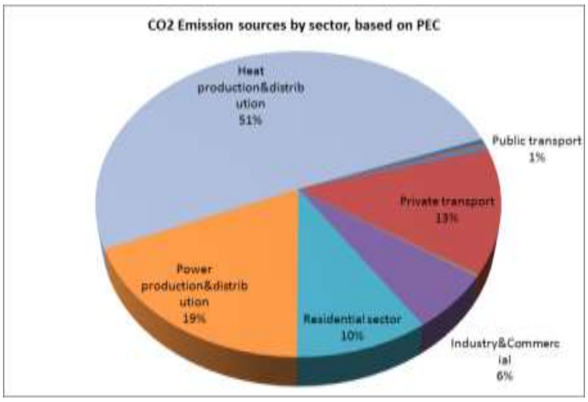


Figure 60. CO_2 emission sources based on primary energy balance





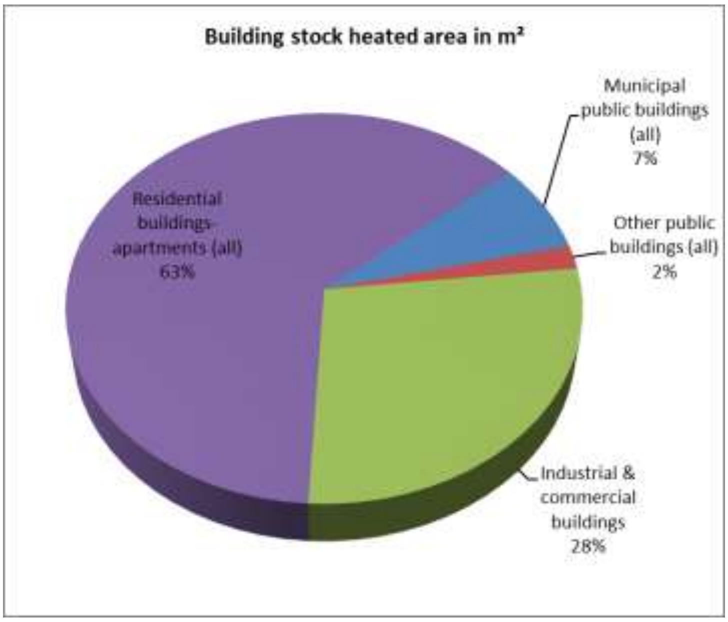
9 Annex 3: Sectoral Analysis of Non-Municipal Sectors

9.1 Sectoral Analysis - Residential Sector[59]

9.1.1 Infrastructure – Building Stock

The residential sector is one the largest energy consumers in Astana. Residential facilities account for 63% of the total building heated area in the city. The city has 36,828 residential buildings comprising 289,244 apartments totaling 20.8 million m². Around 6,352 are multi-storey buildings and 30,500 individual residential buildings. The average living area per household in multi-apartment blocks is 65 m² as compared to 131 m² in individual houses, with an overall average of 2.7 people per household. 80% of city residents live in multi-story apartment buildings (covering 16.8 million m² of the living area), while the remaining 20% reside in individual private houses (4 million m² of space area).

Figure 61.Building stock in Astana - heated area



Approximately 20-30% of the residential building stock in Astana is made of old houses, while 80% has been built in the recent decade. Old apartment buildings have usually nine floors with a total of 54 apartments per building, while new residential constructions have usually 12-16 floors. Due to the population growth in recent years, the housing sector is increasing by one million square meters annually. 80% of multi-apartment buildings and 11% of individual houses are connected to the centralized heating network.

The vast majority of the real estate stock in Astana is privately owned. Residents pay their utility bills directly to the suppliers. The water, power and cooking gas is metered and billed based on actual consumption, while district heat is calculated on the share of the building metered consumption.

[59] For individual residential buildings, industry and commercial buildings no reliable data or statistics on facilities and energy consumption are available. Assumptions have been made based on interviews conducted with the city administration and energy utilities in order to draw a holistic, city-wide picture of energy consumption. No further research or analysis was undertaken.

Figure 62.Multi-apartment residential buildings in Astana

Source: Manuela Mot/World Bank

Apartments inside residential buildings have been privatized by tenants and by the apartment owners associations (AOAs). Building owners delegate to the AOA the right to manage on their behalf the maintenance of multi-apartment facilities. AOAs can contract companies, including an ESCO, for maintenance services to the buildings. However, most AOAs do not have much power, and their role regarding the building management should strengthen. As a part of this process, the responsibility for building maintenance, as well as for paying the utilities at the building level has been transferred to tenants. AOAs are responsible for the maintenance of common areas of the buildings and technical building systems. Building maintenance is financed through monthly charges collected from tenants and paid directly to utility companies.

However, AOAs have played no significant role in the field of utility services, and the utilities still have to deal with a large number of individual clients. While this is quite inconvenient for utilities, it also limits the options for tenants to implement any energy savings measures at the building level. Also, building residents lack information and capacity in managing the AOAs and also effectively deal with residents who are not paying their bills or with empty/vacated apartments.

The CA has no control over the energy use in buildings, and only little influence on the types of energy saving technologies that should be used. The chief architect office of the CA grants construction permits for new residential buildings. The performance criteria are incorporated in the construction laws. The capacity to enforce the performance norms is also limited.

9.1.2 Energy Performance

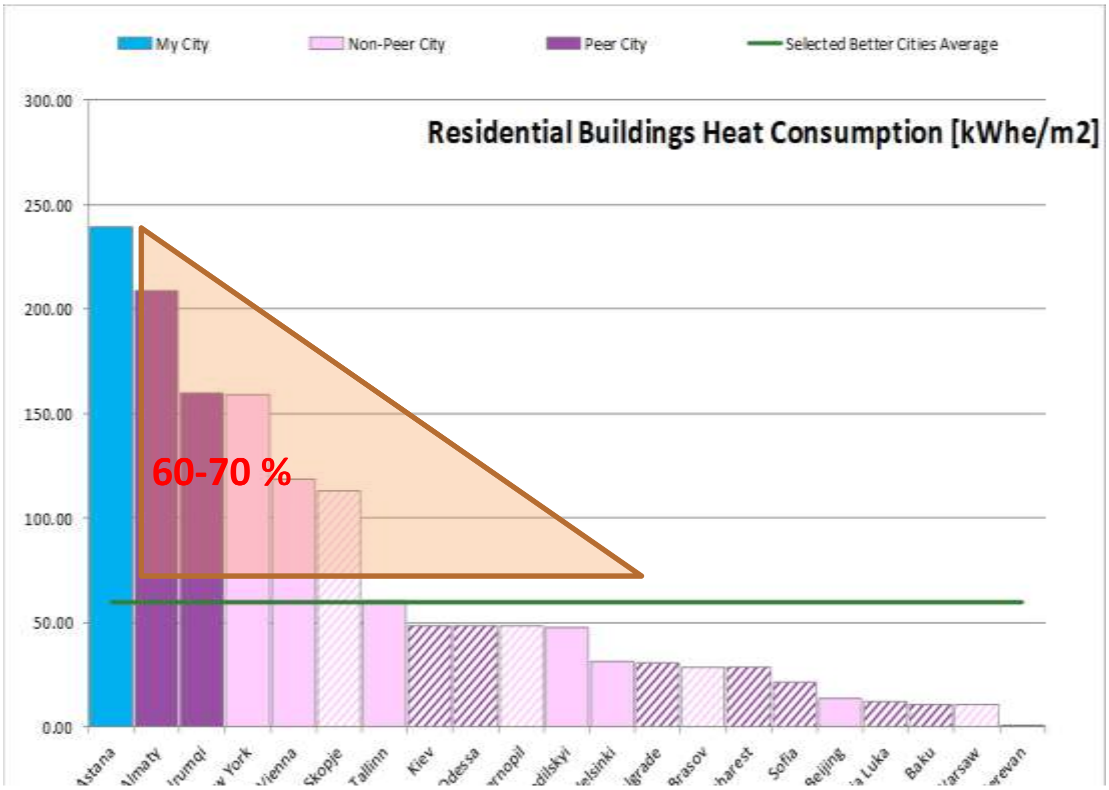
The total energy consumed in the residential sector in Astana in 2015 amounted to 5,761 GWh, of which power was 14%, almost 55% heat, 11% natural gas and oil, while 20% was coal (mainly in individual houses). Expert estimates show that annual energy expenditure in the residential sector in Astana is KZT 24.7 billion (US$ 111 million). Although electricity accounts for 14% of the total energy use, the power related expenditure makes for 59% of the overall energy bill. Residential users pay KZT 18.6 /kWh of power (US$ 0.08). Conversely, although it represents 55% of the energy balance, the heating bill is only 27%. Residential consumers pay KZT 2.1 for one kWh of heat, including 12% VAT (US$ 0.01).

The benchmarking made by TRACE in comparison with peer cities with similar HDI shows that Astana has one of the highest heat consumption - 240 kWh/m², a figure that is by 200% higher than in

Tallinn, Estonia. Compared to selected peer cities, the specific heat demand is high due to several reasons. These are related to cold climate, heat losses in the building envelop because of low quality construction materials, overheating and waste of energy since there are no heat control devices, and limited consumption-based billing. In many cases the actual heat consumption is higher than the normative heat supply according with construction features of the buildings. In the case of flat rate heat tariffs, in reality it is the owners who actually underpay the heat supplied. Energy savings incentives are widely absent, especially since there is no real consumption based billing.

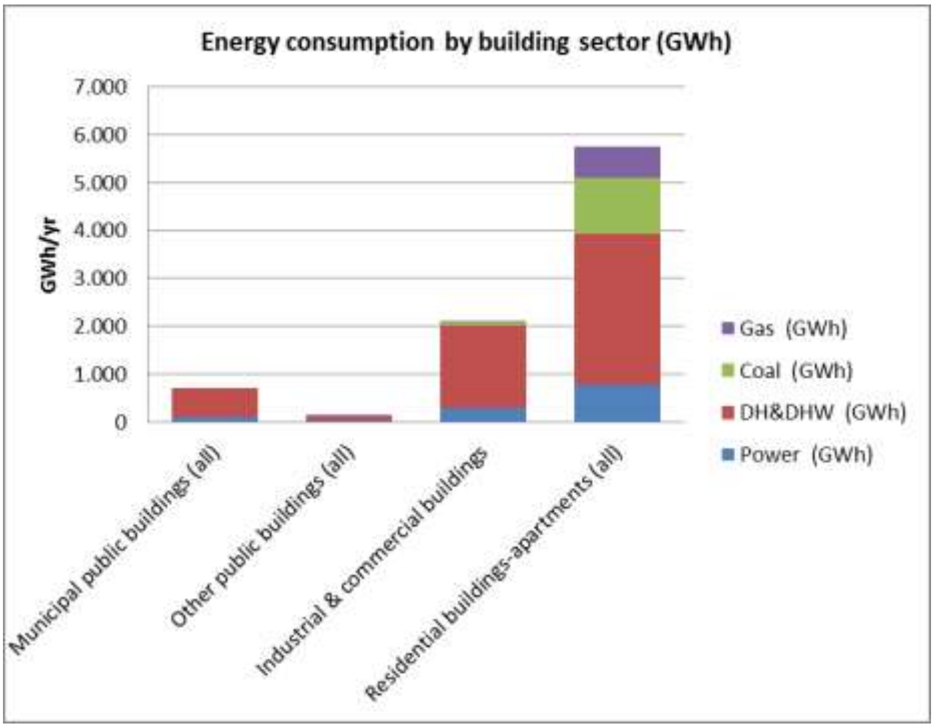
The power consumption of 38 kWh/m² places Astana in the middle of the database with comparable cities, below Almaty or Tallinn, but above Kiev or Tbilisi (30 kWh/ m²). Heat tariffs are cheaper for customers with heat meters (KZT 2.321/Gcal).

Figure 63. Heat consumption in residential buildings in Astana



Altogether there are 33 million m² of buildings in Astana that need 10,200 GWh of energy, totaling KZT 60 billion. Residential sector is the largest energy user, in which central heat is predominant. The second energy intense consumer is the industrial & commercial sector, where heat holds the largest share of energy, with power by only half of it. Finally, municipal buildings are the third largest user,. Most of energy used in municipal buildings in Astana is central heat, followed by power and gas for cooking.

Figure 64. Energy consumption by building sector in Astana



9.1.3 Main Challenges in the Residential Building Sector

With an expected future annual increase in population of maximum 3%[60], the residential living area in Astana is expected to expand by 50-60%, to 34 million m² in 2030m, which would trigger additional 9,500 GWh.

The results of the benchmarking based on TRACE shows that the theoretical relative energy intensity of residential buildings in Astana is between 30 to 40%. This potential can be mainly achieved by implementing EE measures that not only would reduce energy consumption, but also improve the level of comfort in buildings. These include installing LEDs, a heat distribution system with temperature control at the level of building heating point/substation and rooms, and insulation of the heat pipe in the basement of the buildings. A proper thermal insulation of buildings would help increase the level of comfort in apartments. In addition, modernization of heating points located in the building basement is necessary. Some buildings need serious rehabilitation of the heat pipes. Also, an automated energy consumption monitoring system would allow improve control of the energy consumption. Although some EE measures in could be implemented immediately, some may require prior steps to be taken in order to address some of the issues in the sector.

9.2 Sector Analysis - Commercial & Industrial Sector

9.2.1 Infrastructure

According to the Division of Economy of the CA, Astana has 27,373 commercial and industrial buildings that make altogether 9.1 million m². There are 400 medium to large industrial companies and commercial buildings comprising 3.7 million m². Small businesses, trade, shops and other facilities spread over 5.4 million m² make up to 27 facilities or units (for example, shops are located at the ground floor of residential buildings).

[60] The population of Astana grew fast over the last decade, around 5-10% annually. The trend of population growth has decline slightly by 3-5% per year, according to interviews with the architecture office of Astana.

Figure 65.Commercial office buildings in downtown Astana

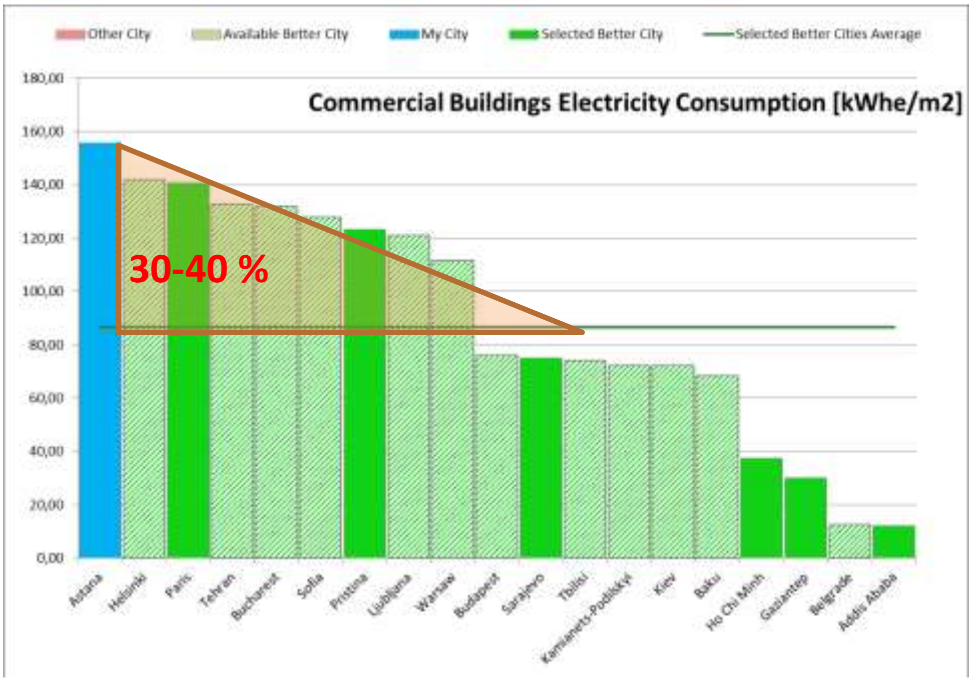
Source: Manuela Mot/World Bank

9.2.2 Energy Performance

The total energy used in commercial and industrial facilities in Astana is estimated at 3.576 GWh, of which power consumption is 40%, district heat 48%, and coal is 11%. The total energy expenditure in a year is KZT 31 billion (US$ 141 million).

According to the TRACE benchmarking, commercial buildings in Astana are quite energy intense, with 392 kWh/m² energy consumption (electricity, heat and fuel altogether), a figure that is placing the city in the higher end of the database. Power consumption is also high – i.e., 156 kWh/m².

Figure 66.Electricity consumption commercial buildings in Astana



The CHP-1 supplies steam to industrial customers for production process and heating. The steam condensate return is limited, causing high energy and water losses. A condensate return and use of heat drainage with continuous blow-down separator at thermal circuit at CHP-1 is required.

Since they are owned by private or legal entities, the CA has no control over the energy use or on energy savings equipment and technology in commercial & industrial facilities. The regulatory framework for new constructions and reconstruction of commercial buildings is the same as for residential buildings.

9.3 Sectoral Analysis - Private Transport

9.3.1 Infrastructure

There are around 500,000 private vehicles in Astana. Officially, 270,000 are registered cars, most of them fairly new vehicles. In addition, approximately 80,000 vehicles drive in daily from other places. Astana gets heavily congested during rush hours, especially from 4 PM to 8 PM. There is a bike sharing system available with bike docking stations from where people can rent bicycles. There are no dedicated bike lanes, so bike users must ride on sidewalks or roads.

Figure 67: Traffic in rush-hour in Astana

Figure 68: Bike docking station in Astana

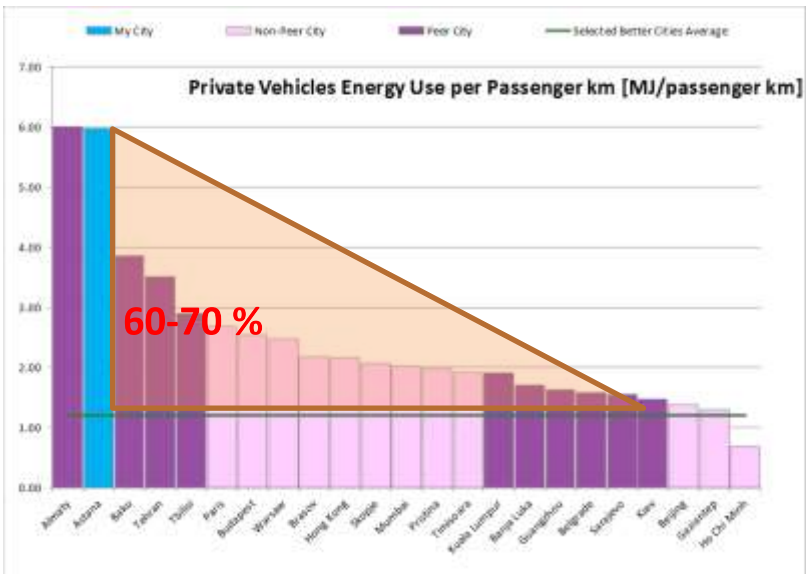
Source: Manuela Mot/World Bank

The city has an adequate number of traffic lights, including intelligent devices. Currently, there are 42 intersections that are part of the traffic management program, and more are to be included in the next years. However, like many cities in the world, Astana has a limited number of parking facilities, and most of them are private.

9.3.2 Energy Performance

Private transport in Astana holds the largest energy consumption among peer cities with similar HDI, as per the TRACE benchmarking. The city needs 6 MJ per passenger kilometer, which is one-third more than in Baku or Teheran, and twice as much as in Tbilisi. One of main culprits for this big consumption is the high share of private transport in the transport modal split, in addition to large distances travelled daily by cars. Almost two thirds of daily commutes take place by private vehicles. Most of the cars are large vehicles, many of them SUVs with big fuel consumption (average estimate of 20 liter/100 km). Annually, private cars in Astana spend US$ 244 million for fuel.

Figure 69. Private Transport Energy Performance



10 Annex 4: Municipal Energy Baseline and Development Scenario

Methodology for the quantitative analysis of sectors

EE investment recommendations were analyzed both from qualitative and quantitative perspective. The qualitative evaluation considers the implementing environment, such as regulatory frameworks and capacities. The quantitative evaluation of investment projects was carried out both in terms of energy and cost efficiency of the projects but also in terms of their potential impact to reduce the municipality's energy balance.

The baseline year for all collected data is 2015. The sector analysis uses average cost per energy type in the sector which subsequently has been used for economic assessment of the respective projects in a sector.

Energy cost savings as result of reduced energy consumption are calculated at the average cost of energy over the implementation period 2018 to 2030. The profitability of each recommended investment measure is indicated as simple Payback Time (PBT) by using initial costs and annual saved costs (including some assumptions for additional operation costs or additional non-energy cost savings). A cash flow analysis can only be prepared after a more detailed assessment of selected pilot projects.

Assumptions on energy prices, tariffs and investment costs

The average cost of energy has been determined by an assumed scenario of energy price escalation. It is necessary to apply such forecast to project the financial benefits and overall profitability of investments over the entire program implementation period from 2018 to 2030. The estimated growth patterns of energy costs are presented in the figures below. The following assumptions have been applied for the preliminary assessment of EE recommendations/energy efficiency measures.

- *Investment costs* at the level of 2017 prices, including import duties (on demand), installation, using the currency exchange rate as of May 2017 (US$ 1 = 310 KZT)
- *Emission factors* for primary energy carriers of the baseline year 2015, CO_2 emission factor are presented in Table 17.

Table 20: Emission coefficients

Energy carrier	CO_2 emission factor primary energy side (kg CO_2 /kWh)
Power (import from KEGOC)	0.90
Power (from city power plants)	0.58
District heat (mix PP&HOB)	0.56
Coal (average Karaganda/Ekibastuz source)	0.36
Diesel/ gasoline	0.19
CNG	0.29
LPG	0.11
Heavy fuel oil (mazut)	0.28
Natural gas	0.16

- *The payback* time is preliminarily calculated on the basis of annually saved energy costs. For this purpose, the 15-year average tariff of the respective final energy carrier is used for the period 2018 to 2030. A moderate annual increase of energy costs of 1.5-2% is assumed.
- The *implementation period* of the EE measure starts in 2018, with delivery of EE benefits in the year 2019 at the earliest. Each EE measure is assumed to be completed by 2030.

Average energy commodities prices used for carrying out simple financial calculation are indicated in figures 69-71.

Figure 70: Energy costs for public entities (US$ per kWh) in 2015[61]

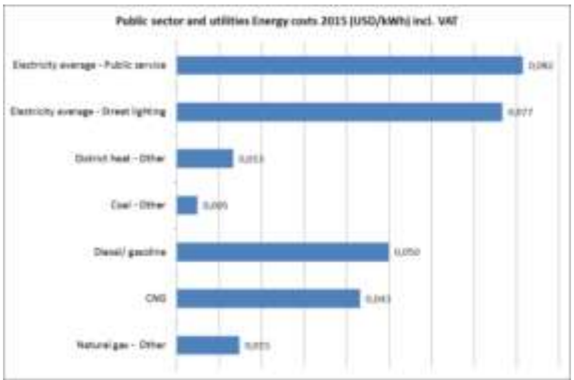


Figure 71: Energy costs for public entities (US$ per kWh) 20 years average 2017-36

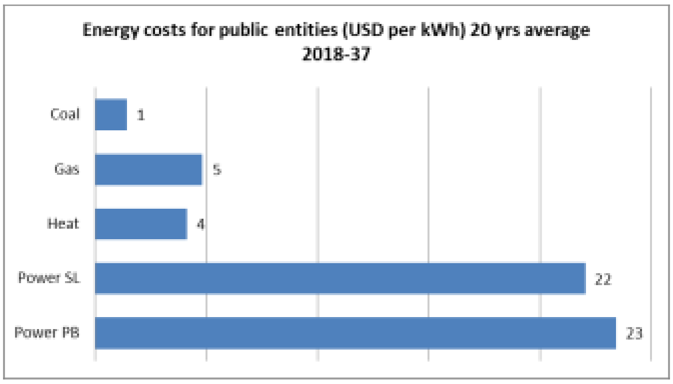
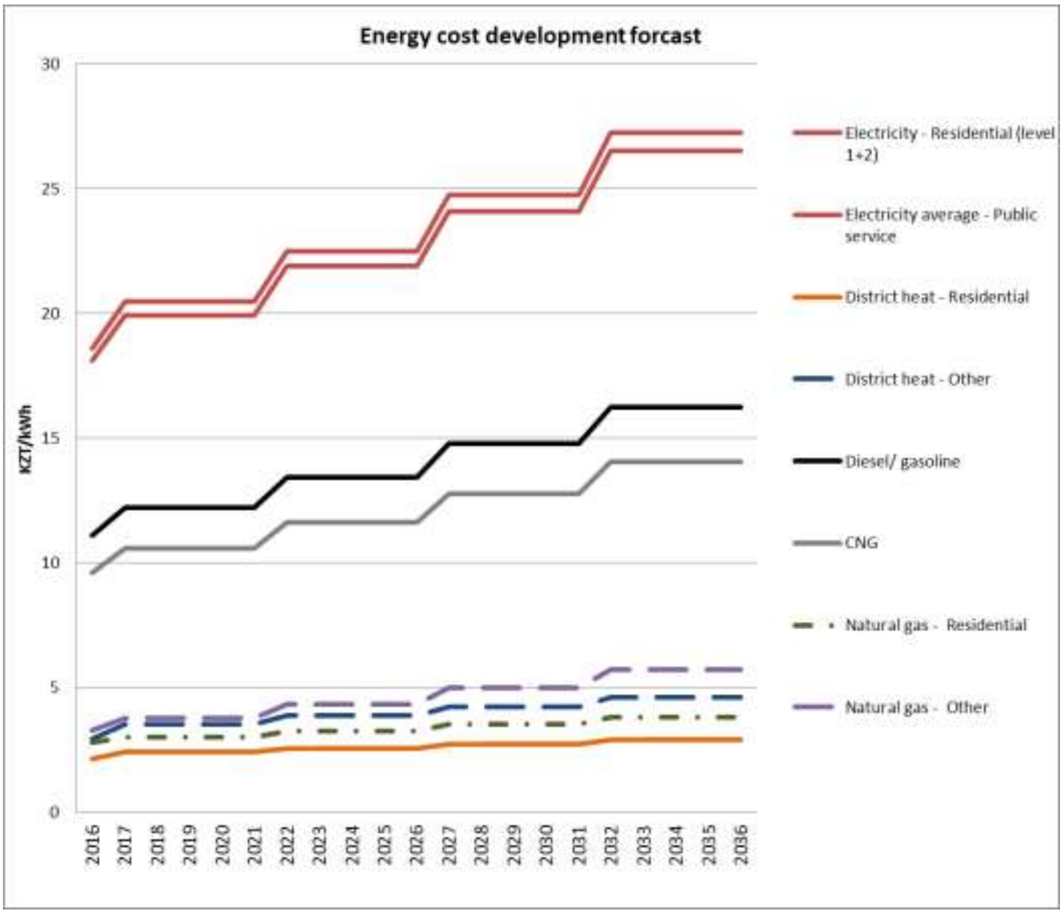


Figure 72: Forecast of energy price development (average 1.5 – 2% increase per year)



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61 Average change rate for 2015: 1 US$ = 222 KZT

11 Annex 5: Key Performance Indicators for Astana (2015)

Municipality Wide Data	**Value**
Population within municipal boundary	872,700
Total GDP within Municipality boundary (US$)	21,665,027,027
Total kWhe, electricity consumed	2,869,957,772
Total MJ, primary energy consumed	79,147,307,000
Total municipal Municipality budget (US$)	1,774,774,775
Total number of households	289,244
Municipal Municipality energy spend (US$)	34,025,398
Municipal area (km^2)	700
Climate type (tropical, arid, continental, temperate)	continental
Human Development Index (by country)	0,780, Kaz average
Transportation Data Points	
Public transportation fuel consumption (MJ)	173,089,914
Private transportation fuel consumption (MJ)	17,594,752,000
Public transportation passenger kilometers	4,170,625,800
Private transportation passenger kilometers	2,945,550,000
Transportation Mode Split (private motorized, public motorized, walk/cycle)	40%, 58%, 2%
Kilometers of high capacity transit	0
Buildings Data Points	
Electricity consumption in municipal buildings (kWhe)	112,312,873
Fuel consumption in municipal buildings (kWht)	598,882,788
Total energy expenditure for municipal buildings (US$)	17,124,887
Municipal buildings, floor area (m^2)	2,456,019
Municipal buildings, average US$/kWh	0.024
Commercial buildings, average US$/kWh	0.039
Residential buildings, average US$/kWh	0.019
Street Lighting Data Points	
Total electricity consumption of street lights (kWhe)	36,814,321
Total length of roads (km)	1,505
Length of lit roads (km)	1,475
Number of light poles	30,869
Total energy expenditure for street lights (US$)	2,823,095
Average electric rates for street lights (US$/kWh)	0.0767
Power and Heat Data Points	
Technical T&D losses (kWhe)	411,128,368
Non technical T&D losses (kWhe)	0
Number of households with authorized electrical service	289,244
Total electricity produced (kWh)	2,869,957,772
Water & Wastewater Data Points	
Total amount of water sold (m^3)	53,246,659
Energy consumed to produce potable water (kWh_e)	40,262,103
Total amount of potable water produced (m^3)	70,995,545
Energy consumed to treat wastewater (kWh_e)	32,440,107
Total amount of treated wastewater (m^3)	51,676,445
Energy expenditures of the water utility, US$	3,741,216
Total expenditures of a water utility	33,190,683
Number of households with potable water service	277,282
Number of households with connection to the public sewage system	215,991
Average water rates (US$/$m^3$)	0.28
Waste Data Points	
Amount of solid waste generated within the municipal boundary (kg)	353,000,000
Amount of solid waste that is recycled (kg)	21,180,000
Amount of solid waste that goes to landfill (kg)	569,620,000

12 Annex 6: Main Financing Options for Municipal Energy Efficiency[62]

Mechanism	Main features	Advantages	Limitations	Performance Risk Allocation
Budget Financing				
Grants	Investment costs funded by grant(s) from donor or national government to municipality	Indefinite term No financing costs Can be applied to all municipalities	Limited grant funding available May encourage non-viable projects Not sustainable or scalable	Donor or government providing the grant
General Budget	EE project investment costs funded from general municipal revenues	Can build market capacity No additional financing costs	Budget resources often limited Sustainability not assured	Municipality
Budget Capture	Financing to municipalities for EE projects from MoF, with repayment through savings from these projects	Makes viability clearer Builds market capacity Provides security to financiers	Can be difficult to ring-fence May require recourse to budget Sustainability not assured	Municipality or financier, depending on extent of recourse
Energy Efficiency Funds				
Energy Efficiency Funds	Independent, publicly owned entity provides financing for EE to public clients, with repayments based on estimated energy cost savings	Financially self-sustaining Can finance municipalities that are not able to borrow; Can leverage funds by pooling or bundling of projects and develop simple ESCO models	Recovering operating costs may be difficult in early fund years Reliance on good fund manager Needs municipal repayment mechanism	Fund in the first instance Ultimately, sponsors of the fund
Public Support for Commercial Financing				
Dedicated Credit Lines	'Soft' public loans to commercial institutions for on-lending to municipalities for EE projects	Allows municipalities to undertake own procurement/implementation Can be scalable Funds can revolve	Serves only creditworthy municipalities Requires strong and willing bank partners to develop project pipeline	Entity providing the credit line, commercial financier, and municipality, depending on sharing of losses
Credit and Risk Guarantees	Risk sharing guarantee from donor or national government that covers part of commercial lenders' loss from loan defaults	Allows leverage of public funds Addresses risk perception of commercial lenders regarding EE projects	Can serve only a limited number of municipalities Requires strong and willing bank partners to develop project pipeline	Guarantor for the covered part of the loan and commercial financier for the uncovered part
Commercial Financing				
Commercial Loans	Commercial financing institutions lend money to municipalities for EE projects either directly or through ESCOs using the ESPC mechanism	Mobilizes commercial financing Can be scalable and sustainable Full project cycle is financed With ESPC, risks are transferred to the ESCOs	Banks or ESCOs exposed to bear credit risk Creditworthy municipalities only High due diligence costs ESCO industry hard to develop	Commercial financier, municipality, or ESCO

[62] Source: Financing Municipal Energy Efficiency Projects, ESMAP, The World Bank, 2015