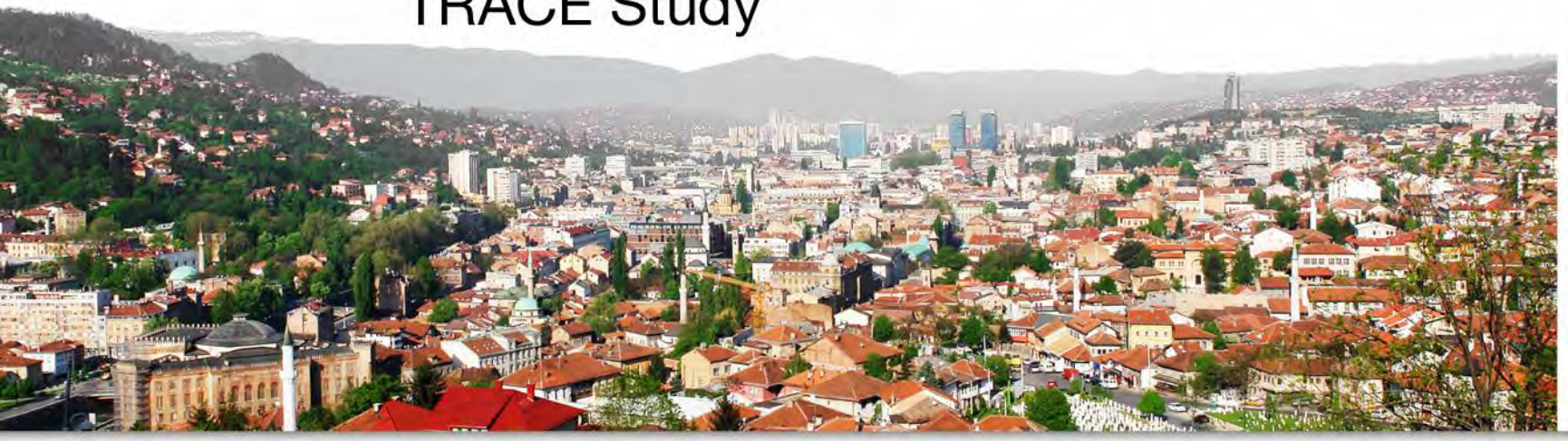
ECA Sustainable Cities:

Improving Energy Efficiency in SARAJEVO

Bosnia and Herzegovina

TRACE Study



SUSTAINABLE CITIES

ESMAP
Energy Sector Management Assistance Program

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The TRACE diagnostic is part of the toolkit of the ECA SCI, which aims to promote sustainable development in ECA cities. Work on the report was done under the guidance of Stephen Karam (ECA Urban Sector Leader) and Vesna Francic (Senior Operations Officer), with a team comprised of Ranjan Bose (Senior Energy Specialist), Marcel Ionescu-Heroiu (Extended Term Consultant), Adnan Papovic (Short Term Consultant), and Senad Sacic (Program Assistant). Throughout the process of collecting data and writing the report, the team has enjoyed an excellent collaboration with local authorities in Sarajevo.

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Executive Summary

Cities in the Western Balkans in Southeastern Europe are uniquely positioned to manage the region's growing challenges of rapidly increasing energy demand and greenhouse gas (GHG) emissions. The region is characterized by relatively high consumption of energy per unit of GDP, high energy savings potential among energy end-users, and heavy dependence on hydrocarbons imported from outside the region. Many cities in this region are currently at a turning point in their development as potentially energy intensive infrastructure and urban design becomes hard-wired into the city fabric - e.g., the growing popularity of private vehicles and corresponding low density development. These developments point to the urgency for city administrations to act decisively with progressive policies and actions that will put these cities in a strong position for the future by addressing rising energy demand, while reaping the co-benfits of reduced GHG emissions and improving energy security.

Sarajevo, with 436,572 people living in the Canton as a whole, in 2010, is the largest city in Bosnia and Herzegovina (BiH). It is the capital of both the state of BiH and of the Federation of BiH. Sarajevo is the most developed canton in the country and is the administrative-political, economic, financial, educational, scientific and research, the cultural center of the state, and a Winter Olympics town. After a period of population and economic decline and infrastructure depreciation in the 1990s, the economic recovery of the region began after the 1995 Dayton Peace Agreement. The structure of the economy has shifted from agricultural and industrial production to services. The authorities believe that the energy sector, and within it, the electricity sector is one of the stronger sectors of the economy with the potential to contribute to economic development in the short and medium-term.

The Government of Sarajevo is committed to the continued development of the region, and to incorporating sustainability principles in future investment decisions. The Public Investment Program of Sarajevo 2010-2012 comprises a total 171 projects[1], valued at around EUR383.5 million. Local budgets provide 77% of needed financing, with the rest coming from a variety of other sources (loans, grants, transfers, etc.).

Strategic development commitments in Sarajevo will not come without their share of challenges. First, the combination of relatively low energy prices and a degree of continuing electricity price subsidies are suppressing some energy-efficient initiatives. Second, Sarajevo has been rapidly sprawling outwards, with more and more people choosing individual detached housing over apartments in high-rise buildings. Car ownership has increased as incomes have risen, in-city car commuting has also increased as people from surrounding sub-urban areas seek opportunities in Sarajevo, waste generation has grown hand in hand with increased consumption, and existing age old infrastructure networks (e.g. water and wastewater, and district heating) have often been left to crumble away as local authorities have focused on providing basic services to the new and underserviced parts of the city.

Despite these challenges, Sarajevo gives the impression of a vibrant center that is poised to become an energy efficient (EE) capital in the region. Sarajevo is the first city in BiH that opened an office for EE on March 21, 2012, with the overall objective of providing its inhabitants all necessary advice, information and informative educational brochures about the rational use of energy, EE measures, and their potential application in households. Activities of the Office of EE are defined by the Sustainable Energy Action Plan – SEAP that was adapted by the City Council of Sarajevo by signing of the *Covenant of Mayors* in July 2011. According to the agreement, the Sarajevo has voluntarily committed to increasing EE and use of renewable energy sources in the city and to meet and exceed the European Union 20% CO_2 reduction objective by 2020. The following report, draws on the implementation of a city diagnostic tool TRACE developed by the World Bank's Energy Sector Management Assistance Program (ESMAP), and it aims to offer some answers to how that can be done.

TRACE (Tool for Rapid Assessment of City Energy)[2] is a software platform for quickly assessing EE efficiency performance of six municipal sectors or service areas: urban passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat.

[1] World Bank. Building Sustainable and Climate-Smart Cities in Europe and Central Asia – CITY FACT SHEETS. ECA Sustainable Development Dept.

[2] More information on the TRACE can be found at: http://www.esmap.org/esmap/TRACE

TRACE consists of three principal components: an energy benchmarking tool which compares key performance indicators among peer cities, a prioritizing process which identifies sectors that offer the greatest potential with respect to energy efficiency improvement, and a "playbook" of tried-and-tested EE measures which helps select the appropriate interventions. It is a simple, low-cost, and practical tool to assist city governments in developing locally appropriate EE strategies.

The TRACE analysis was carried out under the umbrella of the Europe and Central Asia Sustainable Cities Initiative (ECA SCI)[3], and is just one of the components used to assess the potential of promoting sustainable development in ECA. As such, the analysis and recommendations made in this report do not only focus on EE per se, but on sustainability in general. For our purposes, sustainable cities can be understood as resilient cities that can more readily adapt to, mitigate, and promote economic, social, and environmental change. The focus is on triple-bottom line outcomes, with an eye to how urban development can address economic/fiscal, social, and environmental issues.

To complete data collection and to get a more rounded understanding of issues in the city, a World Bank field mission was organized during January 30 - February 3, 2012. Work in Sarajevo was carried out in close collaboration with local authorities, who were consulted on all the critical steps in the process. At the end of this quantitative and qualitative analysis, five major municipal service areas were identified as being critical in improving the Sarajevo's overall energy performance and reduce energy costs: municipal buildings, private vehicles, district heating, potable water, street lighting, and public transport. The report offers following 10 recommendations for these service areas.

Municipal Audit and Retrofit Program- Offices, Schools, Hospitals

Sarajevo owns and manages a quite varied stock of poorly insulated buildings serving different purposes – educational, health-care, administrative and public institutions. Systematic data on energy consumption in public sector buildings are not available. However, estimate from pilot demonstration projects from the region show heat energy savings potential in public buildings are around 40% of current level of energy consumption. And, most energy savings would come from improving the building envelop (thermal insulation of roofs, exterior walls, floors, better sealing, and replacement of windows) and improving or replacing HVAC (heating, ventilation and air conditioning) systems. Local authorities could start by performing a full audit of the existing stock and it will help them to craft a plan for how resources can be allocated to improve energy performance of these buildings. Local authorities should strengthen their support for the refurbishment of their existing building stock in order to raise awareness amongst other consumers, investors and key market players.

Municipal Buildings Benchmarking

The local authorities in Sarajevo should consider developing a buildings energy benchmarking program which collects and reports on an annual basis the energy use, energy bills, water use, water bills, floor areas, and names of building facility managers (if any). However, setting a proper benchmark requires detailed analysis because similar buildings can have significantly varying underlying factors, for example, types of tenants, occupancy density (people per square meter). The goal of the program is to identify the highest energy intensive buildings in the Sarajevo city authority portfolio so as to focus on the best energy efficiency opportunities.

Parking Restraint Measures

Congestion and parking problems will probably remain as intractable in Bosnian cities as in the rest of the world. Elaborate pricing schemes (such as in Singapore) are virtually inconceivable. Considering the price for parking of vehicles has not changed for 12 years in Sarajevo, this diagnostic recommends RAD (the public company in charge or parking management in Sarajevo) to expand and refine the current system of differential parking fees. Increasing parking rates in parking lots on the street and outside the street in the downtown areas of Sarajevo, if well designed, will help reducing traffic congestion. As Western Europe and the United States have learned, massive additions to roadway capacity

[3] More information on the ECA SCI can be found at: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:23050220~pagePK:146736~piPK:146830~theSitePK:258599,00.html

will not solve the congestion problem, since they generally induce more traffic and more suburban sprawl. Nevertheless, Sarajevo authorities must consider at least some additional capacity (roads and parking infrastructure) to meet the new demand for car that has emerged in the Sarajevo area and build and maintain sidewalks for pedestrians.

District Heating Network Maintenance and Upgrade

For the largest district heating (DH) plant in the country, Toplana – Sarajevo, one of the key challenges is to address 10% technical loss (heat loss from the 74 km network) and 8% non-technical loss (revenue loss) from the overall system. Such heat loses can be reduced by adopting a number of supply and demand side measures. Supply side measures, as identified by Toplana, include: (i) introduction of oxygen regulation to optimize combustion in the facility; (ii) implementation of modern sophisticated devices in the facility to regulate heat parameters (flow rate, supply and return temperatures); (iii) replacement of the worst network sections and repair of critical parts (control valves and regulators) of the network with improved heat insulation to minimize losses in the primary and secondary distribution network; (iv) continuous upgrading of roof-top boilers; (v) expansion of the remote monitoring and control SCADA (Supervisory Control and Data Acquisition) system; and (vi) continuous maintenance and upgrade of the heat distribution network. While on the demand side, measures need to focus on extending individual metering and introduction of thermostatic valves for facilities with single-point heating system through installation of ultrasonic heat consumption meters.

District Cogeneration Thermal Plant

The large centralized DH system in Sarajevo offers the opportunity to exploit the advantages of cogeneration (combined heat and power or CHP) to simultaneously generate both electricity and useful heat and reduce local pollution. Currently, all of the used natural gas goes to heat generation, leaving a huge untapped potential of generating both power and heat. Throughout the country, power and natural gas systems experience additional peak demand during extreme cold periods. But since volumes are too small to be served economically by existing DH systems, serving this demand spike is expensive and strains electric power and gas infrastructure in countries that already suffer frequent power outages or gas shortages. Therefore, sourcing heat from cogeneration facilities would help district heat providers cover more heat demand and manage peaks more economically and in flexible manner. Peak demand reduction and/or peak shifting for heating, electricity, and gas would benefit during extreme cold periods, enhance security of supply of electricity and gas, and transform DH into a competitive option through improved design and management (assuming no distortions in pricing policies). The Sarajevo authorities could examine options for the possibilities of high-efficient combined heat and power (CHP) plants to generate energy efficiently and in an environmental-friendly manner. The conversion of DH plants to CHP systems are capital intensive and should be preceded by a rise in electricity tariffs, which are now among the lowest in Europe. Without proper market pricing of electricity, it is difficult to push for CHP technology, as the unit cost of producing energy would be higher than centrally imposed subsidized electricity tariff.

Water System Networks Upgrade

Some sections of the water network in Sarajevo are over 100 years old with large piping system requiring replacement to the current 75% share of non-revenue water. Upgrading the network increases reliability and provides an opportunity to save energy by reducing the risk of burst pipes and leakage. If the system runs more efficiently, the pump delivery head can be reduced making further energy savings and minimizing potential wear/tear on pipes from operating at higher pressures. In some cases it can enable maximum benefits to be obtained from any existing system. Costs may be minimized where existing valves can be used to create a more efficient method of operation, for example, by redistributing the flow to manage overall system hydraulics. It is therefore important for VIK, Sarajevo to initiate a leak detection program in the network using the SCADA system, estimate the investment needs for the replacement of old pipes, and make necessary investments to improve performance of the water distribution network. This recommendation is often implemented by water authorities to improve network reliability and conserve water, with energy efficiency as a co-benefit.

Efficient Water Pumps and Motors

Continuous improvements of water system network must be coupled with investment programs in improved performance of water pumps and motors. Often, simple solution for improving the performance of water pumps and motors can go a long way towards saving energy. Such measures can include the replacement of old pumps and/or motors with new ones, taking out of commission pumps/motors that are not needed anymore, or replacing single speed pumps with multispeed ones, which allow the adjustment of energy use according to needs. It is also critical for VIK, Sarajevo to institute improvements in the routine operations and maintenance protocol that increase the life of the pump and motor, and reduces O&M costs and the potential damage to pipelines and fittings.

Street Lighting Audit and Retrofit

Sarajevo consumes a lot of electricity to light up a kilometer of road based on anecdotal evidence and this could be an indication of the poor design of the system. Further, the street lights in Sarajevo are predominantly mercury bulbs and they tend to be very inefficient, producing a lot of heat. However, there has been a push by the Sarajevo authorities to replace mercury vapor lamps with more efficient high pressure sodium lamps (HPS), a move in the right direction. Light audit and retrofit programs are recognized as being among the surest sustainable development investments cities can make. Such programs help extending the network coverage to the city periphery and sub-urban areas and provide safety and security in public areas. The retrofit costs are usually amortized within a year of two, and operation and maintenance costs are reduced significantly. Consequently, Sarajevo authorities can chose to either finance such project directly, or they can engage an Energy Services Company (ESCO). Also, there are a number of better lighting technologies (like, LEDs) available that also needs to be considered for inefficient bulb replacement and for extending the network coverage.

Street Lighting Timing

Sarajevo authorities could consider integrated solutions to reducing energy consumption by introducing street lighting timing programs (e.g. with light intensity decreasing after mid-night on week-days, or with a central control system that allows the adjustment of light intensity based on how busy a particular area is). A program with strategic timing and/or dimming tailored to the specific needs for lighting in specific areas can significantly reduce energy consumption whilst still delivering appropriate levels of lighting for e.g. providing safety and sense of security in public areas. An intelligent monitoring system can be used to adapt the levels of lighting according to varying weather and activity levels.

Public Transport Development

GRAS, the public transportation company in the Sarajevo Canton, desperately need the financial assistance of central governments. GRAS is dependent on subsidies for daily operation and maintenance needs, and requires significant investment to upgrade the existent rolling stock and infrastructure. Local authorities, for their part, do acknowledge that public transportation in Sarajevo is a critical service area, and different initiatives are planned to improve the system performance. Surveys indicate that the majority of the Central European Citizens support giving public transport traffic priority even though that requires restrictions on car use.[4] A well crafted public transport development plan cannot only lead to better city-wide energy performance by offering alternatives to private vehicle use, but it can also improve energy performance by guiding city growth in a sustainable way. Public transport planning should therefore go hand in hand with city planning, as they are mutually beneficial. For example, an integrated land use and transport plan should allow for higher densities around public transit hubs. Such planning needs to focus on implementing an integrated city development plan with continuous expansion of the bus and tram network and building and maintaining sidewalks for pedestrians to provide better access to people and increase transit ridership. In addition, the Sarajevo government must provide central government to financially support and encourage GRAS and the private bus operator, Centro Trans, and to renew their old second hand buses by investing in modern buses that run on cleaner technology and betters fuels.

[4] Suchorzewski, W. 2002. Urban public transport in Poland: main issues and perspectives. Paper presented at UITP Conference, Brussels, Belgium.

Introduction

Sarajevo is the capital of both the state of Bosnia and Herzegovina and of the Federation of Bosnia and Herzegovina and is the largest city in the country[5]. Since the collapse of the former Yugoslavia in 1992, Bosnia and Herzegovina (BiH) has experienced massive economic and political changes and the country today is largely decentralized. Sarajevo's large manufacturing, administration, and tourism base, combined with a large informal market make it one of the strongest economic regions of Bosnia and Herzegovina (BiH).

While cities worldwide continue to grow, a majority of the countries in Southeastern Europe have already reached high urbanization levels, including BiH, with 60% of its population living in cities. However, the cities in the region face multiple challenges, which many attribute to their transition from centrally planned to market-based economies. Local government officials are ill-equipped to fulfill their expanded responsibilities under decentralization frameworks and find it difficult to meet performance standards for utility services and investment projects. Local authorities in Sarajevo are interested in seeing the recent growth translate into sustainable development.

The work included in this report is part of the efforts undertaken under the World Bank's European and Central Asia Sustainable Cities Initiative (ECA SCI). ECA SCI started in May 2010, with a knowledge exchange event in Copenhagen and Stockholm, from the premise that city-level sustainable development actions can set the stage for world-wide sustainable development. Home to over 50% of the world's population, and accounting for a lion's share of global GDP, employment, and innovation, cities are engines of economic growth. They are at the forefront of economic, social, and environmental change, and as such serve as ideal "laboratories" for generating, testing, and spreading new ideas and innovation. Ultimately, more sustainable cities will lead to a more sustainable world.

[5] For the purposes of our analysis, we will look at Sarajevo Canton, which in addition to the City of Sarajevo (made up of four municipalities) also includes five other peripheral municipalities.

Sustainable development is understood to encompass all aspects that have to do with a city's healthy development, focusing not just on environmental issues, but on the triple bottom line – economic/fiscal, social, and environmental sustainability. It is also understood that successful sustainable development cannot happen without a series of key elements in place: strong city leadership; a clear vision and strategy; enabling national policy environment; implementation, enforcement, and good governance.

Focusing on sustainable development issues in ECA cities is particularly poignant, because they face a number of critical economic, social, and environmental challenges. ECA, for example, has some of the most polluted cities in the world. In fact, it has the highest share of pollution per unit of GDP of any other region in the world, accounting for 7.1% of the world population, 3.1% of global GDP, and 11.8% of global CO_2 emissions from fuel combustion. In economic terms, while ECA countries have registered some of the fastest growth rates in the past decades, they have also registered some of the sharpest economic declines in 2009 – underlining that much of the previous growth was not sustainable. From a social point of view, many ECA cities suffer from demographic decline and an aging population.

To address some of the sustainable development issues ECA cities are facing, ECA SCI uses the following framework:

- *Awareness-Raising and Orientation*, which can include general orientation workshops, learning materials and case studies, knowledge exchange and learning tours, profiling global best practice, peer learning, innovative applications.
- *Diagnostic Assessment (Tools)* – e.g. baseline surveys and benchmarking, urban planning audit, carbon footprint calculation, energy efficiency (EE) diagnostics, shadow bond rating, life-cycle costing, traffic system management studies.
- *Policy Reforms and Investment Strategies* – e.g. updating master plans, updating urban planning regulations, setting emission targets, sustainable city investment strategies.
- *Financing* – e.g. specific investment financing, results-based financing, private sector finance (e.g. Energy Service Companies), carbon financing, output-based aid, donor co-financing.

Sustainable energy is a critical element for economic development and process of European integrations. The State of BiH has entered into agreements entailing commitments to the delivery of energy policy reforms with the EU and with other Western Balkan countries. EE has been recognized as a top priority area in the production, distribution and utilization of energy by end consumers of energy related services. Triggered by the pioneering effort of Banja Luka, the second largest city in BiH, the mayor of Sarajevo city also signed the "Covenant of Mayors" in June 2011. This would help Sarajevo to attract technical and financial support through a regional initiative of GiZ named 'Capital Cities for Climate Change', which links efforts of Zagreb, Podgorica and Sarajevo in the field of climate change, to come up with a Sustainable Energy Action Plan (SEAP).

One of the major components of ECA SCI is to help local authorities in the ECA region begin formulating sustainable urban energy developing strategies, in the context of cities' overall development plans. By ensuring that urban energy supply is secure, reliable, and affordable, and by ensuring demand is efficiently managed, cities can optimize operating costs, improve air quality, and improve quality of infrastructure services, while at the same time supporting economic development and climate change mitigation objectives. This requires investigating beyond the energy sector, to all sectors (notably urban transport and water supply/sanitation) using energy in their production of urban services.

A Note on Methodology

This city report on Sarajevo builds on a city EE diagnostic assessment tool 'TRACE (Tool for Rapid Assessment of City Energy)' referred to above as "stage two" of the ECA SCI framework. Developed by the World Bank's Energy Sector Management Assistance Program (ESMAP), TRACE[6] offers cities quick diagnoses of energy efficiency performance across a city's systems and sectors. It prioritizes sectors and presents a range of potential solutions embedded with implementation guidance and case studies. TRACE is a software platform for assessing energy efficiency performance of six municipal service areas or "sectors": urban passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat. As shown in its Home Page, TRACE consists of three principal components: an *energy benchmarking* tool which compares key performance indicators among peer cities, a *sector prioritizing* process which identifies sectors that offer the greatest potential with respect to energy efficiency improvement, and a "playbook" of tried-and-tested *energy efficiency recommendations* which helps select the appropriate interventions.

TRACE Home Page

The TRACE deployment is a 3-month long assessment process that includes several weeks of upfront data gathering and benchmarking, sector meetings and the preparation of a final report. Based on TRACE results, city governments can identify early wins in key municipal services and start developing a city-wide energy and emissions strategy. It is a simple, low-cost, and practical tool to assist city governments in developing locally appropriate EE strategies.

To be effective in pursuing reforms and changes in municipal governance, civil society and NGOs need to know how well municipalities are performing over time and in relation to other municipalities.

[6] For further details please visit http://www.esmap.org/esmap/node/235

Information on energy performance standards and service outcomes is essential and municipal level to inform local constituents and to encourage public participation in the political process. Such information will allow officials and citizens to evaluate the extent to which a municipality is "well-run", since this is the main objective of many mayors. Better benchmarking information on key dimensions of municipal performance is the heart of the tool - TRACE.

Work on this report started with a scoping mission in Sarajevo in October 2011. The scoping mission was followed by data collection by a locally hired consultant in December 2011-January 2012, and the implementation of the TRACE in the city from January 30 - February 3, 2012. The TRACE diagnostic tool was selected because EE is often considered to be a "low hanging fruit" in sustainable development, with outcomes and benefits that are fairly easy to measure and monitor. This activity is expected to yield important dividends in helping Sarajevo identify investments necessary to develop as a sustainable city.

During the TRACE implementation mission, interviews were held with a range of local authorities. The field mission also involved site visits at the city's main district heating plant, water treatment facility, and at the landfill site. Information gathered during this period enabled a classification of each municipal sector based upon the degree of influence directly or indirectly exerted by the Sarajevo CA, the potential for energy savings in the sector and relative spending on energy in each sector or service area. These enabled a detailed systematic filtering of all of the EE recommendations contained within TRACE, to examine their suitability in Sarajevo. This process demonstrated that a large number of recommendations were:

- either likely to be technically and/or financially unviable;
- outside of the direct control of the Sarajevo CA; or
- already being implemented or in trial phase.

Background

Bosnia and Herzegovina (native name Bosna i Hercegovina (BiH)), is almost a landlocked country, except for 26 kilometers (16 miles) coastline on the Adriatic Sea, and is located in Southeastern Europe on the Balkan Peninsula. In terms of its geography, the country in the central and southern interior is mountainous, in the northwest it is moderately hilly, and the northeast is predominantly flatland. The country borders Croatia to the north, west and south, Serbia to the east, and Montenegro to the southeast. The country has a moderate-continental climate with hot summers and cold and snowy winters. The southern tip of the country has a Mediterranean climate and plain topography.

The population of BiH is comprised of three major ethnic groups: Bosniaks, Serbs and Croats. According to the last official census data from 1991, BiH had 4.37 million inhabitants, equivalent to an average population density of 85.5 inhabitants per square km. However, the 1996 UNHCR census showed a decline in population to 3.92 million.[7] The Yugoslav wars in 1990s caused demographic shifts in the country as a result of large population migrations. No census was carried out since 1991/96 because of political disagreements. Nevertheless, a census has been planned in 2012. Current estimates of population vary depending on the source, but are generally around 3.84 million, indicating a decrease of about half million people since 1991. However, the level of urbanization has increased in the last decade.

BiH is recovering from a devastating three-year war which accompanied the break-up of Yugoslavia in the early 1990s. The 1992-95 conflict was centered on whether Bosnia should stay in the Yugoslav Federation, or whether it should become independent. BiH was made into a decentralized independent state in 1995, but under international administration, backed at first by NATO forces and later by a smaller European Union-led peacekeeping force to help consolidate stability. BiH is currently a potential candidate country for EU accession as it is hoped that EU accession will increase political stability, trade, competition, foreign investment, and regard for social policies, as well as provide a better quality of life to citizens, concerning safety, employment, health, education, and information.

The 1995 Dayton peace accord, which ended the Bosnian war, established BiH as a state with limited central power, and assigned competency for social, educational, health care and fiscal policies to many levels of government and administration. Most important of these levels is the division of the country into two entities: Bosniak-Croat Federation of BiH (FBiH), and the Bosnian Serb Republic, or RS, each with

[7] http://en.wikipedia.org/wiki/Bosnia_and_Herzegovina

its own president, government, parliament, police and other bodies. The FBiH covers 51% of BiH's total area, while the RS covers 49%. Overarching these entities is a central Bosnian government and rotating presidency. In addition there exists the district of Brcko which is a self-governing administrative unit, established as a neutral area placed under joint Serb, Croat and Bosniak authority.

The third level of BiH's political subdivision is manifested in cantons. They are unique to the FBiH entity, which consists of 10 Cantons. All of them have their own cantonal government, which is under the law of the Federation as a whole. The fourth level of political division in BiH is the municipalities. The FBiH is divided in 79 municipalities and RS in 63. Municipalities have their own local government. Besides entities, cantons, and municipalities, BiH also has four "official" cities. These are Sarajevo, East Sarajevo, Banja Luka and Mostar. The territory and government of the cities of Sarajevo and East Sarajevo officially consist of several municipalities, while the cities of Banja Luka and Mostar correspond to the municipalities of the same name. Cities have their own city government whose power is in between that of the municipalities and cantons (or the entity in the case of RS). The largest city is the capital Sarajevo (with the population for the Canton as a whole being 436,572 in 2010); next in size are cities of Banja Luka (226,805), Mostar (140,000), and Zenica (135,000). Cities have their own budgets, financed by own revenues, shared revenues, and grants from cantons (in the Federation) or Entity (in RS). The administrative relationship between cities and municipalities is not always clear and remained to be settled by politics or the judiciary.

Before the war, BiH had an economic structure that was strongly product and commodity based. The war had a devastating impact on the country's infrastructure. Approximately 45% of the country's industry, including 75% of its oil refineries, was either damaged or destroyed. Transport infrastructure suffered greatly; about 35% of the main roads and 40% of bridges were damaged or destroyed. The economic recovery began after the 1995 Dayton Peace. Following several years of strong growth, economic activity in BiH started to decline in late 2008, affected as most countries in the region by the global crisis. Driven by very good export performance, GDP in BiH grew 0.9% in 2010, which was above consensus expectations of 0.5%.

Population dynamic in the ten largest cities in BiH

	City	Population		Compounded annual growth
		census 1991	calculation 2012	
1	**Sarajevo**	**527,049**	**436,572**[@]	**-0.94%**
2	Banja Luka	196,500	226,805[@]	0.72%
3	Tuzla	90,539	99,543	0.43%
4	Zenica	98,750	135,000[@]	1.58%
5	Bijeljina	37,216	78,960	3.48%
6	Mostar	75,612	140,000[@]	3.13%
7	Prijedor	37,568	43,307	0.65%
8	Brcko	40,921	38,968	-0.22%
8	Bihac	45,995	37,511	-0.92%
9	Doboj	27,579	31,794	0.65%
10	Kasindo	6,905	28,443	6.65%

[@]2010 data. Source: World Gazetteer and authors' calculations.

In 2011 the country's human development index, measured by the UNDP, was 0.733 (on the scale of 0.0 to 1.0). BiH ranked 74th, out of 187 countries reviewed.

The highly decentralized state structure carefully balances political/ethnic interests. The national government has few administrative attributes as compared with other national governments, and most power is vested in two entities: the FBiH and the RS, plus the special district of Brcko. The different layers of authority from entity (FBiH or RS) to municipality, can lead to overlaps, confusion, and a lack of systematic organization or interaction between decentralized actors and different levels of government.

National Energy Efficiency Strategy

While energy and EE policies are within the competence of the two Entities of BiH there were as of February 2012 no fully articulated set of energy policies, or EE Master Plan at any authority level (State, Entity). However, in 2001, BiH ratified the Energy Charter Treaty and the Protocol on EE and Related Environmental Aspects (PEERA). By ratifying

the Protocol, BiH committed to formulate and implement policies for improving EE and reducing the negative environmental impact of the energy use. The guiding principle of the PEERA is that contracting parties shall cooperate and, as appropriate, assist each other in developing and implementing EE policies, laws and regulations.

The country review process is a core activity in monitoring and facilitating the implementation of the Protocol. The in-depth EE reviews, implemented under the PEERA, have proven to be an important tool in assessing the progress of BiH in fulfilling its commitments under the Protocol. They also provide peer guidance to governments in developing and implementing EE policies.

In 2011, the Energy Charter Secretariat conducted an in-depth review of EE policies of BiH, following a regular review report submitted by the BiH authorities in 2008. The following elements are reflected in this EE country policy review document brought out in 2012[8]:

- EU accession is a strategic priority for BiH to market reforms. Energy sector reform is being pursued in accordance with the listed priorities of the EU partnership approach.
- Like other countries of the Western Balkans, BiH has chosen a way forward in the framework of the 2005 Energy Community Treaty (EnC) which expresses a shared commitment to market reforms and the development of a regional market.
- The State of BiH has entered into agreements entailing commitments to the delivery of energy policy reforms with the EU and with other Western Balkan countries.
- BiH has established the necessary institutions at State and Entity level to effect and oversee energy market reforms. Regulatory authorities exist at State and Entity levels and certain Entity powers and responsibilities for tariff setting and EE have been assigned to the Entity energy regulators and cross subsidies are being phased out.
- The combination of relatively low energy prices and a degree of continuing electricity price subsidy is suppressing some economically efficient EE activity.
- Promoting EE is evidently an important strategy considering the large capital investments such as repowering of power stations.
- There are EE and renewable energy champions but in general they lack the resources and the legislative mandate to really make a difference.
- Useful progress in raising awareness through the demonstration of practical solutions at local and enterprise level has been made possible through the joint effort of donors, International Financial Institutions and EE actors in BiH at National, Entity and Municipal levels.
- The National EE Action Plan (NEEAP), like the necessary underpinning energy policy, is much delayed and there have been many calls for its finalization and implementation. Resource constraints and other barriers have been cited as reasons for the delay.
- The systematic diffusion of EE considerations as an integral part of policy, regulation and control is yet to begin in BiH. This could be addressed in the completion of the NEEAP and the creation of links that appeal to willing donors and so consolidate the desire to make practical progress that is evident on all sides.

BiH is endowed with basic energy resources, especially solid fuels, other fossil fuels, and hydropower, as well as natural forest biomass and other renewable energies. Indigenous coal, lignite and hydropower are still predominating sources of primary energy consumption. The energy sector in BiH is responsible for between 66% and 72% of CO_2 emissions and much of this is from coal fired power plants. BiH is currently exporting electricity with potential for producing more and becoming a key exporter in the region.

According to the same EE policy review document, in the early 1990's the energy intensity of GDP was exceptionally high. It was more than twice that of its nearest comparator Serbia. From about 1996 onwards the energy intensity of GDP in BiH has decreased, being close to the average of Albania and Croatia and well below that of Serbia. However, the energy intensity of the economy of BiH is high when compared with that of the EU. More than 20% on national GDP is spent

[8] Energy Charter Secretariat 2012. In-depth Review of Energy Efficiency Policies and Programmes: Bosnia and Herzengovina, Belgium: Brussels.

on energy, a clear indicator that suggests more attention needs to be paid to EE.[9]

Power generation in BiH is carried out by three electricity companies: Elektropriveda (EP) BiH, Mixed Holding Company Electropriveda Republike Srpske (EP RS) and EP Hrvatske Zajednice Herceg Bosne d.d. Mostar (EPHZHB). All three companies are in majority owned by the entities of FBiH, RS. Out of total 3,834 MW installed capacity in BiH, more than 98% power generation comes from these three companies. In addition, there are other privately-owned companies and initiatives for construction of new generation capacities.

As regards to heat supply, district heating systems were and are still in place in major cities. Today most of these systems are in bad conditions, they are poorly maintained and obsolete, and require considerable modernization. All district heating systems in the territory of BiH are used only for space heating, in rare cases as industrial processing heat, and not for warm water heating.

There are no EE laws in place at the state or entity level in BiH. However, EE is indirectly covered in other legislation. Regulators, for example, have the responsibility of considering both environmental and EE issues in tariff setting as well as in investment approval regulations and decisions. There are no EE targets in place at State level. The assumption here is that BiH will aim to comply with EU efficiency targets and applicable European Comission Directives.

At the local level, cities in BiH are already becoming aware of the global realities and local authorities have made a dedication to achieving climate change goals by signing the Covenant of Mayors[10]. The goal of the action plan is to reduce CO_2 emissions by 2020 in all sectors by implementing EE measures, increasing the use of renewable energy, through demand management, training and other measures. Stimulated by the results of studies and informed by several energy audit programs, EU awareness raising activities such as the Covenant of Mayors, a number of local authorities have taken action to raise the profile of EE and renewable energy. The main areas of action have been: energy performance of public buildings, sustainability plans and demonstration actions such as retrofitting to insulation to building facades, upgrades to district heating and the regulation of new building energy performance. For example, plans for refurbishment of a district heating system in Banja Luka are understood to be proceeding and to be yielding worthwhile results for the local authority owned district heating company and its customers.

Despite the high energy costs that cities face, most municipal leaders have relatively little awareness of these problems, and the existing solutions. Often, cities are not aware of how much they spend on energy, have little experience in tracking energy costs, do not adequately plan for energy expenses in the future, and cannot identify the energy "*hot spots*" - the buildings with the most flagrant energy waste.

In terms of institutional setup, the key government institutions involved in policy making, managing and operating the energy sector are:

- At the State level: The key ministry is the Ministry of Foreign Trade and Economic Relations (MoFTER); in accordance with the Law, MoFTER's responsibility is "for activities and tasks within the jurisdictions of BiH and which are related to policy defining, basic principles, coordination of activities and harmonization of entities' authoritative bodies and institutions on the international level in the field of agriculture, energy, environment protection, development and usage of natural resources and tourism."

  The key institutions established by statute are: State Electricity Regulatory Commission responsible for regulating transmission, transmission-related activities and international trade. Commissioners rotate on an equal basis the position of Chairman each year. The SERC is financed by regulatory fees paid by regulated companies. SERC has its office in Tuzla.

  Transmission System Operator (TRANSCO) responsible for transmission, maintenance and construction was registered and started operating in February 2006. Independent System Operator (ISO) responsible for the management and control of the transmission network, directing, scheduling and coordinating

[9] http://www.munee.org/node/19

[10] The Covenant of Mayors is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO2 emissions reduction objective by 2020.

maintenance, planning and development of the grid, development of the indicative generation plan with TRANSCO.

- At the Entity level: The key government ministries are - (a) Federal Ministry of Energy, Mining and Industry (FMEMI); it implements the policy and enforces the laws as determined by the legislative body, executes the administrative supervision of implementation of the laws and other regulations, proposes and gives recommendations in the field of legislation, answers to questions of the legislative authorities, and performs tasks of administrative and professional nature. (b) Ministry of Industry, Energy and Mining of RS (MEED); five sections within MEED have energy related responsibilities: section for energy and energy related power utilities, section for energy and fuels, section for development of energy and mining, thermo energetic inspection, and electric power inspection.

  The key institutions responsible for regulating generation, distribution and supply are: Federal Electricity Regulatory Commission – offices in Mostar; Regulatory Commission for Energy of RS – offices in Trebinje.

  A regulatory framework for sustainable energy exists only indirectly. EE and sustainable energy are covered in other legislation. Regulators, for example, have the responsibility of considering both environmental and energy efficiency issues in their tariff making and investment approval regulations and decisions.

There is a wide range of international organizations active in BiH and co-ordination is reported to be increasing with a view to improved targeting and aid efficiency. The principal sources of funds and assistance in implementing reforms of the energy sector include global bodies, the EU and bi-lateral initiatives from many countries. Aid and other assistance are received from the EBRD, EU (CARDS, IPA), Federal German Agency GIZ, KfW Norway, Swedish SIDA, UNDP and USAID. Other valuable assistance comes by way of the panning, verification and peer review processes of treaties such as the Energy Charter and the Energy Community.

Urban Growth and Energy Challenges in Sarajevo

Sarajevo is the largest city and capital of the country BiH and its sub-entity, the FBiH, as well as the Sarajevo. The city is a political, administrative, economic, medical, sports, and university center of the country. Sarajevo is situated 518 meters above sea level and located in the central part of BiH in Sarajevo-Zenica valley, placed between Pannonia dale on the North and Mediterranean on the South.

Sarajevo's climate exhibits influences of oceanic, humid continental and humid subtropical zones, with four seasons and uniformly spread precipitation. The proximity of the Adriatic Sea moderates Sarajevo's climate somewhat, although the mountains to the south of the city greatly reduce this maritime influence. The average yearly temperature is 13.5 °C (56 °F), with January (0.5 °C (32.9 °F) being the coldest month of the year and July (22.0 °C (71.6 °F) avg.) the warmest.

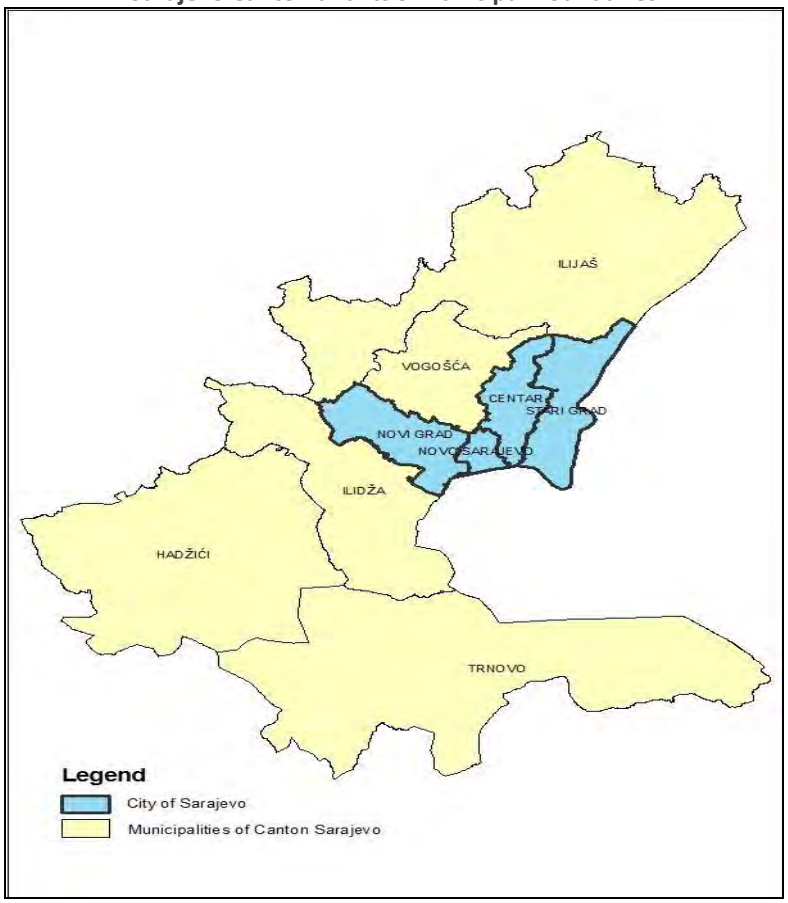
The City of Sarajevo consists of four municipalities: Centar(Center), Novi Grad (New City), Novo Sarajevo (New Sarajevo), and Stari Grad (Old City). The City's total covered area (with 4 municipalities put together) is 142 square km with about 300,000 inhabitants. The New City municipality is the most densely populated part of Sarajevo with about 7,524 inhabitants per square km, while the least densely populated is the Old City, with 2,742 inhabitants per square kilometer. It is an area with economic potential, with a large educated workforce, and a fairly diverse economic base (financial services, transport and communications, industry, tourism, commerce).

At around $10,000 in 2008, the GDP per capita was almost double the rate for the Federation of Bosnia and Herzegovina. Overall, Sarajevo Canton was responsible for around 36% of the GDP in the Federation of Bosnia and Herzegovina (Federation BiH), around 38% of investments, and 51.2% of the total number of tourists. At the same time, Sarajevo Canton amassed only 18.2% of the population, while occupying only 4.9% of the Federation's territory. The Government of Sarajevo is committed to the continued development of the region, and to incorporating sustainability principles in future investment decisions.

Sarajevo is organized as canton with -

- nine municipalities (Stari Grad, Centar, Novo Sarajevo, Novi Grad, Ilidza, Vogosca, Hadzici, Ilijas, and Trnovo).
- the city of Sarajevo constituted of the municipalities of Stari Grad, Centar, Novo Sarajevo and Novi Grad.

Sarajevo Canton and its 9 Municipal Boundaries



Source: Maida Fetahagic, The Sarajevo Canton – Experiences and Challenges in the Development Planning. May 21, 2010

Sarajevo city is administered as a local self-govern unit in Sarajevo with its own constitution. The executive branch consists of a mayor, with two deputies and a cabinet. The legislative branch consists of the City Council. The council has 28 members, including a council speaker, two deputies, and a secretary. Councilors are elected by the municipality in numbers roughly proportional to their population. Sarajevo's municipalities are further split into "local communities" and these local communities have a small role in city government and are intended as a way for ordinary citizens to get involved in city government. They are based on key neighborhoods in the city.

Sarajevo's population is not known clearly and is based on estimates from several sources. During the period from 1991 to 2010, Sarajevo's demographic picture changed; the total Canton's population decreased from 527,049 to 436,572.

Sarajevo's economy has been subjected to reconstruction and rehabilitation programs after years of war. The city's large manufacturing administration, and tourism and catering, combined with large informal market makes it one of the strongest economic regions of BiH. Sarajevo industries include tobacco products, furniture, hosiery, automobiles, and communication equipment. Important industries are: production and processing of food and beverages, tobacco products, chemical products, electric machines, metal processing industry, textile and wood, production of shoes and accessories, construction material and construction itself. Employment in Sarajevo is far under pre-war situation and it presents highly exposed problem in the city and surrounding areas.[11]

Rapid industrial development, uncontrolled urbanization and lack of care for basic infrastructure in rural areas and agriculture, led to sudden deagrarianization in BiH. The deagrarianized population is mostly not urbanized – i.e. they work but they do not live in the cities. Their construction of housing facilities has kept getting closer to the places in which people work, as people built their housing units at the outskirts of urban areas. This is a particular characteristic of the areas around bigger cities like Sarajevo, Banja Luka, Zenica, Tuzla and Mostar. As a result densely inhabited areas were created, mostly around big towns, in the river valleys and in the lower parts of predominantly highland areas. Such development pattern have put significant pressure on the urban environment, particularly in cities.

From a planning perspective, there are several documents that guide development in the Sarajevo Canton. These include: The Sarajevo Canton Development Strategy until 2015 (1999); The Urban Plan for the City of Sarajevo for the period from 1986 to 2015; The Spatial Plan of

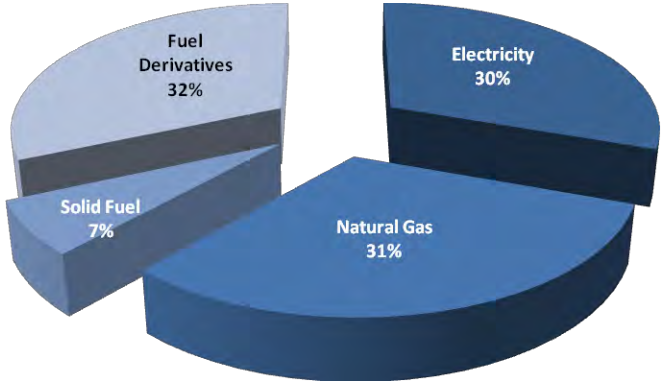
[11] http://www.sarajevo.ba/en/stream.php?kat-144

Sarajevo Canton for the period from 2003 to 2023; and, the Canton Environmental Action Plan (2006).

There is no energy efficiency strategy for the Canton, but an energy study is underway – "Achieving Optimal Energy Supply in Canton Sarajevo". This study will provide an analysis of some of the energy challenges and opportunities the Canton is facing. A special focus in the report will be placed on energy efficiency issues.

In 2010, the Sarajevo Canton consumed around 4,282 GWh of energy (or around 15,415 TJ). There was an almost even split between energy derived from natural gas, electricity, and fuel derivatives (e.g. gas and diesel), with 7% of final energy being derived from solid fuels (e.g. coal, lignite, brickets, wood).

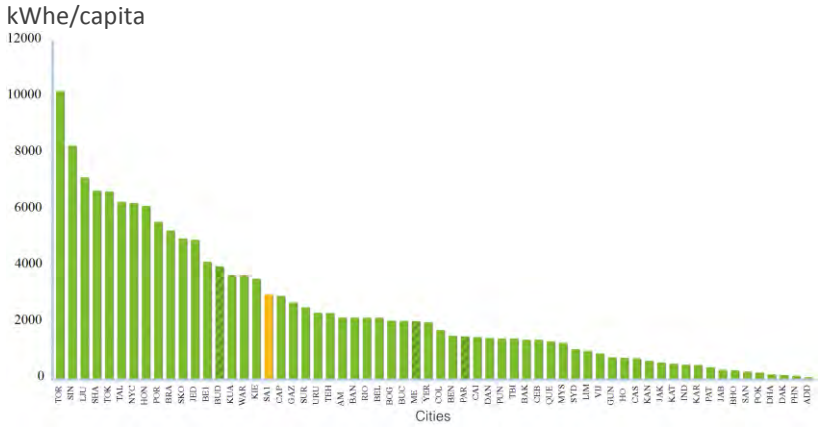
Sarajevo Canton Overview of Energy Consumption, in 2010



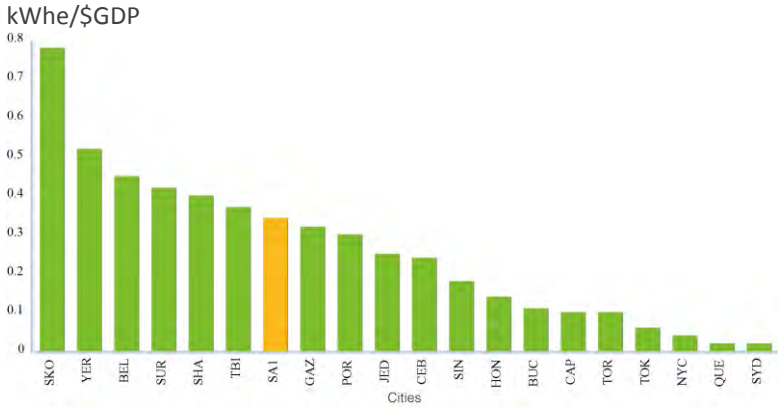
Source: Canton Sarajevo. 2010. Bilans Energetskih Potreba Kantona Sarajevo Za 2011. Godinu

As the following figures highlight, Sarajevo is relatively a high energy intensive economy, characterized by high consumption of electricity on a per capita basis as well as for every unit of GDP produced compared to other cities for which data is available in TRACE database. The Canton would benefit from energy efficiency measures and yield positive economic value through lower energy bills and reduced energy imports.

Primary Electricity Consumption per Capita



Primary Electricity Consumption per GDP

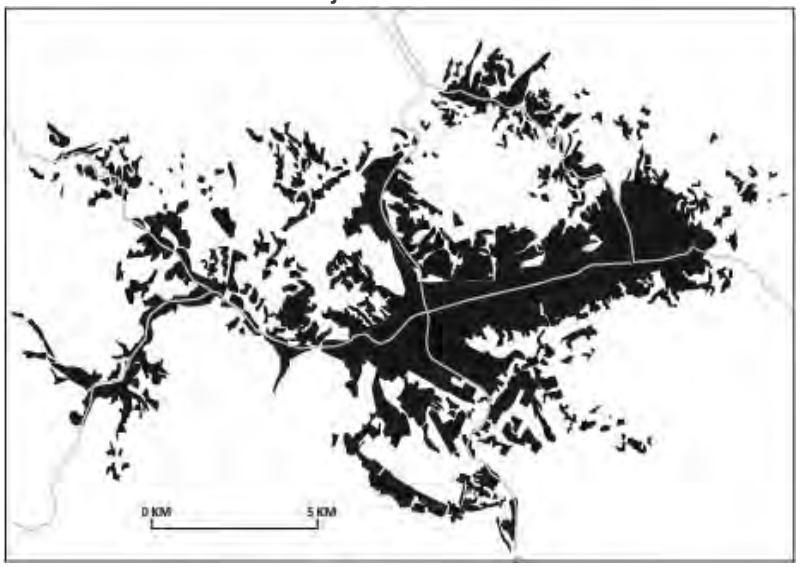


One significant area that is not captured by the TRACE tool is urban mass. Urban mass plays a critical role in determining energy usage patterns in a city. Generally, the denser a city is, the more energy efficient it will be. A dense city makes travel by foot and by bicycle easier; it makes public transport more efficient and economical; it reduces the cost of delivering public services such as water, wastewater, and district heating; it limits the number of light poles required to light

streets and public spaces; it lowers transport times and fuel expenditure for garbage trucks.

Promoting dense development patterns should be the norm for all city authorities. Unfortunately, cities the world over are becoming less dense. Even cities with a stagnating or declining population are witnessing some measure of sprawl. Many of the reasons for this occurrence are known, while others are less intuitive. An aging of the building stock in center cities, the advent of the private car, and rising incomes, have pushed more and more people to cities' peripheries. With no estimating growth of population in Sarajevo, the city should be facing urban development rather than growth and with its large number of undeveloped or badly developed areas.

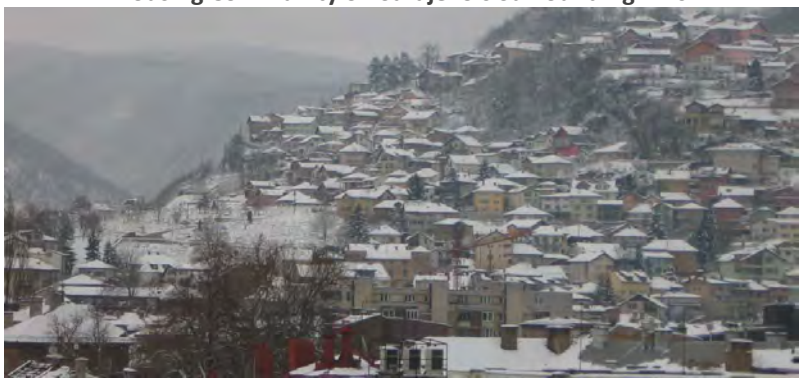
Sarajevo Urban Mass



The challenge for local authorities is to encourage dense development patterns, and discourage sprawl. Local authorities can play an important role however in adjusting the scale of this outward expansion, and improving the city's energy performance.

As the figure above indicates, Sarajevo is no stranger to urban sprawl, with new communities springing up in several peripheral areas. Moreover, most of these new communities go up on hills, putting an additional strain on efficient service delivery. Basically, public services not only have to be delivered to further-off, lower density communities, but they also have to be delivered to higher altitudes. This translates into extra costs for pumping water, extra fuel consumption for garbage collection, lower accessibility for public transport, higher dependence on private cars, and higher fuel usage.

Housing Community on Sarajevo's Surrounding Hills



Sustainable Sarajevo

The following analysis and recommendations are primarily about how Sarajevo can become a more sustainable city. The focus will be on energy efficiency, but the scope of the analysis goes well beyond that. Energy has the benefit of being easy to quantify and to measure, and is a good binding element for thinking about a city in a holistic way. Almost everything that is done in a city requires some form of energy input. Consequently, TRACE is not just a tool for assessing potential energy and cost savings, but it is also a tool that allows local authorities and policy makers to think about cities as a whole. Ultimately, TRACE is a diagnostic tool that allows cities to become more sustainable.

For each of the six service areas, TRACE requires the collection of a number of indicators. These indicators are both energy related (e.g. the fuel consumption of the public transport fleet) and not (e.g. urban transport modal split). The energy related indicators help assess energy and cost savings potential in each service area. The non-energy

indicators help give a more rounded picture of these service areas, and they help fine-tune recommendations so that they go beyond just energy issues.

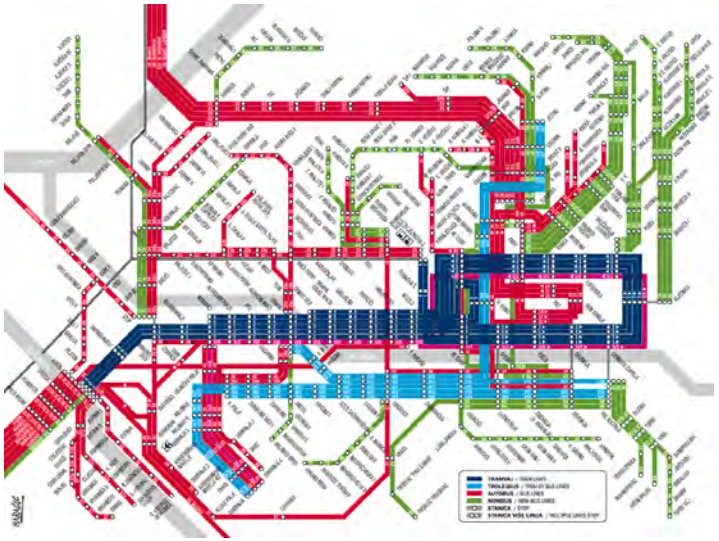
Energy and cost savings potential are assessed through a relatively simple benchmarking process. Basically, individual indicators selected for Sarajevo are compared with similar indicators from other cities included in the TRACE database. For comparison purposes, cities can be selected based on level of development, based on climate, or based on population. The cities that do better than Sarajevo on a particular indicator become a benchmark that Sarajevo itself can aspire to. For example, if several cities have a lower energy consumption per street light pole, it is an indicator that local authorities in Sarajevo could achieve energy savings in the 'Street Lighting' sector (e.g. by replacing energy inefficient light bulbs with more efficient ones). The energy and cost savings potential is calculated for each of the six service areas. Based on where the biggest cost savings could be achieved a priority list is being drawn. The priority list then feeds into a list of recommendations that are likely to have the biggest impact, for the lowest amount of effort and resources invested.

Preliminary on-site interviews and field visits have helped give a more rounded picture of sustainability challenges and opportunities in Sarajevo. The following sections include a quick analysis of each of the six service areas analyzed with TRACE, along with some key findings.

Public Transport

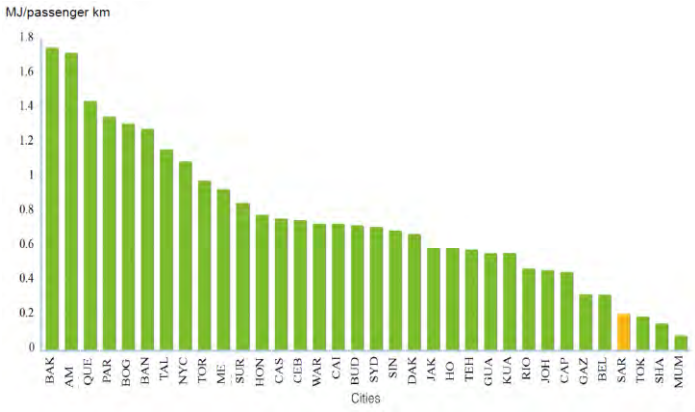
Public transportation in Sarajevo is organized as a public company – JKP GRAS, which runs trams, buses, trolleys, minibuses, and a cable car. In addition to GRAS, there is a private bus company – Centro Trans, which serves a number of routes in the city, and connects suburban and peri-urban communities to the city center. The way the public transport system is organized is quite efficient and it owes a lot to its original design. Thus, tram lines and trolley lines (in dark blue and light blue respectively, in the map below) serve the main axis of the city from East to West, while buses and minibuses (in red and green) serve as feeder lines from North and South. The system's good organization enables not only a higher ridership (as it is easy for people to navigate it), but it also allows for improved fuel performance and energy efficiency, as routes are planned well.

Sarajevo Public Transport Map



As can be seen in the figure below, Sarajevo has one of the most energy efficient public transportation networks of any city with relevant data in the TRACE database. This means that its buses, trams, trolleys, and minibuses consume less energy to transport one passenger for one kilometer.

Public Transport Energy Consumption



Looking at GRAS' fleet alone, one would not expect such high energy efficiency rates. The rolling stock is quite old and in need of replacement. Furthermore, the public transport infrastructure was completely destroyed in the 1992-1995 war, and although large donations were given to improve the system, it has never fully recovered.

For example, much of the bus fleet operating in Sarajevo is made-up of second hand buses that were donated in the 1990s. The Government of Japan was particularly generous, donating several buses in 1998. These buses already had several years of use on them when they were delivered, and although they now operate in fairly good condition, they normally should be taken out of commission by 2014. Other buses are way past their prime and should have been replaced a long time ago. Nothing was done about it though as the required funds are missing.

Bus in Sarajevo

The tram network in the city was originally developed in 1885 and is one of the oldest in the world. During the 1992-1995 war, much of the tram infrastructure was destroyed and had to be completely re-built. A number of trams were donated by the Government of the Czech Republic and they are still operating today.

Overall, the rolling stock in Sarajevo is quite old and often outdated. To improve performance and reduce energy consumption GRAS has undertaken a number of initiatives. For example, 20 trams were retrofitted with newer Siemens engines, which helped reduce energy consumption by 38%. These trams have a special system in place, which allows them to capture the energy generated when breaking, and send it back to the line to benefit on-coming trains (following the regenerating breaking principle).

Tram in Sarajevo

Plans have been hashed out to re-equip an additional 17 trams with more energy efficient engines and there are also talks about converting a number of two-part trams into three-part trams. Such a conversion would allow the transport of a larger number of people with a similar energy input.

Tram in Sarajevo

However, such measures are not as much driven by a drive to improve the energy efficiency of the local fleet, as they are driven by financial difficulties the public company is facing. In 2011, GRAS had expenditures of around $48 million and revenues of only $34 million. The company is heavily dependent on subsidies from the Canton, and it has a debt of around $17.5 million that needs to be paid by 2016.

The problem, similar to what is happening in other service areas in the city, lies in the tariffs that are charged. These have not changed since 2005, although the price of fuel went up by 56% and the price of

electricity went up by 41%. Moreover, around 65% of passengers in Sarajevo use subsidized tickets (e.g. students, retired people, and war veterans).

An un-subsidized monthly ticket, for example, costs around $36. A subsidized one, costs $11. Most of the subsidies however ($13.5) have to be covered by GRAS itself, with only $11.5 provided by the Canton. For many retired people, GRAS has to cover an even higher subsidy, of $22. The fact that GRAS cannot generate enough revenues to cover its operation costs, and the fact that the Canton has little resources to invest itself in system improvements and upgrades, means that not much has done to expand service to the newly emergent communities. Having difficulties to run an ageing public transport infrastructure, GRAS has not done much in terms of creating new routes in some of the areas of the city that are growing more rapidly. For the most part, people living in these areas have to rely on cars for commuting, and on average they incur monthly fuel costs that are more than double what they would have to pay for an un-subsidized monthly public transport ticket - $74.

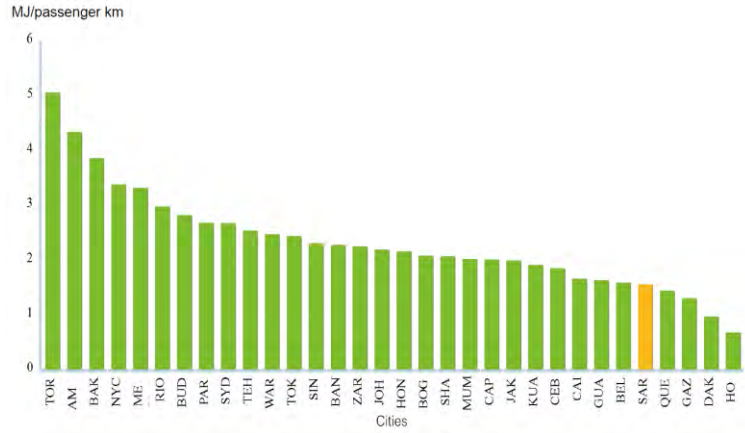
Private Vehicles

As most cities in Eastern Europe, Sarajevo has seen an increase in private vehicles ownership and ridership. However, this growth was to some extent stifled by the war of 1992-1995, with little to no trade happening in that time period. Many of the cars added to the local vehicle stock represent second hand cars, imported from Europe.

Since second-hand cars are usually less fuel efficient than new cars, one would expect to see a relative energy intensive stock of private vehicles in Sarajevo. However, as the figure below indicates, cars in the Canton seem to be quite energy efficient, with a relatively low energy expenditure for each passenger kilometer. This finding is particularly interesting if one considers that Sarajevo's topography is quite difficult with hills surrounding the city on all sides (see image below), and should normally require a higher fuel usage than in a city with a flat topography.

To a large extent, new city growth in Sarajevo has had to go up or around the exiting hills. Since much of the low lying plain was already developed, people built new homes on higher altitude areas around the city. These new communities were most often not served by public transportation routes, and people had to rely on private vehicles to get around. Driving cars up and down higher altitude areas can be quite energy intensive, and if the city will continue to sprawl up the surrounding hills, it is likely that energy intensity in the sector will go up fast.

Private Transport Energy Consumption



Sarajevo Topography

The best way to counter such a trend is to continually invest in public transport infrastructure, and to use urban planning guidelines to encourage compact and high-density city development. The denser new communities are, and the closer they are to the existing built mass, the easier it is to expand public transport routes, and ensure that those routes are run profitably.

In addition to public transport developments, local authorities should also invest in the development of non-motorized infrastructure – particularly pedestrian paths, but also bicycle paths in low-lying areas. Several areas in the city, such as the historic neighborhood of Bascarsija, are completely closed to traffic, and are now congenial pedestrian areas. Similarly, some of the bridges in the city have been closed to car traffic (see image below) and now can only be used by pedestrians. Such a measure makes it harder for cars to get around the city, especially from one side to the other of the River Miljacka, but makes the city friendlier to pedestrians. Another bridge is planned over the Miljacka, and it is also designed to be a pedestrian only bridge.

Pedestrian Bridge in Sarajevo

The old city in Sarajevo is quite compact and easy to navigate by foot. However, some of the neighborhoods in the new city are less pedestrian friendly. To encourage people to walk more in these new neighborhoods, local authorities close certain streets to car traffic on week-ends.

In addition to closing streets to traffic, local authorities have put a number of parking management measures in place. These measures are meant to not only alleviate traffic conditions in the city, but to also improve urban conditions, by reducing the number of cars illegally parked on sidewalks, and to reduce the number of vehicles that clutter a quite compact and dense urban center.

The interesting thing about parking management in Sarajevo is that it falls under the purview of RAD, the Canton's solid waste management company. RAD manages a system of parking automats (see image below) in the city center, and it has a number of open parking areas and parking garages spread throughout the city (with a total of 3,000 parking spots). Parking regulations are enforced quite strictly, and illegally parked cars are removed by trucks equipped with specially designed cranes. When compared to other cities in the region, one sees few incidences on cars parked on sidewalks, and the city's sidewalks are quite easy to navigate.

Parking Automat in Sarajevo

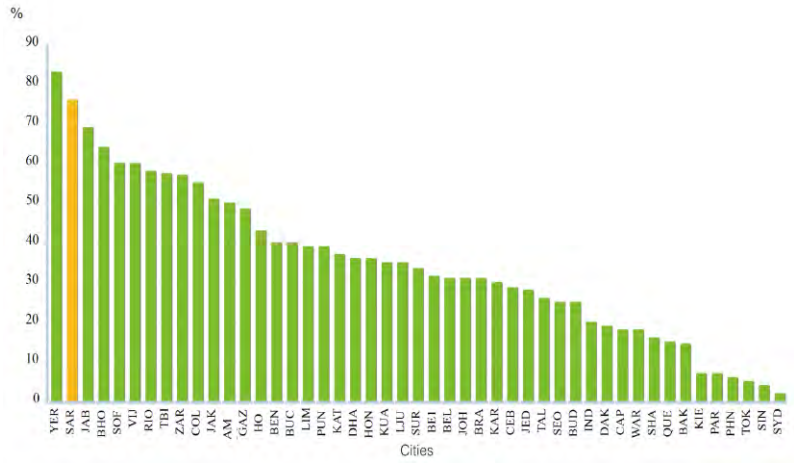
Snow Covered Streets Cleaned by RAD

In addition to parking management, RAD is in charge of cleaning streets of snow in the winter time, and opening them up to traffic again. Their role in relieving traffic conditions became very evident in February 2012, when snow fall was particularly heavy, and car traffic in the Canton was stopped for two days under almost 1.5 meters of snow. RAD responded to the sudden snow flow with a sizeable fleet of snow plows, improving accessibility and traffic conditions.

Water and Waste Water

Water and wastewater services in the Sarajevo are provided by a public company – VIK Sarajevo. The company actually services only 6 of the 9 constituent municipalities of the Canton: Centar, Stari Grad, Vogosca, Ilizda, Novi Grad, and Novo Sarajevo. The other 3 (peripheral) municipalities have their own arrangements for water provision. Most of the water (90%) is drawn from 3 large underground wells (Bacevo, Sokolovici, Stup), and delivered to end-consumers through a network of 1,000 km. Given Sarajevo's difficult terrain, water is elevated from 490 m to 850 m, using a system of 24 pumping stations and 55 reservoirs. The wastewater treatment plant at Butila is designed around a gravitational system, with a network of 750 km of pipes. It has remained un-functional since the outbreak of the war in 1992.

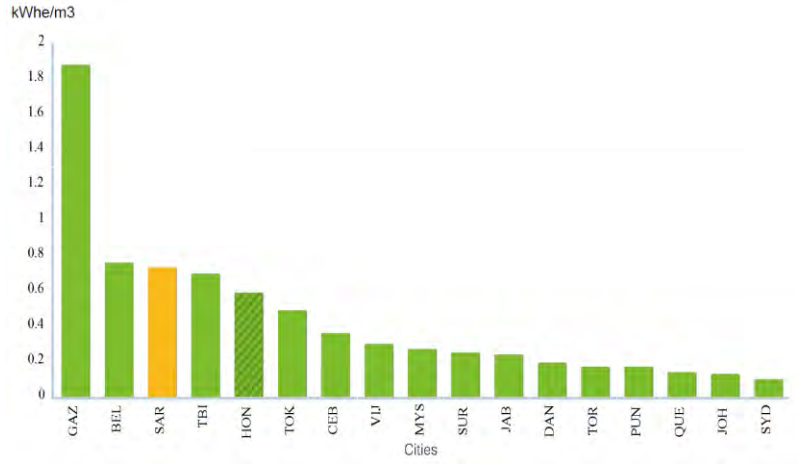
Percentage of Non-Revenue Water



The water system in Sarajevo operates at normal Western European standards, providing water of good quality to around 360,000 end consumers. However, while water quality is good, the performance of the system is not. Of all the cities in the TRACE database, Sarajevo registers one of the highest water losses. Only Yerevan performs worst. For systems that are gravity based such system losses mainly have environmental implications. For systems that are reliant on pumping, these losses also have significant economic implications. Since Sarajevo is dependent on pumps to not only draw water from underground wells and from the River Bosna, but also to pump it up to 48 zones with different elevations, all the lost water in the system translates into wasted energy costs. Basically, much of the water that gets lost, was already treated and pumped through the system, requiring significant energy inputs.

In fact, the energy inputs required to run the Sarajevo water system are quite substantial. As can be seen in the figure below, Sarajevo has one of the most energy intensive water systems of any city with relevant data in TRACE. Its difficult topography and its reliance on underground wells and river water mean that a lot of energy has to be consumed to produce a metric cube of potable water.

Energy Density of Potable Water Production



When produced potable water is so energy intensive and ultimately expensive, losses in the system translate into squandered public money.

The main problem with the Sarajevo water network is that it is quite old (some sections are over 100 years old), with large pipe sections requiring replacement, and with many pumps requiring upgrading. The system also requires improved metering, control systems, and new electric equipment. The current situation is in part a heritage of war damage, but to a large extent it can be blamed on the poor cost recovery and on the increasing costs imposed by system expansion (particularly to low density communities in surrounding hills).

Water tariffs in Sarajevo are quite small (around $0.74 per cubic meter of water), and they haven't been increased since 1997. This, coupled with rising energy costs, has led to a continuous deterioration of the public water company's financial position. In 2011, VIK had expenditures of around $44 million and revenues of only $24 million. This gap not only contributes to a mountain of debt the company has collected, but it also hinders potential investments in system improvements.

In recent years, VIK has tried to cope with the rising water demands in the Canton, as Sarajevo has continued to grow and sprawl outward, and as new, lower density, and higher altitude communities have been added to the system. All of these new communities require not only additional pumping and treatment, but they also require more energy intensive water. Unless the system is reformed, the current problems are likely to grow exponentially in the future, requiring even more upfront investments for upgrades and improved system performance.

A report prepared by EBRD indicated that the water tariff in Sarajevo should increase threefold, to around $\$2.4/m^3$, to ensure system viability. To overcome affordability and social issues, a block tariff could be introduced, with a different system of prices for different consumption levels. Thus, high water consumers are charged a higher tariff, while low water consumers are charged a smaller one. When people are charged what they actually consume, there is a better incentive to conserve water and avoid unnecessary squandering of a precious resource.

To make such a system viable, end consumers have to be properly metered. As of 2012, many of the end-consumers living in apartment buildings only had building level water meters, instead of having apartment meters. This means that individual households pay an equal share of what the entire building has consumed, rather than pay what they individually have consumed. In addition, around 5% of end-consumers are not properly metered at all.

A first step for improving the performance of the water system in Sarajevo is consequently a proper metering of all end-consumers, in tandem with gradual increases of water tariffs. While such a measure may be socially and politically hard to implement, it is critical to ensuring continued quality service in the future. Once such measures have been put in place, other measures can be introduced to improve overall operational performance – e.g. upgrade and replacement of old pumps, replacement of old pumping, extension of SCADA system to the whole system.

In addition, national policy makers could work together with the electricity distribution company, to introduce a peak and off-peak electricity tariff system. In the past, the water company could take advantage of off-peak electricity tariffs (between 1:00 PM and 4:00 PM and between 10:00 PM and 5:00 PM), to pump water and fill existing reservoirs, and then distribute the water to end-consumers during peak hours. Such a system would benefit electricity distribution companies too, as it allows them to better manage electricity distribution during peak hours.

As far as the wastewater system is concerned, it has been un-operational since the start of the war in 1992. Currently, all wastewater generated in Sarajevo is gravitational and discharged untreated in the Canton's river system. Around $325 million are estimated to be required to make the Canton's wastewater system operational. Works are already underway on parts of the system, with a €13 million EU IPA grant, and a €23.6 million loan from the World Bank. The wastewater treatment plant will only service 6 out of the 9 constituent municipalities of Sarajevo (same as in the case of the water system). One of the other three municipalities – Trnovo, already has a small facility, while the other two municipalities would be difficult and costly to connect because of the distance and topography.

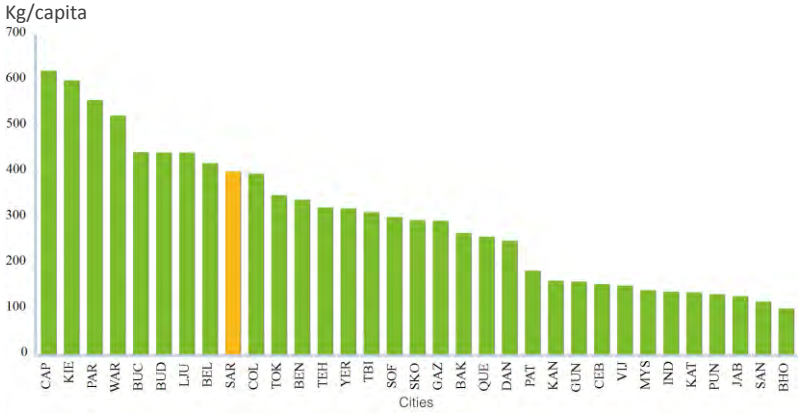
Solid Waste

Collection, transport, and disposal of waste in the Sarajevo, is organized by a public company – KJKP RAD. They service all 9 municipalities, and in addition to solid waste management (SWM) services, they are also

responsible for the cleaning and washing of streets, for snow plowing in winter time, and for parking management.

Unlike other public companies in Sarajevo, RAD seems to be doing relatively well, with revenues closely matching required operation needs, but still reliant on public subsidies for certain investments in system upgrades. With incomes and consumption rising in recent years, RAD had to also deal with increasing quantities of waste. The amount of waste per capita generated in the Canton has increased steadily, requiring more investments in new collection bins and garbage trucks. Currently, Sarajevo has one of the highest wastes per capita generation rates (400 kg/capita/year) of cities with a similar human development index in the TRACE database (see figure below).

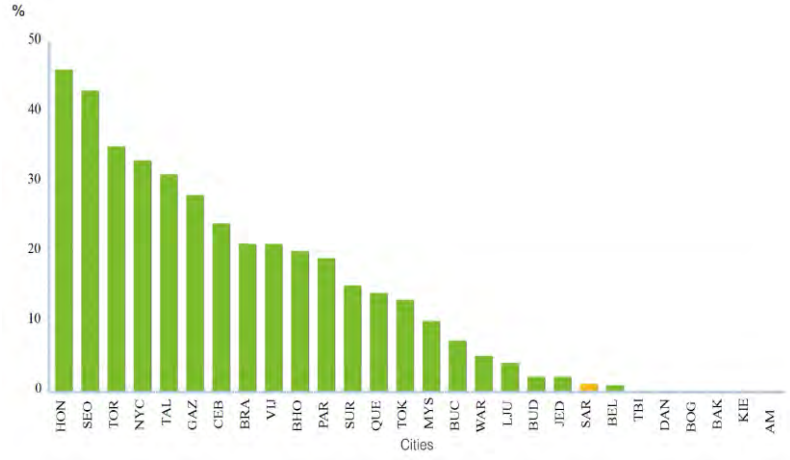
Waste per Capita (for cities with a similar HDI Index)



Such high waste generation rates naturally require investments in system expansion and improvement of logistics works. In 2012, there was a shortage of around 2,000 containers, required for proper waste collection in the Canton. These would need to be added to the stock of already existing 6,000 containers. If plans to introduce separate waste collection at the source are also to be implemented, an additional 2,000 recycling containers would be needed.

Currently, the recycling rate in Sarajevo is among the lowest of all cities with pertinent data in the TRACE database (see figure below). Local authorities plan to bring this figure up, but doing so requires both physical investments and education programs for waste generators. In any case, there is an active and burgeoning market for recyclables in the country, in the region, and in Europe as a whole, and local stakeholders hope to take full advantage of it. In addition to RAD, there are 16 private operators that collection recyclables, and an unknown number of informal collectors that make a living out of recycling. A well designed and well managed recycling system could bring together all the disparate players involved in the sector right now, and help them achieve economies of scale.

Percentage of Waste Recycled



The collected waste is transported to a modernized landfill that is close to town. The landfill is only 5 km away from the city center (see image below), and garbage trucks that serve the Canton on the whole have travel routes of around 20 km, which is quite good for an urban area the size of Sarajevo. The truck fleet operated by RAD is quite diverse and generally in good shape. In particular, RAD has plans to replace a third of their truck fleet, which is 18-20 years old on average. As the photos below indicate, some of their trucks are even older than 20 years, and should ideally be scrapped and replaced with newer ones. RAD has brought down the average age of their vehicle fleet, to ensure more energy efficient operation, to lower maintenance costs, and to reduce their environmental foot print.

In April 2012, 14 new specialized vehicles have replaced a portion of the outdated fleet for collecting and transporting waste. Currently, the average age of the fleet is 7 years, which is same as the average utility companies from Western European cities.

Old trucks often require quite substantial maintenance and operation costs, they consume more fuel than newer trucks, and they cause more pollution and emissions. Moreover, old trucks are less reliable in crisis situations and may lead to unwanted consequences if they fail to perform at expected parameters.

Location of Canton Landfill

RAD Old Truck Fleet

For example, in early February 2012, Sarajevo received a lot of snow in a short amount of time, and the city was quickly covered with a layer that was almost 1.5 meters high in some cases. These sudden precipitations paralyzed the city for more than two days, basically shutting it off from the world outside, with the airport and most major roads being closed down. Responding to such a crisis required the intervention of all of RAD's snow plows, which had to work 24/7 to clear the snow congested streets. In such a situation, every snow plow that fails to perform as expected could affect people's safety and the city's economy. All of the collected waste in the Canton is taken to a nearby landfill.

Old Landfill

New Landfill

The landfill was recently modernized with a World Bank loan (see above before and after pictures), and now operates at good environmental standards. The dumping area is now protected with a system of lining, leachate is collected and treated, methane gas capture devices have been installed, and the old dump was covered with a thick layer of earth and new greenery.

The methane captured from the landfill is used to generate electricity, which is then subsequently sold to the grid. The facility has a capacity of 0.3 MW, but the landfill as a whole could generate 1.5-2 MW. While electricity generation is slower in the winter time (when methane generation slows down because of the low temperatures), landfill gas to energy facilities help generate additional income, and, most importantly, they help reduce the negative effects of one of the most potent greenhouse gases.

In addition to methane capture and electricity generation, RAD also operates a sorting facility at the landfill. The sorting facility was developed with an EU grant, and receives recyclables collected with the help of 560 separate collection containers. This is a pilot program that is hoped to be scaled up, once operators identify what exactly works and what doesn't. Currently, they have difficulties educating people to recycle properly, and they often have to deal with informal collectors which steal recyclables away from existing bins.

Sorting Facility at Sarajevo Landfill

All in all, the SWM system in Sarajevo provides basic waste services quite efficiently, and has piloted a number of forward thinking initiatives, which are hoped to be scaled up in the future. In 2011, RAD had revenues and expenditures of around $27 million, managing to cover its operation costs from charged tariffs. Nonetheless, the public company indicates that higher tariffs would need to allow for continued system upgrades, such as the introduction of a fully functioning recycling system.

Currently, RAD charges households around $0.07/month for each square meter of housing. Thus, people living in an apartment of around 30 m^2, have to pay around $2/month for SWM services. Businesses have to pay around $0.13-$1 per square meter per month. The prices of service for collection and disposal of waste are set by the Government of Canton of Sarajevo and it has not changed for 14 years. Such prices can barely cover operating costs that the RAD has and it prevents self financing or recovery of funds, expanding the range of services through frequency of site visits, equipment modernization, and increased activity in the development of recycling from a selective collection of waste (recycling containers) to the packing of secondary raw materials.

The decision to raise tariffs is taken at the Canton level and social considerations are always weighed before raising tariffs. Moreover, local authorities fear that raising tariffs would push people to forgo paying their bills. Each year, around 15%-25% of people and businesses fail to pay their bills, and RAD has around 50,000 civil suits that await a court decision. Since they can cut people's service off, RAD has to resort to the legal system. This requires of them high transaction costs, high legal fees, and a lot of wasted time and energy. Consequently, better enforcement mechanisms are needed to ensure timely collection, and the tariff system needs to be re-designed, with higher charges for high waste producers, and lower charges for low waste producers. City of Belgrade, for example, plans to introduce an innovative pay-by-weight system, which would allow them to charge household and businesses based on the quantity of waste they produce, while offering incentives people who recycle. According to RAD, such a pay-by-weight system will be difficult to introduce in Sarajevo Canton as there are no technical conditions for citizens and legal entities to switch to this method of payment. Containers for waste, in the urban part of the city, due to lack of space, are often mixed for citizens and legal entities. Furthermore, a large part of citizens live in collective housing (buildings) where the waste containers are located in niches in front of the buildings, and it is open to all citizens to dispose waste without the possibility of monitoring who disposed waste and where. The situation is identical in many suburban areas, where entire neighborhoods were built in an unplanned

manner, without urban and building permits, and these do not have adequate infrastructure for vehicles of KJKP RAD to get near houses and collect waste. A very small number of facilities where it would be possible to introduce this system, would not contribute greatly to increase in recycling, while citizens and legal entities would be put at a disadvantage, and the introduction of this system would lead to much bigger problems in the collection and the dissatisfaction of citizens and other users of services, and at the same time it would necessitate huge costs to change the entire system which in given local conditions are unacceptable to RAD. Therefore, according to RAD, the system of charging per m^2 for collecting and transporting waste from residential and commercial areas is still the most applicable way of billing services as practices in many Western European cities.

Municipal Buildings

The municipal building stock in Sarajevo is quite large, with around 450 buildings, which had a floor area of almost 900,000 m^2. Heating these buildings required 116 million kWh in 2008 (or 130 kWh/ m^2), while powering them required 30 million kWh (or 34 kWh/ m^2). As can be seen in the table below, the municipal building stock is quite varied, with a lot of educational and health-care buildings, along with administrative and public institution buildings. Consequently, implementing energy efficiency measures will require different strategies. Experience from other cities, such as Belgrade, indicate that EE measures in hospitals, for example, render a higher impact for every unit of investment than similar investments in educational facilities. Since hospitals are in use all year round, and all hours of the day, they are large energy consumers, and are likely to register higher energy savings than schools – which are in use only part of the year, and for a limited number of hours weekly.

Of course, when doing buildings benchmarking and deciding what buildings to focus on, other considerations than just cost savings should be taken into consideration, and it is unwise to focus only on the quick wins. The more municipal buildings are made part of an energy efficiency investment program, the better. Different types of buildings have different peculiarities and require different approaches for reducing energy use. Understanding energy use in the municipal building stock is complex as end uses such as lighting, ventilation, heating, cooling, refrigeration, IT equipment and appliances vary greatly from one building category to another within this sector (see table below).

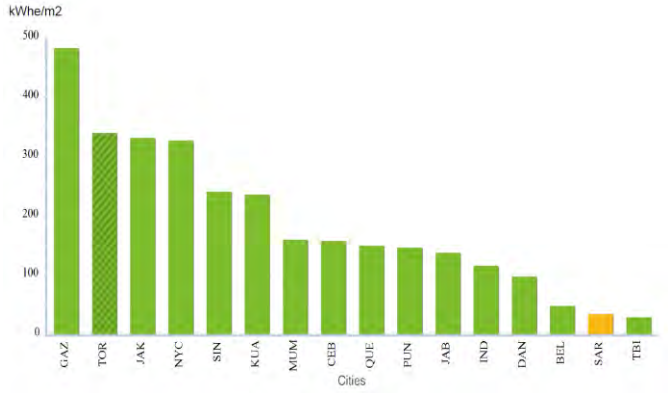
Municipal Building Stock in Sarajevo, in 2008

Building Type	Number of Buildings	Floor Area (m^2)	Electricity		Heating	
			kWh/year	kWh/m^2/year	kWh/year	kWh/m^2/year
Educational	173	525,167	10,365,239	19.74	53,104,928	101.12
Health	109	177,271	9,511,724	53.66	35,170,591	198.40
Administration	77	42,233	2,761,932	65.40	7,207,433	170.66
Cultural	36	52,585	1,357,221	25.81	6,804,794	129.41
Sports	8	81,219	5,373,533	66.16	12,315,232	151.63
Public Institutes	43	15,372	795,780	51.77	1,758,972	114.43
Judicial	3	593	30,917	52.14	66,475	112.10
TOTAL	**449**	**894,440**	**30,196,345**	**33.76**	**116,428,425**	**130.17**

Source: Kolega, Vesna and Haris Lulic. 2011. Akcijski plan energetski odrzivog razvitka Grada - Kantona Sarajevo. PPT Presentation - GiZ projekt: Inicijativa glavnih gradova Sarajevo, 29.06.2011

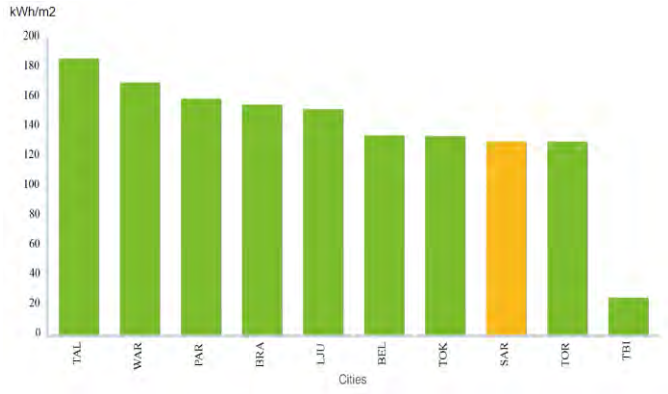
Overall, electricity consumption in Sarajevo's municipal buildings is quite low. Sarajevo has the second lowest electricity consumption (without the space heating) per square meter of any city with relevant data in the TRACE database. Why the figure is so low is not quite clear, as there have not been any widespread upgrades of electronic appliances and light-bulbs in municipal buildings. It is clear however that further investigation is needed to get a better understanding of this service area.

Municipal Buildings Electricity Consumption



As far as energy requirements for heating are concerned, municipal buildings in Sarajevo had relatively high heat consumption, although lower than most cities with relevant data in the TRACE database see figure below). Local authorities indicate that by and large, not much has been done in the way of improving energy efficiency in municipal buildings in Sarajevo. For the most part, these buildings have received no upgrades in recent years. Some of them, particularly those that were developed in the years of communism are in particular bad shape. A large number of buildings developed in the years of centralized planning had relatively thin concrete walls, large and poorly insulated windows, and large and poorly insulated roofs.

Municipal Buildings Heating Consumption



In addition to the deterioration incurred with age, many municipal buildings have also suffered and continue to suffer from the ravages of the war in 1992-1995. Bullet and shell marks can still be seen on the exterior walls of many buildings in Sarajevo (see image below).

Municipal Building with Damaged Exterior Wall

In many cases, the damages incurred during the war have not been repaired, and these buildings are literally energy sieves. Nonetheless, there are also many municipal buildings that have undergone thorough energy efficiency improvements. Some of them have been done on a pilot basis, some have received EE improvements as part of more general refurbishments after the war.

Thermally Insulated Educational Facility in Sarajevo

It is reasonable to conclude that with a large stock of old municipal buildings in Sarajevo which consumes high heat energy per unit of plinth area, the energy savings potential is huge. Sufficient thermal insulation

of particularly the older building envelop is in fact essential for shielding the interior of the building from the exterior environment and minimizing thermal transfer (heat loses or gains) through the building envelop during the winter and summer periods.

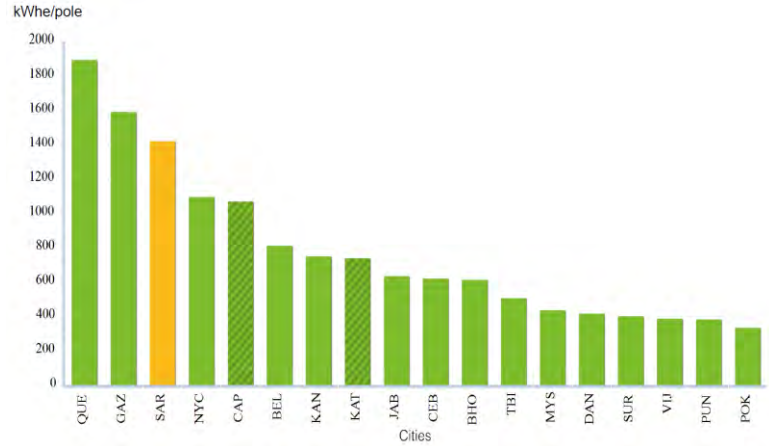
All in all however, there have been no efforts to do an integrated audit and analysis of the entire municipal building stock in Sarajevo. There have been however sporadic attempts financed by the UNDP and GtZ to assess the energy performance of selected groups of municipal buildings. These assessments have indicated that energy savings of between 35% and 40% were possible in a selection of municipal buildings, with simple measures (e.g. thermal insulation of exterior walls, replacement of windows, and insulation of roofs).

Public Lighting

Following the 1992-1994 siege of Sarajevo, the majority of the street lights in the city were destroyed. In 1993, only 84 lights worked properly. In the reconstruction that followed the war, the street lighting system was completely reconstructed. Thus, in 2008, there were 24,604 functioning street lights in the Sarajevo. However, reconstruction funds, mainly coming from donations, did not permit the acquisition of more expensive, energy efficient bulbs. Consequently, most of the newly installed light-bulbs were relatively energy inefficient, and few initiatives were taken since to invest in better technologies. In 2008, 68% of street lights in Sarajevo continued to run on mercury bulbs. 18% of the street lights were equipped with relatively efficient high pressure sodium vapor lamps, while the remaining light poles had different other technologies installed (e.g. fluorescent bulbs).

The street lighting system is responsible for around 2.5% of electricity consumption in the Canton, and energy bills are paid to the Electricity Distribution Company. The energy consumed by the street lights is measured by meters connected to 25-50 poles. (By contrast, in Belgrade, electricity consumption of street lights is billed based on installed capacity – creating no incentives for energy saving.) There are 730 in total, tracking consumption in the over 24,000 light poles.

Electricity Consumed per Light Pole



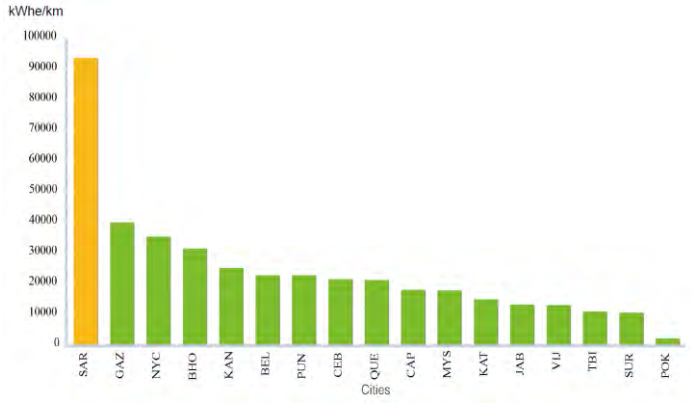
The electricity tariff charged to the Canton is three-tiered. To start with, actual consumption is billed at $0.11/kWh. In addition there is a $0.00067/kWh Renewable Energy Fee (which is supposed to go towards renewable energy projects) and a meter maintenance fee of $3.08/meter/month. On top of the net electricity tariff, local authorities also have to pay 17% value-added tax (VAT).

Electricity consumption by the street lighting system in Sarajevo varies based on the time of the year. The entire system is equipped with astronomic timers with geographic designation. Thus, street lights are turned on based on when nightfall is expected to occur, and turned off at dawn. The longest period of use is between December 19th and January 1st, with lights being turned on at 4:16 PM and turned off at 7:10 AM – or a daily use of 14:54 hours. The shortest period of use occurs between June 7th and July 20th, with lights going at 8:31 PM and off at 4:58 AM – 8:27 hours daily.

However, even if consumption based billing is in place, and even if street lights operate according to astronomic timers, the electricity consumed per light pole is quite high when compared to other cities with comparable data in TRACE (see figure above). Much of this can be attributed to the inefficient mercury light-bulbs that predominate in the system.

In addition to high electricity consumption per light pole, the network in Sarajevo also consumes comparably a lot of electricity per kilometer of lit roads (see figure below). In fact, of all the cities in the TRACE database, Sarajevo seems to score poorest on this indicator, with more than double the consumption per kilometer of lit roads than Gaziantep – the next placed city. Even if the entirety of the road network in the Sarajevo would be lit, it would still score poor on this indicator.

Electricity Consumed per Kilometer of Lit Roads



The fact that Sarajevo consumes a lot of electricity to light up a kilometer of road could be an indication that spacing between individual light poles was not done properly – i.e. failing to take into account a number of factors, such as power of installed bulbs, height of street pole, and traffic intensity in the area. As can be seen in the image below, spacing of street lights on one of the city's main boulevards is quite tight. Of course, this is only anecdotal evidence and a more in-depth analysis needs to be done to determine why it costs so much to light roads in Sarajevo.

Improving the performance of the system can be done quite easily and in a cost effective manner. For starters, mercury light-bulbs can be replaced with more cost-effective ones. In addition, a lighting timing and diming system could be put in place, to allow use and intensity of use, based on needs, actual traffic in the area, and specific time of day. Local authorities plan to invest in a central control unit, which would allow them to control lighting intensity for individual poles.

Street Lighting on Hiseta Ulica

Power and Heat

The basis of the Sarajevo district heating system was set immediately after the Second World War, with the introduction of small, non-standardized boiler houses. In 1968, a District Heating Unit was established within the Housing Company of the Centar and Novo Sarajevo municipalities, and it was extended to all of Sarajevo in 1973. By 1978 Toplane Sarajevo was established as an independent public company responsible for providing heat to the city as a whole. With the establishment of Toplane, the decision was also taken to switch from coal and liquid fuel to natural gas. Thus, starting in 1980, coal, which used to be the dominant fuel used by the district heating system, was gradually phased out, and completely eliminated by 1989. In addition, liquid fuel is only used in small quantities now, to compensate for natural gas shortages, or spikes in natural gas prices. For all intents and purposes, the district heating system in Sarajevo is now run by gas, which has helped lower greenhouse gas emissions in the city significantly.

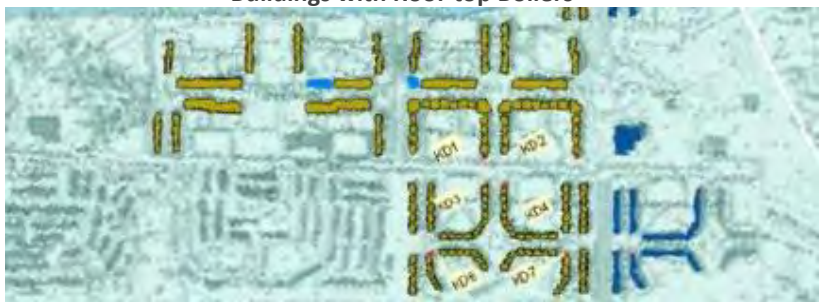
Since 1968 until 2012, the district heating system in Sarajevo has expanded continuously, although at a much slower pace in recent years. In 2010, the system had an installed capacity of 502 MW, of which 326 were actually engaged. A total of 132 boiler houses were used to provide heat to 48,000 flats (40% of the existent housing stock in Sarajevo) and

around 2,200 business premises. Of these 132 boiler houses, 44 were medium and large boiler houses, serving 146 sub-stations, and having a distributive network of 74 km (see image below).

Buildings Connected to Medium and Large Boiler Houses

In addition to these medium and large boilers, there are 88 small roof-top boilers, servicing individual buildings with 30-50 apartments each (see image below). The advantage of such a decentralized district heating system is that the distribution network is relatively small, and so heat losses are more easily managed. On the other hand, decentralized heating systems may be more fuel intensive than centralized systems, and they often require higher maintenance and operation costs.

Buildings with Roof-top Boilers



The Sarajevo district heating system is now the largest single natural gas consumer in the Canton, requiring 37% of the 144 million m^3 consumed there. As can be seen in the table below, around 27% of the heating needs in the Canton are covered by Toplane Sarajevo, and the district heating option is the most energy efficient one – with the lowest energy requirements for every square meter heated.

Heat Consumption in Residential Areas, in Sarajevo Canton (in 2008)

Source	Total Heated Area (m^2)	Heat Consumption kWh/Year	Heat Consumption kWh/Year/m^2
District Heating	2,705,412	309,342,204	114
Electricity	2,045,763	255,720,375	125
Natural Gas	3,903,680	468,841,133	120
Firewood	635,380	79,422,500	125
Coal	591,600	73,950,000	125
TOTAL	**9,881,835**	**1,187,276,211**	**120**

Source: Kolega, Vesna and Haris Lulic. 2011. Akcijski plan energetski odrzivog razvitka Grada - Kantona Sarajevo. PPT Presentation - GiZ projekt: Inicijativa glavnih gradova Sarajevo, 29.06.2011

On the other hand, the district heating system is less efficient in providing heat to commercial buildings. As can be seen in the table below, commercial buildings that used individual gas powered units, required less energy inputs than buildings that were heated by Toplane Sarajevo.

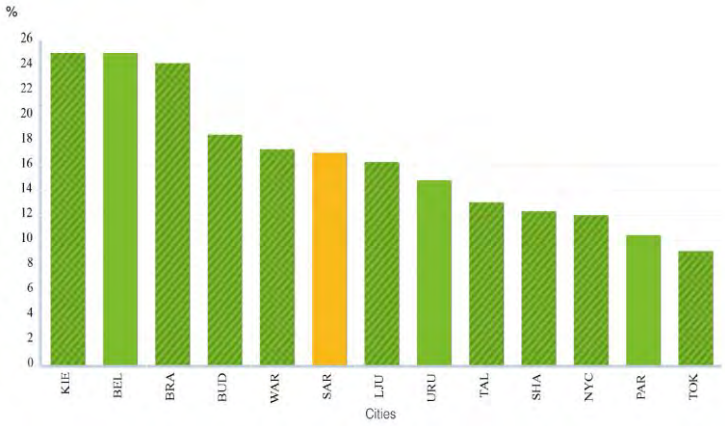
Heat Consumption in Commercial Buildings, in Sarajevo, in 2008

Source	Total Heated Area (m^2)	Heat Consumption kWh/Year	Heat Consumption kWh/Year/m^2
District Heating	287,342	55,853,934	194
Natural Gas	451,367	62,533,526	139
TOTAL	**738,709**	**118,387,459**	**160**

Source: Kolega, Vesna and Haris Lulic. 2011. Akcijski plan energetski odrzivog razvitka Grada - Kantona Sarajevo. PPT Presentation - GiZ projekt: Inicijativa glavnih gradova Sarajevo, 29.06.2011

Technical losses in the system are around 10%, while non-technical losses are around 8%. When compared to other cities with relevant data in the TRACE database, Sarajevo is somewhere in the middle of the pack – performing better than neighbors such as Belgrade, Bratislava, or Budapest, but worse than Ljubljana and Tallinn.

Percent Heat Loss from Network



To address these heat losses, local authorities plan a series of measures that address both supply and demand issues. On the supply side, around 6 km of the distribution network are upgraded every year, roof-top boilers are continually upgraded, and the remote monitoring and control system (SCADA) is continually expanded.

On the demand side, local authorities want to improve collection of bills and to extend individual metering. In 2012, around $4.5 million were owed in unpaid heating bills. It is estimated that the owed sum would have been even larger if heat would have been priced at market levels. Right now, the majority of households (around 95%) are charged a flat fee of around $0.80/m^2/month, up from around $0.60/m^2/month in 2000. This means that heating bills increased at a compound annual rate of 1.6% from 2000 to 2011.

Because local authorities fear that an increase in heating tariffs will force more people to forgo paying their bills, or to switch to individual heating units, these have been kept artificially low. However, while heating tariffs were being kept at a relatively low level, natural gas prices have grown continuously, from $0.20/m^3 in 2000 to $0.54/m^3 in 2011 – a 5.9% compound annual increase (growing 3.7 times faster than heating tariffs). This has of course led to a continuous worsening of Toplane's financial situation, with a widening gap between its costs and its revenues. In 2011, the company had expenditures of around $47 million (70% of which went for the purchase of natural gas) and revenues of around $34 million. Its debt to the natural gas provider has consequently mounted up since 1997, and has reached around $33 million. Subsidies have helped cover some of the losses, but the major problem of proper tariff still remains.

To ensure that higher tariffs will be more easily accepted by the served population, Toplane Sarajevo has to first extend individual metering and introduce thermostatic valves. This will allow end-consumers to adjust heat delivery according to their own needs (rather than receiving the heat at the same temperature from the sub-station or roof-top boiler) and to only pay for what they consume.

The challenge with metering and thermostatic valves is that they are hard to install in heating networks based on a double-pipe system. Double-pipe systems consist of two pipes that go through the apartments in a building. One pipe gets the hot water through, while the other pipe gets the water out. Installing meters and thermostatic valves is hard in such situations because heating units (e.g. radiators) in a particular apartment, are part of an integrated system. Shutting flow to one radiator would basically mean shutting the flow for the entire apartment building.

More modern systems are based on a one-pipe line, which runs through the public area of the building, and branches out to each individual apartment. This means that individual households cannot only adjust the heat flow to the level they desire, but it also means that heating companies can much easier coerce people to pay un-paid bills – i.e. they can de-branch people from the system. In the case of double-pipe systems, the only way people can be de-branched is by removing radiators from the apartment – a measure that is impractical, costly, and fraught with legal implications (i.e. it is hard for the company's representatives to enter somebody's private property and remove radiators).

Of the over 48,000 flats in Sarajevo, only 14,000 are equipped with a single pipe system. Most of these were built before and after the 1984 Winter Olympics. Most new constructions that are connected to the district heating network have one-pipe systems. The rest of 34,000 flats have two-pipe systems in place. Of the entire heated housing stock, only 5% have built-in meters. Local authorities hope to expand the number of individually meters flats, starting with the one-pipe system units.

Hrasno Boiler House

Individual metering would allow end-consumers to adjust heating to their own needs (e.g. turning it down when it is warmer outside, or turning it off when they are on vacation), and it would permit the district heating company to reduce its energy needs. While boilers automatically adjust water temperature according to outside weather conditions (e.g. if it is -17°C outside, the water is sent out at 130 °C, it enters the buildings at 90 °C, and it returns to the system at around 70-75 °C; at -3.5 °C, the water is sent to the system at 65 °C), the delivered temperature does not always fit people's individual needs. Some may prefer a higher temperature, while others may prefer a lower one.

Finally, the district heating system in Sarajevo could be made more energy efficiency by introducing combined heat and power (CHP) generation. CHP plants not only provide a double dividend by generating both electricity and heat from the same energy source, but they also reduce technical losses.

Toplane Sarajevo is seriously considering introducing CHP systems in place, but it has not managed to reach an agreement with the electricity distribution company. Right now, the electricity distribution company wants to buy power generated by a potential CHP unit at $0.05/kWh, but Toplane could only feasibly sell generated power at $0.10/kWh, plus 10% distribution costs. Until this costing matter is resolved, local plans to invest in CHP systems cannot start. Even if funding for such projects could be easily accessed, electricity could not be produced profitably.

Energy Efficiency Recommendations

There is no Energy Efficiency (EE) Master Plan, Program or Strategy in BiH at any authority level (State, Entity). Yet, Sarajevo's interest in pursuing the TRACE diagnostic underscores its commitment to achieving optimal energy efficiency at the city level. The TRACE analysis provided a number of significant findings which helped focus activity during the early part of the study and contributed to the definition of priority areas across municipal service areas.

Key findings of the Sarajevo diagnostics in comparison to other cities in the TRACE database are:

- high electricity use per capita and high electricity use per unit of GDP output;
- relatively energy efficient urban transport system with aging rolling stock and expanding personal vehicles;
- high water and revenue losses from the distribution system and an energy intensive water treatment system to produce a metric cube of potable water;
- high amount of solid waste goes into the landfill and very low level of recycling due to absence of a formal recycling of solid waste program;
- large municipal building stock with high level of heat consumption for space heating and low level of electricity consumption per unit surface area; and
- high intensity of electricity use for public lighting.

The analysis performed with TRACE identifies priority areas where significant energy savings are possible. The prioritization process forms the second module of the TRACE tool and described below.

Identifying Local Government Priorities

The following factors in TRACE were taken into account in prioritizing the six service areas or "sectors" for action in Sarajevo:

- *Greatest Potential for Improvement:* Sectors that have the most potential for EE improvement are identified. To this end, 'improvement' was defined as a factor of:
  - current energy expenditures on a given sector; and
  - energy saving potential based on benchmarking.

- *Scope of Control or Influence of the City Government:* While local governments may be able to implement several measures that reduce energy consumption, the impact may be limited if the sector represents a small fraction of city-wide energy. The degree to which the local government can affect energy consumption in various sectors varies significantly from city to city. Thus, in the sector prioritization process, the level of influence a city ultimately has in improving EE in each sector is extremely important.

To prioritize recommendations, the following factors are also important and need to be considered:

- *Resource Constraints:* Within each sector, multiple fiscal and human resource constraints.
- *Compatibility with Other Development Goals*: In addition to the improvement of EE and reduction of a city's carbon footprint, the city government would also seek to improve the city's environmental, social and economic conditions. Therefore, EE and low carbon activities that would most effectively help the city achieve these parallel objectives would be given a higher priority.
- *Timing:* Given other on-going initiatives in the city, it is useful to identify those activities which would be the most complementary in the short, medium, and long-term.

Sector Prioritization

TRACE software uses the following method to prioritize programs using the following three factors.

1. *Energy Spending Information:* This information was obtained for urban passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat. The information was either gathered from city budget offices or by converting energy use across the city into a monetary value.
2. *Energy Efficiency Opportunity:* Key Performance Indicators (KPIs) from the benchmarking process have been chosen that are most indicative of the energy use in a particular sector. To define opportunity, a calculation is automatically undertaken to establish the mean value of each of the better-performing cities in the peer group, providing a goal or target for the city; this is termed the 'relative energy intensity' of the sector. However, in case of municipal buildings, one of the following two KPIs—electricity use per square meter or thermal energy use per square meter—is selected for calculation of relative energy intensity. Considering buildings in Sarajevo consume a lot of heat energy during winter months, thermal energy use per square meter is selected as the KPI in TRACE.
3. *The Control or Influence that the City Authority:* This factor is determined by establishing the extent of influence that the city authority has in each sector. This ranges from minimum (where national governments have full/greater control) to maximum influence (i.e. full budgetary and regulatory control).

The table below indicates for each sector the amount of energy spent, the relative energy Intensity, and the level of local control the municipality has over these sectors.

Sector	Energy Spending 2010 (US$)	Relative Energy Intensity (%)	Level of Local Control*	Savings Potential (US$)** [PRIORITY]
Municipal Buildings	18,505,832	39.9%	0.85***	6,276,252 **[PRIORITY 1]**
Private Vehicles	104,058,218	29.4%	0.15	4,599,359 **[PRIORITY 2]**
District Heating	34,932,100	12.5%	0.95	4,148,186 **[PRIORITY 3]**
Potable Water	5,297,008	62.5%	0.95	3,149,406 **[PRIORITY 4]**
Street Lighting	5,747,615	30.0%	0.90	1,551,856 **[PRIORITY 5]**
Public Transport	6,304,120	32.3%	0.75	1,530,347 **[PRIORITY 6]**

*0 = no control; 1 = full control. **based on TRACE Benchmarking: these figures are indicative of the quantum of savings that may be possible, not necessarily practicable. ***thermal energy.

The energy savings potential for Sarajevo is calculated by multiplying the three previous columns, and is displayed in the last column of the table. The results of the energy use analysis and prioritization of sectors were discussed with city officials, and recommendations were selected based on concrete local needs.

The level of local control as discussed above plays an important role in determining energy savings potential. In Sarajevo, for example, most service areas are managed by local public utilities or by the Canton itself. Consequently, the level of local public control was generally considered to be high. The only service area were the local of level control was considered lower are 'Private Vehicles'. For 'Private Vehicles' a lot of the decision and policy making powers (e.g. fuel emissions standards) are taken by the central government, with limited scope for local involvement. It was also considered that car drivers themselves are an important constituency, and have significant clout to influence local public policy.

TRACE contains a playbook of 58 EE recommendations applicable across all sectors analyzed above. The recommendations themselves are not meant to be exhaustive. They simply outline a number of policies and investments that could help local authorities in Sarajevo achieve higher EE standards. Following the sector by sector analysis, each individual recommendation was reviewed to establish its applicability in the context of Sarajevo. This filtering process helped focus the process on those recommendations that are both viable and practical. These recommendations were boiled down to 10, spanning most of the service areas. Each of these recommendations and their relevance for the Sarajevo is discussed in more detail below.

A few caveats are in order before we proceed with the individual recommendations. Comparing the performance of a city, with the performance of other cities needs to be done with great care. For the most part, the TRACE tool allows the selection of "peer" cities for comparisons purposes, based on climate (e.g. cities in colder climates would have higher heating requirements than cities in warmer climates), based on development level (the more developed a city is, the higher its energy consumption is likely to be), and based on city size. There are however some relevant criteria that have not been included. For example, density plays a very important role in how a city performs energy wise - the denser a city is, the more efficient it is likely to be. However, accurate density measures are hard to come by, as they should ideally focus on the built mass of a city not on its entire area (which could include vast tracts of open land).

A second caveat is that inter-city comparison on even the most straight-forward indicators can be tricky. When comparing energy performance of municipal buildings, one has to take into consideration that different cities might have different types of buildings under their management. A city that has a high share of local hospitals that it manages will likely have a more intensive energy profile for its municipal buildings (hospitals consume energy year-round and 24 hours a day). Not only is the building stock in Sarajevo municipality large, it is also quite varied with a lot of health-care buildings like hospitals which are large energy consumers.

These shortcomings aside, TRACE does considerably well what it's supposed to – it gives a quick radiography of a city and identifies areas with potential energy cost savings. Below are a number of recommendations that were selected after the TRACE analysis, in close consultation with local authorities. A full list of TRACE recommendations supported by good practice case studies are presented in Annexes. It is however important to note that the methodology used for sector prioritization in TRACE relates to EE only. As the city's urban energy plan extends to issues of energy supply and security as well as opportunities for renewable energy, it seems logical that where these opportunities arise, they are incorporated into the mix of recommendations to be considered in due course without, necessarily, a further prioritization process.

Municipal Buildings

A large number of buildings in Sarajevo are poorly insulated and the estimated heat energy savings potential is about 35-40% of current energy consumption.[12] EE in the public sector (municipal) buildings can be mandated more easily than private buildings sector; the public sector is, therefore, often a good place to start EE programs. According to a

[12] World Bank 2010. Status of Energy Efficiency in the Western Balkans – A Stocktaking Report. ECA Sustainable Department. June 15.

study[13], buildings account for around 70% of total final energy use in East European countries. The performance of buildings depends on a number of factors such as the performance of the installed heating system and building envelop climatic conditions, and behavioral characteristics (e.g. typical indoor temperatures). It is however clear that the oldest part of the building stock contributes greatly to the high energy consumption in the building sector. Older buildings tend to consume more due to their low performance levels. Within the existing building stock in Eastern Europe, a large share (more than 40%) is built before 1960s where there were only few or no requirements for energy efficiency and only a small

Given the higher level of specific building heat consumption and the varied nature of the building stock with different levels of energy use intensity (e.g. office buildings, health-care/hospital and educational buildings), local authorities in Sarajevo should strengthen their support for the refurbishment of the existing building stock and continue their support for relevant demonstrations of high efficiency buildings in order to raise awareness amongst consumers, investors and other key market players. For this, the following measures prescribed in the EU's Energy Services Directive (2006/32/EG) for the public sector buildings are highly relevant for the government to consider: (i) development of a public sector action plan for EE; (ii) introduction of a public sector energy management scheme including national, regional and local authorities; (iii) modification of public procurement guidelines to facilitate energy service contracting; (iv) introduction of an enabling framework for energy service contracting; (v) establishment of a well staffed EE agency to help implement the EE action plan; (vi) setting up a financing scheme for the public sector EE investments; and (vii) establishing obligatory data collection and reporting mechanisms and a public sector EE database for benchmarking, monitoring and reporting.

The following specific measures can offer immediate benefits, not only allowing for a significant decrease of electricity and heating bills in the city annual budget, also allowing for a fast amortization of investment costs to the authorities responsible for managing the public sector buildings in Sarajevo.

[13] Buildings Performance Institute Europe. 2011. 'Europe's Buildings Under the Microscope: A country-by-country review of the energy performance of buildings'.

Municipal Audit and Retrofit Program- Offices, Schools, Hospitals

One of the key challenges is the lack of systematic data on energy consumption in public sector buildings in Sarajevo. The large variation in the age of the physical structures and the type of technology and materials used in construction of buildings (many old buildings date back to the 19th century) influence individual energy consumption. Building regulations and building by-laws varied and changed significantly over time. Old buildings tend to be built out of brick (which has good insulating properties) and generally have thick walls. Buildings developed in the Communist years tend to generally have a poorer thermal performance, with many concrete wall structures. Newer buildings are subjected to stricter building standards, including clear thermal insulation guidelines, so they are generally in good shape. For refurbishment, efforts should focus on raising awareness about the need to refurbish existing buildings efficiency and designing solutions for "mass implementation" of the retrofit of existing buildings to make them more energy efficient.

What the city clearly requires is a comprehensive understanding of its building stock in terms of energy use performance. One of the recommendations made during TRACE implementation process was conducting a performance audit of the municipal building stock. The audit would not only allow a better energy and cost savings estimate, but more importantly would also help determine key areas for intervention. The program will identify immediate savings opportunities, and implement rapid payback items to yield cost savings that can go to other municipal services.

Municipal Buildings Benchmarking

With nearly 450 municipal buildings (of different type and age structure), developing a buildings energy benchmarking program is critical for allocating resources to buildings to achieve the highest impacts. The goal of the benchmarking program is to identify the highest energy intensive buildings in the city authority's portfolio so as to focus on the best EE opportunities separately for offices, schools and hospitals. The benefits of the program are to use EE program resources most effectively and to spend time and money on the easy wins first. The program would also establish annual data for calculating energy/carbon footprint for municipal operations. This requires careful planning and coordination

between different departments and a careful analysis of different building types and their categorization for a like to like comparison.

For each building information and reports need to be collected on an annual basis, looking at energy use, energy bills, water use, water bills, floor areas, etc. Regular monitoring and analysis of building energy consumption indicators and identifying improvement opportunities is a good starting point. However, setting a proper benchmark requires detailed analysis because similar buildings can have varying underlying factors, such as, types of tenants, occupancy density (people per square meter). In addition, the results of the benchmarking process should be published on a regular basis. This often helps generate healthy competitions between different building managers, and it will also foster an exchange of knowledge and experience.

Private Vehicles

Private vehicles are the second priority area in Sarajevo as one of the most energy intensive areas to focus on. People's strong preference for using private cars generally reflects consumer preference for the convenience, comfort, speed, flexibility, independence, and the status private cars offer. As in other European cities, this has generated some serious problems: rising roadway congestion, parking shortages, air pollution, noise and traffic accidents.

To address some of these problems, proper policies need to be put in place. In particular, there is a growing recognition that unfettered car use cause significant social and environmental problems and that certain measures must be taken to control the negative impacts of growing private automobile use. For example, local authorities in Sarajevo should invest time and resources in determining how appropriate travel demand management (TDM) measures could help encourage alternative modes of mass public transportation. The easier it is for people to use public transportation, walking, or biking, and the more comfortable and safe these alternatives are, the more will decide to go that route as discussed earlier. Travel Demand Management (TDM) is critical and needs to be more vigorously used than at present, having usually failed due to: (i) lack of access to public transport alternatives; (ii) lack of skilled-staff for design and enforcement; (iii) political unwillingness to implement and enforce.

To be most effective a range of restraint instruments need to be planned as part of a comprehensive transport strategy, for which many governments are unprepared. A first step to improve the situation is parking restraint measures. These discourage people from using their private cars and make public transport and NMT modes attractive and easily accessible.

Parking Restraint Measures

Designing appropriate parking restraint measures can be a very effective TDM measure, in terms of having an immediate impact on traveler mode choice in Sarajevo. This can be accomplished by increasing parking fees and banning parking in certain designated areas in the city. The price for parking of vehicles has not changed in Sarajevo for 12 years (i.e., since 2000) despite RAD (the company responsible for managing car parking) each year requested the increase of price of parking. Such measures reflect the large infrastructure costs of accommodating vehicles and the costs they impose on pedestrians and the environment at large.

Experience worldwide has shown that an approach aimed at both demand and supply is most effective in tackling traffic congestion. The demand approach discourages the use of personal vehicles and encourages the use of alternative public and non-transport modes (walking and bi-cycling). The supply approach is to enhance the supply and quality of infrastructure for modes other than cars. This includes building and maintaining sidewalks, and rail and bus infrastructure. If complementary measures are not introduced car drivers may attempt to 'beat the system' or to continue travelling by car and park in nearby residential areas.

Parking restraint measures are complementary to virtually all TDM measures, by making driving alone more expensive and more difficult. The focus of parking restraint measures has been on city centers (central business districts), given that these are where (peak period) traffic congestion has been highest and a viable transport alternative (mostly public transport) is generally available. From international experience, a range of policy instruments are available (see table below).

Parking restraint policy instruments

Type of Parking	Dimension of Control	Policy Instruments
On-Street	Price	• Charge for parking, previously free • Increase parking tariffs • Introduce parking permits with a fee
	Supply	• Ban parking (totally or at specific times) • Ban parking with exceptions for special groups • Adjust permitted duration of stay
Off-Street	Price	• Increase parking tariffs • Adjust tariffs: discourage long-term use and encourage high occupancy vehicles • Introduce a parking tax
	Supply	• Prohibit/slow new parking development • Reduce existing parking stock • Adjust operating regimes • Relocate parking

In practice, many of these policies and strategies are difficult to implement. Difficulties can arise from limited data and information, weak administrative and enforcement mechanisms, limited financial and human resources, and political opposition. Creativity is needed in fashioning effective initiatives.

City Streets Occupied by Cars in Sarajevo

District Heating

The biggest centralized district heating (DH) facility in the country, Toplana – Sarajevo, supplies heat to 40% of Sarajevo's inhabitants covering residential, commercial and administrative buildings. The remaining buildings meet their space heating requirement through electricity, wood biomass, and gas. According to the data supplied by Toplana, the total annual operating cost of the DH plant was 70 million KM in 2010 (or $47.5 million), whereas during the same year the total revenue realized by selling heat energy to its customers was 50 million KM (or $33.9 million); annual loss of 20 million KM (or $13.5 million). Such a trend is prevailing since 1997 and between 1997 and 2010, the accumulated debt for Toplana is 50 million KM. One of the main reasons for such huge loss financial loss is the high energy input cost. For instance, in 2010, 70% of the operating cost of the DH plant was only on natural gas. With the price volatility of energy markets and energy prices kept artificially low, particularly for the household sector for social reasons, every year the plant is incurring huge financial loss. To reduce financial losses, Toplana could consider implementing specific energy efficiency measures such as:

Supply side interventions:

- introduction of oxygen regulation to optimize combustion in the facility;
- implementation of modern sophisticated devices in the facility to regulate heat parameters (flow rate, supply and return temperatures);
- replacement of the worst network sections and repair of critical parts (control valves and regulators) of the network with improved heat insulation to minimize losses in the primary and secondary distribution network;
- continuous upgradation of roof-top boilers;
- expansion of the remote monitoring and control (SCADA) system.

Demand side interventions:

- extend individual metering and introduce thermostatic valves for facilities with single-point heating system through installation of ultrasonic heat consumption meters;
- evaluation of applicability of individual metering for older facilities with double-pipe heating system because of the system complexity.

The overall length of the DH distribution network for the heating system in Sarajevo is 74 km which requires continuous maintenance and upgrade to the existent technical losses. In addition, much of the system's capacity to cogenerate electricity remains untapped.

District Heating Network Maintenance and Upgrade

First and foremost, the local authorities need to identify spots in the city DH distribution network with the highest heat and water loses. This would require a system-wide survey by the relevant local authorities. Repairing and replacing the piping network requires an integrated approach and close coordination with other departments (e.g. local authorities responsible for repair and maintenance of roads, water and sewage pipes, and heat distribution pipes in the network) to work together at the same time to improve cost efficiency with as little disturbance to citizens.

A set of investment measures needs to be taken on both the supply side and the demand side (meters, automation, and controls). Together with consumption-based billing, these investments will serve to convert the traditional DH system, where the heat source in effect regulates the heat demand, to a flexible system that consumers can influence according to their preferences and financial means.

District Cogeneration Thermal Plant

Cogeneration is a strategic option promising major energy savings for power and DH in BiH and the neighboring countries. The efficiency of a cogeneration plant can reach 90 percent or even more. Cogeneration (Combined heat and power or CHP generation) offers a substantial benefit compared with a typical power generation efficiency of about 35 percent at thermal condensing power plants and with separate production of heat at heat-only boilers. The benefits of CHP have not been realized in the city compared to the available DH potential. Together with lack of maintenance and financing for technological upgrades, the district heating systems and the connected buildings in Sarajevo have become symbols of energy waste rather than EE. Customers cannot control heat consumption and react to overheating by opening windows, even in winter. The resulting high costs of the district heating systems became apparent in the early 1990s, when primary energy prices increased towards world-market levels. Consequently, expenditures for heat have become major drags on household incomes and municipal budgets.

The way cogeneration works is quite simple. Since all thermal power plants also generate heat, and since this heat just gets released in the atmosphere, it often makes sense to have an adjoining DH plant next to them, which can make use of all the excess heat. There are many examples of how CHP can be put in place where district heating network exist. For example, Skopje in Macedonia is currently developing a CHP plant, which will generate power and use the residual heat to warm-up the water for the already existing DH network.

Throughout the country, power and natural gas systems experience additional peak demand during extreme cold periods. But since volumes are too small to be served economically by existing DH systems, serving this demand spike is expensive and strains electric power and gas infrastructure in countries that already suffer frequent power outages or gas shortages. Therefore, sourcing heat from cogeneration facilities would help district heat providers cover more heat demand and manage peaks more economically and in flexible manner. Peak demand reduction and/or peak shifting for heating, electricity, and gas would benefit the country/region in general but Sarajevo in particular during extreme cold periods, enhance security of supply of electricity and gas, and transform DH into a competitive option through improved design and management (assuming no distortions in pricing policies). Developing cogeneration facilities would also reduce or eliminate the need for subsidies from municipal/cantonal and national budgets.

CHP systems not only offer significant energy dividends, but it also offers significant environmental dividends. Basically one unit of fuel is used to generate both electricity and heat and thus significantly reduces GHG emissions. Given the size of the Sarajevo DH heating network, an integrated CHP system in the city would help make it much more sustainable. The local government should examine the options for the possibilities of high-efficient CHP generation as an alternative to environmentally damaging practices.

Obviously, expanding CHP capacity in Sarajevo is a move that needs to be carefully weighed and considered. The costs required for investments in CHP systems are quite substantial, and they most often require a liberalization of energy prices. At the same time the benefits from such arrangements can be quite substantial too (e.g. ensuring

higher energy security), and with the right legal framework in place, the private sector can be involved to make necessary investments.

Potable Water

In Sarajevo, the law specifies that tariff rates must be set at cost-recovery levels and if that cannot be done, the cantonal budget must make up the shortfall. In practice, however, tariffs are still well below cost-recovery and deficits are not covered due to lack of funds. Water tariffs frequently succumb to local political capture and are set below production prices. The justification given is the need to maintain affordable prices for vulnerable groups, but ironically the socially vulnerable suffer disproportionately from current practices because they are frequently the very people who are excluded from the network, and endure bad water quality and frequent service interruptions. In effect, low tariffs constitute untargeted subsidies that benefit higher income groups to the detriment of the whole water system (with relatively high daily water consumption in Sarajevo; 192 liters per capita daily in 2011). Instead, to protect the access of vulnerable groups to a reliable safe water supply, a targeted subsidy with clear eligibility criteria would be preferable. Otherwise, water should be supplied on a user-pay, cost-recovery basis.

According to VIK Sarajevo, water tariff levels are too low to cover operation and maintenance (O&M), let alone provide sufficient funds for capital investments. Quality and reliability suffer from steadily deteriorating conditions of the water network, eroding consumer willingness to pay and thereby weakening the income base and eroding the capacity to upgrade and expand the existent network. In 2011, VIK Sarajevo's total annual income was 36 million KM ($25.6 million) as against a total operational expenditure of 66 million KM ($45.9 million). In October 2011, there was a proposal to increase the water tariff by 25% but plans were not followed through.

Nonetheless, the water utility company in Sarajevo area, has to deal with an old and inefficient infrastructure, which leads to significant water loses Construction and maintenance of infrastructure is financed by the water utilities and local communities through subsidies, grants, borrowing etc, and partially by participation of the public water management companies. One of the priority measures identified in the 2003 National Environmental Action Plan for water supply is "identification and minimization of water losses in water supply systems where losses are up to 60%". This measure is set as a mid-term measure. No further specification is given on this issue. Consequently, improving the energy performance of the water supply system in Sarajevo could follow a two-pronged approach: improving energy performance of the old and inefficient piping network system together with adjustment of the water pressure and an effective water conservation awareness (WCA) measures.

Water System Networks Upgrade

A properly designed SCADA system for water pumping saves time and money while improving service. Some of the many benefits include: complete information on pumping operation provided in real time; pump operation adjusted automatically as needed to ensure reliable water supply; the need for service personnel to visit sites for inspection, data collection or adjustments is greatly reduced; alarms are sent to the central control location in case of emergency; optimal pressure maintained in the water supply network, minimizing service interruptions; electricity consumption reduced and pump productivity increased; equipment life increased; reports generated automatically. To double the efficiency gains obtained through SCADA, VIK Sarajevo should start an extensive leakage detection program, and determine investment needs for the replacement of old infrastructure (e.g. old piping).

Efficient Water Pumps and Motors

One of the main ways local authorities can increase energy efficiency in the water sector is by optimizing energy consumption in the pumping systems. Aside from an initial set of efficiency measures, it is critical to institute improvements in the routine operations and maintenance protocol. Managers should develop a facility layout showing the location of all critical pumps and use it as a road map for the maintenance technicians to follow for troubleshooting, preventive inspection, cleaning, and minor adjustments. Some routine operations and maintenance procedures that increase the life of equipment as well as efficiency are: proper monitoring of electrical systems, including motors (such as motor operating parameters, power factors, peak and off-peak loads, and electricity consumption); optimize pump variables (pressure, flow, peak load, and motor starting and stopping); cleaning the impellers

and replacing them as needed; periodically running the manufacturer's field test on the pumps and checking the packing and lubrication of the bearings; checking pumps for excessive heat, leaks, vibration and noise; maintaining uniform flow profiles at pump inlets and outlet. By adjusting, upgrading, and/or replacing the pumping technology, considerable savings can be achieved in terms of energy required to run the system. A newer and more efficient pump will also be subject to less wear and tear. This, in turn, reduces O&M costs and the potential of damage to pipelines and fittings.

Street Lighting

The public lighting system in Sarajevo is fairly well developed, but there is significant scope for improvement in the overall system. For example, spacing between individual light poles was not done properly; and also does not take into account a number of factors, such as power of installed bulbs, widespread use of efficient bulb technology, height of street pole, and traffic intensity in the area. While municipalities are responsible for taking care of the lighting system, Sarajevo is responsible for its overall maintenance and operation. Two major things are required to improve overall EE from public lighting in the city: the existent network needs to be better monitored and maintained (e.g. ensuring that lights are turned on only in periods with low natural light illumination level, and making sure that light bulbs that don't work are promptly replaced); overall energy performance of the system can be enhanced (e.g. by replacing remaining energy inefficient bulbs, using light bulbs with a longer life-span, and by introducing improved lighting timing systems). Extending the street lighting system will ultimately mean higher energy costs for local authorities, but these costs can be offset by increasing the efficiency of the existent system. Overall, there are two major recommendations that seem to make sense in the case of Sarajevo. On the one hand there is a need for a better audit and monitoring system to ensure the system is running efficiently with efficient bulb technology. On the other hand, lighting timing can help improve the performance of existing bulbs by adjusting use according to the intensity of the natural light outside (e.g. higher use in the winter time and on cloudy days) and according to the time of day (e.g. lower light intensity when streets are less travelled, such as after midnight on a week-day).

Street Lighting Audit and Retrofit

The aim of this recommendation is to both assess current lighting efficiency and act to retrofit where appropriate. With a proper procurement guide in place, and with a clear idea of what street light technologies have the lowest life-cycle cost, local authorities should continually perform a system audit to determine retrofit needs. Retrofits can deliver the same lighting levels for lower energy consumption levels, reducing associated carbon emissions and reducing operational costs. An increased design life reduces maintenance requirements and costs and also reduces interruptions to service, improving public health and safety.

Currently, local authorities are focussing on using high-pressure sodium bulbs for street-lighting purposes which are quite efficient and cheaper than newer LED technologies. The City also needs to consider introducing LED technology, which is supposed to have a longer life and better EE performance. However the technology is still quite new and its life-cycle performance is not yet clearly established. If new LED technologies, as well as other innovations in the field, prove to have a lower life-cycle cost than the current high-pressure sodium vapor bulbs, the City should consider upgrading the system once the existent bulbs have served their life.

Street Lighting Timing

While many of the inefficient street light bulbs have been replaced, public lighting in Sarajevo continues to have two states of operation – 'ON' and 'OFF'. The fact of the matter is that depending on the time of the day, there are different demands for street lighting. For example, given that few people still walk the streets after midnight on week-days, there is no need for the same light intensity as during the high-traffic hours. Consequently, it makes sense to introduce a lighting timing system, which automatically dims the light after a certain hour (e.g. midnight). Lighting timing systems could also have motion-based detectors, which turn lights on only when someone is actually in the area. The Annex includes a more detailed account of options in this field, as well as the experience of some cities that have successfully implemented lighting timing programs.

There are however a number of features of the Street Lighting system in Sarajevo that make it more efficient than other systems. For example, astronomic timers with geographic designation have been

installed, and these adjust length of use based on the time of the year. Thus, in the winter time, the street lights are kept on for a longer time, while in the summer months they are kept on for a shorter time – based on calculated day-light time for each day.

Public Transport

With the overthrow of Communist governments in Central and Easten Europe, most of the transport policies changed in the region. One important change was a sharp reduction in central government subsidy to public transport. Most of the burden of financing capital investment and operating subsidy was quickly shifted to municipal governments. It is important therefore that local authorities take pro-active measures to expand and improve services and upgrade existing infrastructure, including the rolling stock. By offering frequent, reliable, comfortable, ubiquitous public transportation options, local authorities must create some of the most important premises for enabling the shift from private cars to more sustainable modes of transportation.

Public Transport Development

Recognizing the importance of developing an efficient urban and suburban public transport system, the city needs to consider implementing a number of measures. Some of these include:

- Local authorities also need to think of introducing different types of public transport services for different segments of commuters. Those who place a premium on cost are the poorest sections of society and need to be given affordable prices. The cost of providing public transport for them needs to be subsidized by other sections of society. However, there is another segment that values time saved and comfort more than price. This segment is comparatively better off and would shift to public transport if high quality systems are available to them. The cost of providing public transport to them need not be subsidized and can be met from the fare revenues. To facilitate this, local authorities should think of developing a premium service infrastructure, such as improved bus stations and terminals, improved passenger information systems, use of intelligent transport systems for monitoring and control, etc. To make public transport attractive in Sarajevo, it is essential to improve access to its services. It is useful to lay down standards for accessibility in terms of the distance within which public transport access points should be available. This necessitates the use of personal transport. This can be done by planned integration of public and personal transport operations. Typically this calls for good parking facilities at public transit stations and easy access to public transport from there. The park and ride facilities that exist in many developed countries seek to achieve this.

- Traffic signal priority for public transportation modes, their tracking and passenger information system (through provision of interactive terminals, bus stop schedule displays, and use of satellite based global positioning systems) can go a long way in improving bus speeds, reducing waiting times at bus stops and in scheduling journeys. Experience has shown those faster moving buses, short waiting times (10 minutes or less) and reliable service increase bus ridership as well as helps reduce air pollution significantly. The recent experience of the bus schedule LCD board displays in Tbilisi, Georgia can be a good learning experience for Sarajevo on what can be achieved with innovative, affordable, and well implemented measures.

Clearly, urgent reforms are inevitable for sustainable solutions to Sarajevo's challenge of urban transport services by addressing the following objectives: (i) to bring about better integration of land use and transport planning so as to improve access to jobs, education, etc.; (ii) to encourage public transport and non-motorized transport so that the dependence on personal motor vehicles is reduced; (iii) to offer central government support for investments in public transport systems; (iv) to have a more coordinated approach to management of urban public transport; (v) to provide concessions for the adoption of cleaner fuel and bus propulsion technologies so that the pollution caused by public transport gets reduced.

ECA Sustainable Cities:

Improving Energy Efficiency in SARAJEVO

Bosnia and Herzegovina

TRACE Study

Annexes

September, 2012
Washington, DC

ANNEXES: DETAILED RECOMMENDATIONS

ANNEX 1(A): MUNICIPAL OFFICES AUDIT AND RETROFIT

DESCRIPTION

Develop an audit and retrofit program focused on all Offices to survey and implement opportunities for energy efficiency retrofits and upgrades. The benefits of the program will be cost savings for municipal government offices and reduction in carbon footprint of the CA. The program will identify immediate savings opportunities, and implement rapid payback items to yield cost savings that can go to other municipal services.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Identify Offices Program Leader	Identify a CA staff position or hire a new position to be responsible for execution and delivery of energy efficiency projects in municipal office buildings. This individual must be able to work across agencies, understand building systems and manage subcontractors.
Identify Preliminary Opportunities	Using results from the Benchmarking Program or data collected on office buildings by Office Program staff, identify preliminary opportunities for energy efficiency such as: new lighting systems, new air conditioning systems, new heating systems, new computers, server cooling opportunities, etc. Offices buildings can be more complex buildings and can have a high variety of system types, for example some may have simple window A/C (or no A/C) and others may have larger central A/C systems with chillers, cooling towers, air handlers and ductwork.
Perform Detailed Energy Audits	Walk through a variety of office buildings to identify specific energy efficiency opportunities across the following end-uses and activities: • lighting systems • air conditioning systems • heating systems • computers • server rooms and cooling of servers

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
> US$1,000,000

Speed of Implementation
1-2 years

Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment opportunities
Financial savings

	• appliances (water cooler, fridge, vending machines) The Municipal Offices EE Spreadsheet includes estimation methods for energy efficiency potential for offices which includes equipment retrofits, behavioural changes (turning lights off, heating set points, time of operation, etc.) and procurement guidelines.
Set Budget and Requirements	Allocate budgets for energy efficiency upgrades in municipal office buildings. Combining upgrades with natural building renovations tends to be the best use of limited financing. For example if a new roof is required due to leaks, this is a good time to add insulation and white roof; or if new windows are being installed they could be upgraded to highly insulated windows using Office Building Energy Efficiency Program funds. Alternatively contracts may be set up with Energy Service Companies (ESCOs) who will pay for the first cost of the upgrades and will share in the savings from the retrofits.
Design Retrofits / Upgrades	Considering the benchmarking data, detailed energy audits and budgetary constraints, design retrofits, equipment replacement and renovation upgrades specifically for each building.
Hire Contractor to Implement Retrofits	Prepare an RFP for mechanical or electrical contractors to bid on the retrofit projects. Combining a large number of similar retrofits across dozens of office buildings will allow the CA to obtain economies of scale and quality assurance with lower overheads. Alternatively prepare a RFP and award an energy service contract to a private company (ESCO) who will guarantee energy savings, put forward the initial investment, and share future savings with the CA.
Verify Retrofit and Performance	Walk through and verify each construction project has been performed per the specifications in the energy efficiency retrofit RFP. Continue to collect electricity and heating bills for each building with improved systems and compare to historical data.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- $/m^2 - Benchmark annual energy cost on a per-square-meter basis for all municipal office buildings.
- kWhe/m^2 - Benchmark annual electrical energy consumption on a per-square-meter basis for all municipal office buildings in the city.
- kWht/m^2 - Benchmark annual heating energy consumption on a per-square-meter basis for all municipal office buildings in the city.
- $/yr saved - aggregate total energy savings generated through the life of the program.

CASE STUDIES

Model for Improving Energy Efficiency in Buildings, Berlin, Germany

http://www.c40cities.org/bestpractices/buildings/berlin_efficiency.jsp

The City of Berlin in partnership with Berlin Energy Agency (BEA) has pioneered an excellent model for improving energy efficiency in buildings. They project manage the retrofit of public and private buildings, preparing tenders for work that will guarantee reductions in emissions. CO2 reductions of an average 26% are written into the public retrofit tenders so that winning Energy Systems Companies (ESCOs) must deliver sustainable energy solutions. 1,400 buildings have so far been upgraded, delivering CO2 reductions of more than 60,400 tonnes per year - these retrofits cost the building owners nothing - and the buildings make immediate savings.

Internal Contracting, Stuttgart, Germany

http://www.c40cities.org/bestpractices/buildings/stuttgart_efficiency.jsp

Stuttgart saves around 7200 tonnes of CO2 each year through an innovative form of internal contracting, making use of a revolving fund to finance energy and water-saving measures. The city is able to reinvest savings directly into new activities, creating a virtuous circle of environmental improvements and emissions reductions.

EU and Display Campaign Case Studies

http://www.display-campaign.org/page_162.html

The European Display Campaign is a voluntary scheme designed by energy experts from European towns and cities. When started in 2003 it was initially aimed at encouraging local authorities to publicly display the energy and environmental performances of their public buildings using the same energy label that is used for household appliances. Since 2008 private companies are also encouraged to use Display for their corporate social responsibility CSR activities.

Energy Management System, Frankfurt, Germany
http://www.managenergy.net/download/r164.pdf
In 1996 the City of Frankfurt (Building department) entered into a contract with a private company to install and operate an energy-management system (EMS) for the city hall (Romer), Paulskirche and Museum "Schirn". The goal of the project is to reduce the costs for energy- and water as well as the CO2-emissions.
Based on the annual costs of 2.6 Million DM in 1992/1993 the potential cost reductions were estimated to be approximately 320,000 DM per year. To reach these cost savings an investment of 1 Million DM for control equipment was necessary. Repayment of the invested capital will be provided from the energy savings (54%) over a period of 8 years. The remaining 46% will reduce the operating costs for the buildings.

Energy Efficient Office of the Future (EoF), Garston, UK
http://projects.bre.co.uk/envbuild/index.html
The new Environmental Building at Garston was built as a demonstration building for the Energy Efficient Office of the Future (EoF) performance specifications, drawn up by a number of companies representing the manufacturers, designers and installers of building components and the fuel utilities, as part of the EoF project run by BRECSU.
A key part of this specification is the need to reduce energy consumption and CO2 emissions by 30% from current best practice. Air conditioning is not used in the new building - the major energy consumer in many existing office buildings. Other savings will be made by making better use of daylighting and by using the building's 'thermal mass' to moderate temperatures.

TOOLS & GUIDANCE

Tools & Guidance
EU LOCAL ENERGY ACTION Good practices 2005 - Brochure of good practice examples from energy agencies across Europe. http://www.managenergy.net/download/gp2005.pdf
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf
Energy Conservation Buildings Code provides minimum requirements for the energy efficient design and construction of buildings and their systems. http://www.emt-india.net/ECBC/ECBC-UserGuide/ECBC-UserGuide.pdf

ANNEX 1(B): MUNICIPAL SCHOOLS AUDIT AND RETROFIT

DESCRIPTION

Develop an audit and retrofit program for all municipally run schools to survey opportunities for retrofits and upgrades. The benefits of this program will be a reduction of operational costs (lower electricity and heating bills) and improved school visual and thermal comfort conditions that will improve student learning capability.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Identify Schools Program Leader	Identify a CA staff position or hire a new position to be responsible for execution and delivery of energy efficiency projects in schools. This individual must be able to work across agencies, understand building systems and manage subcontractors.
Identify Preliminary Opportunities	Using results from the Benchmarking Program or data collected on schools by Schools Program staff, identify preliminary opportunities for energy efficiency such as: new lighting systems, new air conditioning systems, new heating systems, new computers, etc. ` Schools tend to be simple buildings, so opportunities may be limited and funding for retrofits may also be limited.
Set Budget and Requirements	Money must be allocated to perform energy efficiency upgrades. Combining upgrades with natural building renovations tends to be the best use of limited financing. For example if a new roof is required due to leaks, this is a good time to add insulation and white roof; or if new windows are being installed they could be upgraded to highly insulated windows using Schools Energy Efficiency Program funds. Alternatively contracts may be set up with Energy Service Companies (ESCOs) who will pay for the first cost of the upgrades and will share in the savings from the retrofits.
Perform Detailed Energy Audits	Walk through schools to identify specific energy efficiency opportunities across the following end-uses and activities:

Attributes

Energy Savings Potential
< 100,000 kWh/annum

First Cost
US$100,000-1,000,000

Speed of Implementation
1-2 years

Co-Benefits
Reduced carbon emissions
Efficient water use
Improved air quality
Enhanced public health & safety
Financial savings

	• lighting systems • air conditioning systems • heating systems • computers • cooking The Municipal Schools EE Calculation spreadsheet includes estimation methods for energy efficiency potential for schools which includes equipment retrofits, behavioural changes (turning lights off, heating set -points, time of operation, etc.)
Design Retrofits / Upgrades	Considering the benchmarking data, detailed energy audits and budgetary constraints, design retrofits, equipment replacement and renovation upgrades specifically for each school.
Hire Contractor to Implement Retrofits	Prepare an RFP for mechanical or electrical contractors to bid on the retrofit projects. Combining a large number of similar retrofits across dozens of schools will allow the CA to obtain economies of scale and quality assurance with lower overheads. Alternatively prepare a RFP and award an energy service contract to a private company who will guarantee energy savings, put forward the initial investment, and share future savings with the CA.
Verify Retrofit and Performance	Walk through and verify each construction project has been performed per the specifications in the energy efficiency retrofit RFP. Continue to collect electricity and heating bills for schools with improved systems and compare to historical data.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- $/m2 - Benchmark annual energy cost on a per-square-meter basis for all schools.
- kWhe/m2 - Benchmark annual energy consumption on a per-square-meter basis for all schools in the city.
- $/yr saved - aggregate total energy savings generated through the life of the program.

CASE STUDIES

Wagga Wagga Primary School, Mbarara District, Uganda

http://www.wisions.net/files/downloads/PREP_06_Energy_in_Schools.pdf

A sustainable, reliable and renewable energy system was implemented at the Wagga Wagga Primary School by constructing a biogas plant to improve energy use from existing traditional cooking stoves (run by large amounts of firewood). The project was implemented within a year, resulting in the construction of a biogas plant with a capacity of 50 cu.m used to prepare food for the school children. Organic manure was provided to farms from around the school, creating employment (for the collection of the cow dung and operation of the plant) and revenue for the people selling the cow dung during the initial charging of the digester. The use of the biogas plant resulted in savings equivalent to 130cu.m of firewood per school year (the cost of one 2 tonne truck of firewood is 3 times more expensive than the cost for the same amount of cow dung). The construction of the biogas plant involved the excavation of a pit; the construction of the plant and collection of cow dung; the installation of a piping system, charging of the mixed cow dung into the digester, training of local operators and the commissioning of the plant. The total project costs were US $3,500. The result is an annual saving of US$1,300 when compared to the cost of firewood, giving a simple pay back period of almost 3 years. The project received funding of US$ 2,000 from Horizont3000, an Austrian Development Organisation.

'Keep the Sun' Project, The Netherlands

http://www.check-it-out.eu/scrivo/asset.php?id=165440

The Dutch project, Keep the Sun, combines an educational programme on climate change and energy savings with the technical energy saving measures. Keep the Sun was implemented over a year and 22 schools in total participated in the project. It was organised by the regional environmental agency, Ecofys Netherlands BV and the centre for international cooperation COS with financial support from the province Noord-Holland. The project involved schemes which improved the energy efficiency of school buildings, and the distribution of a solar photovoltaic system to the school with the best results. Ecofys carried out energy audits at the participating schools to list building construction, insulation, technical installations (heating, lighting, and ventilation) and all energy consuming equipment. Calculations were then done to determine the most efficient energy saving measures and summarised in reports which were then discussed by each school director to put into action. COS organised certified workshops for school teachers to give lessons on sustainable energy. Due to lack of budget the project mainly focused on implementing energy saving measures with no or small investment costs, combined with an educational program to stimulate active pupil involvement in addressing energy savings potential in the schools. The energy audits showed that the energy savings of these measures could reach up to 30% of the total energy consumption.

Energy Agency of Podravje, Slovenia

http://www.rets-project.eu/en/partner_energap/energap.html

One of the projects of the Energy Agency of Podravje (EnergaP) is oriented towards the field of reducing energy consumption in public buildings

and to raise awareness of the importance of energy saving among pupils, teachers and other users of the buildings in Maribor (which is the second biggest city in Slovenia). In a partnership with the Municipality of Maribor, which is also the main source of funding, we have installed the Central Energy Management System (CEMS) in 70 public buildings. CEMS is a software tool, which uses general data from the buildings such as climate characteristics, energy use and consumption (energy bookkeeping). It can take into account saving measures, price of energy, possible savings and CO2 emissions. The system offers around 2-3 % potential energy saving because of the good monitoring availability and 8% cost saving within the first year of installation because of mistakes that are found (i.e. on the bill and in the metering system).

Municipality of Smolyan, Bulgaria
http://www.eu-greenlight.org/index.htm
The Municipality of Smolyan used a financial services contract with an Energy Service Company (ESCO) for reconstruction of the in-house lighting systems in schools and other municipal sites.
The project ensured a reduction of the costs for electricity consumption for lighting. The project saved 1 339 658 kWh/year. In monetary terms it saved 85 034 Euro/year and had a payback period of 5 years.

Upper Canada College, Centennial College, Canada
http://bbptoronto.ca/wp-content/uploads/2010/05/UCC-Case-Study-R1.pdf
Upper Canada College launched its Green School Master Plan in 2001, to renew its facilities while improving energy performance and reducing its environmental footprint as well as integrating sustainability and environmental stewardship into the school's culture and curriculum. The buildings are a challenge to upgrade and retrofit for increased energy efficiency due to the wide range in age and various construction types.
http://bbptoronto.ca/wp-content/uploads/2009/09/Case-Study-Centennial_College.pdf
Toronto's Centennial College encompasses four campuses and five satellite locations, representing approximately 1.08 million square feet. With the majority of its facilities built in the 1970's and 1980's, Centennial College was well positioned to reduce their energy costs and carbon footprint through energy efficient retrofits. Following an energy audit conducted in 2004 by Toronto Hydro Energy Services Inc, several opportunities for improvement were presented that would result in substantial cost savings, including power factor correction and an energy efficient lighting retrofit.

Green-Schools, Ireland
http://www.greenschoolsireland.org/Javascript/tiny_mce/plugins/filemanager_net/files/materials/ireland_research_report_2001.pdf
Green-Schools, known internationally as Eco-Schools, is an international environmental education programme, environmental management system and award scheme that promotes and acknowledges long-term, whole school action for the environment. It is a long-term programme that introduces participants (students, teachers, parents and the wider community) to the concept of an environmental management system. Green-Schools is an initiative of, and co-ordinated on an international level by, FEE (Foundation for Environmental Education). Currently, the Programme is being implemented by 46 delegations in 43 countries around the world, involving 27,000 schools, 6,000,000 students, 400,000 teachers and 4,000 local authorities.

TOOLS & GUIDANCE

Tools & Guidance

Tools & Guidance
EU LOCAL ENERGY ACTION Good practices 2005 - Brochure of good practice examples from energy agencies across Europe. http://www.managenergy.net/download/gp2005.pdf
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf
Energy Conservation Buildings Code provides minimum requirements for the energy efficient design and construction of buildings and their systems. http://www.emt-india.net/ECBC/ECBC-UserGuide/ECBC-UserGuide.pdf

ANNEX 1(C): MUNICIPAL HOSPITAL AUDIT AND RETROFIT PROGRAM

DESCRIPTION

Develop an audit and retrofit program focused on all municipally owned and operated Hospitals to survey opportunities for retrofits and upgrades. Identify energy savings opportunities in city owned or operated hospitals, resulting in lower operating costs, healthier conditions, and improved patient care. Identify immediate savings opportunities, and implement rapid payback items to yield cost savings.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Identify Hospital Program Leader	Identify a CA staff position or hire a new position to be responsible for execution and delivery of energy efficiency projects in municipal hospital buildings. This individual must be able to work across agencies, understand building systems and manage subcontractors.
Identify Preliminary Opportunities	Using results from the Benchmarking Program or data collected on hospital buildings by Program staff, identify preliminary opportunities for energy efficiency such as: new lighting systems, new air conditioning systems, new heating systems, new computers, new laboratory equipment, etc. Hospitals can be more complex buildings and can have a high variety of system types, for example some may have simple window A/C (or no A/C) and others may have larger central A/C systems with chillers, cooling towers, air handlers and ductwork.
Perform Detailed Energy Audits	Walk through a variety of hospital buildings to identify specific energy efficiency opportunities across the following end-uses and activities: • lighting systems • air conditioning systems • heating systems • lab equipment • ventilation heat recovery The Municipal Hospital EE Spreadsheet includes estimation methods for energy efficiency potential for hospital buildings which includes equipment

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
> US$1,000,000

Speed of Implementation
1-2 years

Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment opportunities
Financial savings

	retrofits, behavioural changes (turning lights off, heating setpoints, time of operation, etc.) and procurement guidelines. See Bhubaneswar case study for further details.
Set Budget and Requirements	Allocate budgets for energy efficiency upgrades in municipal hospital buildings. Combining upgrades with natural building renovations tends to be the best use of limited financing. For example if a new roof is required due to leaks, this is a good time to add insulation and white roof; or if new windows are being installed they could be upgraded to highly insulated windows using Hospital Building Energy Efficiency Program funds. Alternatively contracts may be set up with Energy Service Companies who will pay for the first cost of the upgrades and will share in the savings from the retrofits. See Toronto Case Study for further details.
Design Retrofits / Upgrades	Considering the benchmarking data, detailed energy audits and budgetary constraints, design retrofits, equipment replacement and renovation upgrades specifically for each building.
Hire Contractor to Implement Retrofits	Prepare an RFP for mechanical or electrical contractors to bid on the retrofit projects. Combining a large number of similar retrofits across many of hospital buildings will allow the CA to obtain economies of scale and quality assurance with lower overheads. Alternatively prepare a RFP and award an energy service contract to a private company who will guarantee energy savings, put forward the initial investment, and share future savings with the CA.
Verify Retrofit and Performance	Walk through and verify that each construction project has been performed per the specifications in the energy efficiency retrofit RFP. Continue to collect electricity and heating bills for each building with improved systems and compare to historical data.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but

should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- kWhe/m^2 - Benchmark annual electrical energy consumption on a per-square-meter basis for all hospitals
- kWht/m^2 - Benchmark annual heating energy consumption on a per-square-meter basis for all hospitals
- \$/m^2 - Benchmark energy cost on a per-square-meter basis for all hospitals

CASE STUDIES

Better Buildings Partnership (BBP), Toronto, Canada
http://bbptoronto.ca/2010/mount-sinai-hospital/
http://www.mountsinai.on.ca/about_us/news/2010-news/mount-sinai-hospital-receives-over-722-000-from-city-of-toronto-program-for-energy-efficiency-measures
The Better Buildings Partnership (BBP) is a City of Toronto program that works with building owners, managers and builders to ensure that buildings achieve high energy performance and low environmental impact. Knowledge, resources and financial assistance are provided to maximize the outcomes of a range of energy efficiency and renewable energy projects.
The BBP has enabled Mount Sinai Hospital (MSH) to transform their conventional chillers with Enwave's deep-lake water cooling system (DLWC), providing chilled water through an underground piping distribution network instead of cooling their buildings with in-house chillers.
The project cost USD 6,077,431, where over USD 722,000 was funded through a one-time grant from BPP to ease the initial investment in the upgrade to Enwave technology. The upgrade produced annual electricity savings of 2,400,000 kWh and reduced annual CO2 emissions by 2,309 tonnes of CO2.

EU and Display Campaign Case Studies
http://www.display-campaign.org/page_162.html
The European Display Campaign is a voluntary scheme designed by energy experts from European towns and cities. When started in 2003 it was initially aimed at encouraging local authorities to publicly display the energy and environmental performances of their public buildings using the same energy label that is used for household appliances. Since 2008 private companies are also encouraged to use Display for their corporate social responsibility CSR activities.

Bhubaneswar Municipal Hospital, India
http://www.iclei.org/fileadmin/user_upload/documents/South_Asia/Newsletter/WISIONS_e-newsletter_2010.pdf
The Bhubaneswar Municipal (BMC) Hospital was part of a project to identify feasible renewable energy and energy efficiency technologies for the local health sector in India.
A preliminary energy audit was first conducted to enable hospital authorities to identify key areas of intervention, providing renewable energy solutions (for power back up during a shortage) and energy conservation solutions (for the reduction of load and energy savings). Solar

photovoltaic power packs, solar vaccine refrigerators, energy efficient lighting and fans, solar roof lights and solar indoor lighting systems were installed at BMC Hospital as the most critical areas of power requirements took place in operation theatres.
The bulk of the technology costs were borne by funding agencies like GTZ-BMZ (under the ICLEI Local Renewables Model Community Network); and WISIONS, Germany, a non-profit organisation that supports sustainable energy projects through its Sustainable Energy Project Support scheme.
The installed technology was of low maintenance and easily managed by hospital staff (two electrical department members within the existing resource base were trained in operations and maintenance of the installations).
The project was implemented over three years, producing 11% energy savings from the installations in the first two months, along with financial savings of USD 1,054 annually.

Royal Gwent Hospital, UK
http://www.eu-esco.org/index.php?article_id=5&clang=0
An energy services company (ESCo) was engaged in a 15 year scheme to improve the aged infrastructure of the Royal Gwent public hospital, covering 800 beds, 15 operating theatres and a specialist ophthalmic unit. The ESCO introduced a CHP, 3 new steam boilers, a lighting retrofit and water conservation measures. The scheme won the NHS Best Practice Award for Energy Efficiency, producing US $782,707 of guaranteed annual savings.

Energy Management in Hospitals, Slovenia
http://www.managenergy.net/download/opet_gp/summaries/_s029p_gpr_slovenia_energy_efficiency_hospitals.htm
A pilot project for energy efficiency in the public sector was carried out to introduce energy management in Slovene hospitals. This involved the promotion of innovative energy technologies, support for the networking of energy managers, the preparation for energy efficient investments and the introduction of new financial schemes (using private capital for investments) in hospitals.
The project was implemented over 1.5 years, involving 27 hospitals and managed within an OPET Slovenia contract with the European Commission. The processes involved were in data collection (energy surveys), production of software for energy book-keeping, an energy efficiency programme for the hospitals, identification of potential projects, networking of energy managers in hospitals (for information dissemination) and the promotion of energy management in hospitals to the wider public.
The total project cost of USD 47,000 was split between the European Commission and the Slovene Energy Efficiency Agency (AURE). Partners on the project were the Berliner Energieagentur, Germany and EVA, Austria, whose roles involved supplying information on benchmarking and energy savings potential for the preparation of the Energy Efficiency Programme for the hospitals, which compared experiences of other countries' hospital sectors with the locally collected data. Energy savings potential from the project was estimated at approximately 20 to 30%.

TOOLS & GUIDANCE

Tools & Guidance
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

Tools & Guidance
http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=book&fil=LIFE04ENVGR114-EE.pdf

ANNEX 2: BUILDINGS BENCHMARKING

DESCRIPTION

Develop a municipal buildings energy benchmarking program which collects and reports on an annual basis the energy use, energy bills, water use, water bills, floor areas, and names of building facility managers (if any). The goal of the program is to identify the highest energy intensive buildings in the CA portfolio so as to focus on the best energy efficiency opportunities.

The benefits of the program are to use energy efficiency program resources most effectively and to spend time and money on the easy wins first. The program will also establish annual data for use in energy/carbon footprint for municipal operations.

This recommendation is best-suited to larger cities with the size and capacity to implement such a program. Regular monitoring and analysis of building energy consumption and identifying improvement opportunities is a good starting point for most cities. However, setting a proper benchmark requires detailed analysis because similar buildings can have significantly varying underlying factors, for example, types of tenants, occupancy density (people per square metre).

Attributes

Energy Savings Potential
100,000-200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
1-2 years

Co-Benefits
Reduced carbon emissions
Efficient water use
Improved air quality
Financial savings

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Appoint Benchmarking Leader	Appoint, or allocate 1-2 staff with the skills, experience and personality required to be able to gather a wide variety of data from many departments across the city administration. Alternatively hire an external consultant as a leader for the below activities.
Identify Benchmarking Requirements	Define essential and desirable information useful for an energy benchmarking database. Electricity bills are only one part of the benchmarking database, and many other key data points are required to contextualize the information. Data may include: ▪ building name and address ▪ electrical, gas, water utility account numbers ▪ electrical, gas, water utility bills for past 3 years ▪ building floor areas

	▪ energy and water meter locations and associated floor areas ▪ date constructed and date of major renovation ▪ building facilities manager (if any) ▪ building heating, cooling, lighting system types
Set data collection strategy	Set up an efficient process to collect data for the database. Identify which department and which individuals are likely to have access to desired information. Define which data should be collected every year and set up a method to receive the data every year. Set up a method to check and verify data and allow time for validation. Some data may not exist in CA departments, and if so, primary data must be collected by Benchmarking Team (i.e. floor areas, areas allocated to meters)
Begin collecting data	Appoint junior staff to begin the arduous process of requesting data, receiving data, checking data, and collecting primary data from the source. Alternatively write an RFP and award a contract with a specific scope of work to gather energy benchmarking data for all municipal buildings. Data can be stored in spreadsheets or dedicated energy software tools. Care should be taken to ensure quality checks are undertaken at a detailed level to ensure accuracy of data entry.
Analyse and Interpret Data	Conduct an analysis of collected data to ensure accuracy and begin to identify opportunities. Some examples of analysis include: ▪ compare kWh/m2/yr electricity consumption by building type ▪ compare kWh/m2/yr heating energy by building type ▪ compare total $/m2/yr energy consumption by building type Starting with buildings with the highest and lowest performance, verify the floor areas allocated to the utility meters and note any special situations which may increase or decrease energy use (server rooms, unoccupied space, renovations, etc.)
Formulate a Bespoke Benchmark	The results of the analysis stage must be used to formulate a benchmark suitable for the underlying factors affecting energy use in the city. This is required as these factors may vary significantly from city to city and between different buildings. These factors could include: ▪ types of tenants ▪ occupancy density (persons/m2) ▪ building energy management

	This benchmarking is usually doen for the purposes of building labelling. See Singapore case study for further details.
Present Benchmarking Internally	One of the most significant motivators for energy efficiency in building operations is peer pressure as no building owners or operators want to be seen as having the worst performing buildings. So sharing building energy intensity internally across departments and operators will inherently improve energy consumption. This will also allow operators to share experiences to allow knowledge sharing across the CA.
Publish Benchmarking Publically	The boldest statement to show leadership in building energy efficiency is to publish energy performance data to the public, press, voters, and potential political opponents. This last stage of the benchmarking program may be many years after the commencement of the program when the data shows improvements and tells a good story of progress toward efficiency in government operations. The CA could then challenge (or require as some cities have begun to do) private building owners to benchmark their buildings and publish their results.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- kWhe/m^2 - annual electrical energy intensity by type of building (Schools, Offices, Residential, Hospital, Misc)
- kWht/m^2 - annual heating energy intensity by type of building
- \$/m^2 - annual energy cost intensity by type of building

CASE STUDIES

Energy Efficiency in Public Buildings, Kiev, Ukraine

Source: ESMAP (2010). "Good Practices in City Energy Efficiency: Kiev, Ukraine- Energy Efficiency in Public Buildings", available online from 6 http://www.esmap.org/esmap/node/65

Under the Kiev Public Buildings Energy Efficiency Project, 1,270 public buildings in the city of Kiev--including healthcare, educational and cultural facilities—were retrofitted with cost-effective, energy-efficiency systems and equipment. The project focused on the supply-side, such as automation and control systems, and demand-side measures, including installation of metering and weatherization, as well as a sound heating tariff policy. The project was undertaken by the Kiev City State Administration (KCSA). Savings from the retrofitting were estimated at 333,423 Gigacalories (Gcal)/year by 2006--normalized by degree/days in the base-line year--or about a 26% savings compared to the buildings' heat consumption before the project. These upgrades also improved the buildings' comfort level, helped foster an energy efficiency services industry, and raised public awareness of the importance of energy efficiency.

The project cost US$27.4 million and was financed through a World Bank loan, Swedish Government grant, and KCSA funds. Based on the project's success, many other cities in Ukraine have requested information on the project and expressed interest in implementing similar ones for their public buildings.

Building Energy Efficiency Master Plan (BEEMP), Singapore

http://www.esu.com.sg/pdf/research6_greece/Methodology_of_Building_Energy_Performance_Benchmarking.pdf

http://www.bdg.nus.edu.sg/BuildingEnergy/energy_masterplan/index.html

The Inter-Agency Committee on Energy Efficiency (IACEE) report identified strategic directions to improve the energy efficiency of the buildings, industries and transport sectors. The Building Energy Efficiency Master Plan (BEEMP), formulated by the Building & Construction Authority (BCA), details the various initiatives taken by the BCA to fulfil these recommendations. The plan contains programmes and measures that span the whole life cycle of a building. It begins with a set of energy efficiency standards to ensure buildings are designed right from the start and continues with a programme of energy management to ensure their operating efficiency is maintained throughout their life span. The BEEMP consists of the following programmes:

- Review and update of energy standards
- Energy audit of selected buildings
- Energy efficiency indices (EEI) and performance benchmark
- Energy management of public buildings
- Performance contracting
- Research and development

Energy Smart Building Labelling Programme, Singapore

http://www.e2singapore.gov.sg/buildings/energysmart-building-label.html

The Energy Smart Building Labelling Programme, developed by the Energy Sustainability Unit (ESU) of the National University of Singapore (NUS)

and the National Environment Agency (NEA), aims to promote energy efficiency and conservation in the buildings sector by according recognition to energy efficient buildings. The Energy Smart Tool is an online benchmarking system that can be used to evaluate the energy performances of office and hotel buildings. It enables building owners to review the energy consumption patterns within their buildings and compare them against the industry norms. An Energy Smart Building Label, reviewed every three years, is awarded to winners as part of an annual awards ceremony.
Apart from helping to reduce energy consumption and carbon emissions within the buildings sector, Energy Smart Buildings stand to:

- Reap energy savings due to active energy management
- Enjoy higher satisfaction levels by occupants
- Enhance the company's corporate image

Municipal Energy Efficiency Network, Bulgaria
http://www.munee.org/files/MEEIS.pdf
Thirty-Five Bulgarian cities have established the Municipal Energy Efficiency Network (MEEN). EnEffect is the Secretariat of the Network. Since April 2001, MEEN has admitted four municipal associations as collective members. In order to create a successful municipal energy plan, MEEN promotes the development of two key elements: an energy database and a training program for municipal officials.
General information is collected into municipal "Passports". This information is gathered through surveys of various organizations and entered into a database, or energy efficiency information system (EEIS). The EEIS has two layers: database and analysis. The database, a Microsoft Access application, contains objective, technical information, and the analysis contains non-technical information, such as financial, institutional and regulatory documents generated at the national level. This information is organized into three categories: municipality-wide consumption, site-specific consumption, and municipality-wide production.

Energy Management Systems in Public Building, Lviv, Ukraine
Source: ESMAP (2011). "Good Practices in City Energy Efficiency: Lviv, Ukraine - Energy Management Systems in Public Buildings", available online from http://www.esmap.org/esmap/sites/esmap.org/files/Lviv%20Buildings%20Case%20final%20edited%20042611_0.pdf
The Ukrainian city of Lviv was able to reduce annual energy consumption in its public buildings by about 10 percent and tap water consumption by about 12 percent through a Monitoring and Targeting (M&T) program to control energy and water consumption. This generated an estimated net savings of 9.5 million UAH (US$1.2 million) as of 2010. The M&T program was launched in December 2006 and became fully operational by May 2007. It provided the city management with monthly consumption data for district heating, natural gas, electricity and water in all of the city's 530 public buildings. Under the program, utility use is reported and analyzed monthly; targets for monthly utility consumption are determined annually based on historical consumption and negotiations on an adjustment (in cases of foreseeable changes in consumption patterns). Actual consumption is reviewed monthly against the target, with deviations spotted and acted upon immediately and the performance of buildings is communicated to the public through a display campaign.
The M&T program achieved significant savings with minimal investment and recurring program costs. These utility bill reductions have been valuable in light of fiscal constraints and increasing energy prices. The program benefited from a crucial initial condition where most of the city's public buildings were already metered for energy and water consumption and that the city had been collaborating with international aid programs in municipal energy since the late 1990s.

Strong city government leadership and commitment were key success factors of Lviv's public buildings energy and water M&T program. A new Energy Management Unit (EMU) was established within the city administration and resources were mobilized to train all personnel with line responsibility on building utility use in an administrative division, unit, or building. The M&T system established responsibility, created transparency, and enabled informed control of energy and water use in public buildings, laying a solid foundation for sustained improvements in energy and water efficiency.

Public Building Energy Management Program, Lviv, Ukraine

http://www.ecobuild-project.org/docs/ws2-kopets.pdf

As part of the Energy Efficiency Cities of Ukraine initiative, launched in 2007 as initiative of 4 cities, sopported by MHME, NAER and and European Associationof local authorities "Energie-Cites", Lviv has promoted sustainable energy policy and action plans at a local level.

The city has developed a Public Building Energy Management Program through the Energy Efficiency Cities of Ukraine initiative. These involve regular data gathering through various agencies and a subsequent monitoring and analysis of building energy consumption in order to identify easily achievable improvement opportunities.

SMEU Software, Romania

http://www.munee.org/files/SMEU-romania.pdf

The SMEU software was created to set priorities for municipal energy action plans and to assess global energy costs and consumption. The goal of this software is to gather, organize and use energy data so that decision-makers could analyze trends in energy use by consumers and by resources and accurately predict the energy budget for the following period.

The SMEU software divides data into individual and interacting modules to collect data on various aspects of the energy cycle. The Locality Module collects information on an annual basis, including area, population, and average temperature, as well as general information on the municipality such as number of buildings and number of dwellings per building.

NYC Greener Buildings, USA

http://council.nyc.gov/html/releases/prestated_4_22_09.shtml

New York City Municipal Buildings were benchmarked for Energy Efficiency. The project, initiated on December 9, 2009 with the passage of the "Greener, Greater Buildings Plan" (formally known as Intro. No. 476-A, Benchmarking Energy and Water Use), puts the city at the head of a national effort to improve building energy efficiency aimed at reducing America's carbon footprint and its use of highly pollutive fossil fuels to generate electricity.

The project used the U.S. Environmental Agency's (EPA's) Energy Star Portfolio Manager energy management tool, which is integral to the LEED (Leadership in Energy and Environmental Design) certification process, as established and managed by the U.S. Green Building Council, or USGBC.

The Plan aims to reduce the city's total carbon footprint by 30 percent by 2030 (originally 2017), with five percent of that reduction coming from government, commercial and residential building. After the initial phase is completed, building owners will be required to benchmark yearly.

TOOLS & GUIDANCE

Tools & Guidance
Target Finder helps users establish an energy performance target for design projects and major building renovations. http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder
Portfolio Manager is an interactive energy management tool to track and assess energy and water consumption across the entire portfolio of building http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
A presentation by Berlin Energy Agency on Berlin's Energy Saving Partnership - "a Model of Success" , June 29th, 2010. http://siteresources.worldbank.org/INTRUSSIANFEDERATION/Resources/305499-1280310219472/CArce_BEA_ENG.pdf
Energy Efficient City in Russia: Workshop Proceedings, June 2010. A guidance document for Preparing, Financing and Implementing Municipal Energy Efficiency Programs. http://www.esmap.org/esmap/sites/esmap.org/files/Russia%20EE%20Cities%20Proceedings%20ENG%20080210.pdf

ANNEX 3: PARKING RESTRAINT MEASURES

DESCRIPTION

Restricting parking availability discourages car use and provides an incentive to use more sustainable modes of transport, including public transport.

Removing vehicles from circulation reduces fuel use and reduces congestion effects.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Planning measures	The City Authority introduces planning measures which determine car parking provision for residential and office developments. Introducing maximum parking allowances with low car-to-unit ratios discourages private-car acquisition and use. Such measures do not affect the existing parking provision, however, and so need to be supported by additional measures. While areas of intervention can be defined, larger coverage is more effective as it has less potential to overwhelm surrounding areas. A gradient approach solves this by making requirements less stringent from the centre to the periphery. These measures safeguard energy use and efficiency in design and thereby bear no immediate cost to the city authority. See London case study for further details.
Parking fees	The City Authority charges for on-street parking. Implementing a charging regime for car parking and formalizing parking arrangements will enable the parking stock to be controlled and generate a revenue stream for sustainable transport measures. This type of approach requires a supporting system for enforcement, e.g. traffic wardens who issue fines to perpetrators, and are politically very sensitive measures. See San Francisco case study for further details.
Park & Ride facilities	The City Authority promotes multimodality by providing Park & Ride locations at key interchanges. By linking parking to public transport use, the necessities of non-inner city residents are considered. The success of Park & Ride is linked to availability of public transport and unavailability of cheap parking in central locations. The perceived cost should be lower than that of driving the entire

Attributes

Energy Savings Potential
100,000-200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
> 2 years

Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment

	way. Measures of this kind often require major capital investment in infrastructure by the city authority with respect to 'Park & Ride' locations on the periphery of the city, bus terminals and additional buses. See Oxford case study for further details. Complementary implementation activity: Planning measures

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform surveys of parking stock and usage.
- Perform traffic surveys of number of vehicles in circulation by using traffic counters.
- Determine the average travelling speeds on the main transport corridors.
- Determine the mode share of people travelling in the area or city.
- Perform statistical analysis of rate of growth of car registration data.

CASE STUDIES

Parking standards, London Plan, London, UK London (2010). "Chapter 6: Transport" in The London Plan, available from http://www.london.gov.uk/shaping-london/london-plan/docs/chapter6.pdf pp.160-161. The London Plan establishes maximum parking guidelines for residential development. It stipulates that all developments in areas of good public transport accessibility should aim for significantly less than 1 parking space per unit. The main challenge continues to consist of ensuring that these standards are supported other measures which reduce car dependency, both within the development and in the surrounding area, e.g. improved and increased public transportation accessibility.
SF park curbside parking, San Francisco, USA Institute for Transportation and Development Policy (2010) "U.S. Parking Policies: An Overview of Management Strategies", available online from http://www.itdp.org/documents/ITDP_US_Parking_Report.pdf

San Francisco Municipal Transit Agency's (SFMTA) installed new electronic, multi-space meters in 2009 and will activate parking spot sensors attached to the pavement sometime in 2010. The aim is to use pricing to help redistribute the demand for parking. The heart of SFpark is a Data Management System which sorts a tremendous amount of data collected from the networked array of remote sensors in all 6,000 parking spots. These wireless sensors can detect whether a spot is occupied by a vehicle and report parking occupancy information in real time to a central computer. The project will produce valuable data about the effect of meter pricing on occupancy. By 2010 the project will encompass 6,000 of San Francisco's 25,000 metered curbside parking spots in seven pilot neighborhoods.

Parking fees, Aspen, US

Source: Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines", available online from http://www.vtpi.org/parkpricing.pdf

The city used to suffer from high levels of congested on-street parking. In order to reduce the effects of the "ninety-minute shuffle" (where locals and downtown commuters moved their vehicles every 90 minutes to avoid a parking ticket), the city introduced charges for on-street parking using multi-space meters. Parking fees are highest in the center and decline with distance from the core. The city had a marketing campaign to let motorists know about the meters, including distribution of one free prepaid parking meter card to each resident to help familiarize them with the system. Motorists were allowed one free parking violation, and parking control officers provide an hour of free parking to drivers confused by the meters.

Park-and-Ride, Oxford, United Kingdom

Oxford City Council (2009). "Park and Ride Transfer", available online from http://www.oxford.gov.uk/PageRender/decTS/Park_and_Ride_occw.htm

Oxford city has five Park-and-Ride sites serving the city's shoppers, visitors and commuters. These sites used to charge for parking to provide income to cover operational costs, but were not able to generate additional money for repairs or improvement. In order to achieve savings, the management of the Park-and-Ride sites was transferred to Oxfordshire county, resulting in efficiency savings of 250,000 GBP per year for the city administration. These savings were achieved primarily through economies of scale, and by sharing the cost of providing the service with taxpayers across the County, and not just those in the city - both of which used the facilities.

TOOLS & GUIDANCE

Tools & Guidance
Victoria Transport Policy Institute (2010). "Parking Management: Strategies, Evaluation and Planning" A comprehensive guidance document for planning and implementation of parking management strategies. Available online from http://www.vtpi.org/park_man.pdf
Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines" A guidance document for implementation of parking pricing with details on overcoming common obstacles. Available online from http://www.vtpi.org/parkpricing.pdf
Spillar, R. (1997). "A Comprehensive Planning and Design Manual for Park-and-Ride Facilities" A guidance document for the planning and design of Park-and-Ride facilities. Available online from http://www.pbworld.com/library/fellowship/spillar

ANNEX 4: DISTRICT HEATING NETWORK MAINTENANCE & UPGRADE

DESCRIPTION

Many cities already have established district heating networks. The primary plant (boilers), may be operating at low efficiencies, or the pipework distribution networks may have poor or no insulation thereby losing thermal energy or considerable amounts of water through leakage. Advances in materials, boiler design or alternative system configuration (for example, improved heat exchange) mean that higher efficiencies can be achieved, and there are various different methods for detecting leaks. More energy can be delivered to the end user through primary plant upgrades, pipework repair and replacement and better insulation.

The aim is of this recommendation is to develop a program for maintenance and retrofits to upgrade boiler plant, pumps, pipework or insulation.

District energy networks are inherently more efficient than individual systems, but further energy efficiencies could be gained through repairing pipework and upgrading insulation, delivering more resource, operational cost and carbon emission savings.

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
> US$1,000,000

Speed of Implementation
> 2 years

Co-Benefits
Reduced carbon emissions
Efficient water use
Improved air quality
Financial savings
Security of supply

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority establishes appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, power and heat engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study establishes the technological and financial viability, as well as procurement and policy options. It establishes the baseline city energy expenditure associated with power and heat supply and the efficiency of their distribution across the network(s). Technical ability, procurement methodology, incentives and taxes should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.

Direct expenditures & procurement	The City Authority invests in the maintenance of the network as well as upgrades of the infrastructure where necessary. The main expenditures associated with a replacement program are the capital cost of plant and the civil works to access networks where the pipework is buried. The City Authority can pay for these items directly out of the city budget, and recoup the investment through lower primary fuel costs. The City Authority invests in the maintenance of the network as well as upgrades of the infrastructure where necessary. The main expenditures associated with a replacement program are the capital cost of plant and pumps and the civil works to access networks where the pipework is buried. The City Authority can pay for these items directly out of the city budget, and recoup the investment through lower primary fuel costs.
Energy Services Company	The City Authority contracts with an Energy Services Company (ESCO) to assume management of the district heating network, and maintain and investing in repairs to ensure consistent and efficient supply to users. The benefit of this approach is that the CA does not have to commit to significant financial investment in the project or retain ownership of the project related risks. There are a number of potential ESCO contractual structures and it is recommended that if the City Authority explores the various advantages and disadvantages of each. See Jiamusi case study for further details.
Legal or Statutory	The City Authority passes legislation or creates policy that requires minimum efficiency levels in both the generation and supply infrastructure of the district heating network. The efficiency levels should be set to ensure that the replacement program is staggered, targeting the worst performing assets first.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be

complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Establish baseline energy losses due to pipework and pumps(kWh/annum)
- Establish baseline water losses due to pipework and pumps(l/annum)
- Establish the City Authority goal for losses (kWh/annum) due to potential network upgrades
- Compare actual program performance with targeted performance

CASE STUDIES

District heating network pipe maintenance, Seoul, Korea

DBDH, Direct Access to District Heating Technology "Seoul Metropolitan District Heating Network", http://www.e-pages.dk/dbdh/12/

Established in 1985 by a public corporation, the district heating network in Seoul supplies 10,604 GWh of district heating and cooling to 832,000 households, commercial buildings and public buildings. During its first five years of operation, the network suffered from service interruptions caused by construction failures as pre-insulated pipe construction had only just been introduced in Korea and construction skills were too low to assure a good quality pipe construction. By the mid 2000s, 300 km of pre-insulated pipelines (20% of the total length) were around 20 years old, and investigation into pipe construction failure showed that these were mainly caused by loose casing joints (51%) and the use of improper materials (21%). In order to improve the reliability of the supply network, and thereby reduce the cost of water and energy losses, the company invested in improving pipe construction skills and used a leak detection system which enables them to locate 'defaults'. As the leak detection system does not work well with the old pipes, faults are also located by means of "thermal graphic camera" and "injection gas to pipelines" methods.

District heating network upgrade, Jiamusi, China

DBDH, Direct Access to District Heating Technology "Dalkia Management of Jiamusi Urban Heating Network" http://dbdh.dk/images/uploads/pdf-news/hotcool_1_2010_low.pdf

Due to a chronic lack of funds, the Jiamusi district heating network had for many years suffered from reduced maintenance, which had resulted in large energy and water losses. As interruption of service and low in-door temperature were the norm, the operator of the network, Jiamusi Heating Company (JHC), experienced increased dissatisfaction from its users. In May 2007 JHC, which was owned by the municipality, signed a 25-year agreement with an energy services company to take responsibility for the management of the network. A large-scale initiative to improve performance and upgrade the network's facilities was implemented. The heat supply temperature was raised; 90 new substations were built; and a SCADA (Supervisory Control and Data Acquisition) system was installed, enabling real-time management of the substations and the network, and resulting in improved optimization of energy efficiency and user's comfort. As a result, water losses were reduced by 30%, and energy consumption by 13.5%. By improving service quality, the company improved its customer relationships and was able to reduce the bad debt rate from 7% to 2%.

The network has begun expansion and after two years of operation, it has increased its supply from 5.5 million sq. m (29% of the total heating surface) by 56% to 8.6 million sq. m.

TOOLS & GUIDANCE

Tools & Guidance
DHCAN "District Heating System Rehabilitation and Modernisation and Modernisation Guide" projects.bre.co.uk/DHCAN/pdf/Modernisation.pdf. A guidance document for technical improvements resulting in higher energy efficiency and reduction of primary energy use. It attempts to set out a range of solutions from low-cost to high-cost, with consideration of financial circumstances, and links this to the fundamental need for a strategic view.
IEA "Coming in from the Cold- Improving District Heating Policy in Transition Economies" http://www.iea.org/textbase/nppdf/free/2004/cold.pdf. A document which summarises the institutional experiences of district heating rehabilitation, with focus on delivering clear policy on district heating.
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

ANNEX 5: DISTRICT COGENERATION THERMAL NETWORK

DESCRIPTION

Upgrading power plants so that low grade waste heat is captured and used in district heating networks improves the energy efficiency of each plant by utilising an energy source that would otherwise be rejected to the environment, as well as enabling a continuous supply to the user. The aim of this recommendation is to develop a district steam or hot water networks in high density areas in relatively close proximity to new or existing power plants.

Waste heat from power stations represents a significant resource and can deliver lower cost energy as well as carbon reductions.

Power sector regulations, which are implemented at a national level in many countries, can sometimes be a barrier to implementing cogeneration in district heating.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority establishes appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, power and heat engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study establishes the technological and financial viability, as well as procurement and policy options. It establishes the baseline city energy expenditure associated with power and heat supply and the efficiency of their distribution across the network(s). Technical ability, procurement methodology, incentives and taxes should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Network Installation	The City Authority invests in the development of a district heating network. The main expenditures associated with a cogeneration heat network are the capital cost associated with the installation of the pipe network, modifications to the end user's equipment and also to the power plant itself. The City Authority can pay for

- Attributes

Energy Savings Potential
> 200,000 kWh/annum
First Cost
> US$1,000,000
Speed of Implementation
> 2 years
Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment opportunities
Financial savings
Security of supply

	these items directly out of the city budget, and recoup the investment by acting as the network operator and/ or heat supplier. See Kotka case study for further details.
Energy Services Company	The City Authority contracts with an Energy Services Company (ESCO) to provide finance and ownership of the project, as an alternative to direct expenditure. The benefit of this approach is that the CA does not have to commit to significant financial investment in the project or retain ownership of the project related risks. There are a number of potential ESCO contractual structures and it is recommended that if the City Authority explores the various advantages and disadvantages of each. See Aberdeen case study for further details.
Statutory Requirement	The City Authority passes legislation or creates policy that requires utilisation of waste heat from power stations through a thermal network. This implementation action can be used when the City Authority does not wish to own the district generation network. It should also be noted that in many countries, power sector regulations, which are often national, can act as a barrier to co-generation at the district level. Where this is the case, the CA can work with national government and other stakeholders to find statutory enabling solutions. See Copenhagen case study for further details

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Establish the baseline primary energy demand to meet the thermal requirements within the proposed network area (kWh/annum).
- Establish the expected primary fuel saving through implementation of heat network (kWh/annum).
- Compare actual program performance with targeted performance.

CASE STUDIES

District heating network, Kotka, Finland

C40 (2010). "Kotka: District heating", http://www.c40cities.org/bestpractices/energy/kotka_heating.jsp

The local energy company which develops and operates the city-wide district heating network is 100% owned by the CA. The district heating and combined heat and power production (CHP) are sourced by renewable and recycled energy sources and natural gas. Recent investments in a large waste-to-energy incineration facility have further strengthened the role of district heating as a form of power generation for the city. Currently, the network has 55% of the market share for heating in Kotka. Despite high investment costs (USD 215 million) the fuels (wind, biofuels and peat) are cheaper for Kotka Energy to purchase than oil, coal or natural gas. As domestic waste used for incineration has a negative price, CHP production is highly profitable for the CA. Turnover was estimated at 29m Euro in 2006, of which 25m Euro went on fuel and operational costs. The cost of establishing a system like that in Kotka is estimated at 150m Euro (USD 215m).

Social housing district network ESCO, Aberdeen, UK

PEPESEC (2009). "Community Energy in Scotland Aberdeen City Council", http://casestudies.pepesec.eu/archives/73

In order to cost-effectively deliver affordable heating to social housing in need of refurbishment and upgrading, the Aberdeen CA proposed a district combined heat and power scheme. The required funding was estimated to be very high, and as operating a combined heat and power scheme was not regarded as a core competency of the CA, there was a desire to obtain and involve appropriate expertise in the delivery of the network. A not-for-profit ESCO was initiated to develop and manage the network. The contractual relationship between the ESCO and CA is regulated by a framework agreement, which sets out the general obligations of the ESCO to supply heat to the CA, for onward supply to housing tenants. Separately, the ESCO can, and has, entered into Heat Supply Agreements with private owner-occupier properties. As a measure to persuade tenants to save energy, heat usage is not individually metered and users are charged a flat rate. As a supplementary measure, the CA has provided controllable heating systems and face-to-face advice on how to be energy efficient. Notably the scheme has ensured tenant and community participation in the delivery of heat energy, and has also resulted in works being carried out on properties which might not otherwise have been possible for 10 years or more.

District heating network, Copenhagen, Denmark

Copenhagen Energy (2010). "District heating in Copenhagen: An energy efficient, low carbon and cost effective energy system", http://dbdh.dk/images/uploads/pdf-diverse/District_heating_in_Copenhagen.pdf

In 1976, the national government passed the Electricity Supply Plan. This established a national policy requiring electricity generating stations to increase their energy efficiency by recovering and reusing waste heat, rather than exhausting useful thermal energy to the oceans and atmosphere. Combined heat and power (CHP) was established as the standard for electricity generation. In 1979, a new heat supply act was implemented which

started a heat planning process in the municipalities - it enabled municipalities to dedicate a certain area to district heating, and to make it mandatory for households to connect to district heating. In 1984, the five Mayors of Copenhagen, Frederiksberg, Gentofte, Gladsaxe and Taarnby decided to scale up and set up a common wholesale district heating network. As a result, take up rates are almost 100% .The heating price, which is a pool system price, is identical for all five municipalities, and has basically been kept at the same level throughout the whole of the project's lifetime.

District heating network, Bishkek, Kyrgyzstan
"Supporting CHP and district energy system development in Asia" (2009)
http://www.powergenworldwide.com/index/display/articledisplay/370226/articles/cogeneration-and-on-site-power-production/volume-10/issue-5/features/supporting-chp-and-district-energy-system-development-in-asia.html
ADB project report (2002) http://www.adb.org/documents/studies/power_heating_kgz/power_heating_project.pdf
ADB has provided funding for the rehabilitation of the Bishkek district heating system which serves the capital of Kyrgyzstan. The project was co-funded with various parties including the World Bank which provided a soft loan to overhaul and increase the generating capacity of the CHP unit, while ADB provided a $30 million loan to upgrade the Bishkek heat distribution system. Rehabilitating and modernizing the Bishkek district heating network began in 1997 and took 10 years to complete. The break up in 2001 of Kyrgyz National Energy Holding Company, which operated the entire CHP district heating system, into seven joint stocked companies caused delays to the project work schedule including lengthy delays replacing outdated heating pipes in various parts of Bishkek.

Rehabilitating the Bishkek heating system also involved repairing and upgrading seven of the systems 19 pumping stations with variable speed pumps, and the renovation of 2,280 heating substations. The Bishkek district heating system was installed during the Soviet era along with heating systems in several other Soviet republics.

TOOLS & GUIDANCE

Tools & Guidance
DHCAN (2005). "District Heating System Institutional Guide". A guidance document summarising the main institutional arrangements that reflect the specifics of district heating, and discusses their rationale and development in a changing business environment.http://projects.bre.co.uk/DHCAN/pdf/InstititionalManage.pdf
ESMAP (2000). "Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union". http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/12/15/000094946_00112105321115/Rendered/PDF/multi_page.pdf
Risoe National Laboratory for Sustainable Energy (2010). "STREAM" An energy scenario modelling tool which can be used to provide a quick insight into the different potential energy mixes, which can include the dispatching of power plants in the electricity sector and the district heating system. http://streammodel.org/downloads.html

Tools & Guidance
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

ANNEX 6: IMPROVE PERFORMANCE OF SYSTEM NETWORKS

DESCRIPTION

Develop a program to identify the opportunity to improve the hydraulic performance of the following systems:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks

Identify the hydraulic constraints and inefficiencies by investing in Hydraulic Modelling, Flow/pressure tests , and/or Supervisor Control and Data Acquisition (SCADA). Constraints can be used to help determine the appropriate methods of improving the system, which include replacing pipes, relining pipes, upsizing pipes, reconfiguring network through valves and re-zoning, and maximising the use of gravity supply.

This recommendation is often implemented by water authorities to improve network reliability and conserve water, with energy efficiency as a co-benefit. Upgrading the network increases reliability and provides an opportunity to save energy by reducing the risk of burst pipes and leakage. If the system runs more efficiently, the pump delivery head can be reduced making further energy savings and minimising potential wear/tear on pipes from operating at higher pressures. In some cases it can enable maximum benefits to be obtained from any existing system. Costs may be minimised where existing valves can be used to create a more efficient method of operation, for example, by redistributing the flow to manage overall system hydraulics.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study into how best to improve network efficiency. The CA should engage a team that includes network planners, water, energy and

- Attributes
  - Energy Savings Potential
  - > 200,000 kWh/annum
  - First Cost
  - US$100,000-1,000,000
  - Speed of Implementation
  - 1-2 years
  - Co-Benefits
  - Reduced carbon emissions
  - Efficient water use
  - Improved air quality
  - Enhanced public health & safety
  - Increased employment opportunities
  - Financial savings
  - Security

	utilities engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability, as well as procurement and policy options. It should give an understanding of the network pressure distribution and assess the appropriateness of the pressure head available with respect to minimum pressure requirements. Technical ability, incentives and taxes should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Direct expenditures & procurement	Where the water network is owned or run by the City Authority, the CA pays for upgrades to the utility infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. Expenses associated with rehabilitating targeted parts of the system are mainly the costs of raw material and/or piping required and the cost of construction (i.e. trench digging etc.) This lever may not be appropriate if the City Authority does not own the utility infrastructure. Case Study: London, UK; Soweto, South Africa; Ahmedabad, India.
Mediation among various organisation	The City Authority engages a mediator to manage the upgrading process. This will secure unanimous support and acceptance of the solution, help obtaining planning permission, save on costs and protect intervention against vandalism. Different parts of a network may be owned by a number of different organisations i.e. Water companies, private owners, city authority, consumer etc. Upgrading key targeted parts of the network may not particularly benefit the specific site but may for example provide energy saving elsewhere. In order to push forward and implement such interventions, the benefits to and needs of all parties involved must be clarified and communicated clearly. Case Study: Sierra Leone
Partnering Programs	The City Authority liaises with established organisations and/or coalitions (frequently non-profit) to gain access to their experience and expertise in order to evaluate and implement the most appropriate interventions for the

	situation. Together with the partnering organisation, the City Authority and/ or utility company undertakes collaborative efforts, and strategic alliances to optimize resources. Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy-efficiency projects, promotion of technology development and deployment, and/or help to build public-private partnerships. Difficulty can arise where the partnering organisations do not have access or influence over the funds required to implement the initiatives. Case Study: Phnom Penh
Water Company Collaboration	The City Authority incentivises water authorities to drive a collaboration and negotiation process to develop a partnering program to maintain efficient water distribution systems across the city. If the organisations and/or water companies have no interest in the strategy, the City Authority may opt to subsidise the initial expense of any plant or hardware required and support the initiative through associated regulations. If the strategy is successful the CA may receive a rebate from the organisations bearing the costs of pumping and treatment. Case Study: Phnom Penh; Moulton Niguel, USA.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- % Utility services replacements: Measures the total number of utility service replacements (i.e. water or sewage) completed during the reporting period.
- Length of sewer pipes renewed: Measures the total length of the sewer pipes that were renewed during the reporting period.

- Total length of water distribution mains replaced: Measures the total length of the water distribution pipe system replaced during the reporting system.
- Frequency of sewer main breaks and blockages per 1000 properties: Measures the average number of sewer main breaks and blockages registered per 1000 properties during the reporting period.
- % Properties below minimum water pressure: Measures the percentage of properties connected to the water system that are experiencing pressures below the minimum pressure standard out of the total number of properties connected to the system.

CASE STUDIES

System optimization to improve energy efficiency in water supply, Monclova, Mexico

Good Practices in City Energy Efficiency - Monclova, Mexico - Monclova & Border Frontera Drinking Water System, available online http://www.esmap.org/esmap/sites/esmap.org/files/CS_Mexico_Monclova_Water_071010_final_edited.pdf

By optimizing the water distribution network and investing in additional enhancements to the system, Sistema Intermunicipal de Agua y Saneamiento (SIMAS) Monclova (the operating agency for the municipal water system and sanitation services in Coahuila, Mexico) was able to increase water supply from 10 hours/day to 24 hours/day, while increasing access to an additional 40,000 customers, and at the same time reduced the total energy and water consumed. Prior to the project, the system faced 40% technical water losses in its drinking water network and, as a result, could only provide service for about 10 hours/day. A lack of financial resources limited the utility‟s ability to undertake capital-intensive infrastructure upgrades to improve the City‟s water distribution services.

Energy Management Programme, Campinas, Brazil

Good Practices in City Energy Efficiency: Energy Management in the Provision of Water Services, Campinas, Brazil, available online http://www.esmap.org/esmap/node/1171

Between 2000 and 2008, the City of Campinas, in the Brazilian State of Sao Paolo, developed a successful energy management program, increasing tap water connections by 22 percent without additional energy requirements. These new connections, provided through its water and sanitation utility SANASA, primarily serve the urban poor living in peri-urban slums, or favelas. They enabled uninterrupted tap water service to reach 98 percent of the population of the city by 2008, compared to 88 percent in 2000.

In 2007, in its Capivari water treatment plant (one of SANASA's two plants), SANASA undertook an estimated R$1.8 million energy efficiency investment in variable speed drives, achieving over 30 percent reduction in electricity consumption at the plant (1.4 GWh/year) and nearly 20 percent reduction in contracted demand. The simple payback period for this investment was less than four years, consistent with typical commercial investment thresholds.

During this same period (2003-2008), the utility carried out a much broader program – involving non-revenue water (NRW) reduction, system optimization and energy efficiency retrofits – to significantly improve their overall energy use. Based on the analysis of SANASA's operations data between 2003 and 2008, the utility achieved an estimated 200,000 kWh of annual electricity savings (in addition to the Capivari plant investment) compared with the base year (2003), equivalent to about R$410,000/year electricity cost savings (about US$230,000/year). More than 25 percent of these savings were the result of a reduction in electricity intensity while the rest can be attributed to a reduction in NRW, enabling the utility to serve more people from the same amount of treated water. These figures are only an estimate because the detailed costs of other direct or

indirect energy efficiency activities were either not documented by the utility or implemented as part of other programs.

Performance-based management contract for water and sewerage, Yerevan, Armenia

Good Practices in City Energy Efficiency: Water and Sewerage Management Contract, Yerevan, Armenia, available online http://www.esmap.org/esmap/node/1172

In 2000, the Armenian capital's water utility, the Yerevan Water and Sewerage Enterprise (YWSE), entered into a five-year, performance-based management contract with private operator Acea Spa Utility (Acea). Over the contract period (2000-2005), the duration of water supply was increased from 6 to 18 hours per day, collection rates improved from 20 to 80 percent, and electricity consumption was reduced by 30 percent.

The project demonstrated that, under a conducive legal and regulatory framework, private operators can be effectively engaged using a performance-based management contract to deliver significant improvements in service quality, operational efficiency, financial performance, and energy efficiency in municipal water and sanitation utilities. Due Acea's strong performance and overall project results, GOA subsequently entered into a follow-on 10-year lease contract in 2005 with Veolia, a French international water company.

Water infrastructure rehabilitation, Mostar, Bosnia & Herzegovina

Good Practices in City Energy Efficiency: Mostar, Bosnia and Herzegovina: Post-Conflict Water and Sewerage Rehabilitation Project, available online http://www.esmap.org/esmap/https%3A/%252Fwww.esmap.org/esmap/sites/esmap.org/files/DocumentLibrary/EECI_Mostar_Water_Case_Study_Final.pdf

Between 2000 and 2005, Mostar Water and Sewerage Utility (MWSU), a city-owned water and sewerage services provider in Mostar, Bosnia & Herzegovina, rehabilitated selected pumping stations and portions of distribution networks in a post-conflict environment. The challenges of project implementation were considerable following the civil war that had destroyed both the city's infrastructure and its pre-war institutions. In the course of the project period, financial losses were turned into profits, collections of bills improved from 50 to 75 percent, water connections increased by 9 percent, and annual energy use was reduced by 40 percent.

With the experience gained from the project, MWSU received another US$8.9 million funding from the Global Environment Facility (GEF) for further improvements. The demonstration effect of this successful project motivated other utilities and ministries in Bosnia and Herzegovina to request MWSU assistance in managing donor-funded projects.

Victorian Mains, London, UK

http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/2690.htm

Thames Water are currently undertaking a comprehensive replacement of all of London's water mains. Around 12% of London's water mains are over 150 years old, among the oldest in the UK, and more than 40% are over 100 years old. The replacements should mean fewer burst mains, leaks and wastage in the future. In the areas where pipework needs to be replaced, they carry out detailed investigations using state-of-the-art computer modelling to find the best way of renewing the pipe network. Thames Water are working closely with other utility companies to minimize the disruption caused, particularly during diversions, road closures and parking suspensions.

Gravity-fed Schemes, Moyamba township, Sierra Leone

http://sieragrassrootagency.tripod.com/id20.html

Since the end of the war in 2002, the Moyamba District Council with the support of the World Bank has attempted to rehabilitate the old pumping

station and the network of water supply lines in the Moyamba township. However, the high cost of pumping water has meant that water supplied through this improvement cannot be sustained. The Ministry of Energy and Power has introduced a gravity-fed scheme for areas with gravity water sources. The money saved can be partly invested into supporting the pumping system during the height of the dry season when the water flow is low. The capital costs of gravity schemes are, on average, higher than the costs of schemes which obtain water from underground sources. This is due mainly to the cost of long pipelines from the upland sources down to the villages and partly to the cost of providing storage tanks. Running costs are usually low. The project has been implemented by the Kaiyamba Chiefdom Development Committee with the cooperation and support of the Moyamba District Council and the full participation of the staff of the Water Works Department in Moyamba. SIGA, the NGO, represents the donors at the committee and is responsible for the coordination, disbursement and procurement of all project activities. SIGA is also responsible for arranging and assisting with evaluation, monitoring and reporting.

Water Supply and Drainage Project, Phnom Penh, Cambodia
http://www.adb.org/water/actions/CAM/PPWSA.asp
http://www.adb.org/water/actions/CAM/Internal-Reforms-Fuel-Performance.asp
Asian Development Bank's (ADB) Phnom Penh Water Supply and Drainage Project provided the opportunity for PPWSA, the government-owned water supply utility, to partner with ADB and demonstrate its capacity for catalyzing water sector reforms. To phase out non-revenue water, i.e. consumers gaining access to water supplies for free; PPWSA started metering all water connections. It gradually equipped each network with a pressure and flow rate data transmitters that provide online data for analyzing big leaks in the system. They also set up a training centre to respond to in-house training needs. PPWSA renewed old pipes using state-of-the-art materials and labour from PPWSA staff. PPWSA also institutionalized performance monitoring, coming up with progress reports and performance indicators on a regular basis and annually subjecting its accounts and procedures to an independent audit. The project advocated the transfer of more managerial autonomy to PPWSA to enable it to use its own funds on maintenance and rehabilitation programs. The result of the project was that PPWSA became financially and operationally autonomous, achieved full cost recovery, and transformed into an outstanding public utility in the region.

Rehabilitation of the Water Network and Private Plumbing Fixtures, Soweto, South Africa
http://www.watergy.org/resources/publications/watergy.pdf
Johannesburg Water (JW) initiated Operation Gcin'amanzi (Operation Save Water),in Soweto as a multi-faceted project focusing on the rehabilitation of the water network and private plumbing fixtures alongside water metering. Pre-pay metering raises awareness of the amount of water being used. It ensures that everyone gets a basic allowance of water but those who use water excessively are billed accordingly. The project ensures the true value of water is recognized while at the same empowering customers to take ownership of their consumption so that the service of water remains sustainable and affordable. The project was launched after a lengthy consultative, awareness and approval process with communities, councillors, ward committees, and trade unions. Operation Gcin'amanzi is estimated to have a capital cost of 500 million Rand (US $80 million) when completed. Although the project initially received negative publicity, based mostly on misinformation and opposing political ideologies, the project is now supported by 96% of participating residents. Once all phases are completed JW will save almost 270 million Rand (US$45 million) per year in bulk water purchases alone. The effective payback period of the project is less than 3 years. (This does not include savings from the associated reduced energy use of 175 million kWh/year)

Energy Efficiency Strategies, Moulton Niguel, USA

http://www.energy.ca.gov/process/pubs/moulton.pdf

In the early 1990s, facing a major rise in energy costs, Southern California's Moulton Niguel Water District explored other methods to increase energy efficiency. Working closely with Southern California Edison and San Diego Gas & Electric to identify optimal rate schedules and energy-efficiency strategies, the district implemented a program in 1992 that has yielded substantial savings in the reservoir-fed branches of their distribution system. The District modulates wastewater flows by installing a proportional, integral and derivative/variable frequency drives system. Automated controls and programmable logic controllers are also used to enable 77 district pumping stations to benefit from lower off-peak utility rates. It was also specified that all motors used in new construction should be 95-97% efficient. The District now saves nearly $320,000 annually by using programmable logic controllers to control off-peak pumping. First-year savings for Moulton Niguel's Country Village station were over $69,000. In 1994, the District's electric bill fell more than 20%, from $1.5 million to $1.18 million. These savings are particularly meaningful considering that Moulton Niguel has been impacted by a 14% electricity rate increase. The use of the proportional, integral, and derivative/variable-frequency drives system for wastewater pumping has reduced pumping energy costs by about 4%. In addition, San Diego Gas & Electric has paid cash rebates to the District for installing variable-frequency drives - over $30,000 in 1993/1994. Electricity savings, combined with the utility rebates, offset the cost of installing the system.

Reducing Power Consumption, Ahmedabad, India

http://www.egovamc.com/

Capacitors fitted to water pumps in Ahmedabad are reducing power consumption by 12.6%. This has resulted in financial savings of over 2.6 million rupees or US$50,000 a year. The city also replaced its steel water pipes with bigger diameter polyvinyl chloride pipes. These pipes have reduced friction and further helped to improve energy efficiency. This change alone reduced energy consumption by an estimated 1.7 million kWhs each year, saving the city more than 4.48 million rupees (about US$100,000) annually.

TOOLS & GUIDANCE

TOOLS & GUIDANCE
N/A

ANNEX 7: IMPROVE EFFICIENCY OF WATER PUMPS AND/OR MOTORS

DESCRIPTION

It may be possible to replace and/or improve the operating efficiency of pumps and motors associated with the following networks:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks.

Energy is wasted when motors run at inappropriate speeds and pumps are not working at their duty points. Conditions such as this may occur over time because of changes in network flow or general wear and tear. Remedial work which could achieve positive cost benefits could include:

- Upgrading or replacing pump and/or motor to match duty requirements with peak efficiency
- Consider replacing single speed pumps with multistage and/or extending to variable speed
- Re-winding motors
- Relining the pumps
- Trimming pump impellors
- Power factor correction
- Soft start and/or variable speed controls
- Off-peak pumping to even out and reduce daily energy demand and gain benefit of reduced tariffs.

By adjusting, upgrading and/or replacing the main components of pumps and/or motors, general operations can be improved and considerable savings can be made in energy required to work the system. A more appropriately rated pump will be subject to less wear and tear. This in turn reduces the potential risk of damage to the associated pipeline and fittings. Off-peak pumping (for example refilling reservoirs overnight rather than during peak demand) assists power companies to achieve energy efficiencies at their main plant by levelling out the daily demand profile and enabling preferential tariffs to be offered to the end user.

To maintain optimal energy performance over the long term, an appropriate Operation and

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
US$100,000-1,000,000

Speed of Implementation
1-2 years

Co-Benefits
Reduced carbon emissions
Efficient water use
Enhanced public health & safety
Increased employment opportunities
Financial savings
Security

Maintenance Program should also be developed and implemented on pumps and motors.

NOTE: The appropriateness of replacement or upgrading will depend on the associated costs relative to the condition and remaining design life of the component. Each appraisal and development of implementation options must be conducted separately for each specific network.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, water and utilities engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study establishes the technological and financial viability, as well as procurement and policy options. It establishes the baseline city energy expenditure associated with water supply/waste water treatment and the efficiency of pumping and motors across the network(s). Technical ability, procurement methodology, incentives and taxes should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.
Direct expenditures & procurement	Where the water network is owned or run by the City Authority, the CA pays for the audit and upgrades of the pumping/motor infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. This activity may not be appropriate if the City Authority does not own the utility infrastructure.
Energy Services Company	The City Authority enlists an ESCo to undertake the audit and replacement There are multiple tactics for engaging an ESCo, including part- and full- owne the system. It is recommended that if the ESCo approach is pursued, the City A first explores numerous implementation options and assess the pros and cons c

Efficiency Standards	The City Authority regulates the Water Companies to ensure their pumps and motors meet required standards of energy efficiency.
Partnering Programs	The City Authority liaises with established organisations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the pumping/motor infrastructure. Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy'efficiency projects, promotion of technology development and deployment, and/or help to build public'private partnerships. Difficulty can arise where the partnering organisations do not have access or influence over the funds required to implement the initiatives.
Water Company Collaboration	The City Authority incentivises water authorities and the organisations bearing the costs of pumping and treatment to drive a collaboration and negotiation process to develop a partnering program to maintain efficient water distribution systems across the city. If the organisations and/or water companies have no interest in the strategy, the City Authority may opt to subsidise the initial expense of any plant or hardware required and support the initiative through associated regulations. If the strategy is successful the CA may receive a rebate from the organisations bearing the costs of pumping and treatment.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Energy per litre potable water supplied (kwh/litre): Measures the energy required to supply 1 litre of potable water to consumer.
- % Energy saving rate: Measures the percentage energy savings achieved at the end of the current reporting period against the historical energy consumption figure for the pumping station.

CASE STUDIES

No- and low-cost Energy Efficiency Measures, Pune, India

http://www.watergy.org/resources/publications/watergy.pdf

The Pune Municipal Corporation (PMC) partnered with the Alliance to Save Energy to help them to implement no- and low-cost efficiency measures across municipal water utilities. Energy audits were conducted on PMC's bulk water supply systems and hands-on training was held for PMC engineers. PMC also contributed a total of US$189,000 (Rs. 8.5 million) to implement a series of capital intensive efficiency measures. Municipal water utilities in India spend upwards of 60 percent of their budget on energy for water pumping. As a result of energy efficiency measures, PMC experienced annual energy savings of 3.78 million kWh and annual cost savings of over $336,000 (148 lakhs Rupees). The savings achieved at PMC are higher than projected in the energy audit report since the PMC municipal engineers implemented additional low and no cost energy efficiency measures at the pumping stations including distribution pumping stations. This is a direct result of the training provided to the municipal engineers by the Alliance to Save Energy. The implementation of EE measures also resulted in 10% additional delivery of water to community without adding any new capacity. In addition to direct reductions in energy costs, the utility also saved money by qualifying for a rebate program offered by the Maharashtra State Electricity Board to facilities maintaining a good power factor and reducing usage during peak hours. The efficient operation of the largest pumping station, Parvati Water Works, reduced the energy intensity of water supply by 6%, from 375 kWh/million litres of water to 352, and increased its rebate by almost 8% since fiscal year 2003-04, from $110,000 (48.57 lakhs Rupees) to $196,000 (86.27 lakhs Rupees).

Improving the Distribution of Water, Fortaleza, Brazil

http://www.watergy.org/resources/publications/watergy.pdf

The Alliance to Save Energy worked alongside the Companhia de Agua e Esgoto do Ceara (CAGECE) in the Northeast of Brazil to develop and implement measures to improve the distribution of water and the access to sanitation services. The water systems needed to expand to satisfy increasing demand without sacrificing efficient use of energy. The project improved system management by centralizing control. It also developed financing proposals with the Government of Brazil Fight against Electricity Waste Program (PROCEL) in order to implement energy efficiency projects with CAGECE's operations crew. These projects included automation of operations, rewinding and replacing motors, maximizing existing pump systems efficiency, and increasing storage capacity to allow pumps to be shutdown during peak electricity rate hours. Over the course of four years, CAGECE saved 88 GWh of energy, improving efficiency each year. Before CAGECE instituted their energy efficiency program, they provided access to 442,400 households. Four years later, the utility was able to provide 88,000 new connections over the original baseline, while decreasing total energy consumption and costs and maintaining water supply levels. Four years of official data show savings of over US$2.5 million with an initial investment by CAGECE of only US $1.1 million (R$3 million). Another benefit was to introduce CAGECE to the tools and know-how to produce on their own initiatives that save energy and clean water. As a result of this 127 % return on investment after 4 years, CAGECE was initially approved for financing by the Energy Efficiency Fund of PROCEL to work with the World Bank to implement further efficiency measures.

Economical Pumping Solutions, Lichetenau, Germany

http://www.lowara.co.uk/pressroom/casestories.php/24770

Lichetenau is a small municipality with 3,600 inhabitants. Advice on water supply solutions was provided by a sales and service partner of the

water pump company, ITT Lowara. This partner uses the knowledge and support of Lowara to propose more economical and innovative pumping solutions. These sorts of collaborations ensure that even the smallest water boards can achieve considerable savings through improving efficiency of water supply systems. By replacing an old pump with a variable speed version they have reduced energy consumption by around 40%. The frequency converter on the pump ensures that the flow rate can be easily adapted to that of the other pumps in the system. The pump installed has been running perfectly for more than 2 years in Lichetenau, and a recent audit at the same flow rate has shown that the pump consumes only 13.39 kW per hour, providing a saving of 8.34 kW/h against the old cast iron pump. This equates to a saving of 39%. During its service of some 5,827 hours to date, it has consumed less than 48,597 kWh. Based on a current energy cost of 0,18 Euro/kWh, the saving would be 8,748 Euros - and in environmental terms they emit less than 7,500kg/year CO2, giving Lichtenau a production of CO2 well below the federal average.

Energy Efficiency Strategies, Moulton Niguel, USA

http://www.energy.ca.gov/process/pubs/moulton.pdf

In the early 1990s, facing a major rise in energy costs, Southern California's Moulton Niguel Water District explored other methods to increase energy efficiency. Working closely with Southern California Edison and San Diego Gas & Electric to identify optimal rate schedules and energy-efficiency strategies, the district implemented a program in 1992 that has yielded substantial savings in the reservoir-fed branches of their distribution system. The District modulates wastewater flows by installing a proportional, integral, and derivative/variable frequency drives system. Automated controls and programmable logic controllers are also used to enable 77 district pumping stations to benefit from lower off-peak utility rates. It was also specified that all motors used in new construction should be 95-97% efficient. The District now saves nearly $320,000 annually by using programmable logic controllers to control off-peak pumping. First-year savings for Moulton Niguel's Country Village station were over $69,000. In 1994, the District's electric bill fell more than 20%-from $1.5 million to $1.18 million. These savings are particularly meaningful considering that Moulton Niguel has been impacted by a 14% electricity rate increase. The use of the proportional, integral, and derivative/variable-frequency drives system for wastewater pumping has reduced pumping energy costs by about 4%. In addition, San Diego Gas & Electric has paid cash rebates to the District for installing variable-frequency drives-over $30,000 in 1993/1994. Electricity savings, combined with the utility rebates, offset the cost of installing the system.

Energy Management Program, Madera Valley, USA

http://www.energy.ca.gov/process/pubs/madera.pdf

Madera Valley launched an energy management program in 1991 that enabled it to meet higher demand in 1994 without increasing operating costs. The program focused on modifying two wells to better maintain system pressure. At two other wells, Madera Valley has since upgraded its standard-efficiency motors to energy-efficient units. The combined improvements to Madera Valley's pumping operations enabled the agency to provide 22% increased capacity in 1994-from 514 million gallons in 1993 to 627 million gallons in 1994. In addition, energy costs per household fell by 22%-from an average $7.46 per household each month in 1993 to an average $5.82 in 1994. System-wide, this translated into annual savings of about $18,946, or over 15% of total energy costs.

Water Treatment Plant, San Juan, Puerto Rico

http://www.energy.ca.gov/process/pubs/sanjuan.pdf

The San Juan Water District's Sidney N. Peterson Water Treatment Plant was built to be energy efficient and is operated to encourage energy and

water conservation among customers and staff alike. The district even created an incentive program for its employees that rewards them with a percentage of the first year's savings from new cost-cutting techniques that they identify. A state-of-the-art facility, the Peterson plant uses gravity flow to minimize pumping needs for a 120-mgd modular filtration system. Initial plant designs specified 15 horsepower backwash motors instead of 100 horsepower units, which reduced construction costs by 33% and lowered filtration energy requirements by 75%. A supervisory control and data acquisition (SCADA) system optimizes day-to-day performance and energy efficiency. To save more energy and money, district staff replaced standard-efficiency motors with energy-efficient motors to save $5,000 per year. They also installed variable-frequency drives on flocculation and chemical feed pump motors to save $11,000 per year and launched water conservation education, promotion, and enforcement programs. Avoided pumping due to water conservation measures saves around $50,000 per year.

USAID funded Ecolinks Project, Galati, Romania
http://www.munee.org/node/62
As part of a USAID funded Ecolinks Project, the Cadmus Group assessed the city's water supply system and discovered that a series of energy conservation measures could save roughly $250,000 per year in electricity costs. Low cost measures included trimming impellers to better match pumps and motors with required flows and pressures. Moderate cost measures included leak detection and reduction and limited pump replacement. A series of pumps replacements were recommended. For one pump's 5,854 hours of annual operation, it used roughly 2,500,000 kWh. A replacement pump and motor set could save roughly $55,000 per year. For another pump with 6,000 hours of annual operation and consuming 3,000,000 kWh per year a replacement pump and motor set could save roughly $42,000 per year. Cadmus also estimated that reducing the height of the discharge would decrease the static head between the wet well in a low voltage pump station and the actual discharge. If the height of the reservoir were an average of 1 meter below the discharge and the discharge were lowered, roughly 10 percent of the pumping costs could be eliminated. The cost of the measure would include labour and minimal parts (pipe extensions). This measure would save roughly 100,000 kWh/yr or $5,000/yr.

TOOLS & GUIDANCE

TOOLS & GUIDANCE

Kitakyushu Initiative: A report focusing on building the capacity of the local governments to overcome the urban environmental and water problems. http://kitakyushu.iges.or.jp/docs/sp/water/4%20Overview_Analysis.pdf

Pump Efficiency Calculator: An online calculator tool to work out exactly how much could be saved by replacing a fixed speed damped or throttled centrifugal load with a variable speed drive controlled solution.
http://www.abb.co.uk/cawp/seitp202/c253ae5e6abf5817c1256feb0053baf7.aspx

ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world.
http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

ANNEX 8: STREET LIGHTING AUDIT AND RETROFIT

DESCRIPTION

Traditionally used incandescent bulbs in street lights, are highly inefficient by producing little light and much heat energy from their significant power consumption. They are also often poorly designed and unnecessarily spread light equally in all directions, including the sky above, which further increases their energy inefficiency. New bulb technologies can significantly increase their efficiency as well as extend their design life. The aim of this recommendation is to both assess current lighting efficiency and act to retrofit where appropriate.

Retrofits can deliver the same lighting levels for lower energy consumption levels, reducing associated carbon emissions and reducing operational costs. An increased design life reduces maintenance requirements and costs and also reduces interruptions to service, improving public health and safety.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Self-implementation	The main expenditures associated with a street lighting retrofit are bulb / fitting replacement, control system upgrade / replacement, and manual labor for installation. These expenses along with consulting fees are funded directly by the city, which means the city accrues all financial benefits, but also bears the financial risks.
Energy Services Company Retrofit	Enlist an ESCo to take on the project. There are multiple tactics for engaging an ESCo, including part- and full-ownership of the system therefore there are varying levels of benefit in terms of risk mitigation, upfront capital cost, and financial savings over the life of the project. The presence of local ESCos will help streamline the process and make the upgrade more feasibly. Similarly, the presence of a local credible and independent Measurement & Verification agency minimises contractual disputes by providing performance verification. See Akola Street Lighting Case Study for further details.
Supply and Install Contract	A supply and install contract gives the city flexibility to set performance parameters and review contractor performance as part of a phased project. This type of approach will require upfront spending and establishing an

- **Attributes**
- **Energy Savings Potential**
- **> 200,000 kWh/annum**
- **First Cost**
- **US$100,000-1,000,000**
- **Speed of Implementation**
- **1-2 years**
- **Co-Benefits**
- **Reduced carbon emissions**
- **Enhanced public health & safety**
- **Increased employment opportunities**
- **Financial savings**

	appropriate financing plan is essential. See City of Los Angeles Case Study for further details.
Long-term Concession	Long-term concessions free the city from financing pressures but will pass on financial savings accrued through energy saving to the body carrying out the upgrade. This strategy can be beneficial for cities without the financial resources to bear the upfront cost and engages an informed stakeholder to inform the process.
Joint Venture	A joint venture allows the city to maintain a significant degree of control over upgrade projects while sharing associated risks with a partner that is experienced in street lighting issues. Joint ventures are effective in situations where both parties stand to benefit from improved energy efficiency and do not have competing interests. See Oslo Case Study for further details.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- $/km - Benchmark annual energy cost on a per liner km basis.
- Lumens / Watt - average efficacy of illumination for the current operational city street lighting inventory.

CASE STUDIES

Light Emitting Diode (LED) street lighting retrofit, Los Angeles, USA

Source: ESMAP (2011). "Good Practices in Energy Efficiency: Los Angeles, USA: LED Street Lighting Retrofit", available online from http://www.esmap.org/esmap/sites/esmap.org/files/LosAngeles_LED_final_edited_11-9-11.pdf

The City of Los Angeles (LA) Light Emitting Diode (LED) street lighting project is the largest LED street lighting retrofit ever undertaken globally—a collaboration between the LA Bureau of Street Lighting, the LA Mayor's Office, the LA Department of Water & Power, and the Clinton Climate Initiative (CCI) Cities Program. Over a period of five years (2009-2014), the project will replace 140,000 of the city's more than 209,000 street

lights with LED technology which is expected to enhance the quality of municipal street lighting, reduce light pollution, improve street safety, and save energy and money. The US$56.9 million investment required will provide an estimated US$10 million in annual energy and maintenance cost savings (68.6 GWh/year) while avoiding at least 40,500 tons of CO2e emissions each year.

ESCO street light retrofit, Akola, India

Source: ESMAP (2009). "Good Practices in Energy Efficiency: Akola Municipal Corporation, India - Performance Contracting for Street Lighting Energy Efficiency", available online from http://www.esmap.org/esmap/sites/esmap.org/files/CS_India_SL_Akola_020910.pdf

The Akola CA enlisted an ESCO to replace over 11,500 existing street lights (standard fluorescent, mercury vapor, sodium vapor) with efficient T5 fluorescent lamps. The selected contractor financed 100% of the investment cost, implemented the project, maintained the newly-installed lights, and received a portion of the verified energy savings to recover its investment. Under the energy savings performance contract, the CA paid the ESCO 95% of the verified energy bill savings over the 6-year duration of the contract. AEL was also paid an annual fee for maintaining the lamps and fixtures. Initial investments were estimated at USD 120,000 and the retrofit was completed within a 3-month period. Annual energy savings of 56% were achieved, delivering the equivalent of USD 133,000 in cost savings. This gave a very attractive payback period of less than 11 months.

Street light retrofits, Dobrich, Bulgaria

http://www.eu-greenlight.org - Go to "Case Study"

In 2000, the City of Dobrich performed a detailed audit of the current state of the entire street lighting system. The results informed a project which commenced the following year which reconstructed and modernized the street lighting system. Mercury bulbs were replaced with high pressure sodium lamps and compact fluorescent lamps. In total, 6,450 new energy efficient lamps were brought into operation. The street lighting control system was also upgraded, as well as two-tariff electric meters installed. The implemented measures delivered an illumination level of 95% whilst yielding annual energy savings of 2,819,640 kWh. This saved the CA 91,400 EUR/year.

Street Lighting LED Replacement Program, City of Los Angeles, USA

Clinton Climate Initiative, http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative/i/cci-la-lighting

A partnership beween Clinton Climate Initiative (CCI) and the city of Los Anglese, this project will be the largest streetlight retrofit undertaken by a city to date, replacing traditional streetlights with environmentally friend LED lights. It will reduce CO2 emissions by 40,500 tons and save $10 million annually, through reduced maintenance costs and 40% energy savings.

The Mayor of Los Angeles and the Bureau of Street Lighting collaborated with CCI's Outdoor Lighting Program to review the lates technology, financing strategies, and public-prive implementation models for LED retrofits. CCI's modelling and technology analysis, as well as its financial advisory, serves as key reference sources for the development of this comprehensive retrofit plan.

The phased nature of the project allows the city to re-evaluate its approach on an yearly basis. This gives enviable flexibility to the municipality when selecting contractors and the street lighting systems for upgrade. Los Angeles also capitalised on its government status to attract financial institutions offering favourable loans and funding mechanisms as these institutions were looking to establish positive relationships with the city. Due to these and other factors the City of Los Angeles was able to establish a well-developed business case for the retrofit.

Lighting Retrofit, City of Oslo

Clinton Climate Initiative, Climate Leadership Group, C40 Cities http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp
The City of Oslo formed a joint-venture with Hafslund ASA, the largest electricity distribution company in Norway. Old fixtures containing PCB and mercury were replaced with high performance high pressure sodium lights and an advanced data communication system using powerline transmission that reduces the need for maintenance. Intelligent communication systems can dim lights when climatic conditions and usage patterns permit. This reduces energy use and increases the life of the bulbs, reducing maintenance requirements.
The system is now fully equipped with all its components and is being calibrated to sort out some minor problems related to production failure in communication units. Overall the system has performed well under normal operating conditions.

Tools & Guidance
European Lamp Companies Federation. "Saving Energy through Lighting", A procurement guide for efficient lighting, including a chapter on street lighting. http://buybright.elcfed.org/uploads/fmanager/saving_energy_through_lighting_jc.pdf
Responsible Purchasing Network (2009). "Responsible Purchasing Guide LED Signs, Lights and Traffic Signals", A guidance document for maximizing the benefits of retrofitting exit signs, street lights and traffic signals with high efficiency LED bulbs. http://www.seattle.gov/purchasing/pdf/RPNLEDguide.pdf
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

ANNEX 9: LIGHTING TIMING

DESCRIPTION

Public lighting usually only has two states of operation, i.e. 'on' and 'off', and only switches between these states in the early evening and early morning. The demand for lighting varies significantly throughout the day, however, with periods of very little use of public space during the middle of the night. A program with strategic timing and/or dimming tailored to the specific needs for lighting in specific areas can significantly reduce energy consumption whilst still delivering appropriate levels of lighting for e.g. providing safety and sense of security in public areas. An intelligent monitoring system can be used to adapt the levels of lighting according to varying weather and activity levels. The aim of this recommendation is to identify public space usage patterns and adjust the lighting system levels accordingly. Often lighting timing programs are integral to a full audit and retrofit program, but for cities that already have energy efficient public lighting systems, a lighting timing program may still be a small and effective program.

Lighting timing programs can reduce energy consumption, and subsequent carbon emissions as well as operational costs. Such programs often also increase the design life of light bulbs, reducing maintenance requirements and associated costs. The use of intelligent monitoring systems also enables quick detection of faults, allowing for quick replacement, enhancing the quality of the public lighting service.

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
< 1 year

Co-Benefits
Reduced carbon emissions
Enhanced public health & safety
Increased employment opportunities
Financial savings

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Study illumination timing alternatives	Prepare a study to estimate the types of streets and luminaires that have the opportunity to have reduced timing and dimming during late night hours.
Install timers and dimmers on existing street lights	Allocate funding to implement upgrades and retrofits for dimming and timing opportunities. Roll out upgrades over the course of multiple years to achieve 100% coverage of all city public lighting and street lighting installations. See Kirklees and Oslo case studies for further details.

Standards for new lighting	Set up timing and dimming standards for new installations of public illumination and street lighting that confirm to global best practice for energy efficiency and IESNA illumination guidelines.
Monitor and publish energy savings	Measure on an annual basis the energy savings achieved by this program and encourage private sector owners to follow the model of the CA.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Hours per year street lights are illuminated at maximum output.
- Hours per year street lights are illuminated at less than 50% of maximum output.

CASE STUDIES

Control system for public lighting, Kirklees, UK

http://www.kirklees.gov.uk/community/environment/green/greencouncil/LightingStoryboard.pdf

Instead of switching off street lights at certain times of the day, as has been done by other CAs, the Kirklees CA decided instead to dim lights to varying levels throughout the day. This was done partly because not switching public lighting off completely during times of low activity would provide increased safety in the community by preventing crime. Retrofit systems were installed on each existing lighting pole which used wireless technology to monitor and dim the street lights. The retrofitting of these systems simply required the addition of a small antenna to the lamp heads, which plugged into the electronic ballast with no need for additional wiring. Generally the lights are switched on 100% at 7pm, thereafter dimmed to 75% at 10pm, and then to 50% at midnight. If the lights are still on at 5am, they are increased again to 100% lighting. By dimming the lights gradually, eyes are able to adjust to lower lighting levels, and the dimming is barely noticeable. The remote monitoring system also provides accurate inventory information and enables street lighting engineers to identify failed lamps quickly and easily. This reduces the need for lighting engineers to carry out night scouting and has also reduced other on-site maintenance costs. A dimming of lights as implemented in Kirklee can save up to 30% of the electricity used annually. By replacing 1,200 lights, Kirklee CA estimates savings of approx USD 3 million in energy costs per year.

Intelligent outdoor city lighting system, Oslo, Norway
http://www.echelon.com/solutions/unique/appstories/oslo.pdf
An intelligent outdoor lighting system has replaced PCB and mercury containing fixtures with high-performance high-pressure sodium lights. These are monitored and controlled via an advanced data communication system which operates over the existing 230V power lines using specialist power line technology. An operations centre remotely monitors and logs the energy use of streetlights and their running time. It collects information from traffic and weather sensors, and uses an internal astronomical clock to calculate the availability of natural light from the sun and moon. This data is then used to automatically dim some or all of the streetlights. Controlling light levels in this way has not only saved significant amount of energy (estimated at 62%), but has also extended lamp life, thereby reducing replacement costs. The CA has been able to use the monitoring system to identify lamp failures, often fixing them before being notified by residents. By being able to provide predictive failure analyses based on a comparison of actual running hours versus expected lamp life, the efficiency of repair crews has been increased. 10,000 replacements have cost the CA approx. USD 12 million. Currently the program saves approx USD 450,000 in running costs per year. However, it is estimated that if the program is rolled out to the entire city, the increased economies of scale will yield a payback period of less than five years.

Motorway intelligent lights retrofit, Kuala Lumpur, Malaysia
http://www.lighting.philips.com.my/v2/knowledge/case_studies-detail.jsp?id=159544
The project implemented a lighting solution for highways leading to Kuala Lumpur International Airport. The total length of the dual carriage highway covers 66 km. The main requirement for the project was that each individual lamp along the entire 66 km stretch of highway should be independently dimmable. This called for a network linking all 3,300 positions to a central control facility. There was also a need for greater maintenance efficiency while ensuring optimal visibility without compromising on visual comfort on the road. An intelligent lighting system that uses telemanagement control was employed. Telemanagement makes it possible to switch or control every individual light point in the system from a central PC. It also enables specific dimming profiles adjusted to suit conditions on the road for different lamps, instant reception of failure messages, and the creation of a database where all system data is stored. It allows a significant reduction in energy consumption in addition to the 45% savings as a result of the use of dimming circuits.

Tools & Guidance

N/A

ANNEX 10: PUBLIC TRANSPORT DEVELOPMENT

DESCRIPTION

Develop or improve the public transport system and take measures to increase its accessibility and use. Public transport achieves lower emissions per capita than private cars, and has the potential to provide equitable transport network. A reduction in the number of private vehicles in circulation can lower emissions and improve air quality.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Bus priority	The City Authority establishes dedicated bus priority measures. This enables buses to bypass traffic queues enhancing their reliability and journey times. There are a range of measures including bus lanes and priority at junctions that could be implemented. See the Bogota case study for further details.
Signalling	The City Authority invests in the necessary infrastructure for bus-priority signalling. Such systems are linked to buses via transponders which use GIS information, and favour the circulation of approaching buses either by extending green lights for buses or by shortening cycle for cars.
Information	The City Authority provides good quality passenger waiting facilities and as well as good information services. The provision of real-time bus countdown information allows users to understand and manage waiting times. These services enhance the attractiveness of public transport.
Operations	The City Authority invests in the necessary infrastructure for electronic ticketing. This allows for use of multiple buses within a given amount of time with one ticket, reducing the cost of travel, putting buses within the reach of the poorest, while attracting a wider patron base, when in combination with other modes, such as heavy rail or metro.
Planning & regulations guidelines	The City Authority links development densities to public transport availability and funding. The City Authority reviews the city's zoning ordinances and considers making the following changes: Increase the permitted floor area ratio/ plot ratio on sites located near public transport hubs. In areas where it is

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
> US$1,000,000

Speed of Implementation
> 2 years

Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety

	appropriate re-zone single-use lands to allow multiple uses on the same site. Allowing higher densities of development along well-served public transport corridors creates a patron base for public transport and can be used in combination with other planning measures, such as capping parking provision to residential and office buildings, thus discouraging car use. Developers are required to show how a new development links to the existing or planned public transport network in order to gain planning permission. See the Curitiba case study for further details.
Subsidies	The City Authority subsidizes travel on public transport. In certain areas this can provide an incentive for people to use public transport.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform surveys of public transport passenger numbers.
- Determine mode share of people travelling in area or city.

CASE STUDIES

BRT system, Bogota, Colombia

Source: ESMAP (2009). "Good practices in city energy efficiency: Bogota, Colombia - Bus Rapid Transit for Urban Transport Energy", available online from http://esmap.org/esmap/sites/esmap.org/files/Bogota_Case_Study_020310.pdf

With the completion of its first two phases, the TransMilenio BRT system serves about 1.5 million passengers every day and has city-wide fuel consumption by 47%. Key success factors have been city-wide comprehensive planning of infrastructure, use of state-of-the-art technologies, implementation of a variety of design features to accommodate high volumes of passengers, and the use of a simple single price faring system. It does not require subsidies for operation - these are fully covered by fares. The project's capital cost totalled USD 240 million. The system is managed by a company which was set up by the Mayor, but runs independently from the city administration. While the company is in charge of

all planning, maintenance and construction of infrastructure as well as organizing of schedules of bus services, buses and drivers are contracted through private firms, resulting in a complex but innovative management structure.

Land Use and Public Transport Planning, Curitiba, Brazil

Source: World Bank (2010). "Curitiba, Brazil -- Cost Is No Barrier to Ecological and Economic Urban Planning, Development, and Management . In ECO^2 Cities: Ecological Cities as Economic Cities, pages 169-182." available online from http://www.esmap.org/esmap/sites/esmap.org/files/CS_Curitiba.pdf

The case of Curitiba, Brazil, shows that cost is no barrier to ecological and economic urban planning, development, and management. Curitiba has developed a sustainable urban environment through integrated urban planning. To avoid unplanned sprawl, Curitiba directed urban growth linearly along strategic axes, along which the city encouraged highdensity commercial and residential development linked to the city's integrated master plan and land use zoning. Curitiba adopted an affordable but innovative bus system rather than expensive railways that require significant time to implement. Curitiba's efficient and well-designed bus system serves most of the urban area, and public transportation (bus) ridership has reached 45 percent. The city now has less traffic congestion, which has reduced fuel consumption and enhanced air quality. The green area has been increased, mainly in parks that have been created to improve flood prevention and through regulations that have enabled the transfer of development rights to preserve green areas and cultural heritage zones.

Linking development densities to public transport availability, Curitiba, Brazil

Source: Rabinovitch, J. (1992) "Curitiba: towards sustainable urban development", Environment and Urbanization, Vol.4 (2) pp. 62-73

Curitiba's Master Plan integrated transportation with land use planning. Zoning laws are used to direct linear growth by attracting residential and commercial density along a mass transportation lane. High-density residential and commercial development is permitted within walking distance of stops, with much lower densities elsewhere in the city. The city's central area is partly closed to vehicular traffic, and pedestrian streets have been created. In addition, a strict street hierarchy safeguards the right of way for the current BRT, which has significantly contributed to the success of the transportation network.

Integrated urban planning and efficient resource use, Singapore

Good practices in City Energy Efficiency: Eco^2 Cities - Land and Resource Management in Singapore, available online http://www.esmap.org/esmap/node/1230

Singapore is an island city-state at the southern tip of the Malay Peninsula. With a limited land area of 700 square kilometers and a population of 4.8 million, Singapore has become developed because of innovative urban planning integrated with the efficient use of land and natural resources. Singapore's small size poses challenges related to the availability of land and natural resources. To optimize land use, Singapore promotes high-density development not only for businesses and commercial entities, but also for residential structures. High density lends itself to higher economic productivity per unit of land and facilitates the identification of green spaces and natural areas for preservation.

Furthermore, high-density development has translated into greater use of public transportation as major business, commercial, and residential areas are well connected to an integrated public transportation network. In 2004, public transportation as a share of all transportation modes during morning peak hours reached 63 percent. The significant use of public transportation helps reduce greenhouse gas emissions. High public transportation ridership also means Singapore has been able to recover all public transportation operating costs from fares, a feat achieved only

by Hong Kong, China, and by Singapore among modern, highly developed cities.

Integrated regional urban planning, Auckland, New Zealand

Good Practices in City Energy Efficiency: Eco^2 Cities - Integrated Regional Urban Planning in Auckland, available online http://www.esmap.org/esmap/node/1227

The interconnectedness of national and local Auckland issues (such as housing and education) with growth and innovation and the major required investments (particularly in land transport) have created complex and difficult issues among multiple authorities. Despite Auckland's importance to the New Zealand economy and the areas of common interest, such as transportation and energy provision, the national government did not initially play a close role in directing regional and local government planning. Concern emerged that, without agreement on an overarching regional strategy and framework, decision making in the region could become ad hoc and adversarial if each stakeholder tried to have a say from a narrow perspective and without viewing the region as a whole. As a result, there was a clear need for coordinated strategic planning across the Auckland Region to ensure that Auckland would be able to remain competitive in today's globalized world. The response involved a process undertaken in 2001 to prepare a regional growth strategy that aimed to provide a vision of what Auckland could be like in 50 years.

Tools & Guidance

Public Transport Authority Western Australia (2009). "Bus Priority Measures Principles and Design" A guidance document for planning bus priority methods and approaches. Available online from http://www.pta.wa.gov.au/PublicationsandPolicies/DesignandPlanningGuidelines/tabid/109/Default.aspx

Transport for London (2006). "Accessible bus stop design guidance" A guidance document for designing bus stops which help make boarding easier for passengers. Available online from http://www.tfl.gov.uk/assets/downloads/businessandpartners/accessibile_bus_stop_design_guidance.pdf