ECA Sustainable Cities:

Improving Energy Efficiency in BELGRADE Serbia

TRACE Study

SUSTAINABLE CITIES

ESMAP
Energy Sector Management Assistance Program

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Table of Contents

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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 Sabine Palmreuther (Senior Operations Officer), with a team comprised of Marcel Ionescu-Heroiu (Extended Term Consultant), Ranjan Bose (Senior Energy Specialist), Jelena Nesic (Short Term Consultant), Milan Popovic (Operations Officer), and Desanka Stanic (Program Assistant). Throughout the process of collecting data and writing the report, the team has enjoyed an excellent collaboration with local authorities in Belgrade.

Cover design: George Maier (georgemaier@gmail.com)

http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:23050220~pagePK:146736~piPK:146830~theSitePK:258599,00.html

Executive Summary

Around the time of the fall of the Berlin wall, Serbia was one of the most developed countries in Central and Eastern Europe. A decade of transition and conflict however, has taken a heavy toll on the country and its cities. For example, public transport ridership in Belgrade has fallen from around 800 million passengers in 1990 to just above 400 million in 2000; city streets have become increasingly congested with private vehicles; water and wastewater infrastructure has deteriorated; recycling networks have disappeared and waste generation has increased with a growth in consumption; buildings, largely built after 1945 have received little work, continuing to deteriorate throughout much of the transition years.

At the same time, while some of Serbia's neighbors have pushed ahead on a reform path immediately after 1989. Serbia has yet to resolve a number of issues. For example, land still is predominantly in public ownership, and urban land markets are tightly controlled by local authorities. This has helped Serbian cities maintain a compact urban form, but they have also undermined the cities' growth potential.

Electricity tariffs are controlled by the central government and are kept at artificially low levels. With the peak load demand during winter months due to electricity use for heating, Serbia finds it difficult to manage their existing power system. As a result, electricity demand during peak load is often met by higher imports. This often puts electricity distributors in the tough position of importing electricity at market prices from neighboring countries, and selling it to end-users in Serbia at lower prices. Similarly, the low imposed tariffs hamper the development of alternative sources of energy (e.g. solar and wind), or even the development of more efficient ways of generating energy from fossil fuels – e.g. combined heat and power plants.

Nonetheless, much has been done in the new millennium to redress the situation and improve city performance and quality of life. Public transport ridership has gone back up to pre-1990 levels, with the city investing aggressively in existing infrastructure, and with the introduction of private-bus operators on certain lines. A number of ambitious infrastructure projects (e.g. the new Ada Bridge) have gone a long way towards addressing congestion issues in the city. Investments in the replacement of inefficient light bulbs have reduced consumption in Belgrade's street lighting systems, although the City is charged not on actual consumption, but on installed capacity. Ambitious plans to revamp the solid waste management system in the city, may make Belgrade a best-practice study case for other cities in the region – and beyond. On-going audits of the district heating system and of the built stock in Belgrade will open the door for ambitious energy efficiency projects in the future.

Belgrade is already considered to be one of the most livable cities in Europe. It can and should build on that existing foundation to become even greater. The following report, drawing on the results of the implementation of the TRACE tool, hopes to offer some answers to how that can be done.

TRACE (Tool for Rapid Assessment of City Energy) is a simple and quick diagnostic tool that is used to assess a city's energy performance in six service areas (urban transport, municipal buildings, water and wastewater, solid waste management, public lighting, and power and heat), and to provide recommendations for improving energy efficiency. In each of the six service areas TRACE uses a benchmarking algorithm to assess energy cost savings potential, and factoring in the level of influence of local authorities, it prioritizes interventions according to where local authorities can achieve the biggest savings.

The TRACE analysis was carried out under the umbrella of the Europe and Central Asia Sustainable Cities Initiative (ECA SCI), and is just one of the components used to assess the potential of promoting sustainable development in ECA. (More 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) As such, the analysis and recommendations made in this report do not only focus on energy efficiency 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 work trip was organized in January 2012. Work in Belgrade 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, several recommendations were drawn out. These are summarized below.

Energy Efficiency Strategy and Action Plan

One of the first recommendations suggested by local authorities in Belgrade was the development of a proper energy efficiency strategy and action plan. These are critical before embarking on an ambitious project to improve energy efficiency in the city. The strategy and the action plan can lay out vision and objectives for such work, and provide a list of activities that would help the city achieve those objectives.

District Heating Maintenance and Upgrade

Having one of the most extensive district heating systems in Europe, Belgrade also has a challenge of maintaining and upgrading this system. Since most of the heat is generated in a few large district heating plants, heat distribution is reliant on a long system of pipes. Over time this network of over 1,300 km has deteriorated, leading to heat losses in the system that are among the highest of any city with relevant data in the TRACE database. Revamping this network is one of the key priorities of local authorities, and a key step was taken in this direction by preparing an aerial thermal mapping of the entire system. This allows the identification of the areas in the city with the highest heat losses.

District Cogeneration Thermal Network

The district heating system in Belgrade is the largest single consumer of energy, and it is responsible for 25% of total natural gas consumption in Serbia. However, all of the used fossil fuel goes to heat generation, leaving a huge untapped potential of generating both power and heat. Combined heat and power (CHP) plants, are a key way of generating energy in an efficient way, and national authorities are poised to reconvert district heating plants in the country to CHP systems. However, that transition should be preceded by a rise in electricity tariffs, which now are among the lowest in Europe. Without proper market pricing of electricity, technologies such as CHP cannot take hold, as the cost of production for one unit of energy would be higher than the centrally imposed selling price.

Traffic Flow Optimization

Belgrade has an old city grid, with relatively small width streets, it is divided by two large rivers (Sava and the Danube), and the country's largest highway (E-70) cuts right through its middle. This cocktail of circumstances, combined with the fact that private vehicle ownership has grown dramatically (from around 300,000 in 1990, to 470,000 in 2010), often leads to traffic bottlenecks and city congestion. Several large projects have been undertaken to improve traffic flow (e.g. a new bridge over the Sava – the Ada Bridge, and a city beltway to diver heavy highway traffic). However, more can be done in improving access over the rivers of pedestrians and bicyclists, and by doing an integrated traffic management study.

Public Transport Development

Belgrade already has a well developed public transportation system, and a testimony to this reality is the fact that over 52% of people in Belgrade use public transit for their daily commutes. Local authorities plan to continually invest in the efficiency of the existent system, by acquiring more natural gas powered buses, by buying new trams, and by continually expanding the system. One ambitious project that is considered it the development of a metro system in the city. The metro would help decongest streets and improve public transport by offering people a reliable and high capacity means of getting around.

Municipal Buildings Audit and Retrofit

Belgrade owns and manages an impressive stock of buildings. A large majority of these buildings were developed after 1945 and have a poor thermal performance. With other stringent needs filling the agendas of local policy makers, many of these buildings have not seen any rehab or upgrade work in the transition years. There is however a great scope for saving energy from municipal buildings, and local authorities should start by performing a full audit of the existing stock. Once the audit is finished, it may help to craft a plan for how resources can be allocated to improve the energy performance of these buildings.

Municipal Buildings Benchmarking Program

Since the municipal building stock managed by the City of Belgrade is so large, and since resources for energy efficiency improvements have to be

allocated strategically, it is important to first get an idea of which buildings offer the greatest saving potential. This can be done through a simple benchmarking process, using a number of key indicators. By focusing initially on the buildings that offer the biggest impact (pecuniary and non-pecuniary) for every unit invested, local authorities can ensure that more buildings can be covered, and that additional resources can be created from the savings achieved in the completed projects.

Improve Performance of Water System Networks

The share of non-revenue water in the Belgrade water system is around 32% - relatively low when compared to other countries in the region, but quite high when considering that the water squandered had to be treated and pumped first. Thus, every liter of water that is lost, is a liter that has certain energy costs attached to it. In fact, Belgrade has one of the most energy intensive water systems of any city in the TRACE database. Much of it can be attributed to how the system was originally designed – with pumps that work continuously to get water from the river network and from groundwater sources to people throughout the city. A first measure that will help improve system performance is the development of reservoirs in key locations. These reservoirs would allow water to be pumped at night (when electricity costs are four times lower), and distribute by gravity to end-consumers during the day.

Improve 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).

Waste Sorting and Recycling

Belgrade used to have a functioning recycling system. It is now trying to put it back into commission. The way it is planning to do so is quite ingenious and is part of a larger integrated solid waste management plan.

Intermediate Transfer Stations

There are seven waste operators in Belgrade – one of them working in the city proper, while the other ones servicing the former suburban municipalities in the south of the city. Waste collection and transport from these suburban municipalities is not done in the most efficient manner, and local authorities should consider the development of a system of transfer stations (if these actually prove to be economically viable).

Street Lighting Timing Program

Local authorities have already started replacing light bulbs with more efficient ones. They should, in addition, 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).

Background

Serbia is a landlocked country and is located in the central part of the Balkan Peninsula, on the most important route linking Europe and Asia. Serbia is referred to as the cross-roads of Central and Southeast Europe — international roads and railways pass through it, providing the shortest link between Western and Central Europe, and the Middle East, Asia and Africa. Most of Serbia has a moderate-continental climate, with relatively cold winters and hot summers.

Like many other countries in Eastern Europe, Serbia has witnessed population decline in the transition years. This has had a significant impact on existent infrastructure, and on how cities grew and developed. Much of the existent urban infrastructure in the country was developed with a growing population in mind. Basically, central planners expected population to continue growing at a healthy pace in the 1990s, and nobody foresaw the events that changed the geo-political space in Europe in 1989. To a large extent, the 1990s have marked not only by re-adjustments to new economic and political realities (as in the other Eastern European countries), but also by internal strife and conflict. This has had a profound dampening effect on the country's economy.

In the new millennium the situation changed to Serbia favor. The country went through an economic liberalization process, experiencing fast economic growth. The average GDP increase in the last ten years was 4.45% per year.[1] The economy has made the transition from industrial production to a service economy, with over 63.8% of the GDP being generated by the service sector, and only 23.5% by industry. The 2008 global financial crisis has affected Serbia's economy, but the country managed to bounce back relatively quickly, with a moderate 1.7% growth rate in 2010, and a growth in exports of over 16%[2].

In 2001, Serbia started the intense transformation and reform of its legislative and social democratization. Serbia formally regained its independence in 2006, after 88 years in various federations, and became an independent state. The parliament announced a constitutional referendum that replaced the former Yugoslav-era constitution and created the new framework for the country by ratifying a new constitution. Today, Serbia is a democratic state, as defined in its Constitutional Law. The political system is based on the multi-party parliamentary democracy concept. Serbia is on the path of European integration and submitted its request for EU membership in December 2009. The EU is providing guidance to the Serbian authorities on reform priorities as part of the European Partnership.

From and administrative point of view, Serbia is divided into municipalities and cities. In turn, municipalities and cities are part of district, which are regional centers of state authority, but have no assemblies of their own; they present purely administrative divisions. Belgrade, being one of the largest cities in Southeast Europe, is a district of its own.

Population Dynamic Serbian Cities

		Population		Compounded annual growth
		census 1991	calculation 2012	
1	**Belgrade**	**1,602,226**	**1,783,027**	**0.51%**
2	Novi Sad	177,005	202,389	1.69%
3	Nis	173,250	171,385	-0.14%
4	Kragujevac	144,608	145,203	0.05%
5	Subotica	98,873	99,395	0.07%
6	Zrenjanin	80,174	78,433	-0.27%
7	Cacak	69,625	75,323	0.99%
8	Leskovac	61,487	63,687	0.44%
9	Valjevo	58,172	63,434	1.09%
10	Smederevo	61,990	62,469	0.10%

Source: World Gazetteer, Belgrade Statistical Yearbook 2010, and authors' calculations

As can be seen in the table above, growth in Serbian cities has been sluggish, even in the capital Belgrade. Moreover, several cities have actually lost population. From an energy efficiency point of view, and from a purely efficiency point of view, this trend has presented urban areas in Serbia with a particular challenge: how to maintain and operate an infrastructure that was often designed with a growing population in mind.

[1] http://en.wikipedia.org/wiki/Economy_of_Serbia
[2] http://www.cia.gov/library/publications/the-world-factbook/geos/ri.html

National Energy Efficiency Strategy

As the Serbian economy started to recover in the new millennium, and as production and consumption increased, so did energy consumption – from 4,933 kWh per capita in 2000, to 5,567 in 2008. The country has historically been characterized by energy shortages against growing electricity demand. Oil, gas and high quality coal are imported (around 40%), while electricity is mainly produced from local resources (mainly coal and hydro). In 2008, the country's energy consumption was 15.58 million tons of oil equivalent (toe), or 2.12 toe per person.[3] Households, agriculture and public and commercial activities consume 40% of total energy; industry and transport about 30% each. Heating is sourced from natural gas (45% in 2010), liquid fuels (36%) and solid fuels (19%), with industry accounting for 41% of consumption, and households and other sectors for 59%. District heating exists in 55 cities, consisting of decentralized heat sources with an installed power of about 6,600 MW, and appropriate distribution networks, for heating supply to the residential, public and commercial sector. In terms of electricity generation, Serbia has an installed power of 7,124 MW. The state-owned enterprise, Electric Power Industry of Serbia (EPS) generates most of its energy from lignite-powered thermal power plants at Obrenovac and Kostolac, which together constitute installed power of 3,936 MW, but has a detrimental effect on air, water and soil because of the low quality lignite that is used.

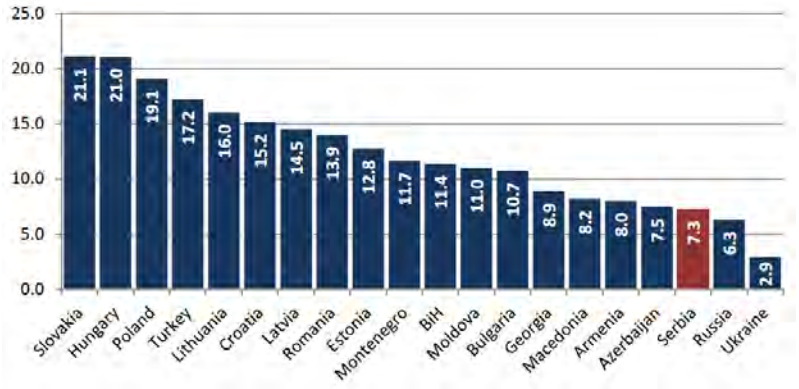
Since 2002, total energy intensity in Serbia has decreased, because growth in the economy has exceeded growth in total energy consumption. In 2008, Serbia's total primary energy intensity was 0.33 ktoe/US$ in 2008. However, the Western Balkan region is characterized by relatively high energy intensities: levels range up to 2.5 times higher than the average for OECD Europe (which is 0.15 ktoe/US$).[4] There are three main factors for this occurrence: the degraded state of energy infrastructure; high energy losses in transformation, transmission and distribution; and inefficiency in the end-use sector.

[3] http://www.eea.europa.eu/soer/countries/rs/soertopic_view?topic=country%20introduction

[4] http://eneken.ieej.or.jp/data/3925.pdf

Pricing is another key issue, which affects the profitability of energy providers, and works as a barrier to energy efficiency measures. As can be seen in the graph below, Serbia has some of the lowest electricity tariffs in Europe, and it hasn't done much to increase them in recent years. The electricity sector is in the public sphere, and tariffs are set by the central government.

Electricity Residential Prices (US Cents/kWh), in 2010



Source: ERRA

Overall, electricity is seen as a social good, so tariffs are kept artificially low, even if countries of similar development level have much higher tariffs in place. Low tariffs are good for keeping more money in people's pockets, but they also create a host of environmental and economic distortions. For example, it is hard to set-up combined heat and power (CHP) generation plants in Serbia (i.e. retrofitting district heating plants to generate both heat and power), because the production costs of electricity from CHP plants are higher that the tariffs that are now being charged. If electricity tariffs would grow by 60%, CHP plants would be a viable option. Another side-effect of low energy prices are energy squandering and higher emissions.

Even though a host of critical incentive measures are missing to push an energy efficiency agenda, the Serbian authorities have started to take first steps in this direction. The Energy Efficiency Agency of the Republic of Serbia was established in 2002, with the mission to improve awareness on energy efficiency issues and the rational use of energy.

The Energy Efficiency Agency aims to align the legislation of the Republic of Serbia with EU directives in the field of energy efficiency (e.g. legal obligations for the certification of buildings), and to increase the use of renewable energy sources.

The most important documents that regulate energy issues in the country are: the Energy Law (2004); Law on Environmental Protection (2004); Amendments to Annex B of the Kyoto Protocol (2207); and Different by-laws on renewable electricity. The Serbian Energy Policy, set in the Energy Law, is being implemented with the help of three basic instruments: the Energy Sector Development Strategy, the Implementation Program for the Energy Sector Development Strategy, and the Energy Balance and Energy Efficiency Action Plan.

The Energy Sector Development Strategy of the Republic of Serbia by 2015 describes priority programs for energy efficiency, using new renewable energy sources, environmental protection, scientific and technological development and energy statistics. The central government is now working on preparing a new Energy Development Strategy through 2025. Energy efficiency is also acknowledged as a priority in the National Sustainable Development Strategy, and the National Economic Development Strategy from 2006 to 2012. Some other relevant strategic documents include: National Strategy for the inclusion of Serbia in the Clean Development Mechanism under the Kyoto Protocol; First Report of the Republic of Serbia according to UN Framework Convention and Climate Change; Program for the Implementation of Energy Sector Development Strategy of Republic of Serbia by 2015 for the period 2007-12; First Action Plan for Energy Efficiency of Republic of Serbia for the period 2010-2012.

The country's Energy Balances are only partially aligned with the EuroStat methodology, primarily because of it is not possible to collect data with the required level of complexity and accuracy. However, central authorities are in the process of developing a data collection framework that will allow the collection and monitoring of energy data according to European standards.

The Ministry of Mining and Energy is working on putting together the Law on Rational Use of Energy. The main purpose of the law is to encourage responsible and sustainable energy use, improving energy security, increasing employment and competitiveness, and improving environmental conditions. It is envisioned that these objectives could be achieved through the establishment of a market for energy efficiency services, by changing the energy consumption patterns of end-users, and by investing in energy efficiency projects.

On another front, the Ministry of Environment and Spatial Planning sets out the legal framework for the introduction of energy efficiency criteria and energy efficiency certificates for new and reconstructed buildings. Significant attention is being paid to the promotion of combined heat and power (CHP) plants. Given that the country has an extensive network of district heating plants, CHP is a very good alternative for producing and distributing energy in a more efficient way. Consequently, energy operators that simultaneously produce electricity and heat while meeting energy efficiency criteria, are considered privileged electricity producers. The criteria required to obtain privileged electricity producer status have been set in a national decree.

All in all, most of the energy efficiency measures taken at the national level are directly or indirectly targeted at cities. Urban areas consume most of the energy in the country, with the buildings sector representing around 45% of the final energy demand. Given that most of the infrastructure in those cities was built before 1990, and given that this infrastructure was not always properly maintained, there is great scope for energy efficiency measures in Serbian cities. Belgrade is no exception

Urban Growth and Energy Challenges in Belgrade

Belgrade is the capital and the largest city of Serbia. The city is also the capital of Serbian culture, education, science and economy. The city is located at the confluence of the Sava and Danube rivers, where the Pannonian Plain meets the Balkans. It is one of the oldest cities in Europe and has since ancient times been an important focal point for traffic, an intersection of roads connecting Eastern and Western Europe.

According to the 2011 Census, Belgrade has a population of around 1.78 million. The population density within the city proper is 3,207 per square kilometer and for the entire metropolitan area it is 508.6 per square kilometer. Belgrade is a separate territorial unit in Serbia, with its own autonomous city authority. The city is divided into 17 municipalities and most of the municipalities are situated on the southern side of the Danube and Sava rivers in the Sumadija region (see image below). 7 of the 17 municipalities (situated in the south of the city) used to be

classified as suburban municipalities in the past. With recent administrative reforms, these 7 municipalities have now the same status as the 10 municipalities that make-up the city proper.

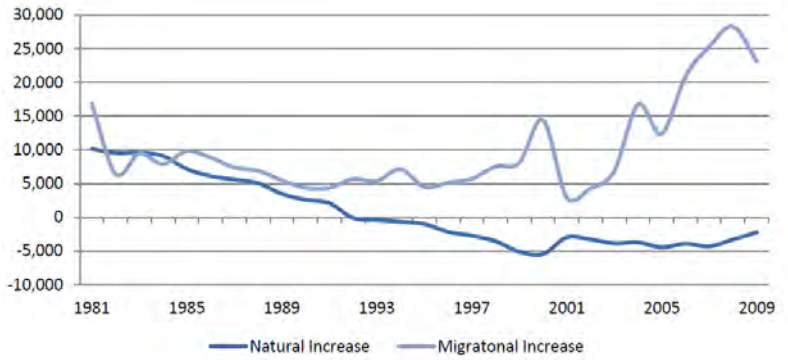
Belgrade City and its 17 Municipal Boundaries

Source: http://en.wikipedia.org/wiki/File:Belgrade_municipalities02.png

Belgrade is larger, by an order of magnitude than the other cities in the country. As such, it has a strong polarizing effect, attracting people, firms, and capital. About 22.5% of the country's population lives in the city, and around 40% to 45% of all energy consumed in Serbia is consumed in Belgrade.

Belgrade is the most economically developed part of Serbia and its largest industrial centre. The city generates more than 30% of the country's GDP and accounts for 31% of national employment.[5] As such, it has a great magnetic pull, attracting people from all over Serbia, and from outside the country. As can be seen in the graph below, population growth in the city in the transition years has mainly been fueled by in-migration. The largest migration wave was witnesses relatively recently, after 2005, as the economy of the city started to pick up.

Drivers of Population Change in Belgrade



Source: Belgrade Statistical Yearbook 2010

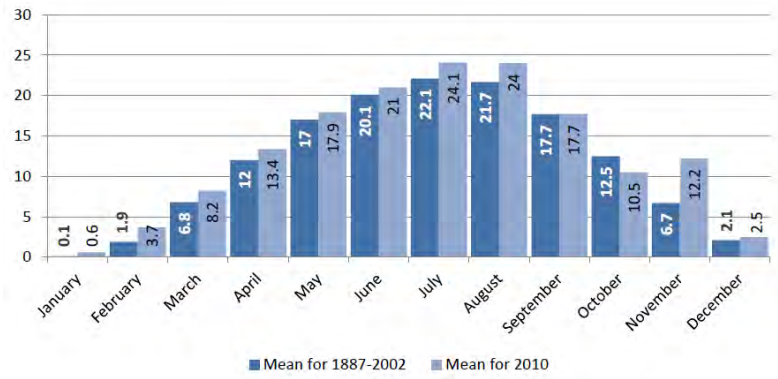
As far as the city climate is concerned, Belgrade exhibits influences of oceanic, humid continental and humid subtropical zones with four seasons and uniformly spread precipitation. Monthly averages range from 0.4°C in January to 21.8°C in July, with an annual mean of 12.2°C. Winters can get quite cold (see figure below), and summers are usually hot. The lowest temperature recorded in the city was around -24°C.

While Belgrade does not really belong to one of the coldest areas in Europe, winters can be really harsh and energy demands are quite high. The district heating network in the city is on 6 month every year, from mid-October to mid-April, from 6:00 AM to 22:00 PM. It is the largest

[5] http://www.siemens.com/press/pool/de/events/corporate/2009-12-Cop15/European_Green_City_Index.pdf

single energy user in the city, and responsible for 25% of Serbia's natural gas consumption.

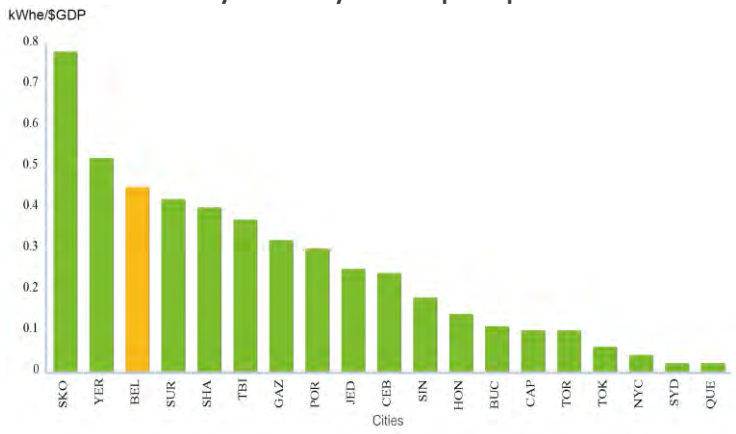
Mean Air Temperatures (°C) in Belgrade, between 1887-2002



Source: Belgrade Statistical Yearbook, 2010

As the figure below indicates, Belgrade has one of the most energy intensive economies of any city with relevant data in the TRACE database. This means there is great scope for improving energy efficiency in the city.

Primary Electricity Consumption per GDP



Its energy efficiency performance is not only tied to energy use, but also to legacies of the communist past and to the way the city is currently expanding. Despite the many appealing qualities of Belgrade's built environment, the city faces a number of severe planning challenges. Some of these challenges are typical, in various degrees, of cities throughout East-Central Europe. These include brownfield redevelopment, pollution caused by the large industrial facilities constructed before 1989, stark socio-spatial stratification, and deteriorating housing stock in some of the communist-era housing districts.

Centrally Planned Buildings in Novi Beograd

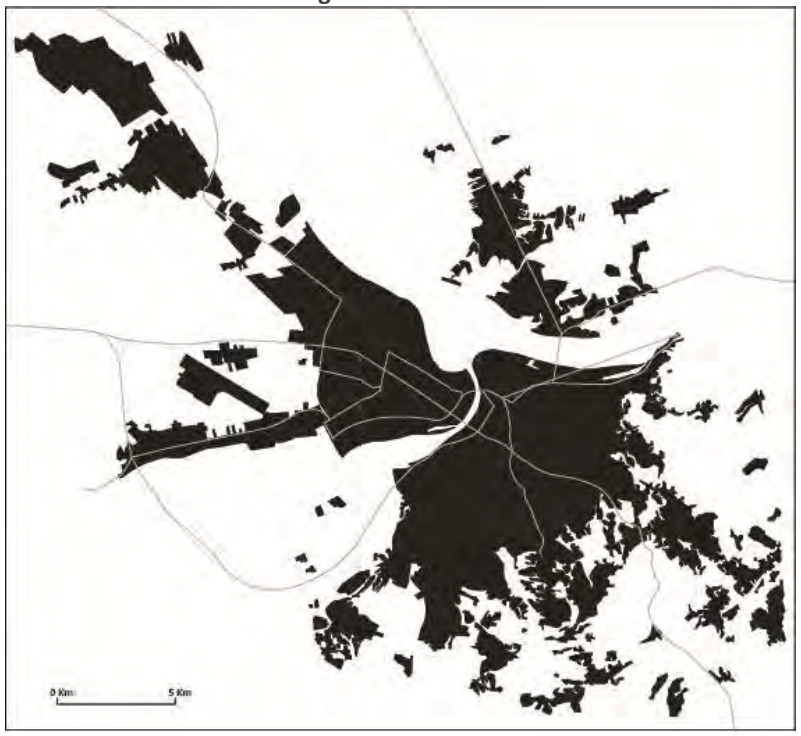
Belgrade's location at the junction of two pan-European transport corridors makes it a regional node of primary significance (these corridors are Corridor VII from Romania to Germany, and Corridor X from Greece to Austria and Germany). At the same time, Corridor X runs right through the middle of the city, bringing in heavy traffic and contributing to the city's already mounting congestion problems.

The growing numbers of private vehicles, city expansion, and the aging infrastructure have prompted local authorities to come up with proper planning solutions to respond to these challenges. Over the last few years, the city has adopted three planning documents: the Master

Plan (2003), the Regional Physical Plan (2004), and the Development Strategy (2008). These documents set a number of goals and strategies around the themes of improving environmental sustainability, economic competitiveness, social cohesion and territorial polycentrism, and strengthening cultural identity.

Whether these goals will be achieved will largely depend on how Belgrade's policy-makers will position the city in the context of European integration. It will also depend on how quickly the unfortunate legacy of the 1990s can be overcome, and on whether planning will be used as a vital tool for fighting problems such as sprawl, loss of public space, and traffic congestion, rather than being a tool used to control markets.

Belgrade Urban Mass



One critical issue facing Belgrade's municipal authorities is resolving the status or urban land. Unlike most other post-communist countries in East-Central Europe, Serbia has yet to fully denationalize developable urban land. Until recently vast chunks of vacant land zoned for construction were under public ownership and could be leased for up to 99 years under conditions prescribed by the city authorities.

As can be seen in the map above, urban sprawl is not as dramatic of an issue as it is in other cities in the region. With the City tightly controlling land markets, urban out-growth is more easily controlled by local authorities. At the same time, centralized land management can create distortions and mis-allocation of land-uses, which in the long run can undermine the city's economy and its competitiveness in the region.

Belgrade Municipalities Statistics, for 2010

	Density (people per km^2)	New Buildings Constructed in 2010	Area of New Buildings (m^2)	Budget Revenues (US78$)
Vračar	20,825.72	536	38,619	23,947,385
Stari grad	10,752.79	245	16,966	21,870,869
Novi Beograd	5,562.00	576	46,347	18,732,935
Zvezdara	4,367.04	1,088	59,765	3,263,548
Rakovica	3,347.79	271	11,608	1,184,108
Savski venac	3,173.51	137	16,135	451,528,022
Zemun	1,328.04	261	10,772	3,410,660
Čukarica	1,121.59	340	19,785	4,224,671
Voždovac	1,065.82	743	40,459	10,856,710
Palilula	359.82	413	18,284	48,650,583
Grocka	271.77	196	15,815	1,344,419
Obrenovac	179.84	337	21,736	2,657,201
Mladenovac	161.25	225	14,987	1,370,267
Lazarevac	158.89	132	9,069	1,885,976
Barajevo	120.42	18	2,633	538,529
Sopot	78.46	50	6,033	633,384
Surčin	0.00	116	9,646	489,493

Source: Belgrade Statistical Yearbook 2010

Also, while Belgrade has managed to evade endemic urban sprawl, it still has suburban outgrowth, particularly in the form of informal settlements. As the table above evidences, most new developments

went up in peripheral and suburban neighborhoods and they often look like the developments in the image below.

Suburban Developments in Belgrade

In fact, although the city proper has managed to control urban sprawl, the 7 suburban municipalities that are now part of the City of Belgrade have very low density (for example, 78 people per square kilometer in the Sopot Municipality, as opposed to 20,825 people per square kilometers in Vracar Municipality, in the heat of Belgrade). Connecting all of these peripheral communities to city life and to adequate infrastructure is one of the greatest tasks the city will face in the future. At the same time, this is a great opportunity to integrate energy efficiency principles in the way planning for the metro area as a whole is done.

Sustainable Belgrade

The following analysis and recommendations are primarily about how Belgrade 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 (Tool for Rapid Assessment of City Energy) 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.

There are six municipal service areas that are the focus of this tool: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste. For each of these 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 Belgrade 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 Belgrade on a particular indicator become a benchmark that Belgrade 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 Belgrade 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.

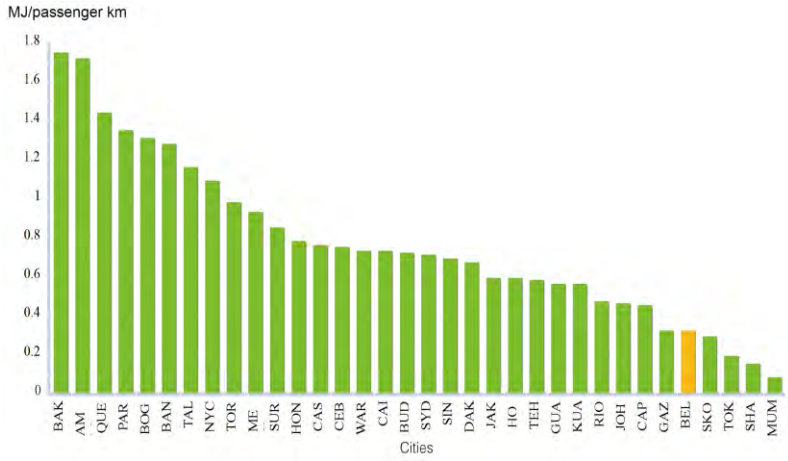
Preliminary on-site interviews and field visits have helped give a more rounded picture of sustainability challenges and opportunities in Belgrade. The following sections include a quick analysis of each of the six sectors analyzed with TRACE, along with some key findings.

Public Transport

In many cities you have to spend some time before seeing a public transportation vehicle. In Belgrade you see them every couple of seconds. They are ubiquitous, and they are usually filled with passengers. This rough assessment alone leads one to believe that the public transportation system is in good shape. And it is indeed in good shape. If one looks at the energy consumption per passenger kilometer, it

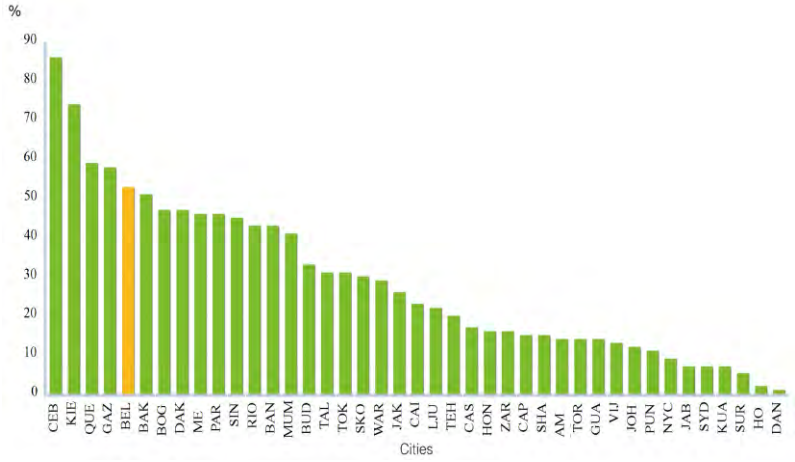
becomes immediately evident that Belgrade has one of the most efficient public transportation networks of any city with relevant data in the TRACE database. This in fact means that the existent public transportation means are usually full with people, which means that less energy has to be spent on moving one passenger.

Public Transport Energy Consumption



The efficiency of the Belgrade public transportation system also has to do with the ubiquity of buses, trolleys, and trams. In fact, this is a classic case of the "if-you-built-it-they-will-come" principle. The availability of public transportation vehicles makes it easier for people to forgo driving private cars for daily commutes. In Belgrade one has the sense that buses and trams are the vehicles fighting for road space, not private cars. The extensive public transportation system offers people an easy way to get around, and over 53% of daily commutes in Belgrade are done this way – one of the highest public transport modal split figures of any city in the TRACE database (see figure below).

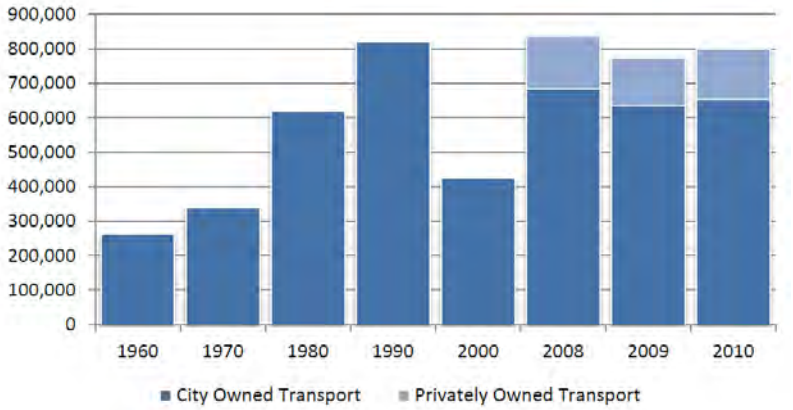
Public Transportation Mode Split



Local authorities indicate however that these achievements were won the hard way. Following the fall of the communist regime and following regional strife in the 1990s, ridership in the public transportation network in Belgrade fell by 50% in just one decade – from over 800 million passengers in 1990, to just over 400 million in 2000. This fall in ridership was followed by a decrease in revenues, a continuous depreciation of the rolling stock, and a general energy efficiency shortfall. In fact, the public transportation system in Belgrade had the same fate of a large majority of public transportation systems in Eastern Europe, during the first transition years.

In the new millennium, the situation in Belgrade gradually improved, with continued investments in public transport networks boosting ridership. Thus, by 2008, the number of passangers carried by public transportation means was slightly higher than in 1990 (see figure below). The only difference is that in 2008, a significant number of passengers (around 18% of the total) were transported by private buses.

Passengers Carried by Public Transportation in Belgrade (in '000s)



Source: Belgrade Statistical Yearbook, 2010

Around 657 private buses run in Belgrade now, along determined routes within the city, as well as along a number of suburban routes – connecting key area in the city with peri-urban and suburban communities. The public fleet numbers 1,872 buses, 204 trams, 135 trolleys, and 7 suburban trains.

Belgrade Public Transport, in 2010

	Lines		Vehicles		Passangers
	Number	*Length*	*Number*	*Seat Capacity*	*(thousands)*
Trams	10	110	204	37,251	97,395
Trolleybuses	8	58	135	16,050	52,340
Buses					
Public	537	12,254	1,872	222,256	502,807
Private	73	1,057	657	70,740	147,389
Suburban Rail	4	318	7		3,016
TOTAL	**632**	**13,797**	**2,875**	**346,297**	**802,947**

Source: Belgrade Statistical Yearbook, 2010

All in all, buses are the main way of getting around in the city, with 81% of public transport riders relying on them. As the image below highlights, buses in Belgrade come in all shapes, colors and sizes. Some of these buses are new, some are older, some are well past their prime. In terms of energy efficiency, the critical task for bus operators is thus to renew the existent fleet and to start relying on more efficient fuels, such as natural gas. Natural gas is not only more efficient and better for the environment, but it is also cheaper - $1 per liter as opposed to $1.6 for Diesel.

Buses in Belgrade

The average age of the publicly owned buses is around 10 years, while the average age of privately owned buses is 5 years. Private operators that want to be part of the urban public transport system have to abide by certain standards (e.g. cars of a certain age, and engines that are

relatively efficient). Overall, the bus fleet is in rather good shape, but there is of course room for improvement. Local authorities work on continually renewing the fleet, and they also think about converting some buses to natural gas. Right now they have a pilot program with around 20 buses (10 public, 10 private) running on natural gas. Depending on their performance, the program might be scaled up to include a large share of the bus fleet.

Trams carry around 12% of all passengers in Belgrade. The large majority of trams operating in the network are quite old, but recently the City has started acquiring a number of new trams from Spain. One new tram costs the City around $3 million, and a total of 37 such trams has been made.

Old and New Trams in Belgrade

The new trams are not only more comfortable and consume less energy, but they also have systems for energy recuperation – e.g. when they break, the generated energy is sent up the line to benefit the next oncoming tram. Investments in new vehicle stock have been doubled by investments in the improvement of existent infrastructure. Thus, 35 km of the existent 110 km of tram tracks are being rehabbed with a loan from EBRD. In addition the public transport company has regular driver training programs, which include courses on energy efficient driving.

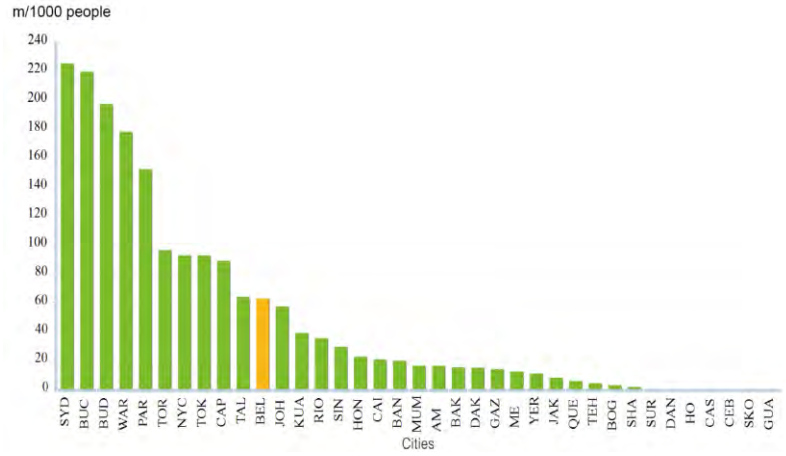
Belgrade does not have a metro system, but a suburban train is running a few routes between the center city and a number of peri-urban communities. While the suburban train is operated by the National Railway Company, it is fully integrated with the city's public transportation network, and people can use the same tickets they use for buses, trams, and trolleys.

Suburban Train

The suburban train is viewed by most in the city as a transition solution until the city will have a fully-fledged metro system. Given the high number of buses on the city's streets, and the congestion they often create, local authorities want to increasingly move towards high-capacity transit options. The city's new metro system, now in the planning stages, will be the center piece of this high capacity network. Right now, the city's tram network places it in the middle field of cities with high-capacity transit option in the TRACE database (see figure below).

Belgrade has 62.6 km of high capacity transit per 1,000 people – as opposed to 219.3 km in Bucharest, 197 km in Budapest, and 178 km in Warsaw. Bucharest, for example, is the same size as Belgrade, but has 286 km of tram lines, and 140 km of metro lines.

Meters of High Capacity Transit per 1,000 People



These investments in the expansion of the city's public transport infrastructure will be covered from international loans, and will be guaranteed by the city. The public transport company, while efficient, is to a large extent dependent on subsidies. A ride on a public transportation ticket costs around $0.73, and this is not enough to cover operating costs. In 2011, GSP, Belgrade's Public Transport Company, received $5.5 million in subsidies every month (or $66 million yearly). In 2012, these monthly City subsidies are expected to go up to $6.6 million (or around $79 million per year).

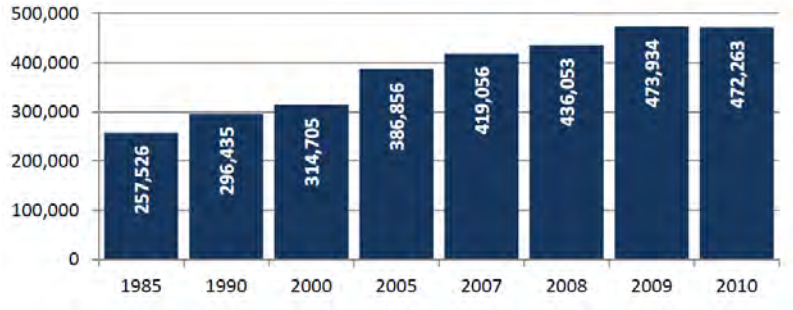
Obviously, there are few public transportation systems in the world that do not require subsidies, and these subsidies make sense not just from a social and an environmental point of view, but also from an economic point of view. Affordable transportation not only reduces pollution in a city but also allows more people access to opportunity.

However, the system could be made more efficient and the reliance on subsidies could be reduced by investing in energy efficiency. To do so, a system of incentives needs to be put in place to encourage GSP to become more energy efficient. As of now, if GSP improves its transport fleet and reduces fuel usage, it will simply lose some of the subsidies it is currently receiving. If however it would get to keep the saved money for continued investments in system improvements, it would be more inclined to do so. GSP's energy costs alone (fuel for buses and electricity for trams and trolleys) are around $50 million yearly.

Private Vehicles

As in other Eastern European cities, traffic in Belgrade is an important problem. Of course, the rise in private car ownership is one of the main culprits responsible for the city's increasingly congested streets. From 1990 to 2010, the number of passenger cars grew by 60%, increasing the load on old city streets designed for lighter traffic. Given people's preference for owning their own car, and given the status symbol that people often attach to cars, it is likely that car ownership in Belgrade will continue to grow in coming years.

Passenger Car Ownership in Belgrade



Source: Belgrade Statistical Yearbook, 2010

However, car ownership is not the only reason why traffic conditions in Belgrade are tough. The city was originally developed as a strategic outpost at the confluence of the Sava and the Danube regions. With the growth and expansion of the city, new communities have started to form on the opposite banks of these rivers. Most notably, Novi Beograd and the older Zemun community became part of the city proper on the left bank of the Sava, with a population of around 400,000. Across the

Danube lies part of the Palilula municipality, with a population of over 150,000.

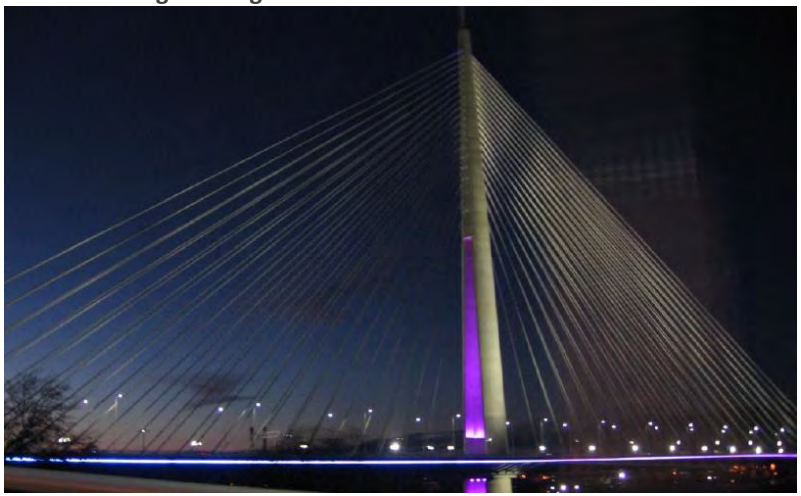
Connecting these communities requires bridges, and bridges are natural bottlenecks for traffic. This became painfully obvious to local authorities, when the city's main bridge – Gazella (second from the bottom in the figure below), started to be crossed by 160,000 vehicles daily, although it was designed for 40,000. The Gazella bridge is used not only for city traffic, but is also part of Serbia's highway system connecting Highway E-75 with Highway E-70, which cut right through the middle of the city and connect to Novi Sad and Western Europe in the North, and to Nis, Macedonia, and Greece in the South.

Main Bridges in Belgrade

To alleviate traffic conditions, the Gazella bridge was completely re-done in 2011, to allow traffic of up to 200,000 vehicles per day. Naturally, traffic conditions worsened significantly while this work was underway. In addition to an upgraded bridge, local and national authorities have started work on a 69 km by-pass for the City of Belgrade, which will re-direct transit traffic around the city. The by-pass is one of the most ambitious projects in the country – estimated to cost around $700 million, and funded with a loan from EBRD and EIB. The by-pass is slated to be opened for traffic in 2012.

Another ambitious project was the development of a new bridge over the Sava river – the Ada Bridge (first from the bottom in the figure above, and depicted in the image below). The bridge was commissioned by the City of Belgrade and the Belgrade Land Development Public Agency, benefiting from an EBRD loan. Work on the bridge was started in 2008 and was completed on January 1st, 2012. It is now the longest single-pylon cable stayed bridges in the world, and has quickly become one of Belgrade's main landmarks.

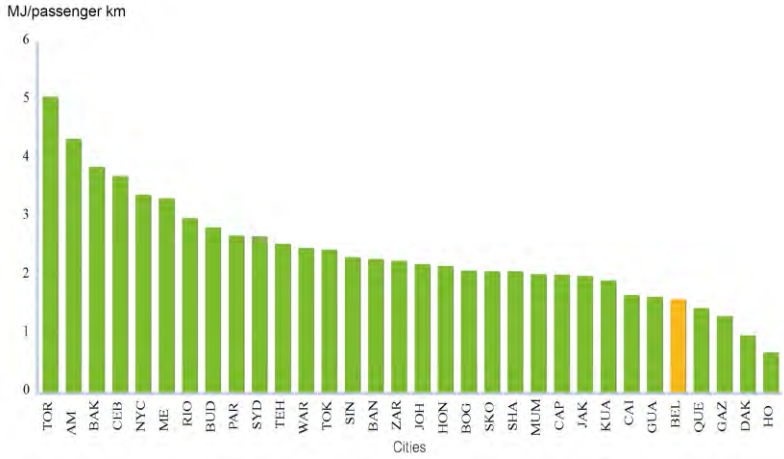
New Ada Bridge in Belgrade



With future planned development across the Danube, local authorities want to develop another major bridge, which will connect these new communities to Zemun and Novi Beograd.

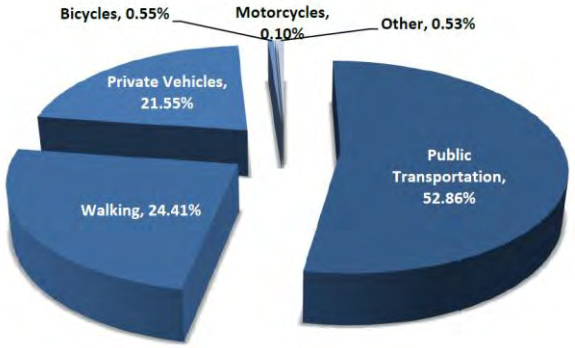
Obviously, making it easier for cars to travel through and around the city, can also translate in more cars on the street. Right now, Belgrade is doing quite well in terms of energy spent by private vehicles per passenger kilometers, and it is important to keep it that way. As can be seen in the figure below, it has one of the lowest private transport energy consumption per passenger kilometer in the TRACE database, and the lowest figure of any city with available data in Eastern Europe.

Private Transport Energy Consumption



Moreover, people in Belgrade do not only drive their cars in a fuel efficient way, but they also rely little on private transportation for getting around. As the figure below highlights, the large majority rely on public transportation and walking for their daily commutes, and only 22% use cars. For a city the size of Belgrade, this is very good news. It is important therefore to identify ways in which these positive trends can be maintained, and maybe even improved

Modal Split in Belgrade



Source: City of Belgrade, Secretariat for Traffic

For example, few people in Belgrade use bicycles for commuting. Although the City has invested in the development of dedicated bicycle lanes along the Sava River and in Novi Beograd (which is relatively flatter than the old city), the large majority of people use these lanes mainly for recreational purposes, not for commuting.

Dedicated Bicycle Lane in Belgrade

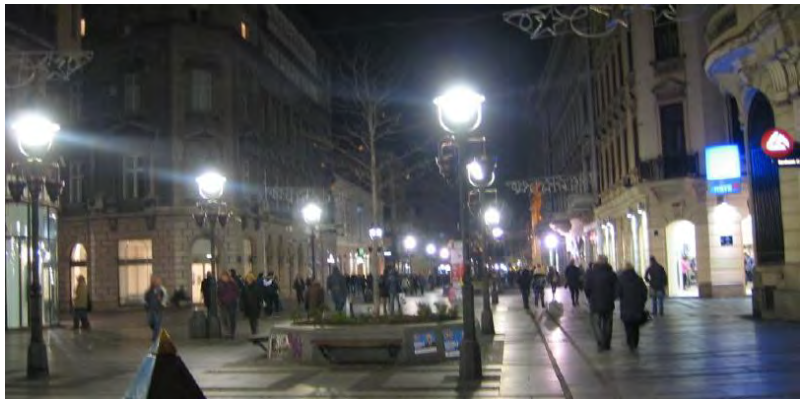
It is often claimed that there is no culture for bicycle commuting in Eastern Europe and that mentalities will be hard to change. However, examples from different cities in the region (e.g. Warsaw, Budapest, Bucharest) indicate that given proper investments in infrastructure, people will use bicycles to get around the city. For Belgrade, this means that bicycle infrastructure should also be designed for commuting, not just for recreation. As of now, cycling is mainly limited to the banks of the Sava and several neighborhoods in Novi Beograd.

Local authorities indicate that the differences in altitude in the old city center would make bicycle commuting impractical. However, cities with a more difficult topography, such as Zagreb, have been very pro-active in developing a bicycle network. An extensive network could also be developed in Belgrade, considering that the biggest altitude differences are between the old city and the low-lying neighborhoods of Novi Beograd and Zemun. The challenge is to make the connection

between these two areas. Right now, bicyclists can only use Branko's Bridge to easily cross from one side to the other. The other three bridges over the Sava do not have adequate bicycle lanes and make it hard for pedestrians and bicyclists to share the same space. If connections between these two city areas would be better, and if the old city would have a more extensive bicycle infrastructure, it is likely that more people would take to cycling as a mode of getting around.

And, while bicycling is not that popular among people in Belgrade, walking is – it is the second most popular way of getting around in the city. For an urban area with 1.7 million people, this is a very good thing. Belgrade has the advantage of being well planned, with relatively small blocks, plenty of sidewalks and space for pedestrians. In addition, it is a good city to experience by foot, with well defined urban spaces, good architecture, and plenty of destinations and places to explore.

Kneza Mihaila Pedestrian Street

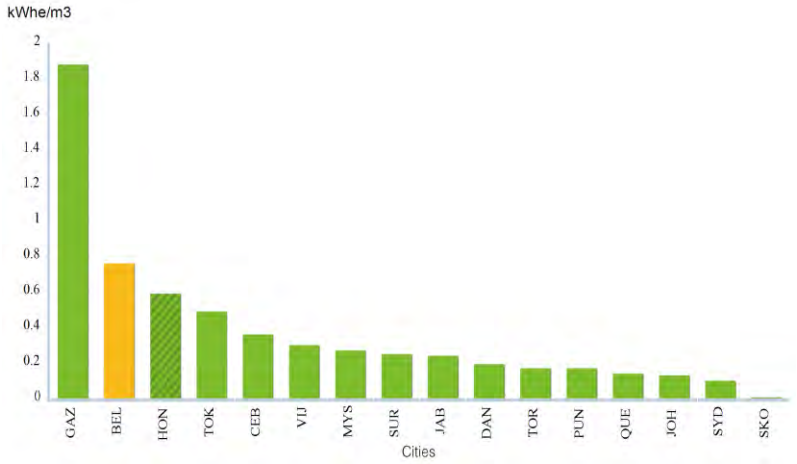


What Belgrade lacks however is more dedicated pedestrian streets. Kneza Mihaila (see image above) is the city's busiest and most popular pedestrian walkway – with plenty of shops, bars, and restaurants, and with a busy nightlife. Skadarlija is another good example in this sense. However, many more streets in the city, both in the old historic center and outside it, could be turned into pedestrian streets – with benefits not only for the environment and for the people, but also for the economy (streets with more pedestrian traffic are streets that make it easier for local businesses to flourish). Local authorities do intend to turn more streets into pedestrian walkways (particularly around the Kneza Mihaila area), but they want to first find adequate solutions to diverting traffic on those streets.

Water and Waste Water

The water system in Belgrade is very energy intensive – the second most energy intensive among cities with relevant data in the TRACE database (see figure below). Much of the energy intensity can be attributed to the topography of the city and the original design of the waterworks network.

Energy Density of Potable Water Production



In 2010, the Water Utility in Belgrade captured 224 million cubic meters of water. Most of the water (61%) was drawn from pump-reliant, and energy intensive underground wells. The rest of the water was drawn from rivers, requiring again a lot of energy for pumping and treatment. The waterworks network was 4,746 km long, with 490 km represented by main waterworks, and 4,256 km represented by the distribution network. Much of the system losses (31.5%) can be attributed to old and leaky piping.

The Belgrade Water and Wastewater Utility Company have identified two main ways in which it could reduce the energy intensity of

its water system. For one, old piping needs to be replaced, to reduce the incidence of lost water. Most of the water gets lost in the distribution network, and getting the water to end consumers requires a lot of pumping and treatment.

The water gets drawn wells and rivers that are at 75 m above sea level, and gets pumped to altitudes of over 300 m. The city is basically divided in three different zones. Zone 1 ranges in altitude between 75 m and 125 m, and amasses around 60% of the city. Zone 2 (125-175 m) covers around 30% of the city, while Zone 3 (over 175 m) covers the remaining 10%. Water is pumped to water towers spread in this three zones, and then distributed by gravity to end-consumers. Thus, much of the water that gets lost in the network is quite costly – requiring energy expenditure both for treatment (particularly the water drawn from the river) and for pumping to grade.

Moreover, since the city does not have an extensive system of water reservoirs distributed in strategic locations, water pumping goes on continuously. Thus the utility company cannot take advantage of lower electricity prices at night (electricity tariffs are 4 times cheaper at night, from midnight to 8:00 AM, than during the day). For example, many water companies pump water at night when demand is low and electricity prices are much cheaper, they store the water in reservoirs, and then distribute it to end-consumers during the day – thus saving not only on energy, but also managing to cover peak-time demand.

On the other hand, the Belgrade water network is monitored by a SCADA (supervisory control and data acquisition) system, which monitors performance in the network, controls valves and pressure in the system, and allows the adjusting of key system indicators in real time. The SCADA system enabled energy savings of around $500,000 in 2011. It is estimated that a new system of reservoirs could enable further yearly energy savings of around $650,000 to $900,000.

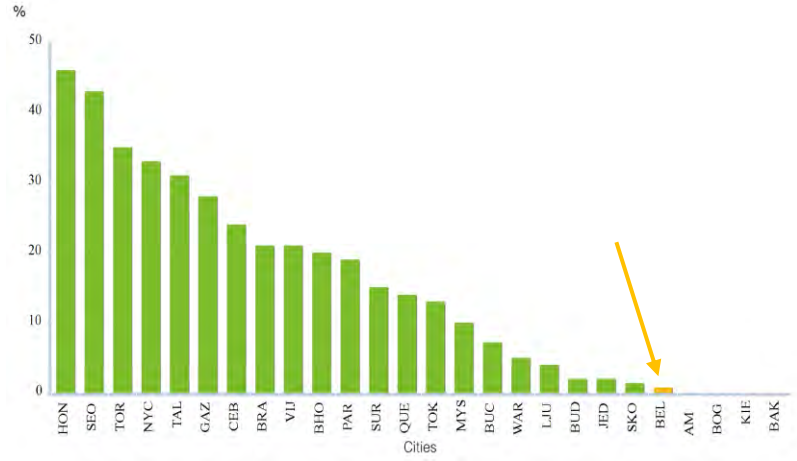
As far as the wastewater system is concerned, it is basically non-existent. The water and wastewater company collects wastewater from water end-consumers, but dumps it untreated in the local river network. Thus, whereas cities like Vienna aim to leave the Danube as clean as it has entered the city, Belgrade contributes to the pollution of Europe's biggest river. There are plans to invest in a city-wide wastewater treatment system, but such as system requires significant investments.

These investments could be covered both from international and national loans, as well as from the City budget and from higher tariffs. In 2011, households were charged $0.45 per m^3 of used water and $0.18 per m^3 of generated wastewater – more than 7 times lower than the norm in many cities in Western Europe (see for example Global Water Intelligence, Vol. 10 (9), September 2009). While the current tariffs allow the Belgrade Water and Wastewater Company to cover the operating costs of the current system, they will likely not allow cost recovery in a system that also does proper wastewater treatment.

Solid Waste

Belgrade has a solid waste management (SWM) that runs on profit and is well managed. It is not a system without its share of problems though. First and foremost, the system is still quite basic, with most of the generated waste being landfilled, and with a very low recycling rate (see image below).

Percentage of Solid Waste Recycled



In addition, the system is fragmented and it requires an integrated management and operations approach. The reason the system is fragmented can be explained by the City's administrative structure. Up to 2010, 7 of the City's 17 municipalities had suburban status. 6 of these (Barajevo, Grocka, Mladenovac, Lazarevac, Obrenovac, Sopot) had their

own individual SWM companies, while the city proper and the Surcin municipality were serviced by JKP Beograd (see table below).

Belgrade SWM System

	Streets being cleaned (1,000 m^2)	Households	Waste Collected (tons)
JKP Beograd	16,517	582,322	512,474
JKP Barajevo	19	14,159	7,440
JKP Grocka	25	14,900	20,400
JKP Mladenovac	274	10,000	20,000
JKP Lazarevac	299	10,360	26,600
JKP Obrenovac	410	21,000	30,100
JKP Sopot	70	2,827	3,700
TOTAL	**17,614**	**655,568**	**620,714**

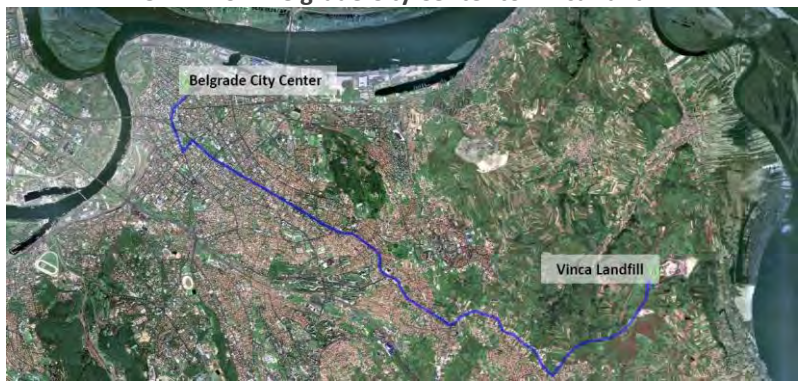
Source: Belgrade Statistical Yearbook 2010

Of the 7 SWM companies that serve the City of Belgrade, 5 dump the waste they collect at the Vinca landfill, which is operated by JKP Beograd. JKP Lazarevac and JKP Obrenovac dump collected waste at a regional landfill that is relatively closer than Vinca.

The Vinca Landfill is close to the city center of Belgrade (see image below), so waste transport can be organized efficiently in the city proper, without the need for transfer stations. On average, garbage trucks in the city proper travel 93 km between the transport unit at Zvezdara, the collection sites, and the final disposal site at Vinca. However, garbage trucks that collect waste in the more distant neighborhood of Zemun, travel on average 147 km per route.

The former suburban municipalities that do dump collected waste at Vinca are even further away, and waste transport can be energy intensive. Thus, Barajevo is 42 km away from the landfill; Mladenovac, 52 km; Sopot, 44 km; and, Grocka, 21 km. This means that just going back and forth between the landfill and the Mladenovac community, without factoring in the distance travelled to actually collect the waste, mean covering over 104 km.

15 Km from Belgrade City Center to Vinca Landfill



Consequently, it would make sense to organize transfer stations to ensure the more efficient collection, transport, and disposal of waste. And indeed, in the new SWM Plan that is being prepared for the city, local authorities plan to develop three transfer stations. These stations would not only improve SWM logistics, but they will also have waste separation facilities, to organize waste into recyclable material and organic waste.

Currently, less than 1% of generated waste in Belgrade is recycled – far away from the City's ambitious goal to reach 50% recycling by 2020. This happens despite a burgeoning market for recyclables, particularly for plastic, metal, and paper. If a functional recycling system would be put in place, the city could not only generate more revenues out of waste, but they could also substantially reduce costs. More recycling equals less waste that needs to be transported to landfills.

Local authorities have realized the critical importance of recycling, and the new SWM Plan envisions clear and gradual steps to be undertaken over the next 7 years, to ensure the establishment of a self-sustaining and efficient recycling system. With the new introduction of the Public Private Partnership (PPP) law, local authorities are also considering PPP arrangements that could increase recycling in the city.

To ensure waste reduction, local authorities want to create a proper incentive system – charging by weight. Charging by weight systems have been successfully implemented in countries like Ireland, where cities are primarily made up of single detached houses and town houses (which

allows for individual collection and weighing). However, such systems are harder to get going in cities like Belgrade, where a large majority of households lives in shared apartment buildings.

To overcome this obstacle, local authorities have started developing a system of underground waste containers (see image below), which will be placed in key high-density neighborhoods. In order for households to dump their waste in these underground containers, they would first have to open the latch using an electronic card system. The electronic card would immediately register who dumped the waste there, and would automatically weigh the waste being dumped.

Underground Waste Container in Belgrade

This pay by weight system would also be followed by an increase in waste tariffs, mitigated by incentives for people who do proper recycling (e.g. tariff discounts). Right now, each household is charged \$0.08/m^2/month for waste pick-up and disposal, or around \$3.6 for the average household. Commercial enterprises are charged \$0.13/m^2/month. These tariffs are sufficient to ensure the profitability of JKP Beograd, and they also generate surplus revenues for much needed investments in the SWM system.

Some of these investments include the renewal of the truck fleet, and investments in more energy efficient garbage truck operation. In 2010, the City was serviced by 358 garbage trucks and 154 vehicles for street cleaning, most of which operated in the City Proper – 303 garbage trucks and 141 street cleaning vehicles respectively. These trucks used around \$4.3 million worth of fuel.

To reduce fuel consumption, the City has already aggressively invested in the renewal of its fleet (see image below). Around 70% of the existing SWM fleet is relatively new and well performing from an energy point of view. Local authorities intend to continually renew the fleet as it is depreciating and as the service area is expanding, and in addition, they are considering switching to alternative types of fuel – e.g. using processed methane gas captured from the landfill.

New Garbage Trucks in Belgrade

Methane gas capture is considered an area with significant energy efficiency potential in the future. Right now, none of the methane gas generated at the Vinca landfill is usefully used. In fact, the landfill, while well managed, is quite basic. There is no system of cells, no leachate protection, and no methane gas capture. The landfill was originally designed to be in operation until 2016, but there are plans to extend its life until 2020.

Although the landfill is basic, it has a number of original design features that will allow it to become more efficient in the future. For one, the landfill was originally developed on a bed of clay, so little of the leachate actually seeps into the ground or groundwater. While there is

no real system of cells, communal waste is dumped separately from industrial waste, and different spots in the landfill have been assigned for inert waste that could be reused (e.g. PET Bottles, construction rubble, paper, metal, bulky waste, tires, etc.). PET bottles, glass, and metal are collected by 80 sub-contracted workers, and are sold for a profit. Construction rubble is recycled for laying road foundations, while used tires are recycled for the production of road asphalt.

Vinca Landfill

The hope is to scale-up such efforts, and to create a SWM system where only minimal quantities of waste will actually go to waste. These efforts will require rethinking of the entire SWM chain – from waste generation, through collection, separation, transport, disposal, and re-use.

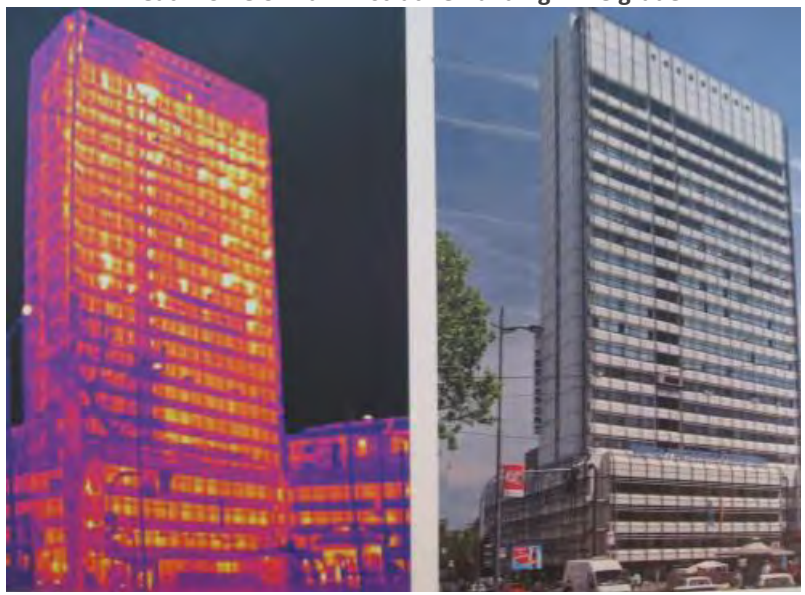
Municipal Buildings

Energy efficiency in buildings is one of the most important areas for action for the City of Belgrade, and one that is recognized as such by local authorities. The City owns and manages a very large stock of buildings, ranging from educational facilities (e.g. primary schools, secondary schools, kindergartens), to health centers, cultural buildings (e.g. libraries, theaters, museums, philharmonic), sports centers (e.g. football stadiums, hippodrome), and around 70 administrative buildings.

All of these buildings combined consume a lot of energy, and a lot of money has to be spent on that energy. As in most other cities with similar climatic conditions, heating amasses most of the yearly energy costs. Even if heating is usually done only 6 month per year (from mid-October to mid-April), the energy spent for heating is usually twice as high as the energy required to deliver electricity for 12 months.

Moreover, many of the municipal buildings in Belgrade, particularly those that were built in the communist times, and particularly those that went up in the 1970s, have a bad thermal envelope and are seen as being energy sieves. Most of these buildings have not benefited from any energy efficiency retrofits since they were built, and their thermal performance has steadily deteriorated over time. As the picture below highlights, one of the main administrative buildings in Belgrade basically functions as an open air radiator. All the bright red and yellow areas represent spots though which heat is lost. A well insulated building would be indiscernible from its surroundings in a thermal image.

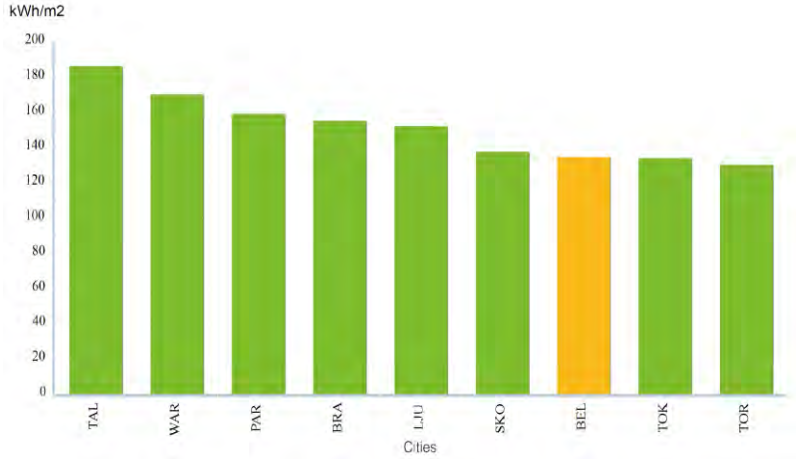
Heat Profile of Administrative Building in Belgrade



Consequently, municipal buildings is an area where significant energy efficiency improvements can be achieved in Belgrade. Even if the building stock that is managed by local authorities is relatively well performing when compared with other cities in the TRACE database (see figure below), local authorities have set ambitious goals. Thus, they want

to reduce yearly heating consumption from the current 144 kWh/m^2 to 67 kWh/ m^2 – a 47% decrease. And, of course, they hope to eventually move towards a completely passive energy building stock.

Municipal Buildings Heat Consumption



To address energy efficiency in buildings, a number of projects have been undertaken by local and national authorities, as well as by international organizations and other stakeholders. For example, the World Bank, in collaboration with the Serbian Energy Efficiency Agency has financed a $25 million project aimed at improving the energy performance of 28 public buildings (12 hospitals and 16 schools) throughout Serbia.

The project has met with immediate success, achieving energy savings from 15% to 63%, with an average savings value for the entire building stock of around 40%. The average payback period was 7.5 years, and average CO_2 reductions were around 41%. On the whole, hospitals had a much higher (almost double) energy savings potential, because unlike schools they are in use all-year round and 24/7. Consequently, they achieve a higher cost saving for every dollar invested in energy efficiency measures.

For example, the Maternity Hospital in Belgrade underwent significant energy efficiency improvements. Starting in 2006, the hospital received new windows and doors, if benefited from thermal insulation of external walls and roof, and it has also invested in the upgrade of the local heating plant (see images below). Total investments amounted to 640,000 Euro (or around 32 Euro per square meter), and annual heating consumption dropped from around 7,125,000 kWh (or 356 kWh/m^2) to 4,246,000 kWh (or 212 kWh/m^2) – a 40% drop. The payback period is estimated at 5.3 years, at current energy prices. This means that yearly around 120,000 Euro are saved from just one hospital.

Maternity Hospital in Belgrade – before and after EE improvements

Source: Republic of Serbia Energy Efficiency Agency. 2010. Serbia Energy Efficiency Project. IDA Credit PO75343

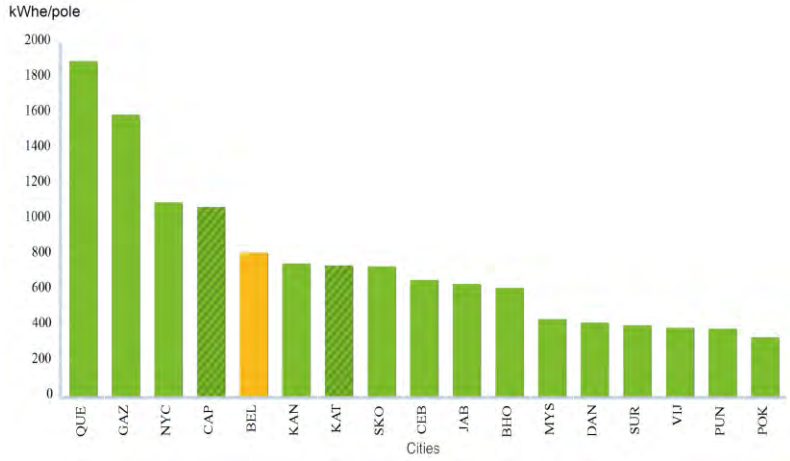
In addition to the existent energy efficiency programs, local authorities in Belgrade want to undertake an ambitious program to retrofit schools and kindergartens. This is hoped to be just the beginning of a larger project that will focus on the entire municipal building stock in Belgrade. Even though there is no specific energy efficiency strategy and action plan in Serbia, the City of Belgrade is committed to making a headway on the energy efficiency agenda.

Public Lighting

There is no incentive for the City of Belgrade to save energy from street lights. They do it anyway. Having been run and managed for a long time by the State Electricity Company, the street lighting system is since March 2011 under the tutelage of local authorities. Electricity bills are paid based on installed capacity not on actual usage, and electricity prices are quite low to begin with. Replacing light bulbs with more energy efficient ones and introducing energy saving systems (e.g. timers and dimmers) do not bring the City immediate pecuniary benefits. They have chosen however to go down this path because sustainability is a corner-stone of the City's development strategy.

The city is served by around 140,000 street lights, covering all 17 constituent municipalities. In 2009, the system was relatively inefficient with the amount of electricity consumed per light pole being higher than many cities with comparable data in the TRACE data base (see figure below).

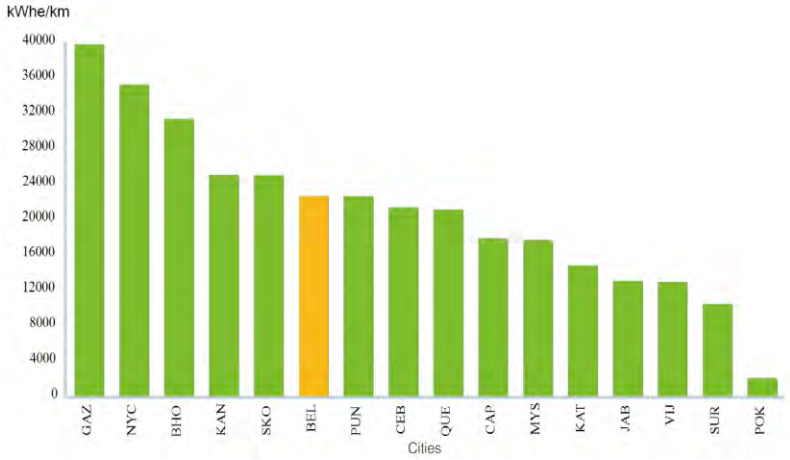
Electricity Consumed per Light Pole



Since then however, many investments have been made to upgrade the system. For example, around 70% of light-bulbs are relatively efficient high-pressure sodium vapor bulbs; 20% are metal halogen lamps; and only 10% are low-efficiency mercury bulbs. This is quite a good mix, considering that many more developed cities continue to rely on neon-lighting.

Spacing between individual light-poles is considered to be adequate, due to good initial planning. Nonetheless, the electricity consumed per kilometer of lit roads in 2009 was higher than in many other cities in the TRACE database (see figure below). Moreover, only around 47% of roads in Belgrade benefit from street lighting – one of the lowest figures in TRACE. This can for the most part be attributed to the city's significant gain in size with the addition of the 7 new municipalities.

Electricity Consumed per Km of Lit Roads



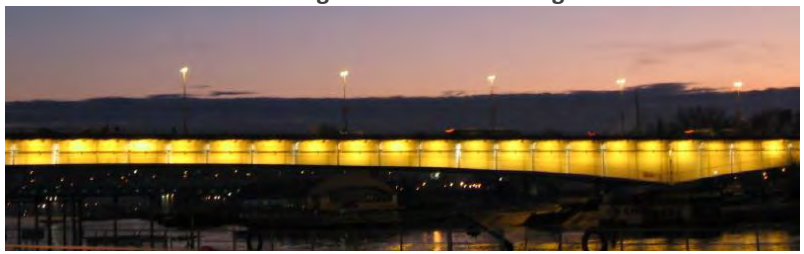
At the time of the writing of this report, these 7 new municipalities had their own directorates and budget for their street lighting system. Investments in the system were done however by the City Directorate. By the middle of 2012 plans were made to move the whole system under central control.

This move is hoped to allow a complete audit of the street lighting system in Belgrade, followed by an integrated investment plan. Solutions, for example, have to be found for efficiently bringing street lighting to low density areas in the city's new outskirts, as well as to the roads connecting these low density areas.

As one of the first measures, local authorities want to invest 5 million Euro in a proper metering system, which would let them know

how much electricity the system is actually consuming, and where there is room for improvement. Thus, a central monitoring system will allow them to track energy usage and adjust consumption based on outside conditions (e.g. more light when the city is overcast, less light when clear skies are out). Moreover, local authorities do not want to see themselves as utility providers. They want to identify ways in which the city's extensive infrastructure can strategically be used – for the benefit of the city and its citizens.

Street Lights on Branko's Bridge



While street lights are managed by the Secretariat for Housing and Communal Affairs, traffic lights and billboards are managed by the City's Roads Directorate. Yearly, the City spends around $1.45 million on electricity bills and maintenance of traffic lights. Since electricity bills represent a fixed fee, charged on installed capacity not actual usage, there are not a lot of incentives for the Roads Directorate to put efficient light bulbs in place. However, the Directorate is thinking about maybe using revenues from the sale of billboard space to continually improve the street lighting system and decrease electricity bills and energy wastage.

District Heating

The Belgrade District Heating network is made up of 15 remote systems (district heating plants), 53 block and individual boiler units, 11 sources with hot water production, and 186 boiler units. The entire pipe network is 1,372 km long and serves 7,854 sub-stations. The installed capacity is 3,391 MW, and most of it (2,334 MW) is dedicated to servicing 288,054 residential flats (half of all apartments in Belgrade), with a total area of 16.5 million square meters. The rest of the heat goes to commercial, administrative, and office buildings.

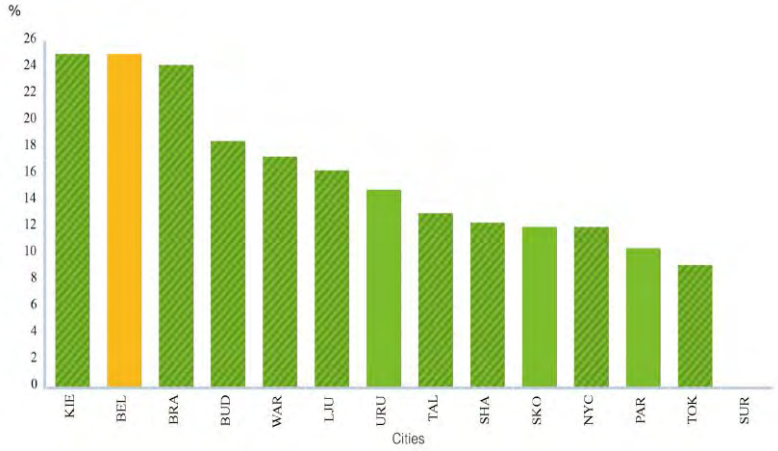
The system currently runs on gas. However, given Serbia's dependence on gas imports from Russia, and considering the relatively high price of natural gas, local authorities are considering to switch the system to mazut (heavy oil), which is both cheaper and easier to buy from different sources – albeit more environmentally polluting.

Switching to mazut is not anything new to the City. In 2009, following the Russia gas crisis, the entire heating system in Belgrade was switched to heavy oil, and continued to run that way for the next two years. The switch back to natural gas was good news for the environment, but also meant a larger energy bill for the city – its largest energy bill at around $223 million. All in all, the Belgrade district heating plant consumed 25% of all natural gas in Serbia in 2011, even though the system was in use only for 6 months – from mid-October to mid-April.

District Heating Plant in Novi Beograd

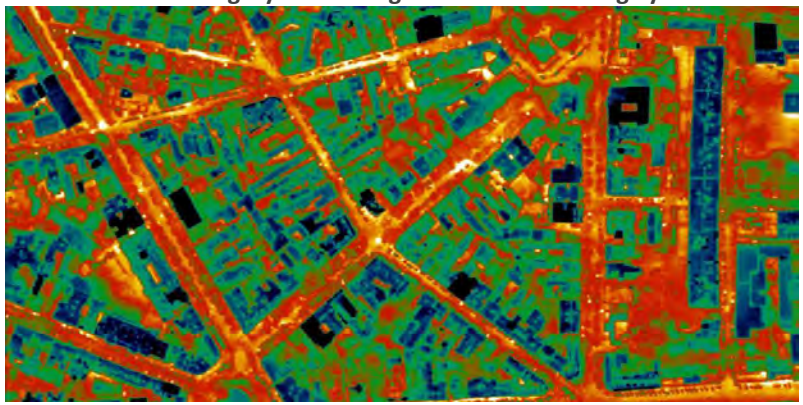
Over the past 10 years, constant improvements have been brought to the system, with many parts of it being reconstructed and re-built. For example, around 95% of sub-stations are automated now. Nonetheless, much remains to be done to make the system even more efficient. Because most of the heat and hot water is produced in a small number of large plants, the district heating system relies on long network of pipes to service its consumers. This network is old, hard to maintain, and plagued by significant heat and water losses. As can be seen in the figure below, along with Kiev, the Belgrade district heating system registers the highest heat losses of all the cities with relevant data in the TRACE database.

Percent Heat Lost from Network



In some parts the system is over 47 years old and heat and water losses are particularly high. To address some of the system issues, local authorities have contracted a company to do thermographic video shoots from the air to identify the areas with the most significant problems (see image below).

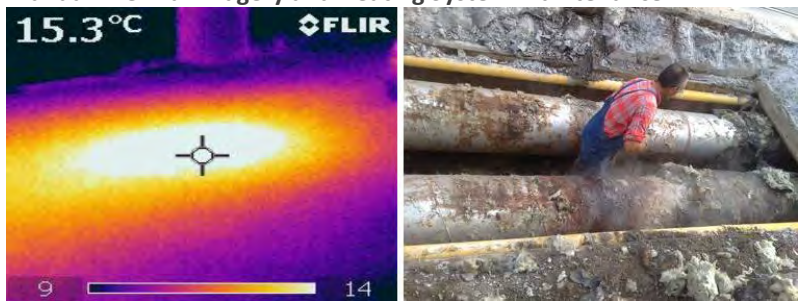
Thermal Imagery of the Belgrade District Heating System



Source: Vasiljevic, Petar, Radmilo Savić, and Goran Jelisavac. 2009. "Applying Thermographic Video Shots from Air in Assessing Condition of Heating System". PPT presentation held at the 40th International Congress on Heating, Cooling and Climatization.

The aerial thermal imagery gave local authorities a clear picture of where the main problems are situated. The particularly inefficient system parts were then subjected to a more finely grained analysis. Manual thermal imagery was used to identify with the highest heat losses, and maintenance and repair crews are continuously deployed to improve system performance (see images below).

Manual Thermal Imagery and Heating System Maintenance



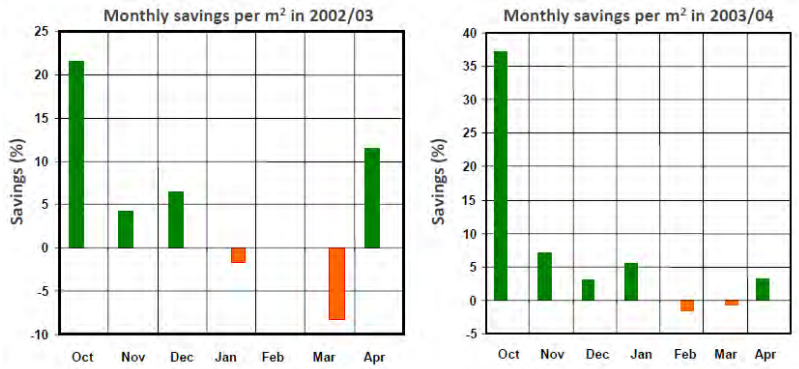
Source: Vasiljevic, Petar, Radmilo Savić, and Goran Jelisavac. 2009. "Applying Thermographic Video Shots from Air in Assessing Condition of Heating System". PPT presentation held at the 40th International Congress on Heating, Cooling and Climatization.

The district heating system could be made more energy efficient by also focusing on demand issues. Thus, proper market pricing, the thermal insulation of exterior walls, roofs, and basements, the replacement of windows and doors with more energy efficient ones, installing heat meters and heat regulators, are all measure that can help reduce energy demand and use in the city.

To address energy efficiency issues at the demand side, the district heating company in Belgrade has started a pilot project to install heat flow meters in apartments connected to the district heating network. These heat flow meters would allow the billing of heat based on actual consumptions and are hoped to encourage people to save more energy. As of now, heat delivery is only metered at the substation level (which usually serve one or several apartment blocks), and people are charged based on the square footage of their apartment, not on actual consumption. Moreover, they cannot adjust heating level in the apartments (everybody gets heat at the same level), and they cannot

reduce or turn off heat when they don't need it (i.e. when they are on vacation).

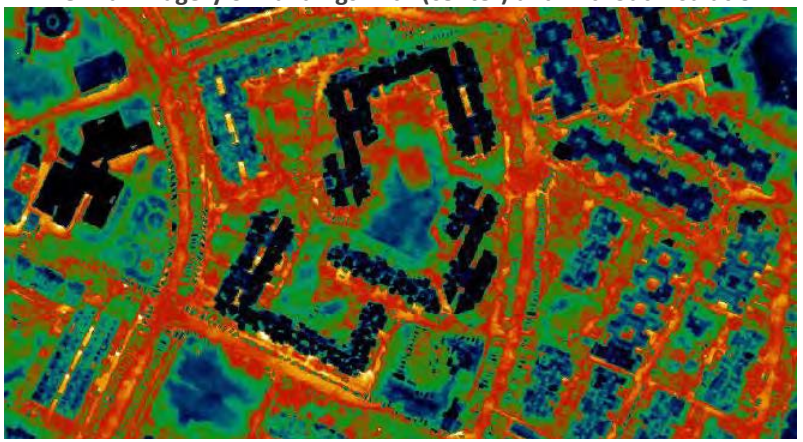
Heat flow meters were installed in a number of pilot buildings, and energy consumption was tracked over the course of two years. The results of the project are quite promising. As can be seen in the figures below, energy savings during the heating season were quite substantial. Particularly in the relatively warmer months of October and April, savings of up to 35% were achieved. The district heating company considers that even higher savings could be achieved if heating tariffs were increased to reflect market standards. Thus, a combination of higher tariffs and proper metering, could lead to yearly energy savings of around 20%. These savings could be achieved without more costly investments, such as thermal insulation of exterior walls and roofs, and replacement of old windows.



Source: Belgrade Faculty of Mechanical Engineering. 2009. "Heal flow meters implementing and resulting effects monitoring in characteristic residential buildings in New Belrade". PPT presentation for the Energy Efficiency National Programme.

Pilot projects were also started to improve the thermal performance of old communist buildings. These were classified based on energy savings potential, and refurbishment work was subsidized – households had to pay only 30% of work costs. Total refurbishment costs for an apartment (including thermal insulation of walls and roofs, windows replacement, heat meters and valves) were on average $6,500. Depending on the building, energy savings of 40% or more are possible following such interventions. As can be seen in the image below, heat losses in buildings can almost be eliminated with the proper measures.

Thermal Imagery of Buildings with (center) and without Insulation



Source: Vasiljevic, Petar, Radmilo Savić, and Goran Jelisavac. 2009. "Applying Thermographic Video Shots from Air in Assessing Condition of Heating System. PPT presentation held at the 40th International Congress on Heating, Cooling and Climatization.

However, refurbishment of old communist apartment blocks is not always an easy task. To complete building refurbishment, all owners have to be in agreement. This is often hard to achieve. For economical (people can't afford it), political, or personal (some people just don't want to do it) reasons, one or more households often refuse to be part of such projects. Even with strong government subsidies in place, it is hard to convince entire household associations to get involved.

In addition to old building retrofits, it is important to continually update and improve building standards, to keep pricing attuned to market changes, and to make sure to enforce existing standards and bills collection.

In Belgrade there is a common bill for all utilities (heating, waste, property taxes). 80% of the bill usually goes to heating, with heating costs being spread throughout the year, rather than during the months when the system is in use. Since metering is hard to implement, there is a flat rate for heating of around $1.1/m^2/month. The tariff is quite high

compared to other district heating system in the region (e.g. more than twice as high as heating tariffs in Skopje and 8 times as high as in Prishtina), but most people tend to pay on time – over 90% of all costumers. Those who don't pay their bills on time are taken to court, with the possibility of having their property taken away from them. Such extreme measures rarely need to be adopted however, and the amount of money owed to the district heating company is unpaid bills is quite low for a city the size of Belgrade – around $500,000 in total.

Compared to the situation of other district heating systems, the Belgrade system has a relatively good economic viability, with only around $2.5 million yearly losses – mostly due to fluctuations in gas prices. If apartments would be properly metered, those losses would be reduced dramatically, or even turned into a profit. As of now, it is estimated that around 45% of apartments in Belgrade consume more heat than they pay for. Moreover, if heat would be priced at market levels, it would not only make the district heating company profitable, but it would also provide an incentive for people to save energy.

Of course, an increase in heating prices has to be done carefully, and ideally it should go in hand with proper metering – i.e. if people are charged more, they should only be charged for what they actually consume. In many cities in ECA, people have de-branched themselves from district heating networks and have installed individual heating units that allow them to both regulate consumption and to adjust heating level to a desired temperature. As of now, there are few people in Belgrade that have de-branched themselves from the network, and local authorities indicate that 3%-5% new connections are added to the existing consumer base every year.

A rise in energy prices would also make combined heating and power (CHP) generation possible. Local authorities estimate that if electricity prices would go up from 5 to around 8 Eurocents per kWh, CHP would be a viable alternative in Belgrade, and the district heating network would be able to have a substantial additional source of revenue. In fact 8 cents/kWh is lower than what specialists in the field assume the market price for electricity should be – 10 cents/kWh.

Power

Power is generated by national electricity companies, and distributed to end consumers in Belgrade by the Belgrade Electricity Distribution Company. Electricity pricing is determined by the Government of Serbia, at the recommendation of the Energy Agency. Serbia is self-sufficient in energy generation, but the sector is not profitable. Electricity is considered to be a social issue in the country and pricing is kept artificially low – at an average of 5 Eurocents per kWh. Because of the artificially low pricing, Serbia often finds itself in the position of importing energy at a higher price (especially in winter when hydro generation is low) and selling it to end-consumers at a lower price.

End consumers usually pay what they consume, and there are incentives for those that do not consume a lot of electricity (see staggered tariff system in table below), or those that consume electricity at off-peak hours. There is an additional 5% discount for those that pay on time.

Electricity Prices in Belgrade (without 18% VAT)

	Flat Tariff	Consumption Tariff (US Cents)	
		Higher (8:00 AM to Midnight)	Lower (Midnight to 8:00 AM)
GREEN TARIFF (up to 350 kWh/month)	5.258814	6.009388	1.502347
BLUE TARIFF (350 - 1,600 kWh/month)	7.887022	9.014082	2.25412
RED TARIFF (over 1,600 kWh/month)	15.77524	18.02816	4.507041

Source: Belgrade Electricity Distribution Company.

For poor families, there is a social discount of around 40%-45%. They receive a 35% flat discount, a discount of 11.89% if their monthly bill is lower than 350 kWh, and an additional 5% if they pay on time. To receive the social discount, households have to be free of debt.

Energy Efficiency Recommendations

The key feature of the TRACE tool is that it allows the estimation of energy savings potential in different city service areas, by benchmarking the performance of a city against other cities. For example, energy consumption per street light pole in Belgrade was compared to energy consumption per light pole in a host of other cities with available data in

TRACE. The energy savings potential for the Belgrade street lighting system was calculated using a simple algorithm that factored in the cities that performed better than Belgrade, and the degree to which these cities performed better. On the whole, the more data points are available in TRACE, the better results it can provide. In a sense, TRACE is like wine – the older it gets, the better it gets.

Another factor that plays an important role in determining energy savings potential is the level of local control. The more control local public authorities have over a particular service area, the higher the energy saving potential is. In Belgrade, for example, most service areas are managed by local public utilities or by the City itself. Consequently, the level of local public control was generally considered to be high. The two service areas were the local of level control was considered lower are 'Private Vehicles' and 'Public Transportation'. 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. In the case of 'Public Transportation', 23% of the public transport vehicle stock (mainly buses) is owned and operated by private enterprises. As such, all of the energy efficiency dividends that are accrued from improving the operation and maintenance of this vehicle stock are accrued directly by these private operators.

Once the savings potential in each service area was calculated, the tool automatically did a sector prioritization based on how large the saving potential was. The priority matrix for the City of Belgrade is included below. A striking difference to TRACE results obtained for other cities is the importance of the district heating network in the overall energy balance of the city. In fact the Belgrade District Heating Network weighs heavy in Serbia's overall energy balance, consuming 25% of the natural gas in the country. The second service area in importance is 'Private Vehicles', with the largest overall energy consumption in the city, but with a much lower level of local control. The other services areas included in the priority matrix below are, to a large extent, under local public control.

It also has to be noted here that the data available for 'Municipal Buildings' is not complete. Given that the City owns a large building stock, and given that all of these buildings are managed by different units (e.g. for sports halls, cultural facilities, administrative buildings, educational facilities, health facilities, etc.), there is no complete picture of this service area. However, the large majority of the buildings were captured in the data collected, and the remaining buildings would not have skewed the final picture too much (particularly the priority order).

Sector	Energy Consumption (US$)	Relative Energy Intensity (%)	Level of local control (from 0-no control, to 1-full control)	Savings Potential (US$) [Priority]
District Heating	222,913,888	20.1	0.95	42,565,405 **[PRIORITY 1]**
Private Vehicles	788,645,701	15.1%	0.25	29,771,375 **[PRIORITY 2]**
Municipal Buildings	25,714,423	34.0%	0.95	8,308,921 **[PRIORITY 3]**
Public Transportation	48,555,148	20.0%	0.75	7,299,922 **[PRIORITY 4]**
Potable Water	9,405,015	40.0%	0.90	3,385,165 **[PRIORITY 5]**
Solid Waste	4,304,991	48.6%	0.95	1,988,871 **[PRIORITY 6]**
Street Lighting	1,826,962	32.0%	0.95	1,826,962 **[PRIORITY 7]**

All of the above priorities were discussed with local officials and decision makers to select a number of recommendations. These recommend-dations were boiled down to 12, spanning all of the identified service areas. All of these 12 recommendations and their relevance for the City of Belgrade will be discussed in more detail below.

Energy Efficiency Strategy and Action Plan

One of the first measures indicated as a need by local authorities in Belgrade was a proper Energy Efficiency Strategy and Action Plan. Although Serbia as a whole lacks such guiding documents, the City of Belgrade is committed to energy efficiency and wants to organize its efforts in this field along clear principles and directions of actions. As

such, it needs to develop a comprehensive blueprint for what the main energy efficiency challenges in the city are, and how these could be tackled.

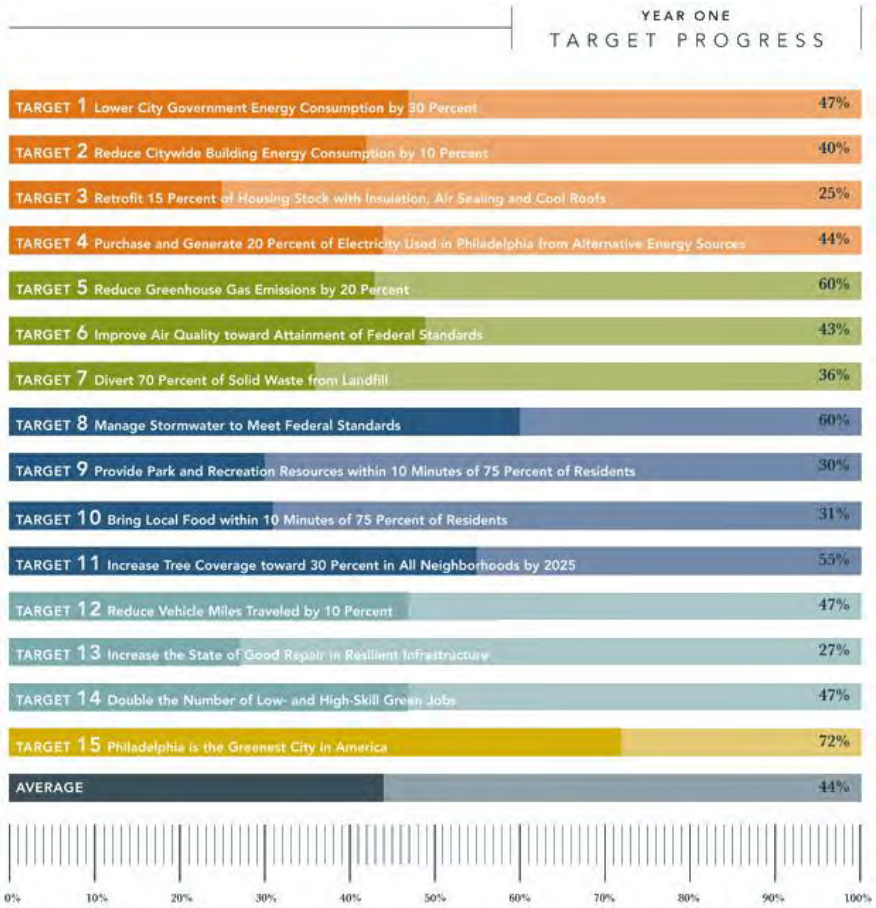
An Energy Efficiency Strategy and Action Plan could be developed as a stand-alone product, or could be part of a larger blueprint for making Belgrade more sustainable. Ideally however, the strategy would have measurable and realistic targets, well-defined timeframes, and clearly assigned responsibilities. Obviously, it is not always easy to measure goals that have to do with a city's sustainability. For example, quality of life is hard to capture in an indicator. On the other hand, energy and energy consumption are both easy to define and to trace. Consequently, energy efficiency strategies offer more opportunities for quick implementation and easy successes.

Achieving those successes however also requires careful monitoring, to ensure that intermediate milestones are reached and that progress is being made towards achieving the bigger strategy goals. This requires both a carefully crafted monitoring plan, and a host of performance indicators that can be tracked at regular intervals. TRACE offers a very good starting point, with a number of energy efficiency key performance indicators that can be used to monitor the city's energy performance. Other indicators could be added to the list however, including, but not limited to indicators on energy efficiency in private buildings and industrial enterprises.

Examples of city energy efficiency strategies and action plans abound. One of the most prominent ones is Philadelphia's 'GREENWORKS', drafted in 2009. In that plan, the City of Philadelphia sets a number of ambitious goals, including reducing the city's energy consumption by 30% by 2015, reducing city-wide building energy consumption by 10% in the same time frame, and retrofitting 15% of the city's housing stock with insulation, air sealing, and cool roofs.

To achieve those targets, the City of Philadelphia has adopted a number of measures, such as retrofitting municipal buildings, replacing the municipal vehicle fleet, encouraging conservation among employees, installing new LED light-bulbs, developing energy efficiency building guidelines, offering tax incentives to energy efficiency star performers, creating neighborhood competitions to reduce energy use (e.g. Energy Smackdown), developing a citywide energy efficiency marketing campaign, building energy efficient public housing, reducing regulatory barriers to solar installation, and installing vertical axis wind turbines on public roofs. All of these measures have created immediate dividends. As the image above indicates, within one year, the City of Philadelphia has made tremendous progress towards achieving its 2015 goals.

City of Philadelphia Greenworks 2010 Progress Report



Source: http://www.phila.gov/green/greenworks/2010-progress-report.html

Copenhagen's 'Climate Plan 2025', set the ambitious goal of making Copenhagen carbon neutral by 2025. Much of the measures laid out to achieve this goal relate to energy efficiency – e.g. generating more of the city's energy needs from local renewable sources, such as wind, biofuels, and waste incineration; improving the city's public transport network and improving non-motorized infrastructure, such as bike paths and a system of parkways and riverfront paths; retrofitting municipal buildings and setting energy savings criteria for buildings that are rented out by the municipality; educating citizens to save energy.

Similarly, the now famous PlaNYC, which sets out sustainable development principles for New York City, lays out a strategy to reduce GHG emissions of the City Government by 30%, from 2007 to 2017. Several initiatives have been started to achieve this goal, such as: improved building codes and regulations; improved energy efficiency in historic buildings; offering energy efficiency financing; and a 21st century energy efficiency workforce.

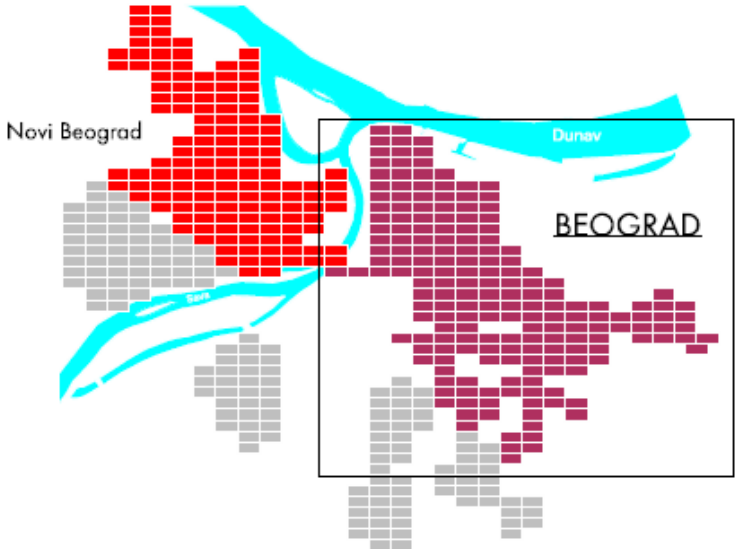
District Heating

Belgrade has one of the largest district heating systems in Europe, and it is the largest single energy user in the city, consuming yearly 320 million cubic meters of natural gas, 50,000 tons of mazut (heavy oil), and 5,000 tons of biomass. The system was first established in 1961, as a means of providing heating to the new neighborhoods of Novi Beograd. Since then the system has expanded gradually, to cover heating demand both in some of the Old City neighborhoods, but also in the newly emerging communities. Since much of the heat generated comes from 12 large district heating plants, the city has an extensive network of pipes that need to be maintained and upgraded to prevent heat loss. In addition, much of the system's capacity to cogenerate electricity remains untapped.

District Heating Network Maintenance and Upgrade

Originally planned for Novi Beograd, the district heating system in Belgrade has been continually expanded. As such, the focus has been more on adding to the existent network rather than properly maintaining it. In addition, in communist time there were few incentives to improve the system as both fuel and delivered heat were heavily subsidized. Nowadays, most of the fuel (primarily natural gas) is imported, and market prices need to be paid for it. Given that the District heating plant is one of the largest energy consumers in Serbia, there is interest both at the local and national level to improve the system's efficiency.

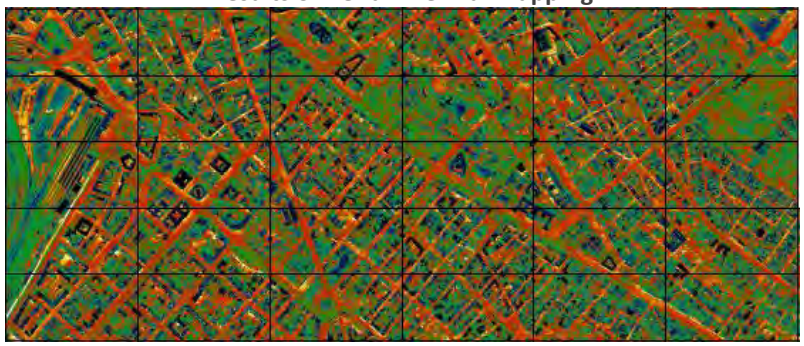
Areas in Belgrade Covered with Thermal Infrared Mapping



Source: JKP "Beogradske elektrane"

Consequently, local authorities have already invested in a system-wide survey. An aerial analysis of heat losses in the system was completed in 2009 (see map above for areas covered in the analysis), identifying the areas in the city were losses are most pronounced (in red and yellow in the map below). As can be seen, heat losses are most pronounced in the distribution system itself, with piping crisscrossing the city under the street network. Since Belgrade relies on a small number of large district heating plants to generate much of the system's heating production, it also relies on a large systems of pipes for circulating hot water to end consumers and recovering used water – over 1,300 km of pipes. Large portions of this network are old, some as old as 47 years. Consequently, they require maintenance, improved insulations, and complete replacement in some cases.

Results of Aerial Thermal Mapping



Source: JKP "Beogradske elektrane"

Local authorities have already started using the aerial thermal imagery to identify the spots in the city with the highest heat losses, and they are using on-the-ground heat imagery to identify the most problematic spots. Repairing and replacing the system requires an integrated approach and close coordination with other departments in the city (e.g. Roads Directorate), to ensure that repair work is done cost-efficiently (e.g. water and sewage pipes could be repaired at the same time) and with as little disturbance to citizens as possible.

In addition to network maintenance and upgrade, local authorities could consider an audit of the heating plants themselves to identify areas where efficiency can be improved. Already all of the substations have been either replaced or upgraded, and an audit of boiler performance could help too. As a study by IEA shows (District Heating Systems in Eastern Europe), district heating systems that rely on a smaller number of large boilers are usually more efficiency than systems that rely on a larger number of individual boilers. Individual boilers are harder to maintain, and they usually have lower efficiency rates.

With the upgrade of the substations, local authorities want to introduce a new bill system – with heat being charged by actual consumption from the substation. This will be an additional impetus for the district heating company to improve the distribution network, as that is where most of the heat losses occur.

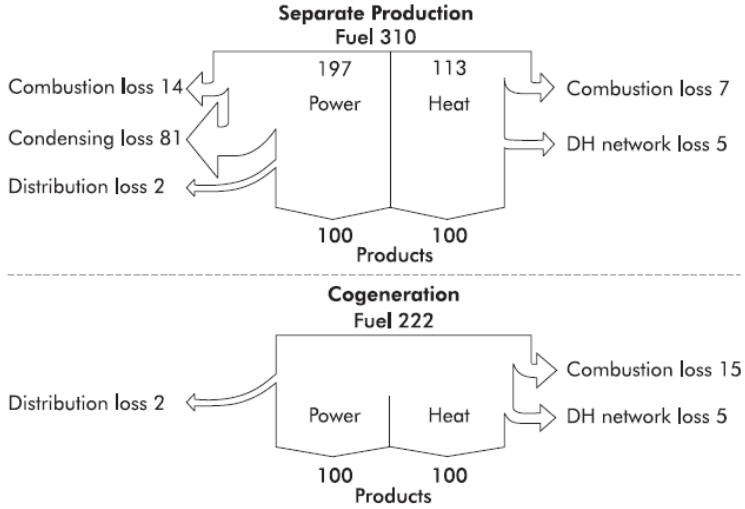
District Cogeneration Thermal Network

Belgrade has a huge potential for combined heat and power (CHP) systems. Currently, only 5 small plants are equipped to generate both heat and power, and their capacity is relatively low – around 70 MW. One of the main reasons for this situation are the very low electricity tariffs in the country. At 5 Eurocents per kWh, the Belgrade district heating system cannot compete with other electricity providers in the country. To become competitive, local operators estimate that the electricity price would have to go up to around 8 Eurocents per kWh. Such a tariff is not too outlandish, considering that surrounding countries like Croatia, Bosnia and Herzegovina, Romania, and Bulgaria, already practice much higher tariffs.

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 district heating 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 is currently developing a CHP plant, which will generate power and use the residual heat to warm-up the water for the already existing district heating network.

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 Belgrade district heating network, an integrated CHP system in the city would help make it much more sustainable. As the image below indicates, to generate 100 units of electric power and 100 units of heat independently, requires 310 units of fuels, for an overall efficiency of 64.5%. Basically, losses in the system (combustion loss, condensing loss, distribution loss, heat loss) are incurred twice. However, if heat and power are cogenerated, the same 100 units of power and 100 units of heat will only require 222 units of fuels, at an efficiency of around 90% - basically, with much lower losses.

Comparative Efficiency of CHP Systems vs. Separate Production



Source: IEA. 2004. Coming in From the Cold: Improving District Heating Policy in Transition Economies.

Obviously, expanding CHP capacity in Belgrade 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.

Urban Transport

Urban transport is considered to be one of the most important areas for intervention by local authorities in Belgrade. The city not only has a large public transportation system, but it is also strategically situated in the region, being crossed by two major European highways. In addition, the urban fabric is broken down by two large rivers – the Sava and the Danube, often creating traffic bottlenecks on the city's main bridges.

The dramatic increase in private vehicle ownership, from around 300,000 cars in 1990 to around 500,000 in 2010, has also contributed to congestion in the city. Local authorities have combated by aggressively investing in public transportation in the new millennium. And, having 53% of people using mass transit for commuting purposes is a crowning achievement for any city – developing or developed. Nonetheless, much remains to be done in terms of improving urban transport in Belgrade, and local authorities seem poised to tackle the challenges ahead.

Traffic Flow Optimization

As most cities with a large historic core, Belgrade has its share of traffic problems. That fact that the city is bisected by two large rivers and a major European highway corridor do not help either. To alleviate some of the traffic issues, local authorities have worked on improving connectivity over the Sava River by building additional bridges and expanding existent ones. However, they found themselves relatively powerless when having to deal with all the highway traffic that passed through the middle of the city on highway E-70.

Addressing the traffic problems brought by the E-70 highway required the intervention of both the City and national authorities, and the financial backing of EBRD and EIB. The Belgrade Beltway (see image below), now under construction, is the most ambitious and expensive infrastructure project in Serbia – slated to be finished in 2012.

The Belgrade Beltway

The development of the Belgrade Beltway will play a major role in easing traffic problems in the city, but other challenges loom ahead. As the city is continually expanding, local authorities have become concerned about the development of the city in a sustainable way. To combat urban

sprawl and the extension of the city at its extremes, local authorities plan a new development in the Palilula Municipality, on the right side of the Danube River. As of now, the right side of the Danube is relatively undeveloped, and it offers prime real estate close to the center of the city.

Developing the available land however, will require proper connectivity measures. In particular, local authorities want to develop another bridge over the Danube, on the left side of the Sava (see image below), to allow the new communities easy access to the city. Of course, these new communities will bring with them additional traffic problems, and proper solutions need to be thought out ahead of time – particularly in terms of providing adequate public transportation options, and non-motorized infrastructure.

Planned Bridge over the Danube

Before solving new traffic issues however, local authorities should pay more attention to still persisting congestion in key areas of the city. One of the main problems Belgrade is facing is proper connectivity over the Sava, which separates two sizable communities. The development of the Ada Bridge is a good step forward. The same goes for the establishment of public transport connections over the Sava, such as Bus-and-Tax-only lanes, and the new rail bridge. Not enough has been done however in terms of making the main bridges over the Sava friendly to pedestrians and bicyclists. With the exception of Branko's bridge, all of the other bridges either have no pedestrian/bicycle infrastructure, or they have uninviting small pedestrian lanes (see image below).

Tram Bridge over Sava

Ultimately, the easier it will be for people to step out of their cars for daily commutes, the easier it will be to deal with traffic challenges. Obviously, bridges pose a particular problem. They represent large stretches of open infrastructure with not much around. They are considered to be unsafe areas, particularly at night, they offer no amenities to passers-by, and they often take a long time to cross. Small changes however can help draw more people.

For example, the availability of proper bicycle infrastructure can provide another opportunity to cross the bridges relatively fast. The addition of simple amenities, such as rest and/or vista spots, can add a great deal to making bridges more inviting to pedestrians. Such measures need to be doubled by the provision of frequent access spots at the extremities of these bridges, as well as the provision of amenities – such as the floating boats on both sides of Branko's bridge.

Measures at improving accessibility over existing bridges can in turn be doubled by measure for improving traffic within the city itself. Such measures are well known in transport circles and need not be elaborated here. They include green wave systems (which limit the amount of time cars wait at successive intersections), roundabouts, one-way streets, or streets that become one-way depending on in-coming or out-going traffic. For example, in Washington DC, Rock Creek Parkway functions as

a one-way thoroughfare during peak hours (allowing commuters easy access in and outside the city), and as a two-way thoroughfare during off-peak hours (see image below).

Rock Creek Parkway (Washington, DC) during Off-peak and Peak Traffic

Public Transportation Development

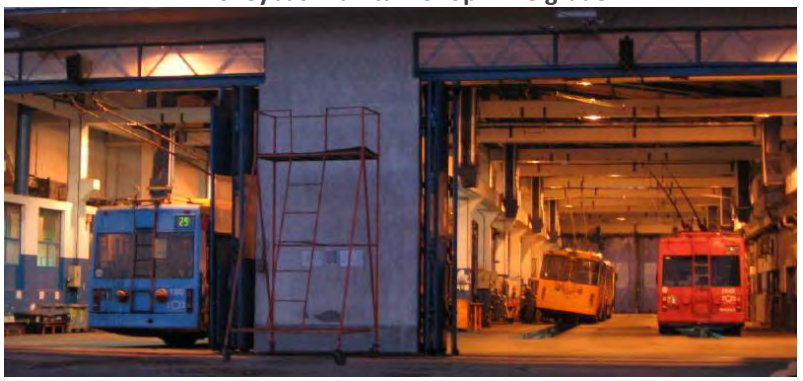
The beauty of a city like Belgrade is that not only private vehicles, but also public transportation vehicles seem to be fighting for available road space (see image below).

Belgrade Trolleys and Bus in Belgrade Traffic

Belgrade has a good and extensive public transportation system and one that is increasingly better maintained. This means that people in Belgrade do not only have access to a plethora of buses, trams, and trolleys, but they can also ride in vehicles that are clean, well-maintained, and increasable better for the environment.

As a way of reducing emissions and fuel costs for the City's bus fleet, local authorities have invested in converting 50 buses to natural gas. This is part of a more ambitious project to renew the city's vehicle fleet, and includes the purchase of new buses, new trolleys and trams, and the conversion of even more buses to natural gas. In addition, the City's public transport company has its own repair shops, were vehicles are maintained and repaired to improve traffic and fuel efficiency.

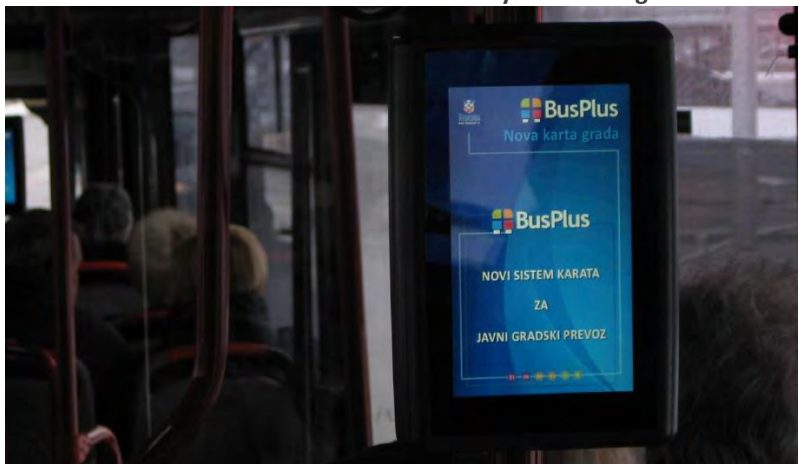
Trolleybus Maintain Shop in Belgrade



Drivers are regularly trained and part of the core curriculum are energy-efficient driving course. Thus, through simple measures, local authorities ensure that the existing fleet, both new and old, is operated as efficiently as possible. Such measures are taken although there are not many incentives for GSP (the City's Public Transport Company) to become more energy efficient. In fact it has disincentives to do so. Since it is reliant on significant subsidies for its daily operation and maintenance costs, GSP risks losing the subsidy quantum it receives yearly if it becomes more energy efficient. Thus, all the money that is saved from a more efficient fleet is money that is subtracted from next year's subsidy pool. It thus pays for the city to think of an incentive system that could allow GSP to use energy savings for investments in further energy efficiency measures.

On the demand side, measures have been taken to improve the commuting experience of passengers. Starting in February 2012, paper tickets have been eliminated, and the entire public transport fleet has made the transition to electronic ticketing. Passengers have to get a pass-card, to which they can add as much money as they desire. Public transport vehicles have been equipped with an electronic card reader where passengers can automatically charge their trips (see image below).

The New BusPlus Electronic Ticket System in Belgrade



Of course, there still are areas where improvements are needed. For example, it is very hard for non-locals to navigate the maze of bus, trams, and trolley lines. Whereas metro systems are easy to read by any newcomer to a city, bus lines often remain an unknown, even to people that have lived in the city for a long time.

Consequently, much can be done in making the public transport system easier to navigate and understand. For example, each bus/tram/trolley station could be equipped with a map that shows the public transit lines that service that stop, as well as connecting lines at further stops. The City of Tbilisi has equipped its bus fleet with simple GPS devices and has installed electronic billboards in the main bus stations. These electronic billboards get the information from the buses' GPS devices and let riders know when the next buses are coming.

Such a measure can help increase ridership and improve the experience of passengers. Rather than being subjected to an unknown waiting time, people have a clear idea of when the bus is coming – thus their choice of waiting or choosing another transport mean is made easier. In many cities people chose metros over buses, because these are more predictable (people know exactly when the next train is coming) and because there is no waiting in traffic.

In that respect, local authorities in Belgrade can invest more in reducing the time buses/trams/trolleys have to wait in traffic. Some measures in this direction have already been taken. For example, many congestion points in the city are equipped with bus-only lanes, which allow public transport means to by-pass peak-hour congestion. Other interventions in this direction could include green-wave systems for public transport vehicles (which minimize the waiting time at green lights and successive intersections), right-off-ways, and bus-only park zones.

In fact, local authorities in Belgrade plan to take more ambitious measures to decrease commuting times on public transport means – they want to invest in a metro system. Since streets are congested and existent buses, trams, and trolleys often contribute to congestion (see image below), they want to divert some of the traffic from surface streets to underground infrastructure.

Belgrade Buses Waiting in Traffic

This will ultimately mean that some of the existent surface means will be taken out of commission, while others will be re-directed to serve the new metro stops.

The idea of a metro system in Belgrade is not a new one. Local authorities in Belgrade have contemplated the possibility of having a metro system in Belgrade since the 1950s. A first plan was drafted in 1958 and it included one line with four stops, connecting the city's historic fortress (Kalemegdan) to the Cubura District. In 1968 a new plan was drafted, which included three lines, with a length of 33 kilometers and 35 stations. In 1976, the plan was again revised and knew its most ambitious incarnation. One of the proposed solutions in 1976 included 173 km of track, 61 stations, and a planned ridership of around 40,000 passengers per hour.

Proposed Belgrade Metro System: 1976 Feasibility Study

Source: http://sr.wikipedia.org

In 1982, the plan to build the metro was eventually abandoned in favor of the expansion of the existing tram network. Internal conflict and economic decline in the 1990s meant that plans to build the metro were even further delayed. In 2004, discussions on the system were brought up again, but plans to build a light rails line were eventually scrapped. In 2010, the metro system became a prominent city issue again, and plans are currently being drawn out for a system which will initially have two lines, 36 kilometers of track, and 55 stations. It is considered to be a national priority, and the third most important project in the country after the Belgrade Beltway system, and the national railways rehabilitation project.

Of course, this is a very ambitious undertaking, and it will be hard for the City to take it on, on its own. The Law on Public Debt puts a cap on public lending. Thus, a city like Belgrade can only take on loans if the ratio between its current budget and the servicing of existing credits is lower than 15%. In January 2011, Belgrade had a ratio of 11%, with an allocated budget of around $1.3 billion. For comparative purposes, Vienna (Austria), with a population similar to that of Belgrade, has an allocated budget for 2012 of around $7.9 billion.

In its current financial and fiscal situation, the City of Belgrade could not possibly undertake such an ambitious project without the assistance of the national government. In addition, many people oppose this project and see it as wasteful spending. However, Belgrade is one of the few cities of its size in Central and Eastern Europe without a metro system, and local authorities seem determined to change that. The fact of the matter is that most cities in the region with a metro system in place are working on expanding their network and areas serviced. For example, Bucharest, will expand its system by 30 kilometers, with new lines to the airport and a number of growing communities around the city.

Municipal Buildings

The City of Belgrade owns an impressive building stock, and all these buildings consume a lot of energy. There is therefore a lot of interest on the part of local authorities to determine ways in which energy efficiency in municipal buildings can be improved. A large share of these municipal buildings were developed after 1945 and they generally have a poor thermal performance – many were developed out of pre-cast concrete slabs, and they allow heat to escape quite easily. In addition, many of these buildings have received no thermal upgrades and improvements since they were developed, and their energy performance is likely to have deteriorated over time.

Given the scale of the problems and given potential benefits in this service sector, local authorities have recently been very pro-active in devising solutions to improve their performance. Such measures are doubled my measures that tackle energy efficiency issues in residential and commercial buildings.

Municipal Buildings Audit and Retrofit

The City has worked with the Faculty of Architecture in Belgrade to devise an overall profile of buildings in the area. It was found, for example, that buildings built in the 1970s, before more stringent buildings standards were introduced, were the worst energy performers. It was also found that older buildings (built before 1945), as well as buildings that have been recently developed tend on the whole to have a better energy performance. Old buildings tend to be built out of brick (which has good insulating properties) and generally have thick walls. Newer buildings were subjected to stricter building standards, including clear thermal insulation guidelines, so they are generally in good shape. Moreover, local authorities want to improve building standards to ensure that average energy consumption per unit will be dramatically reduced from the current base-line. In line with the big ambitions of some of their counterparts in Western Europe, local authorities in Belgrade hope to eventually move to completely energy passive buildings.

However, as of now, there is no concrete full picture of the energy performance in municipal buildings in Belgrade. The table below highlights the data that was collected by the TRACE team in collaboration with the local authorities in Belgrade.

Energy Consumption in Municipal Buildings in Belgrade, in 2009

	HEATING (kWh)	ELECTRICITY (kWh)	AREA (m^2)	Heating Expenditure (in US $)	Electricity Expenditure (in US $)
Primary Schools	87,788,379	18,504,676	710,664	3,653,818	1,493,225
High-Schools	32,533,157	8,056,410	304,887	3,793,870	715,273
Hospitals	62,231,739	28,098,343	269,087	9,159,054	2,630,669
Kindergartens	15,403,175	11,212,501	185,022	2,674,726	523,676
Municipal Buildings	5,431,612	5,651,549	43,731	565,770	504,343
TOTAL	**203,388,063**	**71,523,480**	**1,513,390**	**19,847,238**	**5,867,185**

Some of the other buildings the City owns and manages (e.g. cultural facilities and sports halls), do not have the necessary data compiled in an easily retrievable form. Moreover, since different groups of municipal buildings are managed by different units in the City, it is hard to coalesce a full picture of the sector.

Consequently, one of the recommendations made during the TRACE implementation process was the performance of a full audit of the municipal building stock. The audit would not only allow a better energy and cost savings estimate (which may be higher than the one generated by TRACE now), but it would also help determine key areas for intervention.

For example, the World Bank has worked with the Kiev City State Administration to do an audit of municipal buildings in the city and identify areas for intervention. A total of 1,270 municipal buildings were selected (e.g. healthcare, educational, and cultural facilities) and a range of measures were implemented to improve their energy performance. These measures focused both on the supply side (e.g. automation and control systems) and on demand side measures (e.g. metering and tariffs). After the completion of the project, heating consumption in these buildings was reduced by 26%, or a total of 387,770 MWh/year.

Municipal Buildings Benchmarking Program

A full audit of the municipal building stock would also allow a benchmarking exercise. Such an exercise could help identify the buildings or groups of buildings with the highest energy savings potential. For example, the work that has been done by the World Bank with the Serbia Energy Efficiency Agency showed that it is more cost-effective to improve the thermal performance of hospitals than of schools. Since hospitals are in use all year-round, 24/7, they have a much higher energy demand than schools – which are not in use during vacations, on week-ends, and after school hours.

Given the size of Belgrade, and given the very large building stocks it owns and manages, such a benchmarking exercise is critical for directing resources to buildings where the highest impact (pecuniary and non-pecuniary) can be achieved. However, proper benchmarking requires careful coordination between different departments, and a careful analysis of the different building types. Ideally, benchmarking would be done by one unit (e.g. the Secretariat for Utilities and Housing Services – Energy Administration), which will not only centralize relevant data, but also coordinate the buildings retrofit program.

Key indicators should be collected for each individual buildings, and a database should be set-up to allow a monitoring of performance over time. In addition, the results of the benchmarking process should be published on a regular basis. This often helps generate a healthy competitions between different buildings managers, and it will also foster the exchange of knowledge and experience.

Water and Wastewater

The water system in Belgrade is generally well managed. Operation costs are recovered from charged tariffs, and the percentage of non-revenue water is relatively lower than in other countries in the region. However, the system suffers from some original design issues. The most important of these issues is the lack of an adequate system of reservoirs, which would allow water to be pumped at night (when electricity costs are low), and distributed during the day (when electricity costs are high).

Since energy was highly subsidized in communist times, energy efficiency was not one of the first criteria that went in the design of the system. Even today, electricity continues to be highly subsidized. If it were to be priced at market level, it is likely that the water system would not be able to cover operating costs.

As far as the wastewater system is concerned, raw sewage continues to be dumped untreated in Europe's largest river system. The development of a wastewater treatment plant is one of the most important issues on the agenda of local authorities, and proper funding is sought to commence work on it. Once completed, water and wastewater tariffs will likely have to go up, to cover investment and new operations costs.

Improve Performance of Water System Networks

The share of non-revenue water in the Belgrade water is system is around 32%. This is a lot, but comparatively small when looking at other cities in the region. Yerevan has a share of non-revenue water of around 82%, Sarajevo – 76%, Sofia and Skopje around 60%. None-the-less Belgrade has a lot to gain from reducing the share of non-revenue water. Since all of the distributed water is first pumped to water towers, the water that eventually gets lost in the system, and the water that ends up not being billed, is by-and-large expensive water. Energy is consumed not only in the pumping of the water, but also in its treatment. Consequently, reducing the share of non-revenue water ultimately translates into lower energy costs. As of now, Belgrade has one of the highest energy densities for potable water of any city in the TRACE database.

Reducing the energy density of the system requires first and foremost repairs and upgrades of old and leaky distribution pipes. Belgrade already has a SCADA (supervisory control and data acquisition) system in place, which monitors system performance and ensures that pressure in the system is kept at an optimum to reduce losses.

On a more ambitious level, the water utility company is interested in developing a system of reservoirs throughout the city, which would allow them to run water treatment and distribution in a much more efficient manner. Right now, pumps and motors in the system run continuously, and operators can't take proper advantage of lower electricity prices at night.

Of course, such investments will come with a hefty price tag, and they will ultimately require an increase of existent tariffs. As can be seen in the table below, the water and wastewater tariffs practiced in Belgrade are quite low when compared with other cities.

The only city in the list that has a lower tariff is Yerevan, but they have a local economy that is not as strong as Belgrade's, and they also have the highest share of non-revenue water of any city in the TRACE database.

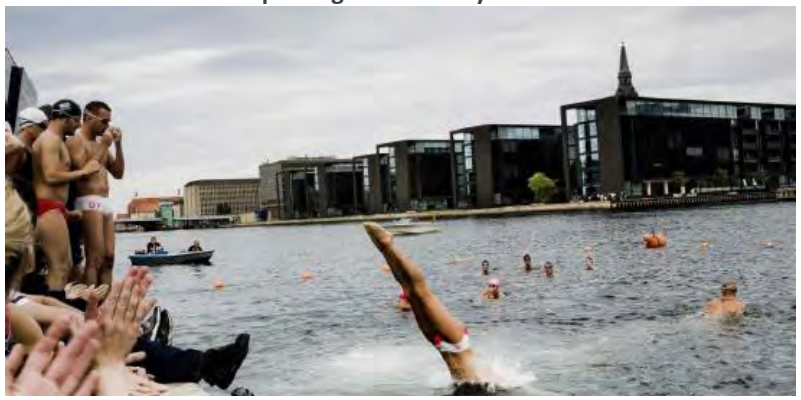
Water and Wastewater Tariffs in Selected Cities, in 2009

City	Country	Total Water and Wastewater Tariffs (US $)	Total Increase (%) water and wastewater on 2008	City	Country	Total Water and Wastewater (US $)	Total Increase (%) water and wastewater on 2008
Belgrade	Serbia	0.661	25.29%	**Amsterdam**	Netherlands	2.467	-2.94%
Bucharest	Romania	1.302	10.66%	**Brussels**	Belgium	4.187	0.87%
Istanbul	Turkey	3.097	8.43%	**Copenhagen**	Denmark	9.072	3.91%
Moscow	Russia	0.866	28.30%	**Madrid**	Spain	1.650	2.21%
Sofia	Bulgaria	1.019	14.71%	**Rome**	Italy	1.310	3.70%
St. Petersburg	Russia	0.720	24.61%	**Stockholm**	Sweden	1.672	0.00%
Warsaw	Poland	2.586	0.00%	**Washington DC**	USA	2.115	4.17%
Yerevan	Armenia	0.471	4.75%	**Zurich**	Switzerland	5.518	0.00%

Source: Global Water Intelligence

The highest water and wastewater tariff in this list is practiced by the City of Copenhagen – 14 times higher than the one in Belgrade. That price however allows local authorities in Copenhagen to offer their citizens a good quality of life. Thus, the wastewater and storm-water are treated so well that when they get discharged in the city's inner harbor, they are clean enough to swim in. In fact, after many years, local authorities in Copenhagen have opened the inner city harbor for swimming and other leisure activities (see image below).

Copenhagen Inner-City Harbor



Obviously, Belgrade will not reach the level of Copenhagen over night. However, other cities in the region, of similar development level (e.g. Bucharest and Warsaw), have managed to increase their tariffs and bring continuous improvements to their water and wastewater systems. Belgrade itself has increased its tariffs by 25% in 2009. Further increases will be needed however to allow for continuous system improvements and to ensure the self-sufficiency of a more complex system.

Improve Performance of Water Pumps and Motors

Continuous improvements of the water network should be doubled with investments in improved performance of water pumps and motors. For one, if energy efficiency improvements will require less pumping, old and inefficient pumps should be taken out of commission. In addition, when and where pumping capacity is needed, local authorities should do a proper analysis of actual needs, and of ways to improve technical performance. Often, replacing old pumps, or ensuring proper maintenance of the existing stocks can reduce energy consumption significantly, and investments can be amortized quite fast.

Other technical solutions to improving the performance of pumps and/or motors include: replacing single speed pumps with multistage pumps (which can moderate energy use based on needs); rewinding motors; relining the pumps; or, trimming pump impellors. For example, an analysis of the performance of the water system in Galati (Romania), a city of about 230,000, indicated that around $250,000 in energy costs could be saved annually though simple and relatively inexpensive measures, such as: better matching pumps and motors with required flows and pressures; replacing some of the old pumps; reducing the height of the reservoir 1 meter below the discharge to save pumping costs.

Solid Waste Management

The solid waste management system in Belgrade is operated and managed in an efficient way. Tariffs allow proper coverage of operating costs, and even allow the generation of surplus revenues to be used for investments. The entire SWM system (collection, transport, and disposal) is operated by a City owned Sanitation Company - BCE. While the system as a whole is quite basic, and while recycling rates are insignificant, the leadership of BCE has very ambitious plans to transform the SWM system in a state of the art one.

Waste Sorting and Recycling

Recycling is one of the main topics of interest to the Belgrade Sanitation Company. Having had an operational recycling system in place before the fall of communism, local authorities are trying to establish one again – based on sustainability principles and taking advantage of the existent market for recyclables. Recycling ultimately means less waste that has to go to the landfill and less energy that needs to be spent on handling that waste (collection, transport, disposal).

Of course, recycling itself requires energy inputs – energy inputs which are often higher than simple disposal. However, these energy inputs and costs are almost always offset by the revenue generated from selling these recyclables. In a nut-shell, there is wealth in trash, and every city should take full advantage of that. Even when markets for

recyclables are not fully developed, local authorities can spur market formation by doing recycling on a pilot basis.

BCE in Belgrade is looking into developing an integrated SWM strategy, with a big component dedicated to recycling. As a first measure, local authorities want to introduce a pay-by-weight system, which will charge people based on the amount of waste they produce. The way this system was envisioned is quite ingenious. Basically, the entire city will be equipped with underground dumps which can be opened by use of a card system. All households will be given such a card, and whenever they will dump their trash, the system will automatically register who dumped the trash and how much of it did they dump. The quantity is then added up to the respective household's bill.

Such a system creates the proper incentives for people to reduce the amount of waste they generate. Moreover, additional incentives are put in place to encourage people to recycle. Thus, if a household does proper recycling, a certain amount is taken off their final SWM bill. The utility company generates back the loss in tariff by selling those recyclables. If the system is properly managed, recycling can even become a profit making activity for the local operators, and may even be privatized.

Recycling at the source will be completed by a recycling stations at the landfill, and maybe by recycling stations at the planned transfer stations. These investments will ensure that the maximum amount of recyclables are captured in the overall waste stream.

Intermediate Transfer Stations

There are 7 public utility companies that do solid waste management in Belgrade right now – BCE services the city proper, while six other operators do waste collection and transport in the city's outlying municipalities. Plans have been drawn however to combine all these operators together, to take full advantage of economies of scale.

Getting all of these operators under one roof also means that the collection and transport system can be run in a more energy efficient way. Right now, garbage trucks in some of Belgrade's suburban communities have to run over 50 km to dump collected waste at the Vinca landfill. Local authorities are therefore contemplating the possibility of developing a system of transfer stations, which will allow small garbage trucks to consolidate waste in a bigger trucks, so that fewer trips are made to the landfill. Such a logistics system would not only allow a reduction in fuel costs, but it will also prolong the life of the trucks and will reduce maintenance costs.

Special attention needs to be paid however to how the transfer station system will be devised. Transfer stations can help improve logistics dramatically, but they are not always a silver bullet for all logistics problems. Depending on the distance to the landfill, and depending on the waste that is actually being transported, some transfer stations may reduce operating costs, some may actually increase them. International best-practice indicates that transportation via a transfer station is usually viable in the following simplified scenarios:

- generated waste exceeds 100,000 tons/year, for a travel distance of around 25 km;
- generated waste is between 25,000-30,000 tons/year for a transport distance of around 50 km;
- generated waste is between 5,000-10,000 tons/year, for a travel distance of over 75 km.

Obviously other factors, such as topography and actual fuel price, play a role in determining the feasibility of transfer stations, and they should be carefully considered when devising such a system.

Street Lighting

It's only through the commitment of the local authorities in Belgrade that energy efficiency improvements are brought to the city's street lighting system. Since electricity usage is paid based on installed capacity, not on actual consumption, there are few incentives for investing in a better system – basically, energy savings will not also translate into cost savings. In addition, electricity should be charge at market prices, to create an added impetus for cities to save.

As of now, local authorities have invested extensively in improving light bulb technology in the city's street lighting system, and they plan to continue to do so, until the network as a whole will be free of energy inefficient bulbs. Moreover, they plan to expand the network to areas that are not served or are underserved, and to newly emerging communities. In addition to these basic measures, local authorities are

also thinking about more complex integrated solutions to improve the performance of the street lighting system.

Street Lighting Timing Program

Lighting timing programs are usually simple and inexpensive system upgrades that can help reduce energy consumption. The basic principle at the core of these measures is that lighting use and the intensity of lighting should vary based on need at a particular time. For example, most street lighting systems in the world have astronomic timers with geographic designations, which allow street light to be turned on according to the season and the time of day – requiring less use in the summer month, and more intense use during the winter.

In addition to astronomic timers, integrated solutions can be devised to adjust lighting intensity based on street activity and based on the time of the day. For example, light intensity can be reduced (either automatically or from a central command center) after midnight. Similarly, streets and alleyways with little traffic can be equipped with motion-sensor bulbs, which only turn on when somebody is around. Some cities, such as Skopje, have started experimenting with solar powered street lights – these are placed particularly in less busy areas, such as parks.

ECA Sustainable Cities:

Improving Energy Efficiency in BELGRADE

Serbia

TRACE Study

Annexes

December, 2012

Washington, DC

ANNEXES: DETAILED RECOMMENDATIONS

ANNEX1: ENERGY EFFICIENCY STRATEGY AND ACTION PLAN

DESCRIPTION

Develop a comprehensive energy efficiency strategy and action plan for the municipality. The strategy should have measurable and realistic targets, set out timeframes and assign responsibilities. It should be developed collaboratively by representatives from across the municipality and other groups who will be affected by the strategy.

A municipal energy efficiency strategy will help bring together a diverse range of initiatives into a coherent plan for city-wide energy efficiency. By presenting a single action plan, the strategy will also make it easier to monitor progress.

The strategy can also be used as an internal and external publicity tool for the municipality to promote and build support for their work on energy efficiency.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Mayoral decree	The mayor issues a mayoral decree for an interdepartmental energy efficiency review and strategy.
Regulation (Annual EE Reports)	The city authority introduces regulations requiring that the public organisations report on total energy usage, measures taken to improve energy efficiency and the impact of efficiency measures on an annual basis.
Appoint EE officer	The city authority appoints a senior officer to monitor energy usage to and efficiency to within city authority departments and public organisations. Incorporate the collection and management of data into the job descriptions of those municipal employees with responsibility for energy efficiency initiatives.

- **ATTRIBUTES**

Energy Savings Potential
100,000-200,000 kWh/annum
First Cost
US$100,000-1,000,000
Speed of Implementation
< 1 year
Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment opportunities
Financial savings
Security of supply

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:

- total city authority energy use, total efficiency savings achieved from energy efficiency initiatives, percentage of energy efficiency initiatives for which data is collected every year.
- total city authority energy use
- total efficiency savings achieved from energy efficiency initiatives
- percentage of energy efficiency initiatives for which data is collected every year

Set targets for the city authority for each KPI, for example, improve KPI performance by 20% in 5 years. Produce annual reports on progress towards set targets. Monitor and update the action plan on a regular basis.

CASE STUDIES

Municipal Initiatives to address Climate Change, Bridgeport, Connecticut, USA

Connecticut General Assembly "Municipal Initiatives to address Climate Change" http://www.cga.ct.gov/2010/rpt/2010-R-0300.htm
Regional Plan Association, Copy of Mayor's Executive Order http://www.rpa.org/bgreen/BGreen_2020_Executive_Order.pdf
Regional Plan Association "BGreen 2020: A Sustainability Plan for Bridgeport, Connecticut" http://www.rpa.org/bgreen/BGreen-2020.pdf

In 2008, the mayor issued an executive order that established a goal for the city government to reduce its annual GHG emissions from a 1990 baseline by 7% by 2012 and 20% by 2020, in accordance with the city's Plan of Conservation and Development. In order to meet this goal, the executive order required the city to obtain at least 25% of its electricity from renewable resources by 2012 and for all new major city construction and major renovation projects to earn at least a silver rating under the Leadership in Energy and Environmental Design (LEED) program, or its equivalent under similar rating systems.

The order established a Sustainability Community Advisory Committee, which is charged with:

- overseeing the completion of a city-wide and municipal government GHG inventory,
- making recommendations to the mayor and the city on how to meet the city's sustainability goals,
- preparing educational materials for households and businesses describing climate change and actions they can take to promote sustainability, and
- identifying economic and workforce development opportunities associated with green jobs.

The city, in collaboration with the Bridgeport Regional Business Council, has developed a program to promote sustainability. The program includes specific measures around auditing energy use, reducing total building footprint within the city, using advanced waste treatment techniques, and analysing the feasibility of installing renewable energy systems on public and private buildings.
Since the order was issued, the city and the Regional Business Council have also developed a comprehensive sustainability plan, BGreen2020. The plan was developed following an 18-month planning process with a Community Advisory Committee and five technical subcommittees. The process involved over 200 participants from city, state, and federal governments, businesses, and civic and neighbourhood groups. The plan is a comprehensive strategy to improve the quality of life, social equity, and economic competitiveness while reducing GHG emissions and increasing the community's resilience to the impacts of climate change.

Energy Efficiency Strategy, Spain
European Commission - Saving & Energy Efficiency Strategy in Spain
http://ec.europa.eu/energy/demand/legislation/doc/neeap/es_neeap_en.pdf
Evaluate Energy Savings http://www.evaluate-energy-savings.eu/emeees/en/countries/Spain/index.php
Spain's Energy Saving and Energy Efficiency Strategy 2008-2012 (E4), which constitutes its National Energy Efficiency Action Plan (NEEAP), aims to achieve security of supply in terms of quantity and price with some basic levels of self-sufficiency, taking into consideration the environmental impact and economic competitiveness.
The plan identifies 7 sectors including: agriculture, buildings, domestic and office equipment, industry, public services, transport, and energy transformation. Within each of these sectors, it sets out sets out strategic objectives as well as the route that energy policy should take to achieve these objectives. The Plan establishes a primary energy saving of 24,776 ktoe in 2012 as quantified energy objective in opposition to the scenario which was used as the base for the initial Plan 2004-2012, involving 13.7%. The plan also monitors progress against previous action plans, identifies investment and the potential for improvement in each sector, and sets targets for the immediate future.
The financing of the Plan is via investments in the private sector and in public services, and are therefore passed on to the end-users (consumers) and employers, who make investments which improve the processes or equipment that they bring to the market, so the services that they provide are carried out with less consumption of energy.

Energy and resource saving program, Brisbane, Australia
Good Practices in City Energy Efficiency: Eco^2 Cities: Energy and Resource Saving Program in Brisbane, available online
http://www.esmap.org/esmap/node/1225
Brisbane’s population is expected to continue to grow over the next two decades. In 2007, the Brisbane City Council issued Brisbane’s Plan for Action on Climate Change and Energy, which delineates the selected actions to be achieved in the short term (about 18 months) and the long term (more than five years). Brisbane has three major challenges: climate change, high peak oil demand, and greenhouse gas

emissions. Analyses suggest that, if Brisbane responds intelligently to these challenges, the city may generate significant economic benefits by developing sustainable industries, while saving resources. Brisbane is actively introducing various approaches to sustainable development. In addition, in the city's "Our Shared Vision: Living in Brisbane 2026" policy document, authorities have committed to cutting greenhouse gas emissions in half, reusing all wastewater, and restoring 40 percent of the natural habitat by 2026.

Integrated resource planning and management, Stockholm, Sweden

Good Practices in City Energy Efficiency: Eco^2 Cities - Integrated Resource Management in Stockholm, available online http://www.esmap.org/esmap/node/1228

The City of Stockholm, the capital of Sweden, has pursued integrated city planning and management to become a sustainable city. The city has a comprehensive urban vision, environmental programs, and concrete action plans to reduce greenhouse gas emissions and tackle climate change. It implements integrated urban planning approaches that consider ecological benefits and efficient resource use.

The ongoing redevelopment in the city's southern district, Hammarby Sjöstad, is a good model for understanding integrated approaches to sustainable urban planning and redevelopment. The area aims to be twice as sustainable as Swedish best practice in 1995. The area implements integrated resource management (waste, energy, water, and sewage) through systematic stakeholder collaboration and has transformed the linear urban metabolism into a cyclical one known as the Hammarby Model.

According to Grontmij AB, a private consultancy firm in Stockholm, primary assessments of the initially developed districts of Hammarby Sjöstad show that the area has achieved, for example, 28 to 42 percent reductions in nonrenewable energy use and 29 to 37 percent reductions in global warming potential.

TOOLS & GUIDANCE

Tools & Guidance
N/A

ANNEX 2: District Heating Network Maintenance & Upgrade Program

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 3: 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,

- **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

	modifications to the end user's equipment and also to the power plant itself. The City Authority can pay for 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-

Tools & Guidance
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
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 4: 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.

- **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

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 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

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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

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

Tools & Guidance
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

ANNEX 5: Traffic Flow Optimization

DESCRIPTION

Traffic can be positively managed to ensure the most efficient operation of the transport system. Management techniques will seek to minimise distance travelled between origin and destination, ensure the efficient flow of traffic and encourage multiple occupancy vehicle travel.
Encourage the efficient use of vehicles and minimise journey lengths, reducing fuel use.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Flow optimisation	The City Authority changes driving patterns either by technical optimisation of traffic signalling, or by means of the provision of information. Real-time information can be provided by means of Variable Message Signing (VMS) or telecommunication where drivers are provided with route switching options, clear directional signing to destinations, and directions to nearest available car parks. This minimises journey length and reduces congestion. Messaging systems have also been used to counter crime by providing information on e.g. kidnappings and terrorist attacks. See Portland and Milton Keynes case studies for further details.
Regulatory	The City Authority establishes high-occupancy vehicle lanes (HOV), producing an incentive for car sharing. The pairing of users can be left to civic initiatives, or driven by city authorities either separately or in combination with its other initiatives (in the latter case initiatives can be communicated to users using the same platform). Achieving a minimum number of users is crucial, as insufficient use results in reduced available road space and increased congestion. The implementation of an effective enforcement and penalties system are equally important, as the lane will otherwise attract an unacceptably high level of non-HOVs, which also reduces effectiveness. See Madrid case study for further details.

ATTRIBUTES

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

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 traffic surveys of number of vehicles in circulation by using traffic counters.
- Determine mode share of people travelling in the area or city.

CASE STUDIES

Arterial 'green wave' traffic flow optimisation, Portland, USA C40 Cities (2010). "Portland, USA: Optimizing traffic signal timing significantly reduces the consumption of fuel", available online from http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp The City Authority optimized traffic signal timing at 135 intersections on 16 of some of Portland's most congested thoroughfares. 'Optimization' of traffic signals consists of re-timing the traffic signals to improve their synchronization across a road traffic network. The cost of an intersection synchronization varied USD 1,000-3,000. The resulting reductions in the frequency by which vehicles accelerate and decelerate, as well as the reductions in the time vehicles spend with idling engines, yielded annual fuel savings of 1,750,000 gallons of gas. This is the equivalent of removing 30,000 passenger vehicles from the road for an entire year. The city went a further step by measuring and eliminating CO2 through the purchase of carbon credits.

Variable Message Signs, Milton Keynes, UK

Department for Transport (2010). "Case Study: Milton Keynes Integrated Traffic Management", available online from: http://www.dft.gov.uk/itstoolkit/CaseStudies/milton-keynes-integrated-traffic-management.htm

In order to achieve a more efficient usage of car parks and encourage shoppers into the central retail area of Milton Keynes, as well as reduce congestion caused by cars looking for parking, the city administration invested in Variable Message Signs which display the location and availability of parking spaces to road users. Installation costs were lowered by making use of existing ducted network in Milton Keynes used by the Police for CCTV. This created the added benefit of providing a large capacity network for future growth in data transmissions. The reduction in congestion and delays resulting from the system are estimated to save motorists and bus passengers in the central area more than GBP 3 million over a 10-year period.

High-Occupancy Vehicle lane, Madrid, Spain

Monzon, A. (1999) "Managing long term congestion in HOV lanes. Effect of 2+ vs 3+ limit on the Madrid N-VI corridor", paper presented at the European Transport Conference, Cambridge, Jan 1st 1999, available online fromhttp://www.etcproceedings.org/paper/download/2493

High environmental standards, low housing density, and high motorization rates influenced the decision of implementing an HOV lane scheme on the median of the N-VI motorway into Madrid. The cut off limit for the lane is 2+ passengers and the facility is separated from the mix-flow lanes by a concrete barrier along the whole length of it. A successful design aspect is the reversible basis on which the system operates to match peak flows, serving the inbound trips during the morning peak, and the outbound trips during the evening peak. Rather than increase ridesharing, the lanes have attracted a growth in public transport mode share (40% in the period 0700-1000 in the year following implementation), resulting in increased frequencies of services.

TOOLS & GUIDANCE

Tools & Guidance
Colorado Department of Transportation (2005). "CDOT Guidelines on Variable Message Signs (VMS)", A guidance document for the design of Variable Message Sign (VMS) messages. Available online from http://www.cotrip.org/its/whitepapers/VMSGUIDE-rev-2005.pdf
Alabama Department of Transportation (2007). "Traffic Signal Design Guide & Timing Manual" A guidance document with detailed

Tools & Guidance
guidelines and recommendations for the designing and timing of traffic signals in the State of Alabama. Available online fromhttp://www.dot.state.al.us/dsweb/Traffic/pdf/AldotTrafficSignalManual122007.pdf

ANNEX 6: Municipal Building Benchmarking Program

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).

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

- **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

	• 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	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

Benchmark	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/m2 - annual electrical energy intensity by type of building (Schools, Offices, Residential, Hospital, Misc)
- kWht/m2 - annual heating energy intensity by type of building
- $/m2 - 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 http://www.esmap.org/esmap/node/656

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 buildings. 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 7: Municipal Buildings Audit and Retrofit Program

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

- **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

	• heating systems • computers • server rooms and cooling of servers • 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:

- $/m2 - Benchmark annual energy cost on a per-square-meter basis for all municipal office buildings.
- kWhe/m2 - Benchmark annual electrical energy consumption on a per-square-meter basis for all municipal office buildings in the city.
- kWht/m2 - 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

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
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 8: 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.

- **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 of supply

	The CA should engage a team that includes network planners, water, energy and 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 9: Improve Efficiency of 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.

- **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 of supply

To maintain optimal energy performance over the long term, an appropriate Operation and 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 project. There are multiple tactics for engaging an ESCo, including part- and full- ownership of the system. It is recommended that

	if the ESCo approach is pursued, the City Authority first explores numerous implementation options and assess the pros and cons of each.
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 10: Sorting & Transfer Facilities

DESCRIPTION

Waste treatment facilities such as materials recycling facilities and landfills can either use excessively large amounts of energy or not fully utilise energy produced by them.
Assessing energy efficiency opportunities in the waste sorting and transfer facilities can help city authorities invest in retrofits with a positive cost benefit. The resulting improvements in maintenance and use or replacement of equipment in waste management facilities can reduce energy use associated with their operation. Other benefits include reduction in environmental and social impacts from operation of waste sorting and transfer facilities, for example, odour control and staff welfare.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Reduce energy use via targets created in AER	Better operations and maintenance programme costs can be offset by savings made in improved energy efficiency performance of facilities. Using Annual Environmental Reports (AERs) can focus individual sites to make a collective improvement to the energy used by this section of the municipality's waste system. See Nenagh case study for more details.
Offer incentives for continued improvement	The city authority offers incentives to encourage facility managers to meet AER targets. Incentives can be financial, planning or contract related or by way of public recognition, for example, an annual awards ceremony. See Summit County case study for more details.
Showcase new practices in waste management	The city authority raises awareness amongst operators about the benefits of fuel-efficient operations. Invite potential suppliers, existing waste management providers and or municipality waste teams to a

- **ATTRIBUTES**

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

	conference to showcase new waste management equipment, processes and encourage trials. Aim to showcase examples of energy and cost-savings from efficient sorting and transfer operations and encourage attendees to form partnerships to implement energy efficient practices. See Naga City and Irvine case studies for more 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:

- Energy used for sorting per tonne of waste (MWh/tonne)
- % of waste recovered by sorting (%)
- fuel use per vehicle per tonne of waste per km travelled (MWh/tonne/km)
- % of waste composted in city (%)

Create baseline for energy use in any municipality owned facilities, targeting individual plant equipment and seek implementation of Annual Environmental Reporting (AER) programme to monitor progress.

Setup monthly maintenance programme to ensure all plant are operating efficiently. Create programme for ensuring options for improved waste treatments are assessed and implemented where possible.

CASE STUDIES

Springfort Cross Waste Transfer Station Reporting Scheme, Nenagh, Ireland

http://www.epa.ie/licences/lic_eDMS/090151b280347fbe.pdf

The waste transfer station at Springfort Cross, Nenagh produces Annual Environmental Reports (AERs) in line with Integrated Pollution Prevention Control (IPCC) licensing in Ireland to reduce emissions, waste and to encourage efficient energy use. The AER contains annual summary reports on all aspects of environmental performance of the facility for effective site evaluation, including resource and energy consumption. The use of summarised energy efficiency audits and waste generation reports helps to focus specific future targets in energy efficiency improvements, with the scheduling of energy efficiency audits

and to decrease fuel consumption in the transfer station. A solid waste management consultancy was hired to produce the AER for submission to Environmental Protection Agency.

Summit County Material Recovery Facility, Summit County, USA
http://www.thegbi.org/assets/case_study/MRFCaseStudy.pdf
As the first facility of its kind to be certified as green, the Summit County Material Recovery Facility (MRF) project was awarded two Green Globes by the Green Building Initiative (GBI) for energy efficiency (on the basis that MRFs typically have high energy consumption used for facility ventilation and lighting of the tipping floor). The MRF site location was oriented to optimise solar gain and provide natural day lighting, saving energy in lighting the tipping floor. The most energy efficient element was the mechanical system of the facility, using electric heating with energy recovery ventilators (ERVs) and ducted ventilation. The ERVs provided the largest energy savings and cost nearly $40,000 less to operate than the typical radiant system, with payback of about 3 years. By focusing on specifying high-efficiency lighting fixtures, lamps, lighting controls/occupancy sensors and heating ventilation and air conditioning (HVAC) equipment, the project shows how incentivised investments in retrofits can provide energy efficiency in a cost-effective manner.

Community Materials Recovery Scheme, Naga City, Philippines
"Sustainable Urban Energy Planning: A handbook for cities" pg 46, http://www.unhabitat.org/pmss/getElectronicVersion.aspx?nr=2839&alt=1 (must be downloaded as a .pdf)
To reduce the amount of garbage brought to landfill or dumped into rivers, Naga City begun materials recovery on a community scale in 1999, which developed into a city-wide Materials Recovery Facility (MRF) launched in February 2004. The facility sorts waste into biodegradable waste for conversion into organic fertilisers for sale in the market. Non-biodegradable waste recovered by the facility are either sold or recycled. The facility sorts 40% of the city's waste for recycling, saving 13,862 tonnes of CO_2e annually. Key to the project is the Build-Operate-Transfer (BOT) agreement with the Lacto Asia Pacific Corporation, which provides direct sales of equipment, shared training expertise, maintenance and service for the efficient management of MRF equipment. The local government invested in the project in terms of land, machineries and equipment, infrastructure and operational costs, totalling $405,000.

'Waste Management' Sorting Line, Irvine, California, US
WM press release
http://www.wmsecurityservices.com/WM/press/pr2009/20091118_WM_Unveils_New_Sort_Line_to_Reduce_Landfill_Deposits_and_Carbon_Emissions.pdf
"Advanced waste sorting line boasts of higher capacity" http://www.ecoseed.org/en/recycling/waste-management/article/84-waste-management/5198-advanced-waste-sorting-line-boasts-of-higher-capacity
In 2009, the private waste services provider 'Waste Management' unveiled its $1.7 million recycling line that would allow the company to recover more reusable materials and thereby reduce landfill deposits and carbon emissions. The new waste sorting line at the company's Irvine processing and transfer facility will be able to process commercial waste as well as recyclables from municipal solid waste streams.
The facility already has a construction and demolition sorting line in place. With the new sorting line, it will be able to process up to 30,000 tons of waste annually. The recycling line utilizes state-of-the-art infrared optical sorting to separate dry recyclables, along with sorting mechanisms such as drum feeders.

The line can process up to 15 tons of materials per hour. Aside from reducing its local carbon footprint, the company said it would generate additional revenues through the new sorting line.
The company, which has several plants across North America, has actively promoting its environmental activities, stating that "Investing in green technology makes good business sense" as it increases consumer demand and provides cost and carbon savings.
The new recycling sort line is part of WMOC's recent environmental initiatives, including: a natural gas power fleet of collection vehicles, GreenOps Tracking Stations, reverse vending machines in Tustin; and food waste recycling machines in Laguna Beach. The company also has plans to provide solar-powered trash and recycling compactors in the near future.

TOOLS & GUIDANCE

Tools & Guidance
N/A

ANNEX 11: Intermediate Transfer Stations

DESCRIPTION

Use transfer stations for bulking of waste to help minimise the number of trips to treatment facilities by smaller city based waste collection vehicles. This recommendation has good synergies with the recommendation "waste vehicle operations fuel efficiency standards" and the city authority should consider implementing them together.

Reducing the distance travelled per tonne of waste can reduce energy demand associated with transfer of waste to large treatment facilities (such as landfills). Co-benefits include a reduction in the number of waste vehicles travelling long distances, leading to reduced noise and dust in residential areas, improved road safety, and improved air quality.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Provide transfer stations as part of the Solid Waste Management Plan	The city authority works with its planning department and waste management team to identify shortfalls in the city's waste collection system and improve the city's Solid Waste Management Plan. Create a flow map of waste that includes the existing waste catchment and planned city development, to highlight gaps and inefficiencies in the city's waste management system and identify opportunities to provide waste transfer stations. The city authority can also seek support from private waste management companies in return for procurement of city waste collection catchments. See New York and British Columbia case study for further details.
Planning regulations for waste management	The city authority planning department makes waste management an integral part of the city's spatial planning strategies, allocating land for waste transfer stations and other facilities in accordance with the Solid Waste Management Plan. Where appropriate, waste management regulations and guidelines should also be included within the city's development control

- **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
Reduced waste vehicle traffic

	documents, for example, requiring developments above a certain size to integrate waste transfer stations into masterplans when certain densities are reached. In order to ensure a site's suitability, coordination is essential with the city's waste management strategy, urban development plans and environmental plans. See Kuala Lumpur and Birmingham case studies 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:

- Energy use per tonne of waste for collection transportation and disposal (MWh)
- Total city energy use for waste transportation per tonne of waste (MWh/t)
- Total annual waste mileage (km)
- Kilometres travelled per tonne of waste (km/t)

Assess number and location of waste transfer stations and map against waste catchments in municipality. Waste catchments can be based on daily collection route extent, districts, or capability of waste collection fleet.

Track city development and establish mapping regime of existing and potential waste transfer stations against expanding municipality catchments.

Ensure distances from collection points to treatment facilities do not exceed recommended travel distances as supplied by vehicle manufacturers.

Compare fuel use per volume or mass of waste transferred pre- and post-transfer station implementation.

CASE STUDIES

Solid Waste Management Plan, New York City, USA
http://www.plannyc.org/taxonomy/term/762

The mayor of New York initiated a Solid Waste Management Plan (SWMP) in 2006 as a framework for dramatically reducing the energy use associated with waste disposal in the city while implementing a cost-effective and environmentally sound system for managing the city's waste. The plan involved the assessment of existing transfer stations to maximise waste management efficiency and create a more equitable distribution of waste storage, transfer and disposal throughout the boroughs.
By exporting 90% of the city's residential waste by barge or rail (rather than by truck), the program will reduce waste truck miles by 2.7 million per year and reduce tractor-trailer travel by 3 million miles per year. This relies on updating transfer stations in every borough, re-opening eight disused transfer stations, and the building of seven new marine transfer stations within the city. The marine transfer stations, due for completion in 2013, are also expected to reduce waste truck travel by 3.5 million miles. However, some sources claim that the marine transfer stations will increase the cost of waste disposal from $77 per tonne to $107.
The project has faced challenges with the construction of the new transfer stations, which has been held-up by lawsuits and community organisations concerned about increased truck traffic, air and noise pollution and water dredging that may harm nearby wildlife. Due to this, only two of the seven marine transfer stations were under construction by May 2010 and none of the barges are being utilised. In March 2009, the Mayor signed a 30-year contract with a private waste management company to oversee a program for transporting waste from Brooklyn's transfer stations to out-of-state landfills by train.

Municipal Solid Waste Guidelines, British Columbia, Canada
http://www.elp.gov.bc.ca/epd/epdpa/mpp/gfetsfms.html
The regional authority (Ministry of Environment) funded a project to prepare a report on guidelines for establishing transfer station facilities for municipal solid waste. The authority hired a private engineering consultancy in Victoria, BC to produce the report on transfer station methodologies, using examples to recommend siting, design and operational guidelines for establishing transfer stations. The guidelines also include cost models that compare direct haul in collection trucks with transfer haul to a landfill, and rural landfills with rural transfer stations. Such cost models can be used as an aid to decide whether a transfer station is justified under particular conditions, as they identify operational and capital costs in detail per relevant case study. The report covers potential issues for future implementation, and the detailed examples of transfer station operation/capital costs in the report make it applicable to municipalities during the implementation of their solid waste management plans.

Kuala Lumpur Waste Structure Plan 2020, Kuala Lumpur, Malaysia
http://www.dbkl.gov.my/pskl2020/english/infrastructure_and_utilities/index.htm
The Kuala Lumpur Structure Plan 2020 is the strategic spatial development plan for the capital, which includes guidelines on improving the quality of its infrastructure and utility services. Solid waste collection and disposal services are integrated into the Structure Plan where coordination of existing landfill sites and capacities are outlined, supported by the allocation of new transfer stations in the city. The Structure Plan identified the limited capacity of the Taman Beringin landfill site, leading to the transfer or waste to a private landfill site

outside the city in Air Hitam. Plans for a new transfer station at Taman Beringin is to be built to support this waste transfer, by sorting waste for recovery of recyclables and compacting of the remaining waste before it is transported to the Air Hitam site for disposal by sanitary landfill. The distribution of existing solid waste disposal sites and transfer stations are planned and mapped out in the structure plan.

Veolia Environmental Services Waste Transfer, Birmingham, UK
http://www.veoliaenvironmentalservices.co.uk/Birmingham/
Veolia Environmental Services, a private waste management company, operates two major waste transfer stations in Birmingham, in the north and the south of the city. These play a key role in managing the waste arisings of the city and act as focal points for recycling management.
The transfer stations accept kerbside collected waste from Birmingham City Council refuse vehicles. This waste is then bulked up and transported either to the recycling reprocessor, the Energy Recovery Facility (ERF) at Tyseley or to landfill.
A normal refuse vehicle will hold about 8 tonnes of rubbish. Bulk vehicles will hold up to 25 tonnes, which means that vehicle movements are reduced by a third by the use of the transfer stations. It also means that refuse collection vehicles do not have to travel across the city to deposit their rubbish, but rather they run into the nearest transfer station. A considerable portion of the rubbish brought to the ERF is transported at night to reduce traffic congestion and improve the efficiency of the operation.
The transfer stations also act as bulking stations for the recyclable materials that are collected either from the kerbside or from the Household Recycling Centres, reducing vehicle movements, easing congestion and reducing the environmental impact of transporting Birmingham's recyclable materials.

TOOLS & GUIDANCE

Tools & Guidance
"Guidelines for Establishing Transfer Stations for Municipal Solid Waste" http://www.env.gov.bc.ca/epd/epdpa/mpp/gfetsfms.html
"Waste Transfer Stations: A manual for decision making" (US Environmental Protection Agency) http://www.epa.gov/osw/nonhaz/municipal/pubs/r02002.pdf

ANNEX 12: Lighting Timing Program

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.

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.

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

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

Tools & Guidance

Tools & Guidance
N/A