ECA Sustainable Cities:

Improving Energy Efficiency in TBILISI Georgia

TRACE Study






ECA SUSTAINABLE CITIES

ESMAP
Energy Sector Management Assistance Program

December, 2011
Washington, DC

Table of Contents

ACKNOWLEDGEMENTS

This report was undertaken under the guidance of Stephen Karam (ECA Urban Sector Leader and Acting Sector Manager) as part of a series of activities done for the Europe and Central Asia Sustainable Cities Initiative (ECA SCI). The team that worked on this report is comprised of Ahmed Eiweida (Task Team Leader), Marcel Ionescu-Heroiu (Extended Term Consultant), and Ranjan Bose (Senior Energy Specialist). Throughout the process of collecting data and writing the report, the team has enjoyed an excellent collaboration with local authorities in Tbilisi.

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

The transition years have not been kind to Georgia and to Tbilisi in particular. Cut off from some of its main markets, cut off from heavily subsidized energy imports (particularly natural gas and oil), and plagued by internal strife, the Georgian economy has dropped a remarkable 75% from 1989 to 1993. Many of the resource flows that enabled city economies to function were lost over night. As a consequence, the City of Tbilisi was faced with the tough challenge of continuing to provide basic services to its citizens, with significantly reduced means. In the process, tough decisions had to be taken, and services that were considered "non-essential" were left to either disappear, or to crumble away. Thus, the city's district heating network, which serviced over 83% of the city's 1.2 million people, was dismantled over night in 1993, leaving people to fend for themselves. The public transportation systems quickly fell apart, with the number of buses dropping from an estimated of 1,200 in Soviet times to around 50 in 2004. The city's metro system was plagued by power outages, lack of maintenance, and a proliferation of crime. The tramway system, consisting of over 54 km of lines, was completely dismantled. The wastewater system is currently not operational, with raw sewage being dumped straight into the Mtkvari River. Even basic and critical services, like water provision, suffered, with a continued deterioration of infrastructure and service quality.

As dramatic as the decline of Tbilisi has been in the 1990s, as impressive was its resurgence after the 2003 Rose Revolution. Economic reforms, coupled with aid and assistance from abroad have lead to a revival of the city. For example, the number of street lights grew from 25,000 in 2005 (lighting mostly the center of the city), to over 125,000 in 2011, covering most of the streets in the city, and garnering Tbilisi the denomination of the City of Lights. Similar improvements have happened in other service areas, with the number of municipal buses increasing from 50 in 2004 to around 1,000 in 2011, with significant improvements brought to the metro system, and with a new and efficient solid waste management system in place. Moreover, local authorities are poised to continue on the path they started, and to bring about changes that might soon garner the city the denomination of the Sustainable City.

In 2011, the City has drafted a *Sustainable Energy Action Plan (SEAP)* for 2011-2020, with clear measures aimed at reducing greenhouse gas emissions in the city by 20% or more by 2020. In addition, the SEAP has offered a baseline of energy indicators that can be used for other purposes, such as this TRACE study.

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 October 2011. Work in Tbilisi 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, four major service areas were identified as being critical in improving the City's overall energy performance: urban transport (private vehicles and public transportation), public lighting, solid waste management, and municipal buildings. Some of the recommendations made for these service areas are included below.

Private vehicles is a service area (or rather a sub-sector of urban transport) where most energy savings can be made. Having witnessed a

dramatic increase in motorization rates, from 80 cars per 1,000 people in 2000, to 205 cars per 1,000 people in 2009, many of Tbilisi's streets are now congested and polluted. Because there are no national laws controlling cars' energy and engine performance, people usually buy and use cars that run on cheap and polluting un-leaded gas. Several measures have been put in place to ease traffic and improve parking conditions in the city, but they have done little to resolve the problem.

With fuel prices rising, and given Georgia's full dependence on oil imports, it is important for local authorities in Tbilisi to identify ways to discourage car use in the city. Three recommendations were made in this respect. For one, the City should consider imposing traffic restraint measures, such as closing certain street to traffic (e.g. downtown streets that are primarily used for on-street parking). Second, the city could consider enforcing a more strict parking policy, banning car parking on sidewalks (more and more pedestrian space in Tbilisi is lost because of illegal parking), and putting a price on the use of vital city space (e.g. a zonal parking fee system). Third, local authorities have to offer people accessible, safe, and comfortable non-motorized transport options. To the extent possible, they should make it easy for people to walk and bike through the city.

Public transportation development is another way of reducing people's dependence on private cars. The more extensive, reliable, and affordable public transportation is, the more people will chose to use it. The City has achieved significant strides in this respect, with the number of municipal owned buses growing significantly in recent years, with important infrastructure improvements (e.g. time-tables in the major bus stations, indicating in real time when the next bus will arrive), and with plans to continually expand and improve the public transportation system (e.g. developing a new 55 kilometers tramway network in the city and expanding the metro system). The momentum that has been achieved in this service area should be kept in coming years.

Public Lighting has seen a major revamping in recent years, garnering Tbilisi the title of the City of Lights. Most of the streets in the city are covered with street lighting, and most of the street lights are quite energy efficient (equipped with high pressure sodium vapor bulbs). More improvements can be brought to the system, by introducing lighting timing measures (which adjust light intensity based on external conditions and based on how busy streets actually are), by having clear procurement guidelines for the acquisition of new light bulbs, and by having an audit and retrofit program in place that can consider replacing existent technologies with even more energy efficient ones (e.g. LED bulbs).

Solid Waste Management is a service area that has seen many improvements in recent years. Most importantly, four operating landfills have been consolidated in one, new and energy efficient garbage trucks have been added to the fleet, and collection and transportation logistics have been designed to reduce energy consumption. The new landfill is fenced in (to prevent the access of scavengers and cattle), it is organized around several individual cells, it has leachate protection, collection, and treatment, and it is equipped with devices for methane capture. The system was designed with energy efficiency in mind, but there also is room for improvement. For example, local authorities could try to identify ways in which the captured methane gas could be used for productive use (e.g. to power garbage trucks, or to generate energy), instead of just being flared as the intentions are right now. In the same vein, fuel efficient waste vehicle operation training course could inform truck drivers on driving patterns that help save fuel. Such courses could be double by incentive packages for drivers (e.g. offering them as a bonus a share of achieved fuel savings).

Municipal Buildings in Tbilisi showed up as being quite energy efficient, especially when compared to other cities with pertinent data in the TRACE database. This is a bit counter intuitive considering that few energy efficiency improvements have been brought to these buildings. Their good performance can be explained by the type of buildings under the management of the City (over half of them are kindergartens that are used only a few hours a day and only for part of the year), and by the fact that energy is quite expensive. While this is not a service area that is a priority for local authorities, it could still benefit from basic energy efficiency improvements, such as the replacement of inefficient light bulbs and windows. In addition, some more innovative improvements could be used for demonstrative purposes, to show households, businesses, and institutions what can be done in the field.

Background

Georgia is a Caucasus country, bordering the Black Sea to the West, Russia to the North, and Turkey, Armenia, and Azerbaijan to the South (see map below). In 2010, it had a population of around 4.45 million – down from a peak of 4.91 million in 1993. Currently, Georgia has one of the fastest population declines in the world, and it also has a lower urbanization rate than the one registered in 1991 – 52.9% as opposed to 55.1%.

Map of Georgia

Source: CIA World Factbook

For much of the 20th century, Georgia was part of the Soviet Union and its urban areas developed as part of a centralized system, where planning decisions were taken from the center. As such, its cities have developed in quite an idiosyncratic ways. For one, the country did not develop a proper system of cities, with urban areas of varying sizes. The capital, Tbilisi, with 1.2 million people amasses about 26% of the country's population. It was followed from a distance by Kutaisi, with around 232,000 people. Basically, Tbilisi was considered to be a regional capital in the Soviet Union, with resources allocated accordingly, while the other cities in Georgia got "lost" in the immensity of Soviet Empire.

Following the dismantling of the Soviet Union in 1991, Georgia gained its independence and became economically self-reliant. This also meant that the economic ties and flows it benefited from within the Soviet Union got lost. All of the sudden subsidized oil and natural gas became a thing of the past, and traditional markets for Georgian producers were separated by a national border. This has led to one of the most dramatic economic declines of any former communist countries, with the GDP dropping 75% from 1989 to 1993. This economic downturn has hit urban areas particularly hard, with most of them losing population after 1993 because of lower birth rates, out-migration to other countries, and urban to rural migration (as people sought to eke an existence out of subsistence farming).

Population Dynamic in Largest Georgian Cities

		Population		Compounded Annual Growth
		1989	2010	
1	**Tbilisi**	**1,243,200**	**1,140,408**	**-0.39%**
2	Kutaisi	232,510	199,443	-0.69%
3	Rustavi	159,016	122,018	-1.20%
4	Batumi	136,930	121,052	-0.56%
5	Zugdidi	49,614	90,131	2.75%
6	Poti	50,569	48,000	-0.24%
7	Gori	67,800	44,929	-1.85%
8	Sukhumi	119,150	39,128	-4.94%
9	Senaki	28,900	30,284	0.21%
10	Samtredia	34,300	29,951	-0.61%

Source: World Gazetteer and authors' calculations

The economic downturn has not only affected urban demographics. Much of the urban infrastructure that was in place before the collapse of the Soviet Union started to crumble too. Without the subsidies required to keep these systems running, Georgian cities were hard pressed to keep district heating systems in place, to deliver water and electricity, to collect garbage and sewage.

Following the 2003 Rose Revolution, Georgia has seen a major resurgence. The economy has started to grow at healthy rates, investments in urban infrastructure, particularly in Tbilisi, have helped improve quality of life in cities, and the road to reform was opened wide. In fact, the World Bank considers Georgia to be one of the world's top

reformers because of the fast progress it has made in recent years. Thus, in the *Ease of Doing Business* rankings, Georgia jumped from the 112th position in 2005 to the 18th position in 2006. Currently, Georgia is ranked 16th in the world, although it ranks even higher on sub-categories – i.e. it is ranked number 1 in terms of ease of registering property, and number 4 in terms of ease of dealing with construction permits.

National Energy Efficiency Strategy

Like most countries in Easter Europe, Georgia has a very energy intensive economy. In 1993, at the peak of its energy use, Georgia had one of the most energy intensive economies in Europe – about 5 times more intensive than the economies of France, the UK, Germany, Spain, and Italy (see figure below).

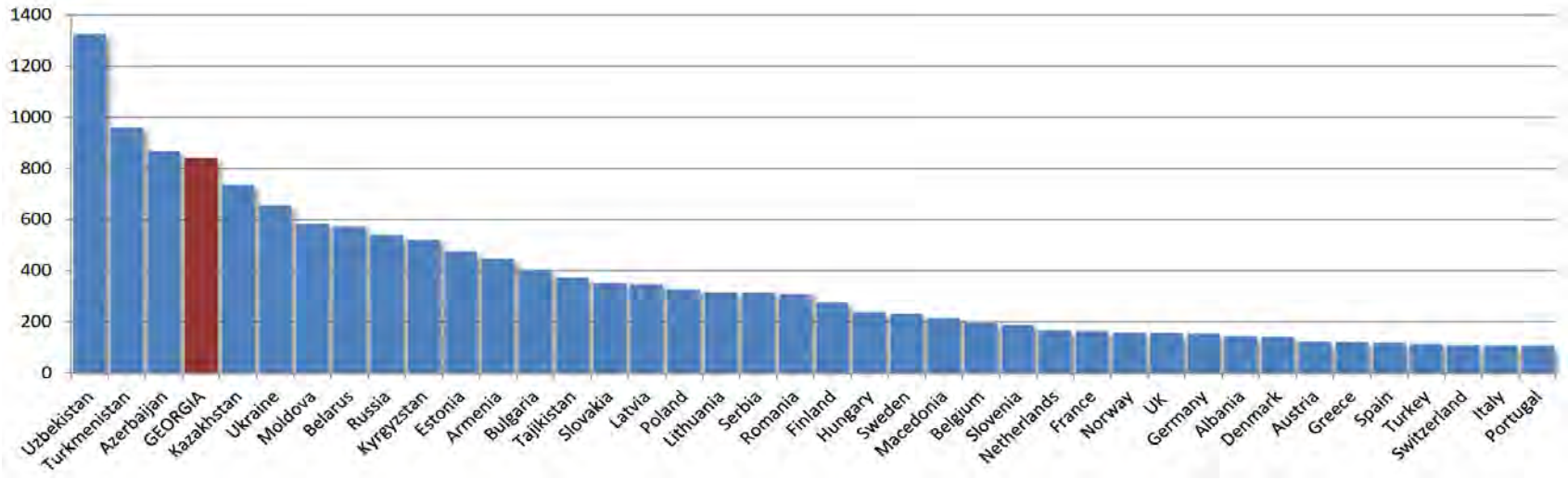
The transition years of the 1990s were, like in most of Europe and Central Asia (ECA), followed by wide-spread de-industrialization and economic decline, and by a decrease in energy intensity. Still, in 2009 Georgia continued to have a more energy intensive economy than every country in Western Europe, with the exception of Finland. Much of the country's energy needs (over 60%) are covered from imports, and while this share has decreased over the years (from around 83% in Soviet times), they represent a significant burden on the country's economy. Thinking about energy efficiency should thus be a priority for both national and local policy makers.

In addition to economic and political considerations, environmental concerns play an increasingly important role. As the Georgian economy started to recover in the new millennium, so did CO_2 emissions, from a low of 0.73 tons/capita in 2002, to 1.38 in 2009. While GHG emissions per capita are still relatively low, the intensity of emissions for every dollar of GDP generated in Georgia remains much higher than in most Western European countries.

Nonetheless, Georgian authorities have started to take first steps in making the economy more energy efficient and more climate friendly. The backbone of a more climate friendly pathway are the country's vast hydro resources – one of the highest per capita endowments in the world, with more than 26,000 rivers, with a total estimated hydropower potential of around 80 TWh. The economically viable hydro potential is around 27 TWh, of which only 20% are currently used in Georgia. The country is now committed to make a complete shift to clean electricity provision, although it will probably still be reliant on natural gas and oil imports for other energy needs.

A good part of the electricity sector in Georgia has been privatized and only transmission, dispatch, and the country's largest hydro and thermal plants are still owned by the state. By 2017-2020, it is hoped

Energy Intensity of Economy (kg of oil equivalent per $1,000 GDP at constant 2005 PPP), in 1993



that the electricity sector will be fully liberalized. The Ministry of Energy and Natural Resources, who is in charge of the energy policy in the country, has also liberalized the wholesale tariff system, and now every generation company can sell electricity to wholesale customers at negotiated tariffs. Retail tariffs (e.g. for residential, institutional, and office end-users) are regulated by the Georgian National Electricity and Water Regulatory Commission.

Many of the improvements that have been brought about in the energy sector have focused so far more on increasing and improving energy generation, rather than improving energy efficiency. It is imperative therefore that a clear energy efficiency strategy be drafted for the country, and for the largest cities in Georgia. Already the country is a participant in and signatory to several international agreements such as the Energy Charter Treaty and Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA); Framework Convention Climate Change (FCCC) and its Kyoto Protocol; European Neighborhood Policy (ENP) Energy Community Treaty. These existent international frameworks could provide a guide for making the Georgian economy more energy efficient. For example, the Energy Charter Treaty, where Georgia applied for an observer status, requires signatories to put in place energy efficiency strategies and action plans.

Georgia's current energy policy does make provisions for the introduction of an energy efficiency legal and institutional framework, using the EU model as a template. It is hoped that making greater strides towards a more energy efficient economy can also: help improve environmental and social sustainability; reduce dependence on energy imports and improve the country' external trade balance. A USAID supported study[1] recommended the following policy measures to create appropriate conditions for realizing country's energy efficiency potential:

- Develop and approve the Law on Energy Efficiency;
- Create a special designated energy efficiency authority ;
- Develop an energy efficiency strategy;
- Develop long- and short-term energy efficiency plans;
- Encourage the activity of energy efficiency organizations such as the Energy Efficiency Center and the Georgian Association of Energy Engineers;
- Support research and development in the field of energy efficiency with sound information and a strong analytical base;
- Develop the planning functionality to incorporate economic and technical factors in the country's development strategy.
- Develop energy efficiency educational programs and information campaigns.

Municipalities have been identified as one of the main driving forces for increasing energy efficiency in Georgia. They are also considered to be key in reducing environmental impacts related to energy production and use, including emissions of GHGs. Tbilisi is the first capital city in the Eastern Partnership countries of the EU to sign the Covenant of Mayors[2] and together with other important obligations, the city become responsible for organizing 'Sustainable Energy Days' every year.

Urban Growth and Energy Challenges in Tbilisi

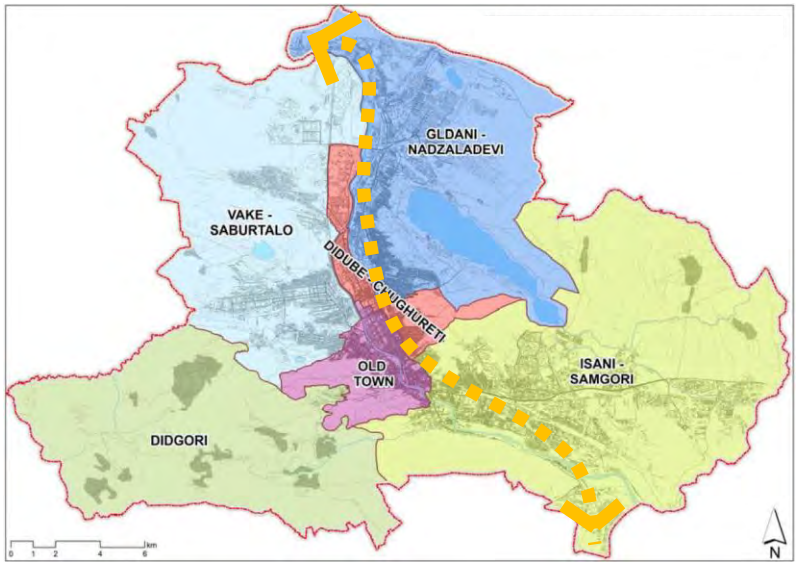
Tbilisi is not only the capital of Georgia and the most important urban and economic center in the country, but it is also an economic, political, and cultural hub in the Caucasus and Eastern Europe as a whole. Straddling the historical Silk Route, Tbilisi continues to have a strategic location at the cross roads between East and West. From Tbilisi, important transit routes for energy, information, and trade are managed.

Constraint by hilly terrain in the East and the West, Tbilisi's growth has followed a linear path along the valley of the Mtkvari River (also known as the Kura River). This growth pattern is less than ideal from an energy efficiency point of view, as it creates longer travel patterns, requires more pumping for water and sewage, and forces larger collection routes for garbage trucks.

[1] USAID 2008. Energy Efficiency Potential in Georgia and Policy Options for Its Utilization.

[2] The Covenant of Mayors is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO_2 emissions reduction objective by 2020.

Tbilisi District and Administrative Boundaries



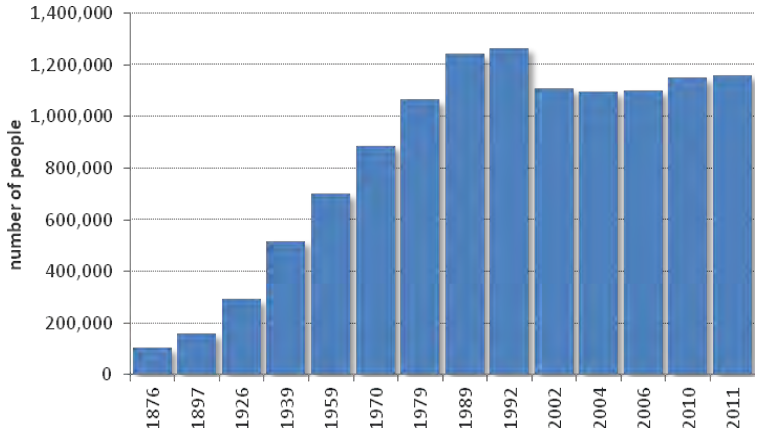
Source:http://geocities-tbilisi.ge/failebi/6678-GEO%20Tbilisi%20Report%2007.10.pdf

As far as climate is concerned, Tbilisi can be considered to be in a continental climate zone, with relatively cold winters and hot summers. The average temperature throughout the year in Tbilisi is around 12.7 °C, with average January temperatures of around 0.9°C and July average temperature of around 24.4 °C. The city receives on average 15-25 days of snow every year, and the lowest temperature registered in the city was -24.4°C, while the absolute maximum was around 40.3°C.[3]

In 2006, the Parliament of Georgia approved the incorporation of some of the surrounding villages within the territory of Tbilisi, and to provide the city with more space for urban growth.. This means that the territory of the municipality increased from 378 km^2 to about 500 km^2, resulting in a population density decrease of about 22% - from 2,937 people per square kilometer, to 2,305. Over the years, the city has continued to expand along urban development fronts in the Southeast, Southwest, and the Northwest. To accommodate this urban expansion, local authorities have drafted a new masterplan for Tbilisi in 2009 (*General Long-Term Plan of Development of the Capital City*), which stipulates that the newly incorporated agricultural and forest areas, have changed zoning to residential, opening them up to new developments.

This rapid expansion of the city, pushing new development in the North and South of the City, have put significant pressure on land and environment, rising energy needs and costs. City expansion has happened even if overall population growth in the transition years has actually been negative. In fact, research conducted at the World Bank with cities from all over the world shows that cities' urban mass grows on average faster than actual population growth. With an increase in motorization rates, with expansion of public transportation options, and with a growth in incomes, more and more people now afford to live further from city centers.

Population Growth in Tbilisi



Source: Data on the population during 1897-1989 have been taken from the Tbilisi City Hall Document – Tbilisi Municipality Economic Development Plan (2006), www.tbilisi.gov.ge; data for the period 1989-2010 have been World Gazetteer http://website.informer.com/visit?domain=world-gazetteer.com and data for 2011 is obtained from State Department Statistics available online http://www.citypopulation.de/Georgia.html

[3] http://geocities-tbilisi.ge/failebi/6678-GEO%20Tbilisi%20Report%2007.10.pdf

As evidenced in the figure above, Tbilisi has witnessed its most dramatic population growth during the Soviet times, and this growth has happened in a particular fashion. For one, new neighborhoods tended to be quite dense, made up of high-rise prefab apartment blocks, they were usually developed around and along public transportation routes (few people owned private cars back then), they were serviced by a district heating network, and they were connected to basic services like water and sewage. The economic downturn that followed the dismantling of the Soviet Union has hit the city hard. The population basically peaked in 1992, and afterwards the city has seen a prolonged demographic decline.

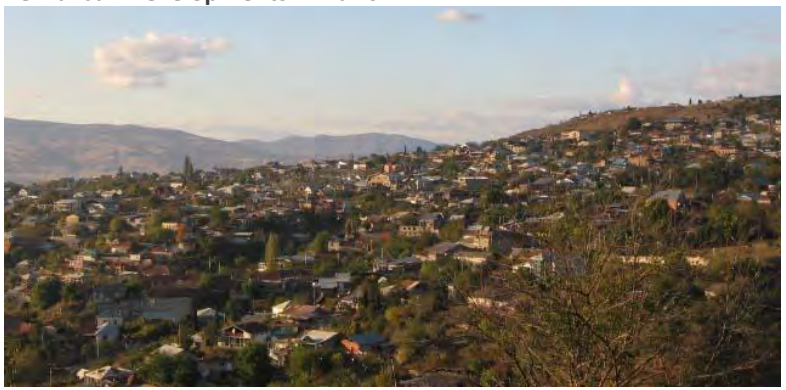
Following the 2003 Rose Revolution, economic conditions have improved considerably, and the city has witnessed a resurgence since, with massive overhauls of infrastructure networks, continued investments towards improving quality of life, and a number of administrative reforms that have, among others, reduced corruption considerably.

This economic resurgence also meant a new development wave. For the most part, Tbilisi has not witnessed the same level of aggressive suburbanization that other cities in Easter Europe have witnessed (e.g. Bucharest and Warsaw), and many new buildings are actually in-fill developments that make the city more sustainable (see image below)

In-fill Development in Tbilisi

Not all new development has followed a sustainable pattern though. Many of the neighborhoods in the Northeast part of the city are generally poorer and have seen a continuous addition of individual housing units that go further and further up the surrounding hills. These new developments have to be connected to the public services infrastructure, and the costs of delivering services to these low-density high-altitude areas is higher than in the low-lying high-density areas along the banks of the Mtkvari River.

Peri-urban Developments in Tbilisi

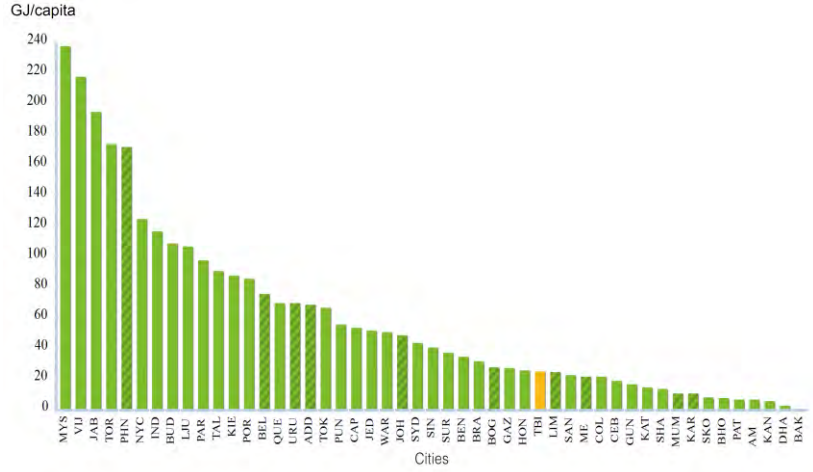


The more a city loses in density, the more energy intensive it becomes. On the whole, Tbilisi consumes less energy per capita than other cities in the TRACE database (see first figure below), and much of it can be attributed to the massive de-industrialization that followed 1993. However, its economy is still more energy intensive than that of most cities with pertinent data in the TRACE database (see second figure below). Thus, for every unit of GDP, Tbilisi consumes more energy than Toronto, New York, or Tokyo. As the city is expanding, other energy challenges are likely to appear.

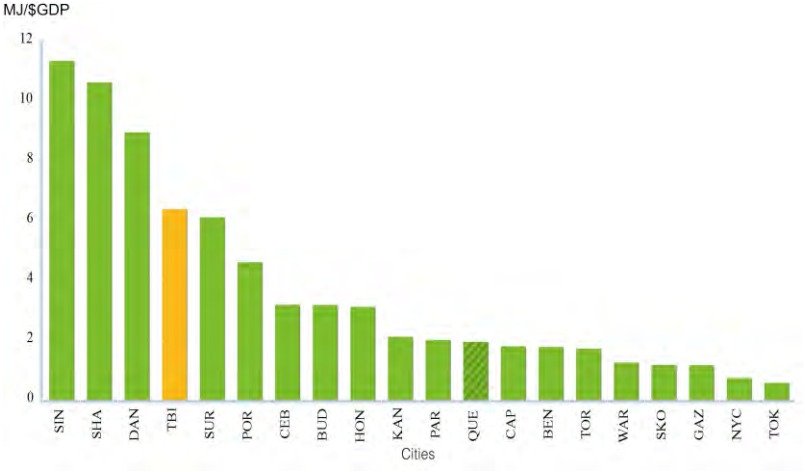
These realities have not gone unnoticed within the city, and local authorities recognize the significant potential of increasing energy efficiency and reducing the environmental impacts related to energy production and use. Consequently, the City has taken initial steps to address the problem.

In March 2010, the Mayor of Tbilisi signed the Covenant of Mayors, an initiative of the European Commission that aims to reduce Carbon Dioxide (CO_2) emissions by at least 20% until 2020.

Primary Energy Consumption per Capita (GJ/capita)



Primary Energy Consumption per GDP (MJ/$GDP)



In order to achieve this goal, the City has elaborated a "Sustainable Energy Action Plan (SEAP)" for 2011-2020, which was approved by the city government on 28 March 2011[4]. Three main energy sectors are discussed in the SEAP: urban transport, buildings and infrastructure (municipal waste and waste water management treatment, street lighting, electricity and gas distribution networks, and green spaces).

A Strategic Plan for Future Development of Tbilisi has been developed based on the Baseline Emission Inventory (BEI) for 2009 and the projection of the increase in CO_2 emissions by 2020 using the SEAP framework. The priority areas identified in the Strategic Plan include: the development of the transport sector; improvement of electricity and heating supply in the city; development of other infrastructure such as water supply and municipal sewage system. In addition, the Plan focuses on the development of green spaces that will result in an increased number of sources for absorbing CO_2 emissions in the city territory.

[4] http://aarhus.ge/uploaded_files/1cf57029e2b73b645fddb7e6b1c1df90d560a1a3cdf29ea1c729b18b5e94292f.pdf

Sustainable Tbilisi

While this report focuses specifically on energy efficiency issues, its scope is broader than that. The TRACE (Tool for Rapid Assessment of Energy Efficiency) diagnostic tool is just one component of the Europe and Central Asia Sustainable Cities Initiative (ECA SCI), which aims to see how cities in ECA can become more sustainable. Consequently, the discussion in the following analysis and recommendations will look beyond energy efficiency issues.

Much of the data required to run the TRACE tool was already collected by the City of Tbilisi for the completion of its SEAP report, which made the task of running the TRACE tool for Tbilisi much easier. To a large extent, the data required to assess greenhouse gas (GHG) emissions abatement potential can also be used to assess energy savings potential – lower energy use translates into lower emissions. However, some indicators required by TRACE were not available in the SEAP analysis, and had to be collected individually during an October 2011 mission to Tbilisi. Benefiting from an excellent collaboration with local authorities, all remaining indicators were collected or were attributed estimated proxy values.

The TRACE work comes to complement the work done by local authorities on SEAP, and it re-enforces the City's commitment to pursue a sustainable development path. The benefit of the TRACE analysis is that it adds an economic point of view to the environmental perspective that is at the core of the SEAP framework. Thus, whereas SEAP focuses on GHG abatement potential, TRACE helps determine energy and cost savings potential in six service areas that are traditionally under the control of local authorities. Moreover, TRACE allows the prioritization of energy efficiency investments, based on cost saving potential, and drawing on a list of recommendations that range from low-cost to high-cost.

At the core of TRACE is a "live" database, which is continually updated with city indicators from all over the world. The current database has indicators for around 65 global cities and was used to benchmark Tbilisi's performance in urban transport (public transport and private vehicles), water and wastewater, municipal buildings, solid waste management, public lighting, and power and heat. The findings are discussed below.

Public Transport

Public transport is one service area in the City of Tbilisi that has witnessed a dramatic resurgence in recent years. It is also one of the sectors in the city that has been most hardly hit by the transition years. When the Soviet Union dismantled, Tbilisi had an extensive public transportation network consisting of a metro system (with two lines and 27 kilometers of double track), a bus system, and a tramway.

The economic and financial difficulties that came with independence caused the public transport system to gradually and systematically fall apart. In the early 1990s, the metro was mostly not working because electricity supply was either poor or non-existent. After that service would frequently interrupt due to power outages. The public bus fleet all but vanished, with just around 50 buses being left in 2004, to service over 1 million people. The tramway system, consisting of 54 km of lines, suffered the worst fate, being completely taken out after the 2003 Rose Revolution. All that remains of the old tramway network are photos like the one below.

The Old Tbilisi Tramway

Source: http://www.pmpvideo.fsnet.co.uk/stills/741.htm

Starting in 2004 however, massive improvements have been brought to public transport. Many of the metro underground stations have undergone renovations, power outages are a thing of the past, and there are several projects underway to improve conditions and comfort in the metro cars. There are however, many things that still remain to be solved. For example, the rolling fleet (a total of 170 cars servicing 22 stations) is quite old (on average 25 years) and not the most energy efficient. This begets particular consideration considering that the Tbilisi metro system is the biggest single electricity consumer in the country. Furthermore, while some metro stations have been renovated, some have seen better days, and many of them do not have proper signage. Moreover, only a few metro stations have signage and directions in English, making it quite difficult for foreigners to get around.

Tbilisi Metro

The bus system has seen the most dramatic improvements in recent years. Before the 2003 Rose Revolution there were few publicly owned buses left to run in the city, and people's transport needs were covered by a growing number of unlicensed minibuses and taxis. Starting in 2004, particular attention was paid to expanding the bus system.

Thus, by 2009 the number of city-owned buses grew to 934 – 17 times more than in 2004. In addition to increasing the number of publicly owned buses and improving conditions in those buses, measures have been taken to integrate the publicly run system with the privately run one. The City has organized an open tender to select 4 private companies that will run routes determined by the municipalities. The number of operators was thus reduced from the previous 56, with a number of conditions set to improve overall efficiency. Thus, the 4 selected private bus operators will have to renew their entire fleet by the end of 2011, and tariffs will be set at the same level for both public and private operators.

Tbilisi's New Yellow Buses

The 2011 Tbilisi Sustainable Energy Action Plan (SEAP) for 2011-2020, includes another host of measures that have been recommended to local authorities. Some of those have already been implemented, or are under implementation. One of the measures is quite innovative, and according to local authorities quite efficient in boosting public transport ridership. It is also relatively inexpensive and relatively simple to implement. It basically consists of a network of electronic display boards (see image below), placed in all of the major bus stops, which tell potential riders when the next bus will arrive.

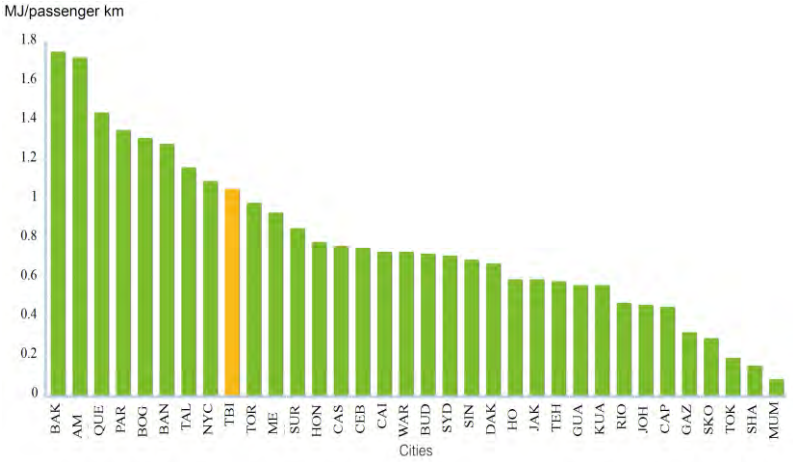
Such a system has worked wonders in increasing public transport ridership, as people know exactly how long they have to wait for their bus. Without such a system in place, and with sporadic service, many people might prefer to just take a taxi or their private car. To allow for accurate display times, all buses have been equipped with GPS systems, which monitor their progress along routes. This GPS system can also be used to monitor daily travel patterns and improve routes to reduce fuel consumption.

Electronic Display Board in Tbilisi Bus Stop

The fact of the matter is that although many improvements have been brought to the system, energy consumption in public transport is still comparatively high (see figure below). Part of this can be explained by the fact that the date used to run the TRACE tool is from 2009, when many of the improvements existent in the system today were not present. Overall, private bus operators ran buses that were not only considerably old, but also highly energy inefficient. Moreover, since there are no environmental restrictions for newly purchased cars, the Yellow Bus fleet that is now run by the city is not equipped with the latest in engine technology although it is quite new.

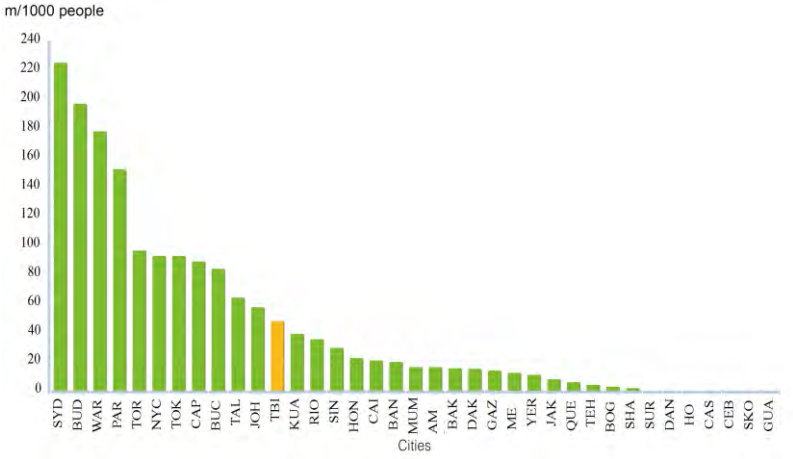
In addition to energy efficiency improvements, there are plans underway to continually expand the system, so that more and more people come to rely on public transport. Right now, most people are within 300 m of a public transport station, but local authorities plan to lower that distance even more and to increase service speed and quality. One particular measure that was recommended in the Tbilisi SEAP was the re-introduction of the tramway line.

Public Transport Energy Consumption (MJ/passenger km)



As can be seen in the figure below, Tbilisi does relatively well in terms of available high-capacity transit infrastructure – all on account of the metro lines. However, if its tramway lines would still be in place today, Tbilisi would rank better than New York City in term of meters of high capacity transit per 1,000 people.

Meters of High Capacity Transit per 1,000 People (m/1000 people)



In 2010, the City has contracted a consulting company to conduct a feasibility study for a new tram network. The network will consist of three lines with a total length of 55 km (about the same as before), and it is predicted to be operational by 2015.

Private Vehicles

There are two forms of the verb 'have' in Georgian. One ('mkavs') is used for living breathing things (e.g. relatives, friends, pets), one ('makvs') is used for inanimate objects (e.g. table, TV, house). There is just one exception: when someone says 'I have a car' they use the first verb form. 'Car' is basically the only inanimate object that 'mkavs' is used for. This is just one indicator of how Georgians in general feel about their cars.

In fact, Georgia as a whole, and Tbilisi in particular has quickly become a car oriented culture. A 2008 survey quoted by the Tbilisi SEAP indicates that a large majority of people in Tbilisi had a strong preference to owning a car and avoiding public transport. Most of the respondents (87%) that did use public transportation claimed they did so simply because they did not own a private car. The large majority of private car owners indicated that they preferred to use their cars for time-saving reasons and for convenience. In the same vein they expressed a reluctance to using public transportation because they saw it as being pricy, comfortless, slow, and unpredictable.

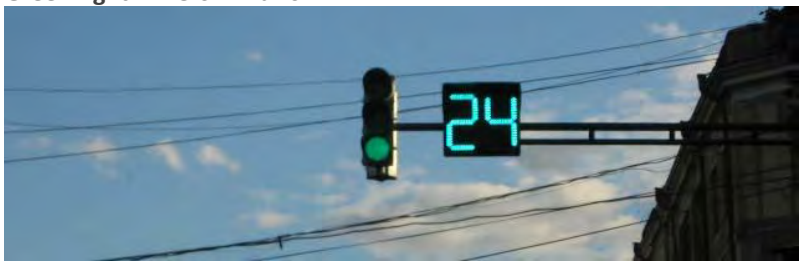
As it is to be expected, and following a trend encountered throughout Easter Europe, the number of private cars has dramatically increased in Tbilisi, especially as the economy has started to pick up. In 2000 there were 80 cars per 1,000 people in the city. By 2009, that figure more than doubled to 205 cars. And, these are only the cars that are registered in Tbilisi. The actual number is considered to be even higher as many people from surrounding areas commute in for work, and there are a large number of unlicensed taxis (driven by people from surrounding villages as a way of generating an income).

The large majority of cars in Tbilisi are old (41% of them are 20 years or older), and they are highly fuel inefficient and polluting. Since there are no laws in place restricting vehicle emissions, people usually buy second-hand cars that run on leaded petrol (which is cheaper then unleaded gas). Moreover, people destroy the catalytic converters of newer imports from Europe, so they can run them un-leaded gas. As a consequence, Tbilisi is now not only a congested city (see image below), but also a very polluted city.

Congestion in Tbilisi

For the most part, local authorities have not managed to curb car use. There are several measures in place aimed at improving traffic conditions (e.g. Green Wave systems on main boulevards), and several investments (e.g. road rehabilitation, new roads development, the introduction of roundabouts, or green-light timers) were done do de-congest streets, but these have not kept up with the dramatic increase in car ownership and car use.

Green-light Timers in Tbilisi



Traffic is also worsened by Tbilisi's urban form. Since it is situated in a valley, the city has grown along a linear path, which makes for long trips between the North and the South of the city. In addition, there are two barriers (the Mtkvari River and the railway line), which hinder traffic flow from the East to the West. With few bridges over the river and few railway crossings, cars often have to travel a substantial distance to get where they need to get.

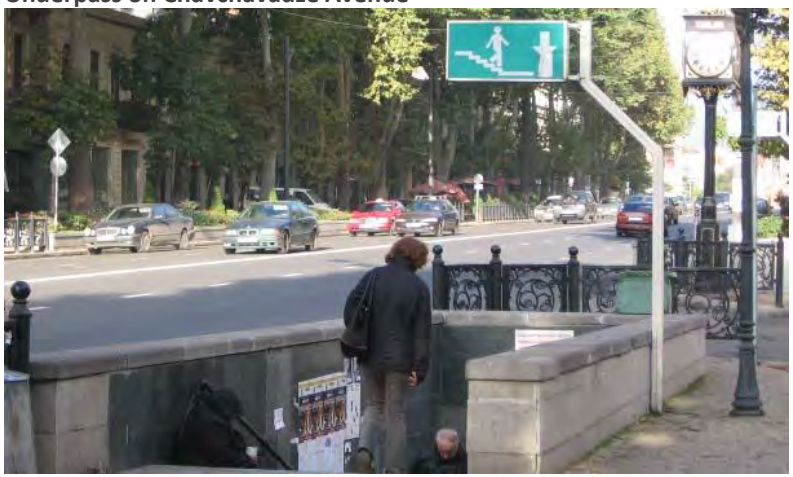
Not only is traffic bad in Tbilisi, but some of the measures aimed at easing traffic have actually worsened conditions for pedestrian and bicyclists. For example, some of the major intersections in the city have roundabouts that allow for smoother car traffic, but they have no pedestrian crossings. People that are on foot or on a bicycle have to basically brave traffic conditions and slalom between cars to get from one side of the street to the other.

Moreover, several of the main avenues in the city have underpasses instead of pedestrian crossings. This in itself is good for car traffic and for the overall energy performance of individual vehicles (with less stops being required), but it creates less than ideal conditions for pedestrians. For one, the distance between underpasses is often quite large (it would have been un-economical to have a more frequent distribution), and people are often forced to take a considerable de-tour when trying to cross to the other side. As can be seen in the image below, the distance between two such underpasses on Chavchavadze Avenue is 400 meters – quite a hike even for the most fit people. On the other hand, underpasses are not the most friendly places at night, and many people avoid them because of that. Consequently, to avoid detours and dark underpasses, many people cross the avenues in full traffic, risking injury and potential accidents.

Available Crossings on a Portion of Chavchavadze Avenue

Pedestrians are not only crowded out on streets, but they are now increasingly crowded out on sidewalks. With the dramatic increase in car ownership and car traffic to the city, local authorities have been hard pressed to create and provide appropriate parking spaces. In 2010 there were around 11,600 approved parking spaces in the city, many of them taking sidewalk space away from pedestrians (see image below). Since the allocated parking spots are not enough to fulfill all the needs, many people simply park on sidewalks illegally.

Underpass on Chavchavadze Avenue



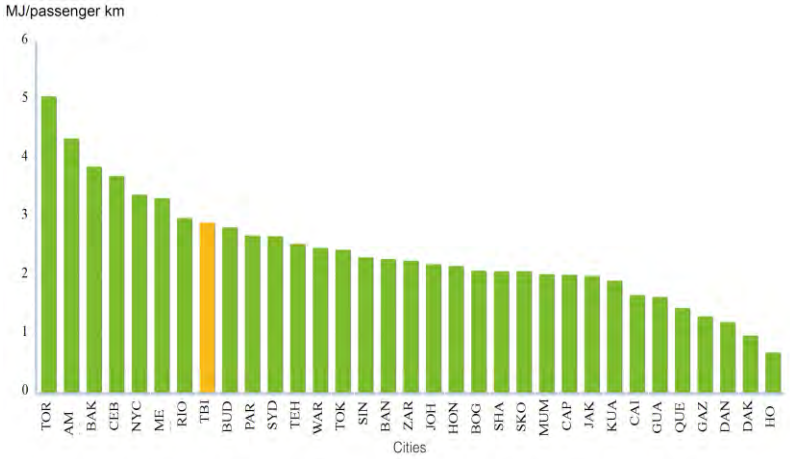
Sidewalk Parking Spots in Tbilisi

The City has signed an agreement with a private company, which was tasked to take on parking management in the City. There are also plans to develop several parking structures, and all new multi-story buildings

have to also provide underground parking. Such measures will likely help address the parking situation in the city, but a well-known conundrum will still have to be faced by local authorities: the more parking spaces are provided, and the more easy it is to travel by car, the more people will chose to drive instead of taking public transportation or using non-motorized modes of transportation (there are basically fewer disincentives for them to do so).

If better conditions for car drivers are created, it would make sense to also create better conditions for public transportation (which is actually happening) and for non-motorized modes of transportation (which is less emphasized in the City's transport policy). The easier it will be for people to use alternative modes of transportation, the more they will come to rely on cars. As can be seen in the figure below, relative energy consumption by private cars is quite high in Tbilisi.

Private Transport Energy Consumption (MJ/passenger km)



This is enabled not only by old and energy inefficient cars, but also by increasingly bigger cars. As the Tbilisi SEAP indicates, the average car size in Tbilisi has been growing continually, and so has fuel consumption – with an average of 12 liters per 100 km. The average distance travelled by private cars was 35 kilometers in 2009, with an average occupancy of around 1.85 people per car.

To be fair, the conditions for developing an extensive and integrated bicycle network in Tbilisi are not exactly ideal. The terrain is quite hilly, traffic is heavy, and people are generally not used to biking. On the other hand, many of the city's large linear boulevards could easily accommodate a bike lane, and on-street parking could be organized so that it shelters bicyclists from traffic. The City plans to develop a few bicycle lanes, on a pilot basis, which could be expanded depending on use and demand.

Pedestrian Streets in Tbilisi's Old City Center

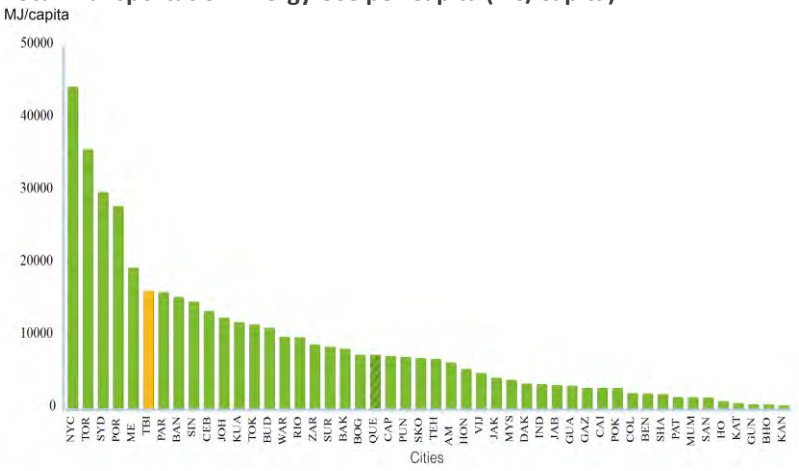
The Bridge of Peace over the Mtkvari River

The conditions for developing better pedestrian infrastructure are also not ideal. The city has many dense areas that can easily be tackled by

foot, and some, like the Old City, are much more amenable and pleasurable for an easy stroll. However, the city's elongated configuration, as well as its topography, often make it hard to get from one neighborhood to another. For example, getting to the Saburtalo from Vake, or more specifically, from Chavchavadze Ave. to Vazha-Pshavela Ave. is almost impossible to do by foot, although the distance is only around 1.5 kilometers (or a 20 minute walk).

Some measures have been taken to improve conditions for pedestrians. Thus, many of the streets in the Old City center have been closed to cars (see image above). Also one of the newest and most impressive landmarks of the city is a new pedestrian bridge over the Mtkvari River. The Bridge of Peace, as it has been dubbed, is 150 meters long and connects the Old City to the new district, making it easier for pedestrians to visit the city's cultural heritage sites.

Total Transportation Energy Use per Capita (MJ/Capita)



Such measures are only a drop in the bucket, and much more can be done to encourage more people to use alternative modes of transportation. Overall, energy use in the transport sector in Tbilisi is remarkably high – higher than in most developing cities with pertinent data in the TRACE database. The only developing city that has a more energy intensive transport sector is Mexico City; the others are from North America or Australia.

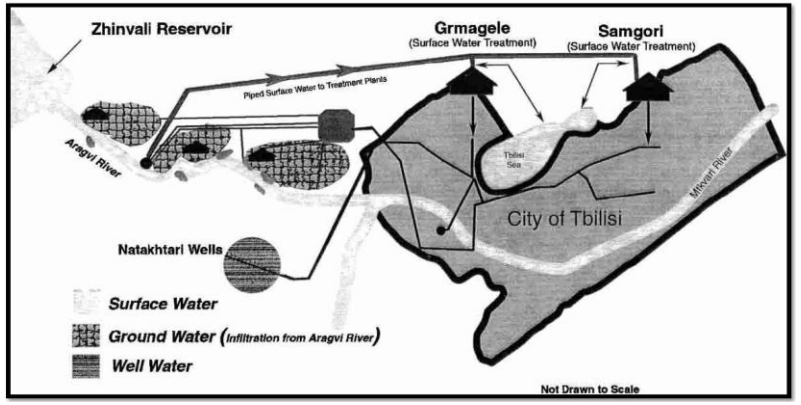
One of the priorities of local authorities in Tbililsi is to increase the importance of public transportation to the detriment of private cars. Another priority should be to increase the availability of non-motorized transport options, and foster the creation of a pedestrian and biking culture.

Water and Wastewater

In 2009, the Government of Georgia has drafted a Water Supply and Waste Water Sector Development Policy, which spells out some of the main directions in which the sector is hoped to move. Among other things, there is an emphasis on increased efficiency, infrastructure and service quality improvement, cost recovery and financial sustainability of utility companies, and proper access to these basic services by the poor and vulnerable.

Within Tbilisi, the City's Strategic Plan makes special reference to infrastructure improvements of the water supply and sewage systems. In particular, improvements are envisaged to the wastewater system, with a focus on the construction of additional collector lines and the upgrade of the Tbilisi-Rustavi wastewater treatment plant.

Tbilisi Water System



Source:
http://envstudies.brown.edu/theses/archive20092010/IrmaMelikishviliPP.pdf

In 2008, the water and wastewater utility company in Tbilisi was tendered for privatization. Up to 2008, the water and wastewater system

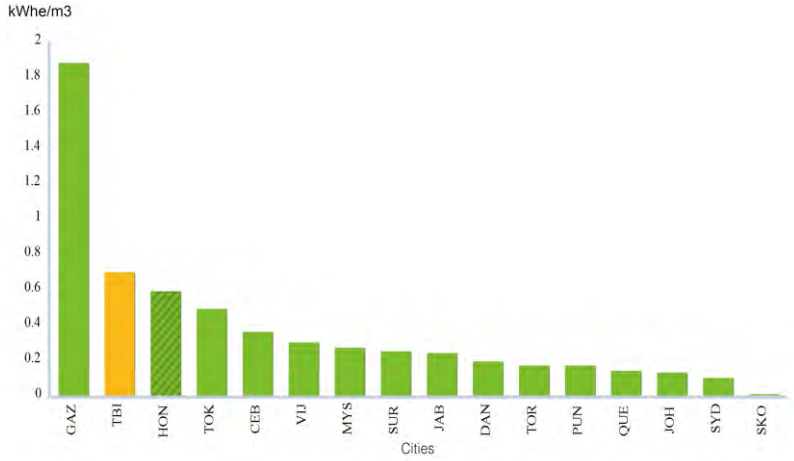
in Tbilisi had, according to IBNET, a very high water consumption rate and only a fraction of end consumers (8%) were metered. The final selection for the privatization process was done not only based on the final price offered for the existent assets, but also based on planned investments, and future tariff scenarios. Since tariffs were doubled in January 2008, from 1.2 GEL/person/month to 2.4 GEL/person/month, local and national authorities considered this to be a sensitive social issue. Consequently, the winning bid was selected not based on the highest price for the assets, but based on the lowest anticipated tariff increases.

Right now Georgia Water and Power (GWP) is a fully privatized utility company, serving about 400,000 customers, 2,000 of which are budget organizations, 15,000 are commercial enterprises, with the rest being residential customers. It has a water supply network of 3,600 km and a sewage network of 1,600 km. Water is drawn from underground and surface sources. Underground water is pumped up from the Aragvi Gorge and the Natakhtari Wells, and is considered to be fairly high in quality, requiring almost no treatment. Surface waters are drawn from two reservoirs (Zhinvali and Tbilisi Sea) and then further treated in the Grmagele and Samgori water treatment facilities. The treated water is then transported and collected in water supply tanks spread throughout the city. High-capacity pumping stations are used to deliver the water to end consumers and to control pressure in the system.

Overall, the Tbilisi water system is very energy intensive. When compared to other cities in the TRACE database, it shows up as having one of the highest energy expenditures for every cubic meter of potable water produced (see figure below). GWP operates 141 pressure pump stations, equipped with engines of 4 to 75 kW. These pumps are used both to draw water and to deliver water to end customers. Tbilisi is situated in a hilly terrain with many variations in altitude. Consequently, water pressure throughout the city has to be adjusted accordingly. Moreover, the city has many high-rise apartment flats, which require an additional 1,000 pumps to deliver water up to the last floors.

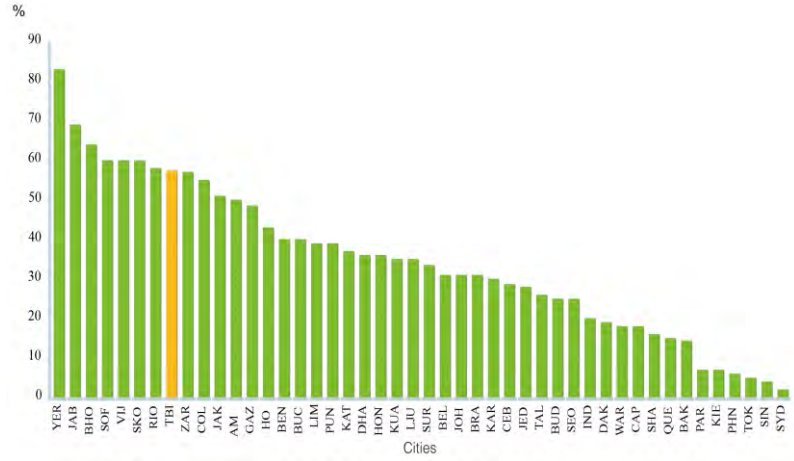
However, while the Tbilisi water system is energy intensive, the energy itself is not a big cost item for GWP. The company owns two hydro-plants (Zhinvali and Tetrikhevi), which not only cover its own energy costs, but also produce surplus energy which is sold to the grid.

Energy Density of Potable Water Production (kWhe/m^3)



Because of that, there are few incentives for GWP to make the system more energy efficient. In fact, efficiency overall has suffered, with the share of non-revenue water growing from 42% in 2008 (IBNET), to 57% in 2010. When compared to other cities in the TRACE database, Tbilisi showed up with one of the highest shares on non-revenue water (see figure below).

Percentage of Non-Revenue Water (%)



The company hopes to none-the-less increase efficiency in coming years, by investing in the rehabilitation of the existent infrastructure, and by introducing water meters to all end-consumers. By the end of 2011, GWP hopes to install over 50,000 water meters. In addition, the company is running information campaigns, encouraging people to use water judiciously. Among other things, people are informed that just one faulty toilet can waste as much as 600 liters of water per hour, or a staggering 5,256,000 liters of water per year – the equivalent of two Olympic-sized swimming pools. Proper metering will act as a further incentive for people to save water and install more efficient faucets, toilet bowls, and shower heads, as they will have to pay for all the water that goes to waste.

As far as sewage is concerned, over 97% of people in Tbilisi are covered by a sewage network, and the city is serviced by a wastewater treatment plant at Gardabani. The plant was developed in 1986 with a capacity of 1.0 million m^3/day, and in recent years it did little more than just mechanical cleaning of the discharge water. In 2008, the treatment plant suffered a malfunction leading to a situation where most generated wastewater is now being dumped raw in the Mtkvari River. There are plans to rehabilitate the wastewater treatment plant, with the introduction of full biological treatment, but it is unclear when these plans will be finalized. As of 2011, none of the received wastewater was being treated, with the "benefit" that no energy was spent in the sector either.

Solid Waste

Georgia does not have a specific Solid Waste Management law, and disposal of household waste is left at the discretion of local authorities. Consequently, there is no regional solid waste management system in place (which could try to take advantage of economies of scale), and waste is most often dumped openly without any further treatment.

Even Tbilisi, the largest urban agglomeration in Georgia, was serviced by 4 individual landfills in 2004 – Gldani-1, Gldani-2, Lilo, and Iagluja. None of these landfills had even the most basic protection systems in place (e.g. fencing to restrict access of scavengers and cattle), and they completely lacked environmental infrastructure (e.g. leachate collection and treatment, or methane capture).

Starting in 2006 however, the SWM system in Tbilisi was significantly revamped, with important investments in a range of areas. Thus, all of the four old landfill were closed and a new one, servicing all of the Tbilisi region, was opened in 2011 – the Norio Landfill. The new landfill is designed to not only handle the waste currently generated in the area (around 310 kg/capita/year in 2010), but also anticipates a growth in waste quantities due to increased consumption, population growth, and the inclusion of other surrounding communities in the Tbilisi service area.

All these investments have helped create a SWM system that is quite energy efficient. Thus, there are around 10,000 new metal garbage cans spread through-out the city, and measures have been put in place to prevent illegal dumping. The waste dumped in these garbage cans is collected by 220 garbage trucks.

Garbage Truck in Tbilisi

In 2009, local authorities have invested in the optimization of waste collection routes, and every time new cars are added to the system the collection routes are updated. The optimization of waste collection routes also included the introduction of a transfer station at Beliashvili. Up to that point, garbage trucks would collect the waste and transport it all the way to the landfill. With the introduction of the transfer station, around 70% of collection trucks consolidate waste in larger transfer trucks, which then do the final transport to the landfill. 30% of collection

trucks, those that run routes closer to the Norio landfill, go straight to the dump site, which is about 25 km away from the city.

The transfer station has allowed fuel savings of around 20% since its introduction, and it was designed to accommodate future city growth. Further energy savings were made possible by investments in a new vehicle stock. All of the 20 larger transfer trucks are new and energy efficient. Of the 220 collection trucks, around 120 are new and equipped with energy efficient engines – the other 100 are somewhat older. For the same volume of waste transported, old garbage trucks used around 55 liters of fuel per 100 km, whereas the new cars consume only 35 liters. By replacing the remaining 100 older garbage collection trucks, local authorities hope to make even more energy savings possible. They plan to acquire garbage trucks with a lower horse power, as these consume less fuel.

The landfill itself is also a major improvement from the old state of affairs. Thus, the perimeter is all fenced in, preventing the access of scavengers and cattle. All incoming trucks are weighed at the gate for proper monitoring of waste streams. The waste itself is dumped in individual cells (see image below), rather than just being dumped openly.

Waste Cell at Norio Landfill

The waste cells are equipped with protective linen that prevent the contamination of the soil and groundwater with leachates, and with a drainage system that collects the leachate in a treatment pool. The waste collected in individual cells is covered with soil at regular intervals, and all cells have been equipped with methane capture devices (see image below). As of now, there are no plans to use the captured methane for productive purposes. All of the captured gas will instead be flared to avoid emission into the atmosphere and potential spontaneous ignitions and explosions.

Methane Capture Devices at Norio Landfill

Another key improvement to the SWM is of a financial nature. The way the system is operated now, all of the costs are covered from waste tariffs. Moreover, the collected tariffs permit further investments in infrastructure upgrades and the procurement of new equipment. The way waste tariffs are collected is quite ingenious. Since there is no clear way to determine how much waste each individual client is generating, they are charged according to a pre-determined proxy. For example, households are charged a percentage of their electricity bill ($0.03 for every kWh consumed). It is thus assumed that people who use more electricity, do not only generate more waste, but they also are more likely to afford a higher tariff. Commercial users and institutions are billed at a higher rate, according to a system of 29 different proxies. For example, restaurants are charged based on the number of chairs available in their establishment, hospitals are charged based on the number of beds, while office buildings are charged based on their floor area.

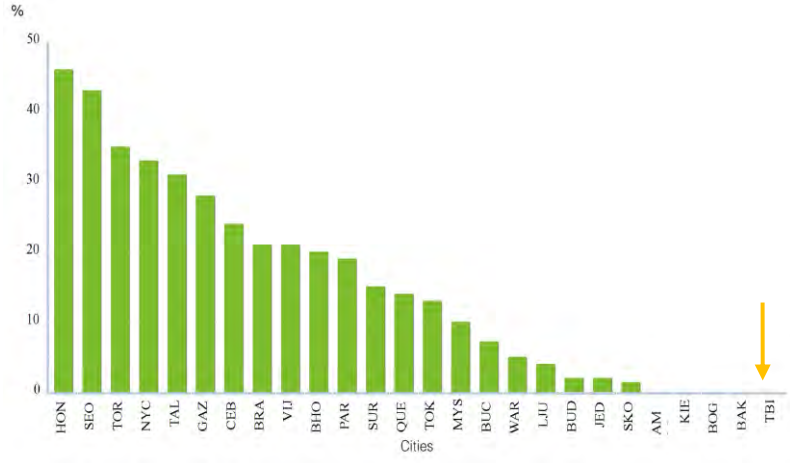
The enforcement of waste tariffs is also very good. Since all utility bills are connected to the electricity bill, the consumers that don't pay their bill risk to be cut off from all utilities. Such instances are rare since tariffs for households are still relatively low, while commercial and institutional users have not openly complained about the higher tariffs

they had to pay with the introduction of this system. As a positive side-effect, such a system helps reduce energy consumption all-around, especially in the residential sector, as a lower electricity bill will ultimately translate into a lower bill for the other utilities as well.

The negative side-effect of such a measure is that while electricity will be used more judiciously, other services will not. There are therefore plans to introduce better metering and tracking of how individual services are used.

One of the things that is conspicuously missing from the Tbilisi SWM system is proper recycling. Basically, none of the generated waste is recycled and used for economic benefit – not even by the informal sector. There are plans to introduce a waste separation facility at the landfill, to utilize recyclables for economic benefit and to reduce the amount of waste that ends up being landfilled. As of now, local authorities have identified markets for recyclables like paper and plastic, but not for glass and metal.

Percentage of Waste Recycled

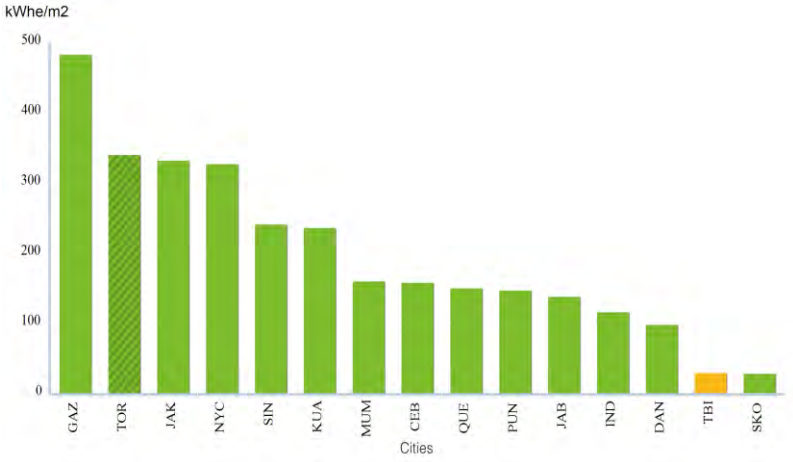


Another SWM efficiency issue is ties to the access road to the Norio landfill. In October 2011, the road was in particularly bad shape, leading to higher fuel consumption by garbage trucks (these had to dodge pot-holes and drive around road sections that seem to be missing).

Municipal Buildings

There are around 200 public buildings in Tbilisi that come under the immediate care of local authorities. These municipal buildings can be divided in the following categories: educational and cultural facilities; sports facilities; health care facilities; administrative facilities. Of these, almost half are represented by kindergartens (schools are under central government control).

Municipal Buildings Electricity Consumption (kWhe/m^2)



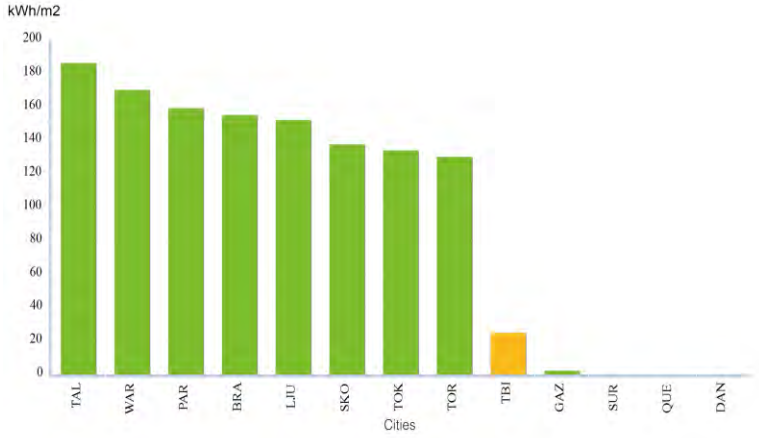
Technically, the energy performance of these buildings should be quite poor. There have been no major rehab works done to them, there were very few energy efficiency interventions over the years, and existent infrastructure (e.g. boilers) is often old and poorly performing. However, when municipal buildings in Tbilisi are compared to municipal buildings from other cities with pertinent data in the TRACE database, Tbilisi actually shows up as a star performer. Both in terms of electricity and in terms of heating, Tbilisi municipal buildings do quite well.

A look at the image above indicates that only Skopje (Macedonia) has a lower electricity consumption per square meter. Several explanations

can be found for this occurrence. For one, kindergartens represent a significant share of municipal buildings in Tbilisi. Educational buildings in general are not continually used (only when school is in session), and kindergartens in particular have a reduced program (thus they require less energy inputs). Other types of municipal buildings (e.g. hospitals), are used 24/7 and all-year round, and they are likely to have higher electricity bills. The fact that electricity is delivered at market prices could also constitute an incentive to save energy. Finally, other cities may rely more on electricity for generating heat. In Tbilisi, only an estimated 14% of all electricity needs go to heating (a relatively small share), with the rest being used by appliances (37%), lighting (23%), hot water (16%), cooking (7%), and cooling (3%) (Tbilisi SEAP).

Heating seems to be another area where municipal buildings in Tbilisi do comparatively quite well. Not only is the amount of heat consumed per square meter six times smaller than in Warsaw (see figure below), but it is three times smaller than the figure registered in Tbilisi in 1993 (George Abulashvili. 2010. *District Heating System in Georgia*, ERRA PPT Presentation).

Municipal Buildings Heating Consumption (kWh/m^2)



An explanation for this occurrence can be found in the dismantling of the city's district heating system in 1993. All of the City's public buildings were connected to the central heating network, and all had to identify individual solutions for providing heat after 1993. What is known about the district heating system, when it existed, is that it was highly inefficient, with a lot of losses in the system, with high subsidies and low tariffs that encouraged energy squandering, and with no measures in place for adjusting temperature (all buildings received the same amount of heat from their respective district heating plant).

One of the main causes for the dismantling of the district heating system was the disappearance of subsidies for natural gas (the main fuel used by heating plants), internal conflict, and a dramatic economic downturn. Thus, from being able to use natural gas for almost nothing, Georgian authorities have found themselves in a situation where they had to import it at market prices, in an environment where overall economic output had fallen by 75% compared to 1989. Consequently, energy savings was not so much a choice as a necessity.

In either case, municipal buildings is one service area in Tbilisi which would benefit from a more in-depth and more detailed scrutiny. Few improvements have been brought to existent buildings, many have a deteriorating thermal envelope, and they generally lack even very basic interventions (e.g. replacement of energy inefficient light bulbs with more efficient ones).

Public Lighting

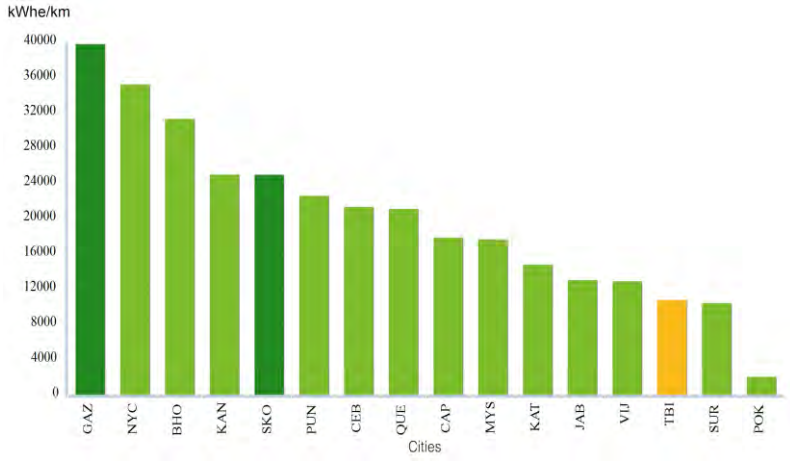
Tbilisi went from being a city basked in darkness to being the City of Lights. In 2005, there were only around 25,000 fixtures illuminating mostly the city center, and they were on for only around 2-3 hours per night. By 2011, the number of fixtures rose to 125,000, and they were working the whole night.

Tbilisi at Night

The interesting this is that while the number of light bulbs increased five-fold in six years, the energy use of the public lighting system in Tbilisi only increased two-fold. Much of this can be attributed to the improvements that were brought to the system, and to the new technologies used in this respect. Thus, for the most part, inefficient mercury vapor bulbs were replaced with high pressure sodium bulbs, and many 1,000 Watt bulbs were replaced with 250 Watt ones.

All in all the Tbilisi public lighting system is relatively new and quite efficient. Coverage has been increased dramatically and the installed light-bulbs are efficient. When compared to other cities in the TRACE database, Tbilisi out-performed almost all of those that had relevant data (see figure below). The two cities that seem to be doing better, Surabaya and Pokhara, may have a street lighting system that is not working all night long, or they may have many deficient and not working street lights (hence the lower energy consumption).

Electricity Consumed per Kilometer of Lit Roads (kWhe/km)



Local authorities have also considered introducing LED technology, which have even lower energy consumption and a longer life than high-pressure sodium vapor bulbs. They even piloted the technology on a number of main streets. They soon found out however that the start-up and maintenance costs of using LED technology are quite high, so they prefer to wait an learn from the experience of other cities, rather than expanding now, before the performance of this new technology is well understood and properly monitored.

In addition to energy efficient light bulbs, local authorities make use of 800 management units, which monitor the system all night long. These management units assess the need for street lighting during certain hours and adjust luminosity accordingly. Thus, between 2 AM and 5 AM, lights are usually dimmed to save energy. There are plans to replace those 800 individual management units, with a digital and centrally controlled distance management unit, which could be used to adjust light intensity through the entire city.

Electricity for the public lighting system is bought from 5-6 retailers, according to the price offered. Electricity prices fluctuate, but there is a national committee on energy that informs the utility company on where they can obtain the lowest price. Because there is competition on the electricity market, prices don't go up too high, usually fluctuating between $0.05/kWh and $0.10/kWh.

Street Lights in Tbilisi

Overall, Tbilisi has a well run public lighting system, with efficient street lights illuminating the main boulevards in and out of the city (see image above), as well as the main neighborhoods in the city. There are a number of low-density city areas, peripheral neighborhoods, and new

developments, which are still poorly lit. Local authorities plan however to continually expand the street lighting system to these areas too.

Power and Heat

Like many other cities in Europe and Central Asia, Tbilisi used to have a district heating system. The construction of the system started in 1958, and by 1989 80% of the people in Tbilisi received central heat supply. The rest received heat from the Tbilisi Thermal Power Station (6%), from industrial thermal stations (5%), or they used individual boiler units (9%). The large majority of the customers of the central heating system were residents of large apartment flats (like the one depicted in the picture below), and most of the public buildings in the city. Virtually all of the apartment flats that were built by central planners after 1958 were connected to the district heating network. (George Abulashvili. 2010. *District Heating Systems in Georgia*, ERRA PPT Presentation)

Soviet-Era Apartment Building in Tbilisi

Tbilisi's central heating system was run by 47 thermal stations, which had an installed capacity of around 4,295 MW. However, because of deteriorating infrastructure and boiler inefficiencies, the actual capacity in 1993, when the system was dismantled, was only 2,930 MW. The specific heat consumption was about 90 kWh/m^2/year for residential units, and around 75 kWh/m^2/year for public buildings (Ibid.). These figures are smaller, although close to the figures registered by other cities in the TRACE database. However, they are much higher than the figures currently registered in Tbilisi. Thus, in 2009, heating consumption in Tbilisi's municipal buildings was on average 25 kWh/m^2/year – 3 times lower than in 1993.

This discrepancy in heating levels can partly be explained by the inefficiency of the system at the time of its dismantling. For one, the infrastructure has deteriorated over time and was not properly maintained and upgraded. On the other hand, there was no viable market pricing scheme in place to allow for even minimal cost recovery. For example, a family living in an apartment of around 50 m^2 paid in 1990 25 Rubles per year for heating – or around 0.5% of the average family income at the time. Such steep subsidies were possible because natural gas, which was used to power most of the central heating system, was heavily subsidized in Soviet times. However, after the dismantling of the Soviet Union, Georgia became an importer of natural resources, and it had to buy it at market prices. This, coupled with internal strife in 1993 and with a dramatic decline in industrial output (of over 60.5%), meant that the district heating system in Tbilisi could no longer be maintained.

In 1993, central heating in Tbilisi vanished in one fell swoop, and the 870,000 people that depended on this system were left to provide for themselves. For the most part, people now use individual electric and gas heaters. Around 87 buildings in the Saburtalo district (Tbilisi SEAP) receive hot water from a geothermal spring in the area. The supply is sporadic (especially in the winter time), the distribution pipes are not insulated, and the used hot water is not re-injected in the aquifer. Moreover, there is no metering and households are charged a small flat rate of – around $1.75/month. An analysis was carried out however to assess the feasibility of extending the system, and the conclusion was drawn that existent technologies have to be improved and modernized to have an efficient and effective system in place.

As far as power generation is concerned, the City of Tbilisi itself does not really generate any of its electricity needs. The district heating system could have also been converted to also generate electricity, but restoring the old network back seems close to impossible – the infrastructure was left to fall apart and many of the system parts (e.g. piping and radiators) have been dismantled and scrapped.

Electricity provision in Tbilisi is done from the grid, with two types of customers – those that pay retail prices to distributor companies, and those that pay wholesale prices and get electricity directly from the transmission grid (usually large factories). Pricing is done at market rates

and significant improvements have been brought to the system, which limit transmission and distribution losses. Almost all residential dwellings are properly metered, the meters are situated outside apartments (making it easier for bill collectors to read them, and making it harder for end-consumers to temper with them), and a progressive tariff structure is in place (to encourage energy conservation). Thus, people who consume less than 100 kWh per month pay $0.078; those that consume between 101 and 300 kWh per month pay $0.093; and finally, those that consume more than 300 kWh per month pay $0.102. For comparative purposes, the average electricity tariff in the US is around $0.112.

Energy Efficiency Recommendations

By benchmarking the urban indicators collected for Tbilisi with similar indicators from other cities in the TRACE database, the TRACE tool has identified five priority areas that could benefit from energy efficiency interventions (listed in the table below). The savings potential was determined by also taking into consideration the level of local control the City has over each specific service area. Thus, since water and wastewater is wholly in private hands now, it was not selected as a priority sector, although the analysis showed that it's quite energy intensive.

Energy Efficiency Priority Areas in Tbilisi

Sector	Energy Consumption (US$)	Relative Energy Intensity (%)	Level of local control (from 0- no control, to 1-full control)	Savings Potential (US$) [Priority]
Private Vehicles	536,923,033	31.2%	0.25	41,954,054 **[PRIORITY 1]**
Public Transportation	58,179,524	20.2%	0.74	8,596,675 **[PRIORITY 2]**
Public Lighting	3,643,708	42.1%	0.95	1,460,484 **[PRIORITY 3]**
Solid Waste	494,940	44.7%	0.95	210,377 **[PRIORITY 4]**
Municipal Buildings	1,657,950	3.5%	0.95	56,172 **[PRIORITY 5]**

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

A second caveat is that inter-city comparison on even the most straight-forward indicators can be tricky. For example, when comparing energy performance of municipal buildings, one has to take into consideration that different cities might have different types of buildings under their management. For example, a city that has a high share of local hospitals that it manages will likely have a more intensive energy profile for its municipal buildings (hospitals consume energy year-round and 24 hours a day). On the other hand, a city like Tbilisi, with many kindergartens under its management, is likely to have a less intensive energy profile (kindergartens are only open for a few hours a day, and only for a part of the year).

These shortcomings aside though, TRACE does considerably well what it's supposed to – it gives a quick radiography of a city and identifies areas with potential energy cost savings. As such, it offers local authorities and policy makers a way of dealing with urban challenges and opportunities in a holistic way. Below are a number of recommendations that were selected after the TRACE analysis, in close consultation with local authorities.

Private Vehicles

Not only did private vehicles come out as the priority 1 in TRACE, but the sector is also considered by the SEAP report to be critical to reducing GHG emissions in coming years, and it is one of the most important issues on the City's agenda. A rapid increase in private car ownership and use, the lack of proper regulation for car energy and engine performance, and people's strong preference for using cars over other modes of transportation, have lead to a very energy intensive transport sector. More and more of Tbilisi's streets are congested, and more and more of its neighborhoods are polluted by car exhaust. To counteract congestion, local authorities have put a series of measures in place that aim to ease traffic. These measures have been quite effective, but they have also worked to invite more cars on the streets.

The more space is created on city streets for cars, the more will people see this as an invitation to use their cars. Consequently, it is important that local authorities also invest time and resources in determining how traffic and parking could be restraint in certain areas, and how alternative modes of transportation could be encouraged. The easier it is for people to use public transportation, walking, or biking, and the more comfortable and safe these alternatives are, the more will decide to go that route.

Traffic Restraint Measures

With increasing motorization level, traffic congestion is expected to grow rapidly in Tbilisi. Congestion happens mainly at peak hours, particularly at major intersections in the city center. In the downtown area, most of the major corridors have reached their nominal capacity with 17,000 vehicles per hour, but some bottlenecks reduce the capacity to 11,000 vehicles per hour.[5] Significant efforts have been made in recent years to improve the quality of traffic management through marking or traffic lights but much more needs to be done. Signals are not obeyed, there are frequent cases of unlawful and inappropriate behavior, and driving laws are not poorly enforced.

City transport planners in Tbilisi need to give increasing attention to the possibility of reducing downtown use of cars by such means as limited parking, higher parking charges and tolls, sale of special central area permits or licenses, or a complete ban on automobiles on selected streets. Among the possible benefits of these auto restraint schemes is less congestion: even if only a small percentage of automobiles are eliminated from central area streets during the peak hours, traffic speeds, both for the remaining automobiles and for buses and other forms of public transport, may improve significantly. Reduced use of cars in the central area may also alleviate air pollution and other environmental problems there and help to conserve energy.

There is a bias for private cars in Tbilisi, and the city has developed a car-oriented culture in recent years. Directly restraining road traffic through travel demand management is therefore critical. However, little has happened in this area due to a number of critical factors: (i) lack of an attractive high quality public transport alternatives that provide the same level of convenience and time saving which a private car offers; (ii) lack of staff for design and enforcement; (iii) political unwillingness to implement and enforce. To be more effective, a range of traffic restraint instruments need to be planned as part of a comprehensive city transport strategy, for which city government needs to take effective action. The new challenges of environmental and financial sustainability thus require government to increase their understanding of the process through which transport impacts the environment, while extending and refining the range of fiscal and regulatory instruments to address the problem.

Strict licensing policy as applied in Singapore by limiting the number of car licenses and allocating the licenses on the base of a tender, in combination with high import duties on cars, has helped to restrain car traffic to a sustainable limit. In Europe, car free central districts have contributed to a remarkable increase in the quality of urban life and of the attractiveness of central districts. The City Authority can also impose vehicle-type bans which exclude entire vehicle categories from circulation. But such direct controls are not without problems. In the absence of high quality public transport, and inadequate facilities for modal interchange (bus to rail, bicycle to transit, etc.) it is hard to make a case for private car restraint measures. “Non-auto days”, as put in place by Mexico City, selective license plate enforcement as done by the City of Athens, or “no-driving days – one-day rest” as in Puerto Princesa City (the Philippines), have shown perverse effects in rescheduling activities or encouraging increased car ownership rather than restraining total amounts of traffic.

Use of market instruments in demand management has the advantage over a purely administrative approach by allowing decentralized decision making to select the form of adjustment best suited to individual preferences. While the calculation of “right prices” of externalities remains controversial, the available evidence does suggest optimal charges for urban road use sustainability above those prevailing at present even in Western Europe.

Several pricing instruments can be considered. Higher prices of fuel have been a component of comprehensive strategies for controlling the impact of transport on the environment in countries such as Mexico,

[5] Source: http://www.adb.org/Documents/RRPs/GEO/42414/42414-01-geo-ssa.pdf

Thailand, and Indonesia. This can be supplemented by increased parking charges, as implemented, for example in Korea and Poland. Electronic road pricing in Singapore may help though the effects of this device on total emissions is not certain.

Parking Restraint Measures

There are many ways to restrain the rapid growth in private car use to reduce traffic congestion in Tbilisi. Designing appropriate parking restraint measures can be a very effective Travel Demand Management (TDM) measure, in terms of having an immediate impact on traveler mode choice in Tbilisi. This can be accomplished by increasing parking fees and banning parking in certain designated areas in the city. Such measures reflect the large infrastructure costs of accommodating vehicles and the costs they impose on pedestrians and the environment at large.

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

Parking restraint measures are complementary to virtually all TDM measures. Parking restraint supports other TDM measures by making driving alone more expensive and more difficult (more difficult to find a park and further to walk to destination). From international experience, a range of policy instruments are available to exercise parking control in a city (see table below). In practice, many of these policies and strategies are difficult to implement. Difficulties can arise from limited data and information, weak administrative and enforcement mechanisms, limited financial and human resources, and political opposition. Creativity is needed in fashioning effective initiatives.

Parking restraint policy instruments

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

The focus of parking restraint has been on city centers (central business districts), given that these are where (peak period) traffic congestion has been highest and a viable transport alternative (mostly public transport) is generally available. In addition, parking restraint has focused on commuters as this group makes up the majority of peak period travelers. The table below presents parking restraint measures implemented in different cities around the world.

Recognizing the increasing parking problem in Tbilisi, a new parking system for Tbilisi and designated parking areas was approved by the City Council in 2007. By 2010, the city had put in place approximately 11,600 formal parking spaces.[6]

[6] Draft of the Road Map of Georgian Sustainable Urban Transport Project. SYSTRA, 2010.

Parking Restraint Measure	Scheme Features	Locations Implemented
On-street Parking		
Parking Charges – on-street	Charged on-street parking	Many cities world-wide
Residents Parking Zones	Residents only-parking by permit	London, other UK cities, US cities
Controlled-Parking Zones/ Parking Concepts	Management of parking in area to balance demand and supply	UK cities, German cities
No long-stay parking in city centre	Time restrictions preventing all-day parking	UK cities
Bus Lanes/Clearways	Removal of on-street parking during peak periods	London, many UK cities
Pedestrian-only streets	No traffic at all in street	UK cities, European cities
Off-street Parking		
Maximum Parking Standards	Maximum number of car parks for new development	London, other UK cities, US cities
Commuted Payment Schemes	Developers pay dollar amount in-lieu of providing car parks	London, other UK cities, US cities
Parking ceiling	Maximum number of total spaces in city centre set	Portland, Boston
Ban parking spaces in new buildings	Parking spaces banned in new buildings in certain parts of city	Zurich
Ability to Reduce Minimum Standards	Minimum parking standards can be reduced if carpool spaces or free PT passes provided	Seattle, USA
Maximum Parking Standards tied to Public Transport (PT) provision	Maximum number of car parks – lower maximum where higher PT level of service	Zurich, Berne
Park & Ride/ Peripheral Parking	P+R facility on periphery of city centre in conjunction with dedicated bus service	Oxford, Canterbury
Employer Funded Parking		
Fringe Benefit Tax on Parking	Tax on employer funding of carparks	Australia, New Zealand
Cashing Out	Requires employers to provide employees with the option of receiving the cash equivalent of parking subsidy.	California

Source: Booze, Allen, Hamilton. 2006. *International Approaches to Tackling Traffic Congestion.*

The city government creates parking lots and controls unofficial parking in close collaboration with the Patrol Police. However, due to a large motorization level in the city with heavy traffic volume, inadequate official parking areas, and inappropriate driving habits, random street-side parking still prevails.

The municipality has outsourced the operation of the parking system management to a private company. The Tbilisi municipality establishes parking fees and/or fee ranges, but the private operator can set parking fees within the municipal range based on factors like the time of day, location, or the day of the week.

Currently, the city municipality has set the official parking fee at 50 GEL per year and 2 GEL per week for residential parking. The city also offers several secured parking lots where overnight parking costs 2 GEL (~$1.2). The city is planning to introduce a diversified parking pricing system apart from more outdoor and off-street parking places in the city development plan.[7] According to existing requirements by the city municipality, every newly constructed multi-storey residential and

[7] The idea of construction of an off-street parking area is under development and negotiation with EBRD.

commercial building must provide an underground parking area that significantly improves the parking practice in the city.

Non-motorized transport modes

The two major modes of non-motorized transport (NMT) are walking and various forms of cycling. For Tbilisi, the city's steep slopes do not promote the use of bicycles and car drivers' behavior makes riding two-wheelers very dangerous. The city is not convenient for pedestrians and road safety is a critical issue. In many cases the pavement is damaged and/or occupied by parking cars, some major intersections are dangerous to cross in absence of pedestrian cross-walks. All these factors undermine passenger safety, particularly on fast sections of main road corridors. There are few zebra crossings and they are generally not respected by car drivers. Walking is not safe and quite dangerous for old or disabled people. The municipality plans to build 37 footbridges to cross the main roads and 10 are already being built.[8]

Clearly, walking dominates for shorter trips, but even in terms of distances traveled, walking accounts for over 50% of all trips in some countries. The increasing injury rates of pedestrians in Tbilisi city emphasize the need to design and manage roads to secure better separation of living and working space from moving space, provision of separated space for pedestrians, and a stronger protection of their rights of way needs to be a high priority. Pedestrian improvements are usually implemented by local governments. It usually begins with a pedestrian plan to identify problems and prioritize projects. Right now the city does not have the basic infrastructure to separate motor traffics from other NMT modes. But, this could be introduced in the city by providing a network of protected lanes for bicycles in some designated areas where the city slopes are not steep. It would be important therefore for the city government to seriously consider some pilot NMT projects and supporting policies that encourage walking and bicycle use by prioritizing non-motorized over motorized vehicle access to address a key objective of protecting urban environment. A pilot bicycle path project is already underway, with plans to expand it based on use and further demand.

Non-motorized transport modes tend to have high shares in countries such as the Netherlands and Switzerland. The major elements of a strategy for NMT should include the following strategies:[9]

- Clear provision for the rights, as well as responsibilities, of pedestrians and bicyclists in traffic law;
- Formulation of a national strategy for NMT as a facilitating framework for local plans;
- Explicit formulation of local plans for NMT as part of the planning procedures of municipal authorities;
- Provision of separate infrastructure where appropriate (for safe movement and for secure parking of vehicles);
- Incorporation of standards of provision for bicyclists and pedestrians in new road infrastructure design;
- Focusing traffic management on improving the movement of people rather than of motorized vehicles;
- Training of police to enforce the rights of NMT in traffic priorities, as well as in accident recording and prevention;
- Incorporation of responsibilities for provision for NMT in road fund statutes and procedures;
- Development of small-scale credit mechanisms for finance of bicycles.

A point of special importance here is the application of advanced technologies such as Information and Communications Technologies (ICT) in transport. ICT is gradually increasing the quality of motorised transport modes, making them more comfortable, and providing travelers with information. An aspect that is easily overlooked concerns the potential contribution of ICT to improve the situation of non-motorized travelers. Governments have a responsibility in this respect because in the case of non-motorized transport there are no strong parties that have an interest in promoting ICT applications (in motorized transport car manufacturers and public transport operators obviously do have such an interest). Several opportunities exist to avoid a pro-motorized transport bias in ICT applications. For example, ICT could be

[8] Source: http://www.adb.org/Documents/RRPs/GEO/42414/42414-01-geo-ssa.pdf

[9] Source: World Bank 2002. Cities on the Move – A World Bank Urban Transport Strategy Review.

used to impose strict adherence by car drivers to speed limits in residential areas. Similarly, ICT could also be applied at a larger scale to provide pedestrians and bicyclists a fair treatment at traffic lights. Also, ICT may be a promising solution to the problem of bicycle theft since it makes the tracing of stolen bicycles much easier.

Public Transportation

The development of the public transportation network is one of the main priorities of the City of Tbilisi, with an aggressive expansion of the municipal bus fleet in recent years, and with significant improvement brought to the bus infrastructure. In addition, several improvements have been brought to the metro system, and plans have been hashed out to re-introduce a tramway system. By offering frequent, reliable, comfortable, ubiquitous public transportation options, local authorities create some of the most important premises for enabling the shift from private cars to more sustainable modes of transportation.

Public Transport Development

It is well known that public transport occupies less road space and causes less pollution per passenger-km than personal motor vehicles. As such, public transport is a more sustainable form of transport and its development is critical to the welfare of the urban poor and a crucial element in any poverty oriented city development strategy.

Recognizing the importance of public transport, the city municipality has taken a number of very good actions to make public transport services more attractive, reliable, and affordable for people. The SEAP report has drawn a list of very good measures in this respect, some of which include:

- *Information campaign, marketing and public transport web page* and *guide* to popularize campaign for public transport.
- *Electronic display boards on 450 bus stops, new comfortable minibuses, electric display boards in minibuses, better top-up of plastic travel cards, technical inspection of minibuses, increased safety, improved ticketing system, improvement and optimization of routes*, and *dedicated bus lanes* to make public transport more comfortable and easier to use.
- *Optimization of the bus fleet, extension of subway to the university station,* and *introduction of tram line in the near future* to introduce alternative modes of public transport.

In Tbilisi, the current average public transport ticket is around GEL 0.40 (~$0.25) per passenger, the average revenue is GEL 0.20, and the average operating subsidy is GEL 0.10.[10] Closing this gap is one of the main challenges for the Tbilisi public transport system. This situation is exacerbated by (i) the high passenger fraud rate and fare evasion (about 30%), and (ii) fares that do not take into account the length of trips. The problem is also affected by the urban morphology of Tbilisi: a north-south urban trip can be as long as 20 kilometers.

In the present day context, however, public transport serves another social purpose. It helps reduce congestion and air pollution, if users of personal vehicles can be persuaded to shift to public transport. Their needs are, however, for improved quality and not so much low fares. It is therefore necessary to think of different types of public transport services for different segments of commuters. Those who place a premium on cost are the poorest sections of society and need to be given affordable prices. The cost of providing public transport for them needs to be subsidized by other sections of society. However, there is another segment that values time saved and comfort more than price. This segment is comparatively better off and would shift to public transport if high quality systems are available to them. The cost of providing public transport to them need not be subsidized and can be met from the fare revenues.

To facilitate this, local authorities should think of developing a premium service infrastructure, such as improved bus stations and terminals, improved passenger information systems, use of intelligent transport systems for monitoring and control, etc. To make public transport attractive in Tbilisi, it is essential to improve access to its services. It is useful to lay down standards for accessibility in terms of the distance within which public transport access points should be available. This necessitates the use of personal transport. This can be done by planned integration of public and personal transport operations.

[10] Source: http://www.adb.org/Documents/RRPs/GEO/42414/42414-01-geo-ssa.pdf

Typically this calls for good parking facilities at public transit stations and easy access to public transport from there. The park and ride facilities that exist in many developed countries seek to achieve this.

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

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

Public Lighting

The public lighting system has underwent a massive expansion in recent years and is quite efficient, with mostly new and well performing light bulbs. When compared to just a selection of peer cities, Tbilisi's public lighting system comes out as a star performer, and would not necessarily require further improvements. However, we have chosen to go with the full-city benchmarking version, because there seems to be a lot of momentum at the local level in continuing with the good work that has already been done. For the most part, local authorities have already identified a number of ways in which the city's public lighting system could become even more efficient. Thus, Tbilisi has the opportunity to be not only the City of Lights, but also the Energy Efficient City.

Street Lighting Timing

Most of street lights in Tbilisi are relatively new and quite energy efficient. In addition, there are 800 monitoring units throughout the city, which can adjust light intensity according to outside conditions and according to traffic intensity. Thus, for example, on a busy cloudy day, light intensity might be turned up. Similarly, at 2:00 AM in the morning, with little traffic on the streets, light intensity might be turned down.

Having a monitoring system that allows such adjustment is a good thing. However, 800 individual management units are cumbersome and costly to run. The City is therefore interested in introducing a centralized and digitalized public light management unit. Such a unit would allow the management of the entire public lighting system from just one place, reducing the amount of man power required, and improving data collection and analysis. In addition, the life of individual light bulbs could be extended, by efficiently using them only when they are also needed.

In addition to such a centralized management unit, the City could also consider introducing, maybe on a pilot basis, solar powered street lights and light poles with automatic switches and dimmers. For example, infrequently travelled areas (e.g. parks or walk paths on the outskirts of the city) could be equipped with autonomous solar powered street lights. In the same vein, in-city areas with reduced traffic (e.g. parks, small side streets, or open/parking spaces between apartment blocks) could be equipped with street poles with motion detectors, which only turn on the light when someone is actually around. Automatic dimmers could be introduced in all areas of the city, adjusting light based on the specific time of day – i.e. providing more light at 9 PM on a winter night than at 3:00 AM in the morning.

Procurement Guide for New Street Lights

In addition to measures aimed at improving the way street lights function, local authorities should think of developing a procurement guide for new street lights. The system as it stands now is quite new and efficient. However, with the passing of time, it will require increase maintenance and upgrade work. As light bulbs get old, or as they start to malfunction, they have to be replaced with new ones. It pays therefore to have a plan going ahead for procuring new street lights.

Devising such a plan should take a life-cycle approach into consideration, which includes not only upfront costs, but also the

maintenance and operation costs expected over the entire life-time of a bulb. Thus, it may come out that a technology that requires higher upfront costs (i.e. it is more expensive) will have a lower life-cycle cost than a cheaper technology.

Street Lighting Audit and Retrofit

With a proper procurement guide in place, and with a clear idea of what street light technologies have the lowest life-cycle cost, local authorities should continually perform a system audit to determine retrofit needs.

Currently, local authorities have focused on using high-pressure sodium bulbs for street-lighting purposes. Those are quite efficient and cheaper than newer technologies. In particular, the City has considered introducing LED technology, which is supposed to have a longer life and better energy efficiency. However the technology is still quite new and its life-cycle performance is not yet understood. Therefore, local authorities have opted to wait and see how LED street bulbs perform in other cities, and, if deemed viable, to consider its introduction in Tbilisi too.

This is a sensible approach as not everything that glitters is gold. However, if new LED technologies, as well as other innovations in the field, prove to have a lower life-cycle cost than the current high-pressure sodium vapor bulbs, the City should consider upgrading the system once the existent bulbs have served their life.

Solid Waste

Although Tbilisi has seen many improvements of its solid waste management (SWM) system in recent years, Georgia as a whole is not doing so well. One of the critical missing pieces in this area is the lack of a law on waste, a waste strategy, and a clear solid waste management plan. For example, solid waste management in the country is not organized regionally, to take advantage of economies of scale. Cities dump waste in individual open landfills, most often without any further treatment, while smaller towns and villages dump their waste in makeshift and wild dumps.

With overall consumption in the country continuing to grow, solid waste will become an ever increasing problem – even for Tbilisi. The City has taken significant strides in the area by consolidating four city landfills into one. The landfill enjoys important environmental features (e.g. dumping in individual cells, leachate protection, collection, and treatment, and methane gas collection) and covers operation costs from waste tariffs. However, the Tbilisi SWM system only serves the municipality, not the entire region. There are numerous settlements around the city, which, in the absence of proper and cost-effective disposal facilities, dispose of waste in makeshift dumps. Over time, these wild dumps will proliferate around the city and will become a health, safety, and environmental hazard. It is therefore important to figure out how the new Norio landfill could serve the Tbilisi Region, not just the Tbilisi Municipality.

Of course, the Norio landfill could itself benefit from further improvements, including several in the energy efficiency field.

Waste Landfill Gas Capture and Use

While the landfill disposes of methane capture devices, there are no clear plans for actually using the methane for productive uses. As it stands, all captured methane will be flared. In and of itself, this is a good measure for the environment, but it could become an economic smart measure by identifying ways in which captured methane could be used for productive use.

Some cities use converted landfill gas as fuel for their garbage trucks, some use it to generate electricity and heat, some collect, clean, and sell the gas to private users (e.g. taxi drivers). Options in the area abound, and more and more options will become available as technologies in the field are improved.

What is important for local authorities is to consider, as in the case of the street lighting system, the lice-cycle cost of new technologies – i.e. if investments in a methane capture and use facility prove to generate a profit over the lifetime of the investment, they deserve the proper consideration. Of course other factors play an important role, and local authorities often have to chose between a limited number of investments they can make at a specific point in time. However, they should avoid the trap of short-sightedness and give proper consideration to potential long-term benefits, not just immediate ones.

Efficient Waste Vehicle Operation

A good share of the garbage trucks operated in Tbilisi are new, and plans have already been hashed out to replace the existing old ones. Furthermore, the collection and disposal logistics system is organized in an efficient way and continually improved. As such, the SWM system in Tbilisi is quite energy efficient, and will become even more efficient in coming years.

What was missing in the way the system is designed and operated are some simple, cheap, and often quite effective measures – proper training of truck drivers in fuel efficient waste vehicle operation. An anecdotal assessment of garbage truck driving in Tbilisi revealed that it was quite similar to how most of the people in the city drive – fast, reckless, and with little attention to fuel performance. There seems to be a greater focus on getting from A to B in the quickest time possible, rather than giving some attention to how to get from A to B with the lowest energy expenditure.

Often simple means (e.g. avoiding speeding and frequent breaks) can lead to significant improvements in fuel performance. Local authorities could take it upon themselves to offer quick courses on energy efficient driving to all of the drivers that run municipally owned/managed cars. Such courses could be buttressed by incentive schemes to encourage drivers to drive more attentively. For example, each driver that achieves a better fuel performance could be given, as a bonus, a share of the saved fuel costs.

Municipal Buildings

Municipal buildings in Tbilisi seem to be doing much better than other cities with pertinent data in the TRACE database. However, their good performance has little to do with pro-active measures to improve energy performance. For the most part, municipal buildings in Tbilisi lack even basic upgrades, such a thermopane windows or LED bulbs. Furthermore, improving the energy performance of municipal buildings does not seem to rank too high on the local authorities' agenda.

Nonetheless, there are measures that can offer immediate benefits, not only allowing for a significant decrease of electricity bills, but also allowing for a fast amortization of investment costs.

Municipal Offices Audit and Retrofit

Around 60% of electricity needs in municipal buildings go to appliances and lighting. Consequently, these are also the areas where the most significant savings can be achieved. For example, replacing inefficient light bulbs with LEDs can offer immediate dividends. Similarly introducing simple and inexpensive automatic shut-off systems (e.g. motion-based systems that turn off the light when nobody is in the room) can go a long way in terms of saving energy. Simple measures like that could be doubled by an internal procurement system that favors the acquisition of energy efficient appliances.

There are a number of cheap and easy to do things that can not only reduce the locality's energy bill, but that could also have a powerful demonstration effect, encouraging all of the city's citizens to use energy more sparingly.

Pilot programs aimed at reducing electricity use could be followed by more complex programs aimed at reducing heating needs (e.g. boiler replacement programs, thermal insulation of roofs, exterior walls and windows, and automatic shut-off systems).

ECA Sustainable Cities:

Improving Energy Efficiency in TBILISI Georgia

TRACE Study

Annexes

ESMAP
Energy Sector Management Assistance Program

ANNEXES: DETAILED RECOMMENDATIONS

ANNEX 1: PUBLIC TRANSPORT DEVELOPMENT

Description

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

Implementation Options

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

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

	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

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

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

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

Case Studies

BRT system, Bogota, Colombia

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

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

million. The system is managed by a company which was set up by the Mayor, but runs independently from the city administration. While the company is in charge of all planning, maintenance and construction of infrastructure as well as organizing of schedules of bus services, buses and drivers are contracted through private firms, resulting in a complex but innovative management structure.

Land Use and Public Transport Planning, Curitiba, Brazil

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

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

Linking development densities to public transport availability, Curitiba, Brazil

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

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

Integrated urban planning and efficient resource use, Singapore

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

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

Furthermore, high-density development has translated into greater use of public transportation as major business, commercial, and

residential areas are well connected to an integrated public transportation network. In 2004, public transportation as a share of all transportation modes during morning peak hours reached 63 percent. The significant use of public transportation helps reduce greenhouse gas emissions. High public transportation ridership also means Singapore has been able to recover all public transportation operating costs from fares, a feat achieved only by Hong Kong, China, and by Singapore among modern, highly developed cities.
Integrated regional urban planning, Auckland, New Zealand Good Practices in City Energy Efficiency: Eco^2 Cities - Integrated Regional Urban Planning in Auckland, available online http://www.esmap.org/esmap/node/1227 The interconnectedness of national and local Auckland issues (such as housing and education) with growth and innovation and the major required investments (particularly in land transport) have created complex and difficult issues among multiple authorities. Despite Auckland's importance to the New Zealand economy and the areas of common interest, such as transportation and energy provision, the national government did not initially play a close role in directing regional and local government planning. Concern emerged that, without agreement on an overarching regional strategy and framework, decision making in the region could become ad hoc and adversarial if each stakeholder tried to have a say from a narrow perspective and without viewing the region as a whole. As a result, there was a clear need for coordinated strategic planning across the Auckland Region to ensure that Auckland would be able to remain competitive in today's globalized world. The response involved a process undertaken in 2001 to prepare a regional growth strategy that aimed to provide a vision of what Auckland could be like in 50 years.

Tools & Guidance

Tools & Guidance
Public Transport Authority Western Australia (2009). "Bus Priority Measures Principles and Design" A guidance document for planning bus priority methods and approaches. Available online from http://www.pta.wa.gov.au/PublicationsandPolicies/DesignandPlanningGuidelines/tabid/109/Default.aspx
Transport for London (2006). "Accessible bus stop design guidance" A guidance document for designing bus stops which help make boarding easier for passengers. Available online from http://www.tfl.gov.uk/assets/downloads/businessandpartners/accessibile_bus_stop_design_guidance.pdf

ANNEX 2: NON-MOTORIZED TRANSPORT MODES

Description

Non-motorised transport modes have zero operational fuel consumption and require low capital costs for implementation. In addition to improving the health of users, their use reduces noise pollution and improves air quality.

Benefits include improved air quality, lower operating costs for users and providers, and lower infrastructure requirements.

Implementation Options

Implementation Activity	Methodology
Pedestrianization	The City Authority pedestrianizes networks of streets or larger city areas. Either permanent or temporary, the closure of streets to motor vehicles increases public awareness of non-motorised modes and removes noisy and polluting vehicles, as well as creating opportunities for street markets and other initiatives. The City Authority researches the feasibility and probable take-up from origin and destination surveys, existing mode splits, and subsequently designs networks to suit commuting patterns and local/neighbourhood travel. See Oxford case study for further details.
Dedicated networks	The City Authority includes dedicated cycle / walking route networks in its transportation or city land use plans. Replacement or reservation of rights-of-way in new-built areas creates the necessary conditions for adopting non-motorised modes that may otherwise be less favoured if roads cater to cars only. The key to success is the linkage of cycle and pedestrian networks at local level, and the quality of the environment provided, that requires good drainage and adequate lighting and shading. See Bogota case study for further details.
Microcredits	The City Authority makes micro credits available which can be used to increase the ownership of bicycles. Increased cycle ownership can have significant financial benefits to low-income workers who may no longer be dependent upon expensive, inefficient and infrequent public transport. See Lima case study for further details.

Attributes

Energy Savings Potential
100,000-200,000 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

Rental programs	The City Authority introduces bicycle rental programs which provide bicycles on demand for a fee. The key factor for success to is the setting of tariffs that encourage use as well as security procedures that avoid and penalise theft. Registered-user schemes require a credit card or bank details of users, but are not necessarily open to all. Non-registered user schemes are more flexible, but more open to abuse. Branding of bicycles and facilities can create revenue for local authority. See Paris 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:

- Perform surveys of the number of cycles in circulation by using traffic counters on roads and cycle lanes.
- Determine the mode share of people travelling in the area or city.
- Determine KPIs such as % non-motorised transport mode, modal shift, km of dedicated cycle/walking infrastructure, take-up of cycle promotion schemes by analysing registers of subsidies

Case Studies

Pedestrianization with road closures, Oxford, England

European Commission, Directorate General for the Environment (2004). "Reclaiming city streets for people: Chaos or quality of life?", available online from http://ec.europa.eu/environment/pubs/pdf/streets_people.pdf

The main retail streets have been fully pedestrianized, while other through roads in the central area are only accessible to buses and pedestrians. The adoption of a step by step, integrated approach to the implementation of the road closure program has been seen as critical to the success of the significant road space reallocation element of the scheme. Opposition to the USD 6 million scheme was raised most notably on the basis that traffic congestion on two key routes in the city would worsen, as well as from retailers concerned about delivery access and trade levels. These concerns were attended to via an extensive consultation process and an effective publicity

campaign prior to the implementation of the scheme. This included leaflets, advertisements on buses, city-wide poster boards, and a series of press releases
Dedicated cycle network, Bogota, Colombia C40 Cities (2010). "Bogota, Colombia: Bogota's CicloRuta is one of the most comprehensive cycling systems in the world", available online from http://www.c40cities.org/bestpractices/transport/bogota_cycling.jsp CicloRutas is considered a unique cycling network where design has taken the topography of the city into consideration in order to create maximum flow and function (manmade and natural features, hills, waterways, parklands, essential facilities). In a period of just 7 years, following an investment of USD 50 million, the use of bicycles on the network increased by more than 268%. CicloRutas plays an important role for lower income groups, as more than 23% of the trips made by the lowest income group in the city are by walking or by bike. The development of CicloRutas has also helped to recover public space along riverbanks and wetlands, as for many years the city's wetlands were occupied by illegal settlements.
Bicycle micro credits, Lima, Peru ICLEI (2009). "Case study 46: Assistance to purchase bicycles - Lima, Peru" in Sustainable Urban Energy Planning: A handbook for cities and towns in developing countries, available online from http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2839 In 1990, the Municipality of Lima set up a micro-credit programme to help low income citizens purchase bicycles. By saving on daily public transportation costs, workers can see their income effectively rise more than 12% once the loan is paid off. In order to enhance the success of the program, efforts have been made at standardizing the use of bicycles in the city. Actions to achieve this have so far consisted of the development of a manual of technical standards for the design and planning of cycle ways.
Bicycle rental, Velib, Paris, France C40 Cities (2010). "Paris, France Velib - a new Paris love affair", available from http://www.c40cities.org/bestpractices/transport/paris_cycling.jsp Paris launched a 24/7 cycle hire scheme through Velib; a public private partnership between the city of Paris and a company led by a major advertising group. Users must purchase a subscription by day, week or year, and bike rental is free for the first half hour of every individual trip, after which it costs a fixed rate. The increasing price scale ensures the bikes are kept in circulation. Notably, the City of Paris generates revenues from the project without any investment (which cost USD 108 million). The public-private partnership is the reason for this success, with the private company paying operating costs plus rights to advertising space to the City, funded by advertising revenues.
Tools & Guidance
Sustrans (2007). "Technical guidelines for the development of cycle facilities" A series of guidance documents for professionals on the details of bicycle network design. Available online from http://www.sustrans.org.uk/resources/design-and-construction/technical-guidelines

Transport for London (2010). "London Cycling Design Standards" A guidance document for designing to reduce barriers to cycling, in order to support road safety targets. Available online from http://www.tfl.gov.uk/businessandpartners/publications/2766.aspx

ANNEX 3: TRAFFIC RESTRAINT MEASURES

Description

Discouraging potential drivers from using their cars leads to fewer cars in circulation. This encourages people to use alternative modes, which in turn will increase their viability (increased public transport patronage for example).

Removing vehicles from circulation reduces fuel use and reduces the need for road space.

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

Implementation Options

Implementation Activity	Methodology
Blanket bans	The City Authority imposes blanket bans. Possible types of blanket bans include vehicle-type bans which exclude entire vehicle categories from circulation; or licence plate bans, by which certain number plates are banned from circulation. A weakness of licence plate bans are that they tend to result in wealthier residents purchasing second cars, not only negating the aims of the ban, but thereby also disadvantaging those with lower incomes. See Guangzhou case study for further details.
Licensing	The City Authority rations permits. The establishment of quotas for private vehicles allows for only a certain number of vehicle registrations over a given period of time. However, as demand for cars tends to be inelastic, this often results in very high purchase prices for the licenses - a mechanism which favours the wealthy and marginalizes the lower income brackets of society. See Singapore case study for further details.
Civic initiatives	The City Authority sanctions and encourages 'no-driving days' to educate and lead by example. Participation in these initiatives is voluntary, however, and therefore not enforceable. See Puerto Princesa 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:

- Perform traffic surveys of the number of vehicles in circulation pre- and post-implementation.
- Determine the mode share of people travelling in an area or the city.
- Collate registration data of users to paid schemes or voluntary schemes.
- Perform statistical analysis of rate of growth of car registration data.

Case Studies

Vehicle bans: Motorcycle ban, Guangzhou, China Institute for Transportation and Development Policy (2008). "Case study: motorcycles in Guangzhou", available online from http://www.itdp.org/documents/Guangzhou%20Case%20Studies%20-%20Motorcycles%2015-Sep-08.pdf Motorcycles have been completely banned in the City of Guangzhou. The ban was implemented in phases, beginning with a moratorium on new licenses, extending to various roads and time periods. Gradual implementation has been crucial to allow time for the public to adapt, and efficient supply of additional infrastructure/services has supported the induced modal shift. Many motorbike riders have shifted to bicycles and buses, and cycle rickshaws have also emerged as a popular substitute. Road accidents have dropped by 40% since the initial implementation of the ban.
Rationing, Singapore, Singapore Sustainable Urban Transport Project (2010)."The Vehicle Quota System in Singapore", available online from http://www.sutp.org/index2.php?option=com_content&do_pdf=1&id=1582 Singapore fixes the number of new vehicles allowed for registration. Potential buyers need to bid for a non-transferable licence, which entitles them to own a vehicle for a fixed number of years. The scheme had to be modified soon after implementation to safeguard against speculative action. The licences used to be transferable and within the first two months of the first round of release, 20% changed hands in "buy and sell" transactions with speculators making sizable profits of up to S$5000. As the rationing system does not control annual mileage, the success of the rationed registration in limiting vehicle usage has been dependent on support from other traffic restraint measures, such as high road tolls, parking fees, and electronic road pricing.
No-driving days, One Day Rest, Puerto Princesa, Philippines ICLEI (2001). "Vehicular Reduction Strategy for Air Pollution Prevention and Climate Change Mitigation; A Case of Puerto Princesa City,

Philippines", available online from http://www.iclei.org/index.php?id=1193
Introduced as part of a zoning and rerouting, this program stipulates a one day rest for tricycle drivers in the central business district. Regulation of illegally operated tri-cycles is a major impediment, as enforcement irregularities pose questions of inequality between illegal and legal tri-cycle taxi drivers. Furthermore, the income potential of those who comply with the rest day is lost to the illegal operators

Tools & Guidance
Sierra Club of Canada (2001). "How to Stage a Car Free Day In Your Community" A guidance document for preparing and planning a community-driven car free day. Available online from http://www.worldcarfree.net/wcfd/documents/cfd_howto.pdf

ANNEX 4: PARKING RESTRAINT MEASURES

Description

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

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

Implementation Options

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

Attributes

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

First Cost
< US$100,000

Speed of Implementation
> 2 years

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

	parking in central locations. The perceived cost should be lower than that of driving the entire way. Measures of this kind often require major capital investment in infrastructure by the city authority with respect to 'Park & Ride' locations on the periphery of the city, bus terminals and additional buses. See Oxford case study for further details. Complementary implementation activity: Planning measures

Monitoring

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

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

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

Case Studies

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

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

Parking fees, Aspen, US
Source: Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines", available online from http://www.vtpi.org/parkpricing.pdf
The city used to suffer from high levels of congested on-street parking. In order to reduce the effects of the "ninety-minute shuffle" (where locals and downtown commuters moved their vehicles every 90 minutes to avoid a parking ticket), the city introduced charges for on-street parking using multi-space meters. Parking fees are highest in the center and decline with distance from the core. The city had a marketing campaign to let motorists know about the meters, including distribution of one free prepaid parking meter card to each resident to help familiarize them with the system. Motorists were allowed one free parking violation, and parking control officers provide an hour of free parking to drivers confused by the meters.

Park-and-Ride, Oxford, United Kingdom
Oxford City Council (2009). "Park and Ride Transfer", available online from http://www.oxford.gov.uk/PageRender/decTS/Park_and_Ride_occw.htm
Oxford city has five Park-and-Ride sites serving the city's shoppers, visitors and commuters. These sites used to charge for parking to provide income to cover operational costs, but were not able to generate additional money for repairs or improvement. In order to achieve savings, the management of the Park-and-Ride sites was transferred to Oxfordshire county, resulting in efficiency savings of 250,000 GBP per year for the city administration. These savings were achieved primarily through economies of scale, and by sharing the cost of providing the service with taxpayers across the County, and not just those in the city - both of which used the facilities.

Tools & Guidance

Victoria Transport Policy Institute (2010). "Parking Management: Strategies, Evaluation and Planning" A comprehensive guidance document for planning and implementation of parking management strategies. Available online from http://www.vtpi.org/park_man.pdf

Victoria Transport Policy Institute (2010). "Parking Pricing Implementation Guidelines" A guidance document for implementation of parking pricing with details on overcoming common obstacles. Available online from http://www.vtpi.org/parkpricing.pdf

Tools & Guidance
Spillar, R. (1997). "A Comprehensive Planning and Design Manual for Park-and-Ride Facilities" A guidance document for the planning and design of Park-and-Ride facilities. Available online from http://www.pbworld.com/library/fellowship/spillar

ANNEX 5: STREET LIGHTING TIMING

Description

Public lighting usually only has two states of operation, i.e. 'on' and 'off', and only switches between these states in the early evening and early morning. The demand for lighting varies significantly throughout the day, however, with periods of very little use of public space during the middle of the night. A program with strategic timing and/or dimming tailored to the specific needs for lighting in specific areas can significantly reduce energy consumption whilst still delivering appropriate levels of lighting for e.g. providing safety and sense of security in public areas. An intelligent monitoring system can be used to adapt the levels of lighting according to varying weather and activity levels. The aim of this recommendation is to identify public space usage patterns and adjust the lighting system levels accordingly. Often lighting timing programs are integral to a full audit and retrofit program, but for cities that already have energy efficient public lighting systems, a lighting timing program may still be a small and effective program. Lighting timing programs can reduce energy consumption, and subsequent carbon emissions as well as operational costs. Such programs often also increase the design life of light bulbs, reducing maintenance requirements and associated costs. The use of intelligent monitoring systems also enables quick detection of faults, allowing for quick replacement, enhancing the quality of the public lighting service.

Implementation Options

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

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

	for energy efficiency and IESNA illumination guidelines.
Monitor and publish energy savings	Measure on an annual basis the energy savings achieved by this program and encourage private sector owners to follow the model of the CA.

Monitoring

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

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

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

Case Studies

Control system for public lighting, Kirklees, UK

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

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

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

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

Tools & Guidance
N/A

ANNEX 6: PROCUREMENT GUIDE FOR NEW STREET LIGHTS

Description

Traditionally used incandescent bulbs in street lights, are highly inefficient in that they produce little light and much heat energy from their significant power consumption. They are often also poorly designed, emitting light equally in all directions unnecessarily, including the sky above, which further increases their energy inefficiency. New bulb technologies, can often significantly increase their efficiency as well as extending their design life. Traditionally used luminaires usually have short design lives of about five years, requiring frequent replacement. The aim of this recommendation is to produce a guide to inform the procurement of new bulbs when replacing faulty ones.

The replacement of lighting technology can deliver the same lighting levels for lower energy consumption, reducing associated carbon emissions as well as operational costs. The improved design life also reduces maintenance requirements and costs and further reduces interruptions to service, thereby improving public health and safety.

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
Financial savings

Implementation Options

Implementation Activity	Methodology
Improved Street Lighting Design Manuals	Prepare a design manual for public street lighting which follows best practice IESNA public lighting for visibility and safety guidelines. The design manual should include parameters for illumination, pole spacing recommendations, luminaire and lamp type recommendations and dimming or time of night illumination operations for all types of typical streets in the city.
Energy Service Contracts for new street lighting installations	Prepare an RFP for energy service companies (ESCOs) to bid on providing street lighting illumination for the city. The requirement should include design, installation, maintenance and operational (energy) costs. The contracts should be for a long time period (more than 10 years) and include strict requirements for illumination (minimums and maximums). The goal of the contracts will be to entice competition in the private sector to provide the lowest operational cost possible.

Life Cycle Cost analysis component in procurement submissions	Require all procurement submissions for purchasing of new street lighting installations, lamp replacement purchases, or maintenance costs to provide a life cycle analysis of first cost, maintenance costs and energy costs over the span of 7 years.

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:

- Lumens / Watt - efficacy of illumination for the current design standards for lamp procurement
- Watts / km - averages for different street widths and types

Case Studies

Midlands Highway Alliance (MHA), UK

http://www.emcbe.com/Highways-general/idea%20case%20study.pdf

Working under the East Midlands Improvement and Efficiency Partnership (EMIEP), the Midlands Highways Alliance (MHA) will save the region GBP11 million across highways maintenance and improvements by 2011.

Supported by Constructing Excellence, the nine councils in the region and the Highways Agency have been making efficiency savings through a best practice procurement frameworks for major and medium sized highways schemes and professional civil engineering services, sharing best practice in maintenance contracts and by the joint procurement of new technologies such as streetlighting and signage. The document outlines the minimum and desired specifications for street lighting technologies in order to achieve the carbon emissions and cost reductions required.

"Lighting the Way" Project, Australia

http://www.iclei.org/fileadmin/user_upload/documents/ANZ/CCP/CCP-AU/EnergyToolbox/lightingtheway.pdf

Australia is committed to reducing its growth in greenhouse emissions. Currently initiatives are underway at all levels of government to improve the efficiency of public lighting, including State and local government trials of more efficient public lighting. Public lighting of minor roads is a major source of greenhouse gas emissions for local government. There are many opportunities to improve the quality of

the lighting while reducing both the costs and greenhouse emissions.
The various stakeholders have produced a procurement guide, "Lighting the Way", which provides information to assist local governments in improving the public lighting of minor roads in their communities while reducing their greenhouse emissions, lowering their costs and decreasing their liability and risk. These outcomes can be achieved through use of energy efficient solutions that provide better service in street lighting and comply with Australian Standards (AS/NZS 1158).
It outlines technical and other issues related to energy efficient lighting. It also provides some guidance for councils on techniques to improve their ability to negotiate public lighting issues with distribution businesses. A number of lamp types offer considerable advantages over the standard 80 watt mercury vapour lamps in terms of power consumption, lumen depreciation, light output, maintenance, life span, aesthetics and performance in various temperatures.

Tools & Guidance
European Lamp Companies Federation. "Saving Energy through Lighting", A procurement guide for efficient lighting, including a chapter on street lighting. http://buybright.elcfed.org/uploads/fmanager/saving_energy_through_lighting_jc.pdf
New York State Energy Research and Development Authority. "How to guide to Effective Energy-Efficient Street Lighting" Available online from http://www.rpi.edu/dept/lrc/nystreet/how-to-officials.pdf
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

ANNEX 7: STREET LIGHTING AUDIT AND RETROFIT

Description

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

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

Attributes

Energy Savings Potential
> 200,000 kWh/annum

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

Speed of Implementation
1-2 years

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

Implementation Options

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

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

Monitoring

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

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

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

Case Studies

Light Emitting Diode (LED) street lighting retrofit, Los Angeles, USA
Source: ESMAP (2011). "Good Practices in Energy Efficiency: Los Angeles, USA: LED Street Lighting Retrofit", available online from

http://www.esmap.org/esmap/sites/esmap.org/files/LosAngeles_LED_final_edited_11-9-11.pdf The City of Los Angeles (LA) Light Emitting Diode (LED) street lighting project is the largest LED street lighting retrofit ever undertaken globally—a collaboration between the LA Bureau of Street Lighting, the LA Mayor's Office, the LA Department of Water & Power, and the Clinton Climate Initiative (CCI) Cities Program. Over a period of five years (2009-2014), the project will replace 140,000 of the city's more than 209,000 street lights with LED technology which is expected to enhance the quality of municipal street lighting, reduce light pollution, improve street safety, and save energy and money. The US$56.9 million investment required will provide an estimated US$10 million in annual energy and maintenance cost savings (68.6 GWh/year) while avoiding at least 40,500 tons of CO2e emissions each year.
ESCO street light retrofit, Akola, India **Source: ESMAP (2009). "Good Practices in Energy Efficiency: Akola Municipal Corporation, India - Performance Contracting for Street Lighting Energy Efficiency", available online from http://www.esmap.org/esmap/sites/esmap.org/files/CS_India_SL_Akola_020910.pdf** The Akola CA enlisted an ESCO to replace over 11,500 existing street lights (standard fluorescent, mercury vapor, sodium vapor) with efficient T5 fluorescent lamps. The selected contractor financed 100% of the investment cost, implemented the project, maintained the newly-installed lights, and received a portion of the verified energy savings to recover its investment. Under the energy savings performance contract, the CA paid the ESCO 95% of the verified energy bill savings over the 6-year duration of the contract. AEL was also paid an annual fee for maintaining the lamps and fixtures. Initial investments were estimated at USD 120,000 and the retrofit was completed within a 3-month period. Annual energy savings of 56% were achieved, delivering the equivalent of USD 133,000 in cost savings. This gave a very attractive payback period of less than 11 months.
Street light retrofits, Dobrich, Bulgaria **http://www.eu-greenlight.org - Go to "Case Study"** In 2000, the City of Dobrich performed a detailed audit of the current state of the entire street lighting system. The results informed a project which commenced the following year which reconstructed and modernized the street lighting system. Mercury bulbs were replaced with high pressure sodium lamps and compact fluorescent lamps. In total, 6,450 new energy efficient lamps were brought into operation. The street lighting control system was also upgraded, as well as two-tariff electric meters installed. The implemented measures delivered an illumination level of 95% whilst yielding annual energy savings of 2,819,640 kWh. This saved the CA 91,400 EUR/year.
Street Lighting LED Replacement Program, City of Los Angeles, USA **Clinton Climate Initiative, http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative/i/cci-la-lighting** A partnership beween Clinton Climate Initiative (CCI) and the city of Los Anglese, this project will be the largest streetlight retrofit undertaken by a city to date, replacing traditional streetlights with environmentally friend LED lights. It will reduce CO2 emissions by 40,500 tons and save $10 million annually, through reduced maintenance costs and 40% energy savings. The Mayor of Los Angeles and the Bureau of Street Lighting collaborated with CCI's Outdoor Lighting Program to review the lates technology, financing strategies, and public-prive implementation models for LED retrofits. CCI's modelling and technology analysis, as well as its financial advisory, serves as key reference sources for the development of this comprehensive retrofit plan.

The phased nature of the project allows the city to re-evaluate its approach on an yearly basis. This gives enviable flexibility to the municipality when selecting contractors and the street lighting systems for upgrade. Los Angeles also capitalised on its government status to attract financial institutions offering favourable loans and funding mechanisms as these institutions were looking to establish positive relationships with the city. Due to these and other factors the City of Los Angeles was able to establish a well-developed business case for the retrofit.
Lighting Retrofit, City of Oslo **Clinton Climate Initiative, Climate Leadership Group, C40 Cities http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp** The City of Oslo formed a joint-venture with Hafslund ASA, the largest electricity distribution company in Norway. Old fixtures containing PCB and mercury were replaced with high performance high pressure sodium lights and an advanced data communication system using powerline transmission that reduces the need for maintenance. Intelligent communication systems can dim lights when climatic conditions and usage patterns permit. This reduces energy use and increases the life of the bulbs, reducing maintenance requirements. The system is now fully equipped with all its components and is being calibrated to sort out some minor problems related to production failure in communication units. Overall the system has performed well under normal operating conditions.

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

ANNEX 8: WASTE LANDFILL GAS CAPTURE

Description

Landfill gas, or biogas, is a natural by-product of the decomposition of organic waste (such as food waste, green waste and paper) in landfills. If captured, it can be used as a source of energy through the generation of electricity and/or heat or by being processed for gas supply.

Landfill gas capture has the potential to provide alternative energy sources for municipalities.

Reduced fuel consumption and energy use as a result of good planning and allocation of suitable facilities.

Gas from landfills that contains a high proportion of methane, which can be converted to electricity or used to power vehicles as an alternative fuel.

As methane is a potent greenhouse gas, reducing the volume released into the atmosphere has significant environmental benefits.

Implementation options

Implementation Activity	Methodology
Feasibility study for landfill gas capture	A feasibility study establishes the technological and policy framework to implement a landfill upgrade program across the city. This should consider: ▪ Gas yields and generation rates over the next 10, 20, 30 years ▪ Technology ▪ Capital and operational costs ▪ Procurement options ▪ Finance options ▪ Operation and management requirements ▪ Coordination with environmental programmes The establishment of appropriate partnerships is central to the success of the study - partners can include national and regional government with industrial and technical support from private sector companies, research companies, or universities. These partnerships help garner support for expansion of the initiative and inform how the program fits into the larger policy and commercial framework. If there is an existing general

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 gain
Operational efficiency

	directive to support programs such as gas capture from landfill, the feasibility study should be formulated to fit with these policy prescriptions. Other municipality cost centres can also benefit from the study if biogas displaces other types of fuels, e.g., biogas-powered bus fleet. See Ho Chi Minh City case studies for further details.
Planning Policy Coordination / Regulation	The coordination of landfill gas capture programs with wider urban plans and planning policy allows the City Authority to develop a high level plan for gas capture, and through the policy system, the responsibility for developing landfill gas capture can be passed onto various bodies including developers or landfill operators. Planning policy that relates to gas capture should be developed in the context of the wider policy framework and existing resources, e.g. technical capability, landfill retrofit potential. See California, Hong Kong and Ho Chi Minh case study for further details.
Procurement Program	The City Authority institutes a procurement policy or guidelines that allow a third party to install and operate a gas capture system on existing or new landfills. This implementation activity has good synergies with Kyoto Protocol Mechanisms: Joint Implementation and the Clean Development Mechanism, and these and other routes for obtaining financial support should be investigated. Coordination with environmental regulations is essential, as some programs require close monitoring to ensure they are safe and don't negatively impact the environment. See Hong Kong, Dar Es Salaam and Ethekwini 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:

- Increase in volume of gas captured (litres/annum)
- Increase in MW electricity produced

Asses gas quantities produced. Establish targets for gas generation rates for the next 10, 20, 30 years in phases.

Case Studies

Landfill gas recovery program, Tianjin, China
Source: ESMAP (2009). "Tianjin, China - Landfill Gas Capture for Electricity Generation – A Case Study", available online from http://www.esmap.org/esmap/node/661
The city of Tianjin, the fifth largest city in China, has implemented a project to recover landfill gas (LFG), which was otherwise being released into the atmosphere, and burn pretreated LFG for electricity generation. The project was located at the Shuangkuo Landfill, one of five municipal waste landfills in Tianjin. The planned capacity of the project is 4.3 MW which is being installed in stages. The first generator, 1.03 MW, started operation in May 2008, currently utilizing 500-600 cubic meters of landfill gas. The electricity produced is being sold to the North China Power Grid under a long-term contract. Through the project, the city was able to use waste to generate revenues and gain local environmental benefits.
The project was initiated by the Tianjin Municipal Government, which has invested CNY46.7 million (US$6.9 million) in the project. The project has been implemented and is being operated by a specially created entity, the Tianjin Clean Energy and Environmental Engineering Co. Ltd. (TCEE). The project will obtain revenues from the sale of electricity which, over the project's life, will amount to CNY245.2 million (US$36.2 million). The project has been registered as a CDM project under the Kyoto protocol and reached an agreement with the World Bank to purchase the certified emission credits (CERs) from the project.
The successful implementation of the project provides an excellent demonstration of the technology and the institutional mechanisms for LFG recovery and electricity generation, which can be applied to many other large Chinese cities.

NENT Landfill Gas Utilisation Scheme, Hong Kong, People's Republic of China
Source: Environmental Protection Department, The Government of Hong Kong, available online from http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_lgu.html
Hong Kong has implemented large-scale schemes to extract gas from landfill sites in order to help reduce the use of fossil fuels in the town gas production process. The North East New Territories (NENT) Landfill Gas Utilisation Scheme is one of the largest off-site landfill gas utilisation schemes in the world, helping to minimise the use of fossil fuel in the town gas production process and reduce the release of methane into the environment. Landfill gas (LFG) is recovered from the NENT Landfill and used for on-site energy demands (electricity for site facilities and heat for wastewater treatment), whilst surplus landfill gas that is not utilised on site is used for the landfill gas export scheme. A LFG treatment

plant has been installed at NENT landfill to treat the raw landfill gas, removing CO2, hydrogen sulphide and non-methane hydrocarbons. The product gas (80% methane) is then delivered to the Towngas production plant through a 19km underground pipeline. The scheme produces annual reductions of up to 135,000 tonnes of C02e emissions annually. An agreement to construct the LFG treatment plant is held between the contractor of the NENT Landfill, Far East Landfill Technologies Limited (FELT) and the Hong Kong and China Gas Company Limited (HKCG). FELT and HKCG have invested US$ 10.4 million in the LFG treatment plant and US$ 19.6 million in the gas pipeline respectively.

Sanitary Landfill Gas CDM Project, Ho Chi Minh City, Vietnam
UNFCC "CDM Project 1913: Phuoc Hiep I sanitary Landfill gas CDM project in Ho Chi Minh City" http://cdm.unfccc.int/Projects/DB/DNV-CUK1214915267.84/view
R.E.E. Mechanical & Electrical Engineering Joint Stock Company "Ground Breaking Ceremony the project to recover methane emitting from the landfill and to generate power according to the Clean Development Mechanism" http://www.reeme.com.vn/Eng/tincongtyen.php?Idtin=39
Ho Chi Minh City has contracted KMDK (Vietnam) Co. Ltd to develop projects for methane recovery and power generation from the three landfills of Phuoc Hiep, Cu Chi Ward and Dong Thanh, under the Clean Development Mechanism (CDM). At the three municipal landfills, REE and KMDK South Korea are the main partners responsible for the installation of landfill gas (LFG) collection systems, LFG flaring facilities, leachate recirculation systems and electric power generation facilities. One of the projects (at the Phuoc Hiep I landfill) involved the installation of a full-scale LFG collection system to monitor the flare systems, quantity and quality of gas available from the site. KDMK provided further support by producing a feasibility study and design report on landfill gas collection efficiency.
The CDM projects by KMDK produce 42 million KWh/ year to supply nearly 20,000 households and reduce CO2e emissions by 252,000 tonnes each year. Their estimated total capital investment has been between US$ 25 - 30 million. Socioeconomic benefits from the project include new technology development, local employment and minimized explosion risks by controlling methane emission.

Durban Landfill-to-Electricity Clean Development Mechanism, eThekwini, South Africa
eThekwini Municipality http://www.durban.gov.za/durban/services/cleansing/gastoelec
UN HABITAT, ICLEI, Sustainable Energy Handbook
http://www.iclei.org/fileadmin/user_upload/documents/Africa/Programs/Energy_and_Climate_Change/Sustainable_Energy_Handbook_Low_Res.pdf
South African Government Online "Minister Peters launches component two of the Durban Landfill Gas to Electricity Clean Development Mechanism (CDM) project, the first landfill gas to electricity in Africa" http://www.info.gov.za/speeches/2010/10012616251001.htm
The Durban Landfill-to-Electricity Clean Development Mechanism (CDM) project aims to enhance the collection of methane at three landfill sites of the eThekwini Municipality by installing 180 production wells for more efficient landfill gas extraction. The project aims at a collection efficiency rate of 85% at the highest level and 45% at the end of the project's commercial lifetime, over the three landfill sites. The captured methane gas is to provide fuel for the production of 10MV of electricity for supply to the South African municipal grid. Durban Solid Waste (DSW), the municipal agency responsible for management and operation of multiple landfills in the eThekwini metropolitan area, is the technical advisor and the operational entity of the project. The total cost for the integrated 3-site project is US$ 13.8 million, producing an

estimated 350,170 tonnes CO2e reduction at one of the project's landfills (Bisasar Road Landfill).The project is funded from an estimated total project income revenue of approximately US$ 620,000 per month, realised from the sale of carbon credits and methane-generated electricity under a long-term power purchase agreement to Durban municipality.

Landfill Gas Recovery and Electricity Generation Project, Dar Es Salaam, Tanzania
UNFCC "CDM Project CDM Project 0908 : Landfill gas recovery and electricity generation at "Mtoni Dumpsite", Dar Es Salaam, Tanzania
http://cdm.unfccc.int/Projects/DB/DNV-CUK1169853184.14
UN HABITAT, ICLEI, Sustainable Energy Handbook
http://www.iclei.org/fileadmin/user_upload/documents/Africa/Programs/Energy_and_Climate_Change/Sustainable_Energy_Handbook_Low_Res.pdf
Geneva Trade and Development Forum "Clean Development Mechanism as Tool for Sustainable Development: Case Study of Tanzania"http://www.gtdforum.org/download/Case%20Study%20Tanzania.pdf
The Dar Es Salaam City Council was approached by a private firm from Italy to establish a gas recovery and energy generation project at the Mtoni Dumpsite to reduce methane emissions, as a basis for a CDM project. The city authority granted the private firm, Consorzio Stabile Globus (CSG) the rights to capture and burn all biogas produced at the landfill over a 10 year period. CSG held responsibility for the construction and management of the gas extraction and flaring system, by setting up and operating an extraction plant. Annually, the project is estimated to reduce emissions by 202,271 tonnes C02e and generate about 200,000 carbon credits. Total investment costs for the project are approximately US$ 5.3million. Revenue from electricity sales and revenue from sale of carbon credits (US$ 2.65 -3.18 million) the expected return on investment is 2 years. CSG invested in the project whilst the city council continued to own and manage the landfill site, making the landfill capture program economically feasible for the city authority.

Altamont Landfill and Resource Recovery Program, California, USA
Waste Management World 2010 "Green Giant" http://www.waste-management-world.com
The Altamont Landfill and Resource Recovery Facility in northern California are owned by the private corporation Waste Management Inc., who commission the world's largest landfill gas (LFG) to liquefied natural gas (LNG) plant. Waste Management and Linde North America (a leading global gases and engineering company) joined ventures to build a LNG facility costing US$ 15.5 million, receiving state grants from the California Integrated Waste Management Board, the California Air Resources Board, the California Energy Commission and the South Coast Air Quality Management District. The plant provides enough fuel to power 60% of Waste Management's LNG vehicles in California, reducing Waste Management's dependence on foreign fossil fuel and introducing a domestic green energy source to the fuel market. An estimated 18 million litres of Altamont biofuel is produced annually, reducing CO2 emissions by an estimated 27,000 tonnes per year.

Tools & Guidance

United States Environmental Protection Agency tool "Landfill Gas to Energy Benefits Calculator" http://www.epa.gov/lmop/projects-candidates/lfge-calculator.html

ANNEX 9: FUEL EFFICIENT WASTE VEHICLE OPERATIONS

Description

Improving the working practices of waste vehicles and their crews can reduce fuel use per tonne of waste collected and transported. An assessment of current waste collection systems will be required to identify what alterations can be made. Upgrades can include improvements to driver training, route planning and/or management of service.

This recommendation offers the potential for affordable but reasonable energy use improvements without the need for vehicle fleet replacement or expansion, as options for improvement can be made via softer actions such as better management and planning.

Direct benefits include reduced fuel use, better productivity leading to increased vehicle payloads and reduced numbers of heavy goods vehicles in residential areas, and release of resources to collect more or segregated waste from larger or additional areas.

Indirect benefits include reduced accident rates and lower air emissions.

Implementation options

Implementation Activity	Methodology
Set fuel use reduction targets for waste collection and transportation fleets	The city authority sets targets for fuel-efficiency of waste collection and transfer operations. Defining targets over 5-year periods is an effective approach; for example, reduce fuel use per tonne of waste by 20% in 5 years. The city authority can appoint a Fleet Manager or a Maintenance Manager to measure fuel use, total waste collection quantity per year and distance travelled in order to set a baseline KPI for fuel-efficiency of operations. This should be completed for individual vehicles and the entire fleet. This system can be established internally and used in conjunction with the "Waste Vehicle Fleet Maintenance Audit and Retrofit" recommendation. See Oeiras case study for further details.
Route selection optimisation	Encourage waste operators to appoint resource or utilise in-house capability to plot out and digitise all collection points and routes on a map base. This is best done using a Geographic Information System (GIS) and it is important to seek route optimisation improvements, for example, ensure all waste vehicles are full at

Attributes

Energy Savings Potential
>200,000 kWh/annum

First Cost
< US$100,000

Speed of Implementation
< 1 year

Co-Benefits
Reduced carbon emissions
Improved air quality
Enhanced public health & safety
Increased employment opportunities
Financial savings
Improved working conditions
Reduced waste vehicle traffic

	disposal points, eliminate vehicle backtracks and minimise long distance haulage of waste in small vehicles. Consider alternative modes of transport such as via waterways to save energy and reduce heavy traffic on roads. The city fleet manager should regularly review routes with operators to ensure best use of resources. See Trabzon, Daventry, Oeiras and Paris case studies for further details.
Continued driver training and improvement	The city authority requires waste operators to provide a driver training and improvement programme in conjunction with the human resources team and fleet manager. A staff training team can be employed to create and manage an accredited training programme after an initial assessment. The city authority might also appoint a third party to install vehicle trackers and monitor all drivers following staff training. In addition, encourage operators to incentivise good driving where possible, for example, by providing drivers with a share in fuel costs saved. This implementation activity works well with educating operators about the benefits of efficient operations. See General Santos City and Oeiras case studies for further details.
Inform operators about the advantages of fuel-efficient operations	The city authority raises awareness amongst operators about the benefits of fuel-efficient operations. This can be done by one-to-one sessions or arranging a conference for key players in waste sector showcasing the energy and cost-savings from efficient operations including eco-driving, correct operation of vehicles, route optimisation, bulk transfer stations, etc. Set up a website or have an officer available to provide more information and advice after the event. See Maribor and General Santos City case studies for further details.
Incentives: charging	The city authority levies a surcharge on waste, for example a gate fee or eco-taxes for waste disposed at landfills. This is used to generate revenue and direct to new infrastructure improvements

	and waste monitoring/policing department. This implementation activity might also be used to encourage fleet operators to ensure that vehicle movements to landfills are kept to operationally efficient levels. See Paris and Italian Local Authorities' Waste Management 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:

- Fuel use per tonne of waste collected and transferred and per km travelled
- Improvement in fuel use per tonne of waste collected and transferred

Measure current performance utilising data from Maintenance Department, where feasible. If this information is not readily available, it is advisable to measure current fleet performance over a reasonable period, for example, annual reviews over 5 years.

Produce monthly management targets and schedules to help identify how the program is performing and the magnitude of effort that will be required to achieve initially set KPI.

Case Studies

Energy Study on Oeiras' Municipal Fleet, Oeiras, Portugal

ManagEnergy 2010 "Good Practice Case Study: Energy Study on Oeiras' Municipal Fleet, Portugal"
http://www.managenergy.net/download/nr263.pdf

The Municipality of Oeiras (CMO) worked in partnership with the Technical University of Lisbon (IST) on a project to carry out a review of the current performance of the municipal fleet, which included waste collection trucks. The objectives were to assess the fuel consumption by vehicle type, establish performance indicators (km/L), propose simple measures to improve efficiency (eco-driving training), study the potential of implementing alternative fuels (biodiesel and natural gas), and perform an environmental assessment. In the absence of

complete data, the project used refuelling data and mileage records to estimate the total fuel consumption of waste collection trucks and its impact on the municipality's budget. A more advanced fleet management system was planned for the later phases, utilising technologies supported by GPS to allow for better control over fleet operations and improve the data available. The total project costs amounted to US$ 45,384, fully supported by the Municipality.
By the end of 2006, the project allowed OEINERGE (the project coordinator) to estimate that simply by processing the existing used frying oils in the County into biodiesel and using it to fuel some of the fleet's waste trucks, a reduction of approximately 10% in fossil fuel consumption could be achieved. In addition to allowing the municipality to understand the full functionality of the waste vehicle fleet and helping identify the potential problems in its management, the project has an important role for best practice dissemination, emphasising the importance of accurate data recording and monitoring to introduce fuel and cost savings.

Route Optimization for Solid Waste Collection, Trabzon City, Turkey
Global NEST 2007 "Route Optimization for Solid Waste Collection: Trabzon (Turkey) Case Study"
http://www.gnest.org/Journal/Vol9_No1/6-11_APAYDIN_388_9-1.pdf
As part of the municipal solid waste management system, a study was undertaken to determine whether waste collection costs could be decreased through route optimization in Trabzon. Data related to present spending, truck type and capacity, solid waste production, number of inhabitants and GPS receiver data for each route were collected and recorded (using GIS software) over 777 container location points. The solid waste collection/hauling processes were optimised using a shortest path model with "Route View Pro" software. The optimization process produced fuel savings of 24.7% in distance and 44.3% in time for collection and hauling. The improvements also provided savings of 24.7% in total expenditure

MasterMap Integrated Transport Study, Daventry, United Kingdom
Ordinance Survey 2010 "Optimising waste collection using OS MasterMap Integrated Transport Network Layer Case study"
http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/layers/Docs/DAVENTRY.pdf
Daventry local authority worked with the Northamptonshire Waste Partnership (NWP) to rationalise the number of domestic waste collection routes from nine to eight, reducing diesel costs by 12% and increasing spare capacity by 14% without increasing labour hours. The project was carried out by an external environmental advisory and management company using the OS MasterMap Integrated Transport Network (ITN) Layer with Road Routing Information (RRI) - which includes detailed road routing and drive information such as width, height and weight restrictions, taking account of delays from left and right turns and intersections. This allowed each waste vehicle route to be optimised by balancing the workload between routes on a daily or on a weekly basis.
The system enabled optimisation of existing waste collection procedures, resulting in increased spare capacity which could be retained for areas of new housing growth, in turn reducing the need for new routes. The project produced savings of over US$ 154,136 per annum for Daventry alone (not including savings by neighbouring local authorities). Since the project was funded by procuring regional public funds, the overall savings are identified to be greatly in excess of the sum of the contract value and authority time.

Eco-Driving Project, Maribor, Slovenia

Recodrive 2009 Press Release, "Eco-driving leads to fuel savings in waste management in Maribor, Slovenia" http://www.recodrive.eu/index.phtml?id=1039&study_id=2596
Maribor's public waste collection, management and transport company (Snaga) conducted a comprehensive 3 month training programme for drivers to implement and test eco-driving. Carried out as part of the EU-wide "Rewarding and Recognition schemes for Energy Conserving Driving, Vehicle procurement and maintenance" (RECODRIVE) project, the programme achieved an average 4.27% reduction in fuel consumption over 8 months. The savings in fuel costs were used to provide wage bonuses to fuel-efficient drivers. In addition, by making additional changes in their optimised routing plan, Snaga is able to collect the same amount of waste in the same area using one less vehicle.
The RECODRIVE project also constitutes information dissemination to achieve fuel savings beyond 10% in municipal fleets across Europe. Participating fleet owners further the RECODRIVE concept by inviting other fleet owners to hands-on workshops and conferences on eco-driving and fuel-efficient vehicle operations. Despite being an EU-wide scheme, RECODRIVE's knowledge hub (internet-based information dissemination) could be applied on a city-wide scale to achieve fuel efficient-operations amongst municipal waste management operators.

Garbage Collection Efficiency Project, General Santos City, Philippines
USAID "Introducing Measures To Improve Garbage Collection Efficiency" http://pdf.usaid.gov/pdf_docs/PNADB349.pdf
USAID "Moving Towards an Integrated Approach to Solid Waste Management" http://pdf.usaid.gov/pdf_docs/PNADB344.pdf
General Santos City Solid Waste Management Council organised a series of hands-on workshops to formulate ways of improving efficiency of the current collection system and management of dumpsite operations. Formerly, waste collection was concentrated only in the CBD with no regular routing or collection schedule. With the help of various stakeholders, the city formulated new collection schedules and routes and identified pre- and post-collection intervention strategies for the community. Routes were modified to reduce the number of left turns and U-turns taken by the trucks to increase speed of collection and reduce accidents. The number of staff per compactor truck was reduced from five to a maximum of three people, and waste collection trips were reduced from six trips to two-three trips per day. The enhanced collection efficiency allowed coverage of a wider area without increasing the number of trips, accelerated waste collection and provided more time for vehicle maintenance and crew rest. High levels of community representation and coordination of working groups were key to producing more efficient solutions to the current collection system.
The above improvements were complemented by simultaneous campaigns for segregation and recycling. The city government also improved management of the dumpsite while a new landfill is being prepared.

Isseane EfW and Materials Recycling Facility, Paris, France
The Chartered Institution of Waste Management "Delivering key waste management infrastructure: lessons learned from Europe" http://www.wasteawareness.org/mediastore/FILES/12134.pdf
The Associate Parliamentary Sustainable Research Group, "Waste Management Infrastructure: Incentivising Community Buy-in" http://www.policyconnect.org.uk
In 2008, the Isseane EfW (Energy from Waste) and Materials Recycling Facility was opened on the banks of the Seine by SYCTOM

(Intercommunal Syndicate for Treatment of Municipal Waste) to replace an existing incinerator that had been in operation for over 40 years. The project was approved by the municipal council of Issy-les-Moulineaux in July 2000 with a total investment cost of US$ 686 million, which will be financed over a seven year period by a type of prudential borrowing, based upon gate fee revenues from the communes.
Isseane is conceived on a proximity principle so that waste travels no more than six miles to be treated. The design of the facility also takes traffic movements into careful consideration. Waste deliveries taking place below ground level to control dust, noise and odour levels. The location of the facility makes use of the river Seine, with barges taking away inert bottom ash from the incineration process for use in ancillary projects.

Local Authorities' Waste Management, Italy
The Chartered Institution of Waste Management "Delivering key waste management infrastructure: lessons learned from Europe" http://www.wasteawareness.org/mediastore/FILES/12134.pdf
Waste services in Italy are delivered through public bodies known as 'ATOs' which are funded directly by local authorities, responsible for defining the services required to manage local authority waste streams. New waste management infrastructure is often funded directly from the local authorities' own resources, although for large facilities there may also be some private finance, in effect through a form of prudential borrowing. In some cases waste facilities or services may be procured through a tendering process from private sector waste management companies, with contracts in place either directly with a local authority or the relevant ATO. An ATO can also fund a waste infrastructure project either in part or completely, through the use of eco-taxes. The CONAI scheme, for example, raises US$ 324million annually from an eco-tax on all packaging that sets aside funds for new waste infrastructure.

Tools & Guidance
"Integrated Toolbox for fleet operators" http://www.fleat-eu.org/downloads/fleat_wp3_d32_toolbox_updated.pdf
"Policy mix for energy efficient fleet management" http://www.fleat-eu.org/downloads/fleat_wp3_d33_policymix_final.pdf
RECODRIVE online knowledge hub http://www.recodrive.eu/window.phtml?id=1008&folder_id=38

ANNEX 10: MUNICIPAL OFFICES 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 • heating systems • computers • server rooms and cooling of servers

Attributes

Energy Savings Potential
> 200,000 kWh/annum

First Cost
> US$1,000,000

Speed of Implementation
1-2 years

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

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

Monitoring

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets)

should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.
Some suggested measures that relate specifically to this recommendation are as follows:

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