

ECA Sustainable Cities:
Improving Energy Efficiency
in **SKOPJE**
Macedonia

TRACE Study



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Executive Summary

Skopje is one of the burgeoning cities of the Western Balkans. After a period of economic decline and infrastructure depreciation in the 1990s, the city has seen a resurgence in the new millennium. With more resources made available locally by economic growth, authorities have invested in a wide range of projects, including several energy efficiency projects. However, this new growth has not come without its challenges. The city has been rapidly sprawling outwards, with more and more people choosing individual detached housing over apartments in high-rise buildings, car ownership has increased as incomes have risen, in-city car commuting has also increased as people from surrounding areas seek opportunities in Skopje, waste generation has grown hand in hand with increased consumption, and existent infrastructure networks (e.g. water and wastewater) have often been left to crumble away as local authorities have focused on providing basic services to the new and underserved parts of the city.

Despite these challenges, the city gives the impression of a vibrant center that is poised to become a sustainability capital in the Western Balkans. Many things have already been done in this direction, but more remains to be done. The purpose of this TRACE analysis is to identify further sustainable development avenues Skopje could pursue.

TRACE (Tool for Rapid Assessment of City Energy) is just one of the tools used by the Europe and Central Asia Sustainable Cities Initiative (ECA SCI) to promote sustainable development in ECA cities. Thus, although TRACE specifically focuses on energy efficiency issues in cities, the discussion in this report will go beyond that, to focus 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. More information on the ECA SCI can be found at: <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:23050220~pagePK:146736~piPK:146830~theSitePK:258599,0.html>

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 Skopje 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), municipal buildings, public lighting, and solid waste management, and municipal buildings. Some of the recommendations made for these service areas are included below.

Private Vehicle use is probably one of the most pressing issues in Skopje, with car use and ownership growing dramatically in recent years, with an increased number of people commuting in by car from surrounding areas, with congested and polluted streets, and with over-parked sidewalks and a city center that is choked up by cars. Despite a number of comprehensive measures that have been put in place, such as traffic easement (e.g. roundabouts, green waves) and a center city parking system, traffic continues to be a major problem.

Following the TRACE analysis, several recommendations emerged for this service area. For one, local authorities could consider expanding on the good work they have already done in creating a non-motorized transportation infrastructure – particularly for walking and biking. Walk and bike-paths could be integrated with public transportation routes, to offer people as many opportunities as possible to get out of the car. A large majority of people already use walking to commute to work. Local authorities should ensure that their commutes are not only safe (e.g. by sheltering them from traffic, or by providing proper lighting for walk-paths), but also comfortable and pleasant (e.g. by improving worn-out paths, and by adding greenery and other amenities). In addition to expanding non-motorized transportation infrastructure, local authorities should consider measures aimed at reducing car traffic, such as more stringent parking restraint measures (e.g. enforcing steep fines for illegal side-walk parking), and traffic restraint measures (e.g. by continuing to convert streets to pedestrian only areas).

Public Transportation has seen a revival in recent years, with much of the bus fleet being renewed, and with a expansion of serviced city areas. This revival comes however after over 15 years of decline, with ridership on publicly owned buses dropping from 160 million passengers in 1988,

to 60 million in 2005. The introduction of new double-decker buses has done much to win back some of the lost ridership. Plans to integrate the privately run and the publicly run bus fleets, will also help boost ridership. Such measures have to be continued in coming years, and local authorities seemed poised to do so. There are for example plans to introduce a tramway system, which by 2030 is hoped to become the main transportation mean in the city. To the extent possible, the public transportation infrastructure should be seamlessly integrated with the non-motorized transportation infrastructure (e.g. walk and bike paths), to make it much easier for people to leave their cars behind.

Municipal Buildings is one service area where a host of energy efficiency measures have already been implemented, with a quite a number more planned. Many buildings managed by local authorities (e.g. schools) have, for example, been equipped with energy efficient windows, they now have thermally insulated roofs and exterior walls, they have been equipped with new and energy efficient boilers and with automatic shut-off systems (which turn off lights and heat when nobody is in the room). Even when compared to other cities in the TRACE database, municipal buildings in Skopje seem to be doing well, with a relatively lower electricity and heat consumption.

Nonetheless, many municipal buildings have yet to receive any energy efficiency improvements. Consequently, the audits that have already been performed, could be used for implementing, or rather continuing to implement a host of good measures in the field. In particular, making municipal offices more energy efficient, by applying new and innovative technologies could have a good demonstration effect for other institutions, businesses, and the public at large. With such improvements in place, local authorities could also consider introducing energy efficiency codes for new buildings, which complement and properly enforce the national building codes already in place.

Public Lighting is a service area that is divided between the City of Skopje (i.e. the city-wide authority) and the 10 municipalities that Skopje is comprised of. The City of Skopje is in charge of public lights along the main boulevards in the city, while municipalities are in charge of public lights on secondary streets within their jurisdiction. The City has taken

many steps to make the street lighting system more energy efficient, and has installed new light poles while replacing energy inefficient mercury light bulbs with energy efficient high-pressure sodium light bulbs. Municipalities have also followed suit, although to varying degrees.

Nonetheless, more can be done in this sector. For one, the street lighting system can be expanded to cover the entire city (including new and/or underserved neighborhoods), defective light bulbs need to be replaced (as part of an integrated public lights assessment program), and a timing system should be put in place for a more efficient use of street lights – e.g. with lower light intensity when external conditions warrant it (e.g. long summer days) and when traffic is low (e.g. after midnight on week-days).

Solid Waste is a service area where much has happened in recent years, both from the public and private side. Collection and transport of waste is done quite effectively by the city, with well planned routes and a mobile transfer station that limits trips to the disposal facility. The disposal facility itself, the Drisla Landfill, meets only basic environmental requirements, but plans have been hashed out to privatize it. These plans also include the capture and use of landfill gas for productive purposes. In addition to such energy efficiency measures, local authorities could also consider training garbage truck drivers to drive their cars in fuel efficient way (e.g. avoiding frequent speeding and breaks). An incentive system could be put in place to convince drivers to take fuel efficient driving seriously (e.g. they could be offered as a bonus a share of the achieved fuel savings).

Background

Macedonia is a land-locked country situated in the Western Balkans (see map below). It is urbanized, with 68 percent of its population residing in cities, and with most of the country's wealth and pollution being generated in urban areas. 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 use and CO₂ emissions. Although CO₂ emissions continued to decline as the economy started to recover in the new millennium, this is mostly the result of a shift from industrial production to services, rather than of targeted government policies: pollution remains much higher than in many Western European countries.



Source: CIA World Factbook

To catch up with European Union (EU) income levels, while at the same time improving environmental sustainability, Macedonia needs to unleash the full potential of its cities through well targeted urban policies, regulations, and investments. The way Macedonian cities are planned, financed, and managed will have a determining effect on the quality of life of its citizens – today and in the future.

Unlike most other countries in ECA, Macedonia has had a growing population in the transition years following 1989. Most of the population growth was amassed by the largest cities in the country. As can be seen from the table below, all cities have registered healthy growth rates in the transition years, with the exception of Bitola. The biggest growth rates have been registered in the capital, Skopje, and in cities that are close to the capital, such as Kumanovo, Tetovo, and Gostivar.

Population Dynamic in the Largest Macedonian Cities				
City	Population		Compounded Annual Growth	
	1994	2010		
1 Skopje	444,760	482,626	0.51%	
2 Kumanovo	94,589	115,894	1.28%	
3 Bitola	86,176	85,463	-0.05%	
4 Tetovo	65,318	75,651	0.92%	
5 Prilep	71,899	73,675	0.15%	
6 Veles	56,751	57,616	0.09%	
7 Ohrid	52,732	55,098	0.27%	
8 Gostivar	45,740	52,822	0.90%	
9 Štip	46,372	48,509	0.28%	
10 Strumica	43,868	45,657	0.25%	
11 Kavadarci	37,189	39,018	0.30%	
12 Struga	35,509	37,760	0.38%	
13 Kočani	32,051	34,804	0.52%	

Source: World Gazetteer and authors' calculations

For these cities, sustainable energy is a critical element, and the larger scope of this work is to identify ways in which cities in Macedonia can become more energy efficient and ultimately more sustainable. The

focus will be on the largest city in Macedonia, Skopje, as it stands to benefit most from a tool like TRACE. In 2009, Skopje amassed about a quarter of Macedonia's population, and around 60% of its GDP (Macedonia Statistical Office). As the country continues on its current development path, it is likely that more and more people and businesses will concentrate in Skopje in search of economies of scale and scope.

This growth will come with significant energy requirements, and local authorities in Skopje will be pressed to identify suitable solutions. Moreover, by ensuring that urban energy supply is secure, reliable, and affordable, and by ensuring demand is efficiently managed, Skopje can optimize operating costs, improve air quality, and improve quality of infrastructure services, while at the same time supporting economic development and climate change mitigation objectives.

National Energy Efficiency Strategy

Macedonia has taken several significant steps towards becoming a more sustainable country, both in terms of its legal and regulatory framework, and in terms of how its cities and its economy are organized. On February 2011, it has passed its first *Energy Efficiency Law*. The Law makes several provisions for public sector entities, requiring energy efficiency improvements for buildings, building units, devices, and plants. Among other things, the Law stipulates that public entities need to adopt three-year programs on energy efficiency and implement the measures included in there. Municipal buildings have to be subject to energy efficiency audits at least once every three years, and they need to have energy certificates. When new municipal buildings are constructed, or when existent ones are subjected to major renovations, they have to be equipped with solar heaters – if such an investment is deemed cost-effective.

Prior to the adoption of the Energy Efficiency Law, several strategies and action plans were drafted, which have a bearing on energy efficiency and urban sustainability in general. *The Strategy for Energy Development of the Republic of Macedonia until 2030* sets guidelines for more efficient use of energy sources and for an increase in the use of renewable energy. Many of the activities outlined in the Strategy have a direct bearing on how cities are organized and managed. This overarching energy strategy is further buttressed by *The Strategy for Utilization of Renewable Energy Sources in the Republic of Macedonia by 2020*.

The Strategy for Improvement of the Energy Efficiency in the Republic of Macedonia until 2020 sets the goal to accelerate the adoption of energy efficiency practices in Macedonia so that by 2018 energy consumption will be at least 9% lower than the average registered for 2002-2006. By 2020, overall energy savings are expected to reach 14.5% - close to the 20% target set in the EU. Most of these savings are expected to come from cities, with lower electricity and heat use in buildings, more efficient public utilities, and a more sustainable transport sector. Reform initiatives will focus on the **legal and regulatory framework** (e.g. updating the Energy Law, imposing clear Building Energy Codes for new constructions, improving the legal framework concerning energy service companies (ESCOs) and their functioning), on **institutional and capacity building** (e.g. special courses in higher education, awareness raising and promoting of energy efficiency principles), on **social measures** (e.g. energy efficiency in social housing which translate into lower bills, block-tariffs for electricity to allow poor families to cope with planned tariff increases), and on **financial issues** (e.g. energy efficiency fund).

The First Energy Efficiency Action Plan of the Republic of Macedonia until 2018 is pursuant to the EU Directive 2006/32/EC on energy efficiency, and was done with assistance from USAID. The Action Plan outlines the measures that will help Macedonia achieve energy savings of 9% by 2018, as indicated in the 2020 Energy Efficiency Strategy. It is estimated that around €406 million are needed for the implementation of these energy efficiency measures, which will ultimately lead to energy and cost savings of around €1,360 (at liberalized energy market prices). Most of the measures focus on cities, and some of them are particularly tailored to Skopje (e.g. introducing a tramway system in Skopje, or revamping the district heating network).

In addition to Government initiatives, several international organizations have been active promoters of energy efficiency in Macedonia. The World Bank has offered, on a pilot basis, a \$1.2 million Global Environmental Facility (GEF) Grant to six municipalities in Macedonia, for the improvement of the thermal performance of three municipal buildings in each municipality. Two of those municipalities, Gazi Baba and Kisela Voda, come from Skopje. The GEF Grant focuses on targeted measures such as replacing window panes, thermal insulation of outer

walls, roofs and basements, and installation of central heating. Once these pilot projects will be finished, the GEF Grant will be extended to other municipalities in Macedonia, but will focus on co-financing. Municipalities will be selected based on how much co-financing they will be able to provide themselves. It is thus expected to secure buy-in from vested local stakeholders. All in all \$2 million will be provided for the refurbishment of up to 30 buildings, with the expectation that half the total costs will be covered by municipal co-financing.

USAID is also an active player in the energy efficiency field, providing assistance for the drafting of the 2018 Energy Efficiency Action Plan and engaging in the implementation of energy efficiency measures in public buildings (primarily schools). As such, USAID has worked closely with municipalities, the Economic Growth Office, the Democracy and Governance Office, and the Education Office. Energy efficiency improvements in public buildings have managed to not only reduce energy costs, but, according to user surveys, have also created warmer and safer environments, have led to better lit spaces, with less noise and dust.

GIZ has provided technical assistance through the Open Regional Fund for Energy Efficiency, to help prepare several Rulebooks (e.g. Rulebook on Building Energy Efficiency Codes) as supporting documents to the Energy Law. It has also helped develop local capacity in energy management, monitoring, verification, and evaluation.

Urban Growth and Energy Challenges in Skopje

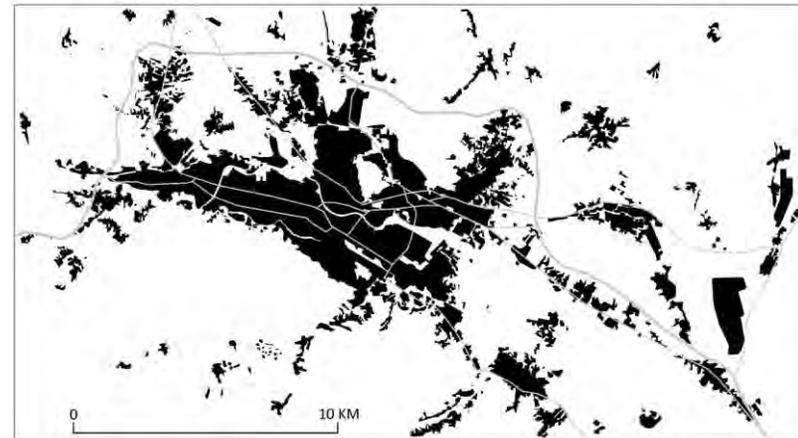
One significant area that is not captured by the TRACE tool is urban mass. Urban mass plays a critical role in determining energy usage patterns in a city. Generally, the denser a city is, the more energy efficient it will be. A dense city makes travel by foot and by bicycle easier; it makes public transport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

Promoting dense development patterns should be the norm for all city authorities. Unfortunately, cities the world over are becoming less dense. Even cities with a stagnating or declining population are witnessing some measure of sprawl. Many of the reasons for this

occurrence are known, while others are less intuitive. An aging of the building stock in center cities, the advent of the private car, and rising incomes, have pushed more and more people to cities' peripheries. In Europe and Central Asia sprawl is also encouraged by a set of idiosyncratic factors: high demand for housing (most centrally planned systems did not manage to provide housing at the rate required by population growth and urbanization); demand for more housing variety (most housing units built during Communism were 1-4 bedroom apartments in multistory buildings); and a general atomization of households (with a dramatic increase in the number of one-person households).

Skopje has followed such a pattern in the transition years, with its urban mass almost doubling. Much of the city had to be rebuilt after the 1963 earthquake, and many of the new neighborhoods that emerged afterward were high density. However, following the fall of Communism, urban growth in Skopje happened in a haphazard manner (see figure below). With the elimination of centrally drafted master-plans, and lacking proper local urban planning regulations, new developments went up wherever land was available.

Skopje Urban Mass



Usually, people opted for building individual detached homes and they tried to locate them close to existing infrastructure (roads, water,

sewage, etc.). Most often, the available infrastructure was represented by roads going in and outside the cities. Consequently, people tried to identify parcels of land close to those roads, and new neighborhoods followed a radial pattern outside the city. As can be seen in the figure above, instead of expanding outward in a compact fashion, Skopje seems to grow along different fronts, following the main thoroughfares outside the city. This has happened for several reasons: land markets outside the city are highly fragmented (made up of small agricultural parcels); there were few developers in the transition period that had the capital to finance large scale developments; and local authorities did not have the means to develop infrastructure that could guide development (e.g. an external street grid).

Many new developments are of the suburban type, as the one highlighted below. However, there are also many new high density developments, and there are also many in-fill developments throughout the city. Thus, while the city and the metropolitan area as a whole are becoming less dense, parts of Skopje are actually becoming denser.

Suburban Developments around Skopje

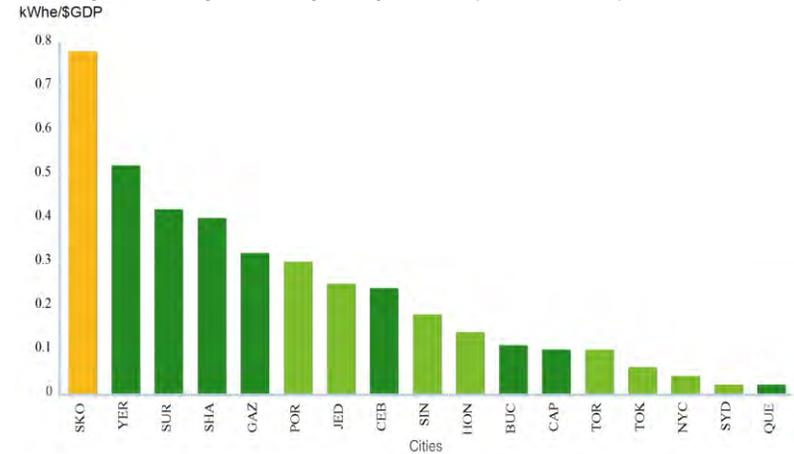


The challenge for local authorities is to encourage dense development patterns, and discourage sprawl. Given that the city does not have many natural barriers apart from the Vodno Mountain, and given its continued population growth, some amount of outward expansion is inevitable.

Local authorities can play an important role however in adjusting the scale of this outward expansion, and improving the city's energy performance.

Right now, Skopje has one of the highest rates of energy use per capita of any of the cities in the TRACE database, and it is the most energy intensive when it comes to the electricity consumed to produce one unit of GDP (see figure below). There is therefore great scope for improvement.

Primary Electricity Consumption per GDP (kWh/\$GDP)



Addressing energy efficiency challenges in Skopje will require the inputs and efforts of not just one local authority, but 11. Skopje itself is made up of 10 municipalities (see image below) and the City of Skopje. The City of Skopje is the only jurisdiction of its kind in Macedonia, and was set-up to manage city-wide issues and help deliver public services that would benefit from economies of scale. Thus, rather than having each of the 10 municipalities deliver public transport on their own, the City was tasked with managing this service area – this enables better planning, better integration, and more efficient delivery. The same was done for water and wastewater, and for solid waste management. Street lighting, on the other hand, was parceled out, with the City of Skopje being in charge of the street light on the main boulevards, while the 10 municipalities are in charge of street lights on secondary streets within their jurisdiction. It

was considered that since there are little economies of scale that can be achieved in the street lighting sector, it was best if each individual municipality was responsible for its own network. Thus people would elect their municipal representatives based on how well they delivered such services, as well as other services they are responsible for. It should also be mentioned here that as the city is growing and becoming more interconnected with the surrounding region, more and more people talk about the Skopje Metropolitan Area, not just the City of Skopje.

Municipalities of the City of Skopje



Source: en.wikipedia.org/wiki/Skopje

Formally, the Skopje Metropolitan Area includes seven other municipalities, mostly in the South and South-East of the city: Aračinovo, Čučer-Sandevo, Ilinden, Petrovec, Sopište, Studeničani, Zelenikovo. The reach of Skopje is much wider than that however. People commute into Skopje from as far as Kumanovo, Tetovo, Gostivar, and Veles. As such, the Skopje technically has a direct impact on a region of over 1 million people.

Following national level efforts to promote energy efficiency, local authorities have also taken significant steps to make Skopje a more energy efficient city. Most significantly, in 2011, with assistance from GiZ, the City has drafted a Sustainable Energy Action Plan (SEAP), with

clear measures aimed at reducing green-house gas (GHG) emissions from urban transport, municipal buildings, and public lighting. An Energy Efficiency Unit is in charge of implementing the measures included in the Skopje SEAP, and a number of immediate successes have already been registered. Several of the baseline indicators used in the SEAP report were used to run the TRACE tool. All of the mission indicators, as well as qualitative information, were collected during a work visit to Skopje in October 2011.

Efforts like TRACE and SEAP seem to have come at a good time, as energy use and pollution in the city seem to be an ever pressing problem. In December 2011, pollution in Skopje reached 360 index points. Local authorities are by law obliged to declare a health warning for the population, when the index exceeds 300 index points. Consequently, people in Skopje were advised to stay at home and reduce their activities. Mayor Koce Trajanovski acknowledged that this is a problem that the City should not run away from, but tackle head on.

Sustainable Skopje

The following analysis and recommendations are primarily about how Skopje can become a more sustainable city. The focus will be on energy efficiency, but the scope of the analysis goes well beyond that. Energy has the benefit of being easy to quantify and to measure, and is a good binding element for thinking about a city in a holistic way. Almost everything that is done in a city requires some form of energy input.

Consequently, TRACE (Tool for Rapid Assessment of City Energy) is not just a tool for assessing potential energy and cost savings, but it is also a tool that allows local authorities and policy makers to think about cities as a whole. Ultimately, TRACE is a diagnostic tool that allows cities to become more sustainable.

There are six municipal service areas that are the focus of this tool: urban transport, municipal buildings, water and wastewater, power and heat, street lighting, and solid waste. For each of these service areas, TRACE requires the collection of a number of indicators. These indicators are both energy related (e.g. the fuel consumption of the public transport fleet) and not (e.g. urban transport modal split). The energy related indicators help assess energy and cost savings potential in each service area. The non-energy indicators help give a more rounded picture of these service areas, and they help fine-tune recommendations so that they go beyond just energy issues.

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

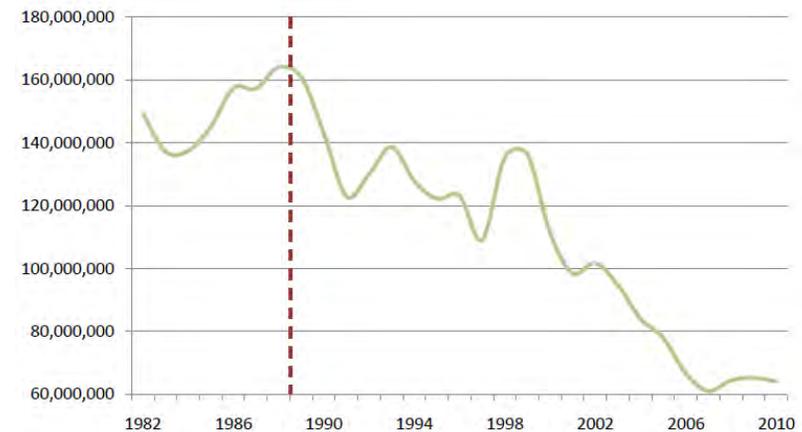
are likely to have the biggest impact, for the lowest amount of effort and resources invested.

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

Public Transport

Public transportation in Macedonia has quickly fallen apart in the transition years. From a peak of over 160 million passengers in 1988, ridership dropped to around 64 million passengers in 2010. Between 2006 and 2010, the length of public transport routes has fallen by 42%, the number of transit lines has dropped by 25%, and the total number of buses decreased by 16%.

People Using Urban Public Transport in Macedonia



Source: Statistical Yearbook of the Republic of Macedonia, 2011

Most of the remaining public transport infrastructure in Macedonia is concentrated in the City of Skopje. Of the total of 64 million public transportation passengers in 2010, 63 million were carried by Skopje buses. Buses actually represent the only public transport means available in Macedonia, and out of 494 urban public transport buses, 459 were operating in Skopje. Of these 459, an important part were relatively old.

As can be seen in the table below, there were almost no efforts to renew the bus fleet from 2001 through 2007.

Number of new buses in Skopje by Year

1990	1991	1992	1993	1994	1995	1996	1997	1998
23	55	19	23	4	6	13	1	61
1999	2000	2001	2002	2003	2004	2005	2006	2007
0	20	0	1	1	0	0	0	0

Source: Skopje SEAP

In fact, local officials in Skopje acknowledge that the main reason for the dramatic decrease in public transport ridership can be attributed to the decrease in quality and comfort of services offered. The drop in ridership has also reduced revenues of public transport operators, which in turn led to a further deterioration of assets and infrastructure. In addition, private bus operators were allowed to enter the market in 1994, and they entered in direct competition with the publicly run buses.

Only recently has the City become more engaged in the renewal of its public transit fleet, and has contracted with a Chinese company for the purchase of 200 new double-decker buses. 100 of these have already been delivered and are operating in the City. They are very popular with locals and visitors, as they are both comfortable and attractive (see picture below).

New Double-Decker Bus



Still, a considerable number of buses are old, energy inefficient, and polluting (see image below). The majority of those old buses are run by private operators, running routes both within the city and connecting to suburban and ex-urban communities. With suburban commuter buses included, the stock of public buses in Skopje was 617 in 2008. Of these, 357 were run by the City of Skopje, and the rest were run by private operators.

Old Public Transport Buses in Skopje



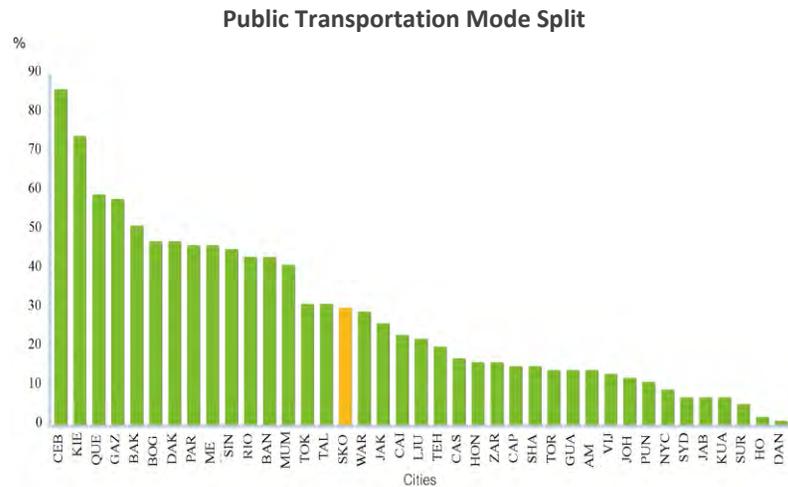
While the City plans to completely renew its fleet by 2014, private operators seem to be less keen to do so. They usually run busy routes, and they keep ticket prices slightly lower than the City run buses. Local authorities intend to address this issue by creating an integrated public transport system, with clear planning of routes, with single-priced tickets that can be used on all buses, and with clear regulation in place concerning the performance of the vehicle stock. Thus, all buses will need to be energy efficient and equipped with Euro 4 or Euro 5 engines.

Such measures will ultimately benefit all public transport operators. It is well known that one of the pre-conditions to encouraging public transport use is to offer good quality and comfortable services. In addition, it is much easier to promote other energy efficiency projects, such as the renewal of the passenger car fleet in the city, when local authorities lead by example.

As can be seen in the figure below, the share of people using public transportation in Skopje is smaller than in many cities in the TRACE database. There are also a good number of TRACE cities that perform worse than Skopje in this area. Nonetheless, considering the dramatic drop in ridership since 1988, it is clear that there is a lot of room for

improvement. In fact, the mayor of the City of Skopje considers public transport to be one of the first priorities of the city.

Public investments in this service area have already started to garner results. Thus, ridership has increased substantially with the introduction of the red double-decker buses. In 2011, Skopje public buses carried 10% more passengers than in 2010. It is not clear how the private bus operators have performed in the same time-line, as they run the routes that they want, when they want, and are de-facto self-regulators. Local authorities plan to integrate public and private operators and create a streamlined system that allows for economies of scale, better planning and logistics, and higher overall efficiency rates.

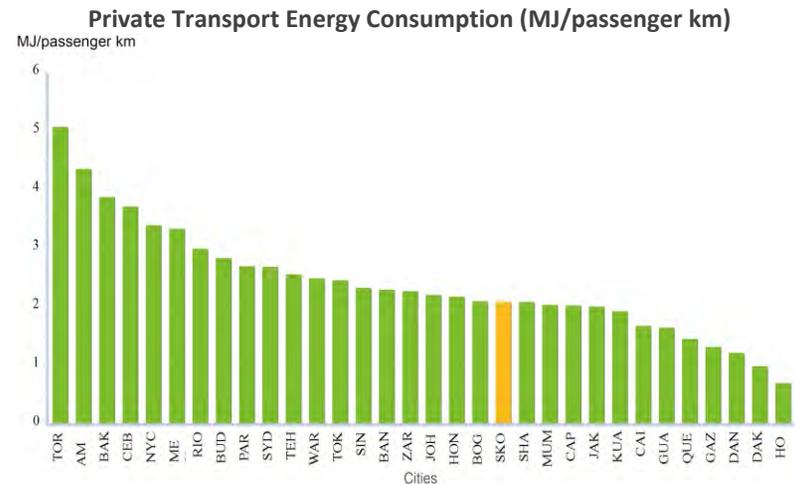


Plans have also been hashed out for the development of a light railway line. For a city its size, Skopje is conspicuously missing high capacity transit options. In 2007, local authorities have commissioned a Light Rail Feasibility Study, with plans to develop up to four lines. By 2012, it is hoped to have a tender for a private concessioner, who will develop and operate one of the tramway lines. The other lines are hoped to be built with public funding, and potentially with the help of EU Funds (once Macedonia will join the EU). The light rail cars will have a high capacity (around 250 people), and the development of this new transit system is hoped to substantially boost the use of public transportation modes. By

2030, the light rail is planned to become the main mode of mass transport in Skopje.

Private Vehicles

In 2010, there were around 152,000 vehicles in Skopje, up from 108,000 in 1994. Of these, 130,000 were passenger cars, or around 250 passenger cars per 1,000 people. Skopje has the highest concentration of cars in Macedonia, with almost double the nation-wide figure (137 passenger cars per 1,000 people). The large majority of vehicles ran on gasoline (73.5%), with a smaller share running on diesel (23.5%) or gasoline-gas (3%). Diesel powered cars are usually better not only for the environment (because of the low combustion temperature of diesel engines, they emit less greenhouse gases), but they are also better from an energy and economic point of view (they tend to have lower fuel consumption, and a lower price per liter). Obviously, the age of the car plays an important role in this equation too, with older cars having a poorer fuel and energy performance.



Overall, the vehicle stock in Macedonia is quite old, with around 54% of vehicles being built before 1997 – more than 13 years old. (Macedonia State Statistical Office. 2010. *Statistical Review: Transport and other services*). Consequently, energy consumption of private vehicles is

relatively high (see figure above), although by far not the highest in the TRACE database.

To reduce energy consumption in the private transport sector, local authorities have a number of means to their disposal, with potential benefits for the City, for drivers, and for the city's citizens as a whole. Thus, they can help drivers consume less fuel by streamlining traffic and reducing the amount of time cars spend on the streets, at intersections, and at traffic lights. (Of course, such measures can and often backfire by making it more convenient for other people to use their cars – which ultimately leads to more congestion.) They can convince people to use their cars less, by providing adequate parking options in the city, and by improving public transportation and non-motorized transport (e.g. walking and biking) options. And, they can introduce restrictive regulation (e.g. limiting the number of taxis, introducing non-driving days or the option of driving on only some days depending on whether one has an even or an odd license plate number) or taxing (e.g. congestion charges).

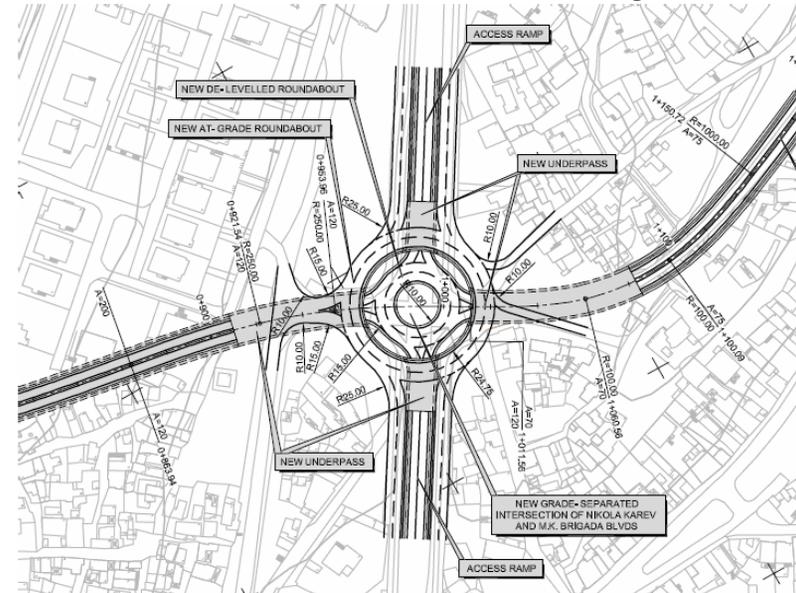
While Skopje is nowhere nearly as congested as Moscow or London, it does have major problems with congestion (see image below), and the rise in private vehicle ownership is likely to only make matters worse. With the expansion and the suburbanization of the city, and given its economic role in the region, the city has seen a continuous rise of people who commute in from outside the city. In 2009, a staggering 94,000 people (or around 18% of Skopje's population) commuted in and out of the city. The large majority of those (55,442) used private cars.

Congestion in Skopje



In a wealthier region, and provided alternatives modes of transportation are available, one could consider the use of congestion charges to moderate traffic in-flow. However, since a large majority of commuters depend on their jobs in Skopje and could not afford to pay the congestion charges on a regular basis, traffic planning management was considered to be a better alternative (although cars that transport goods have to pay a fee when entering the city). Consequently, all major boulevards now have a green wave system in place, minimizing the time cars have to wait at red lights. Several roundabouts have been developed at major intersections, and the mayor announced plans for the development of several underpasses, including a by-pass under the city center.

Traffic Alleviation Plans for the Macedonia-Kosovska Brigada Junction



Source: Skopje Transport Master Plan

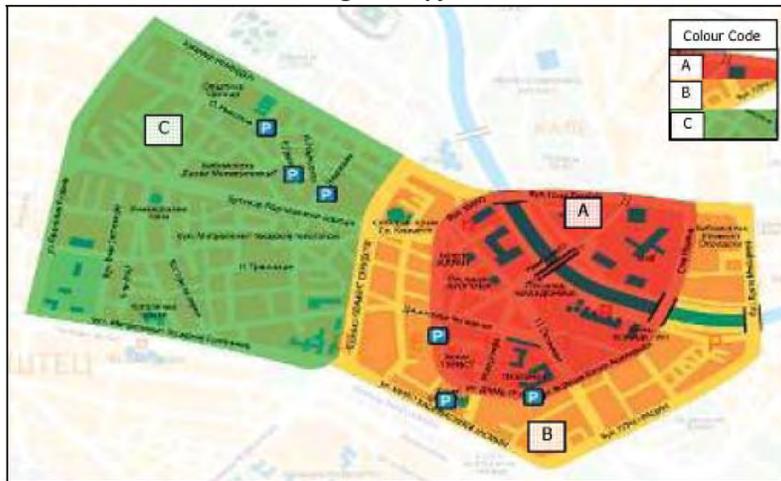
To reduce emission and congestion generated by the taxi fleet in the city, local authorities have introduced a licensing system for taxis. The number of licenses is limited to 3,000, and in order to obtain a license, taxi drivers need relatively new cars. These measures ultimately

increased tariffs for taxis, and as conditions in the public transport sector started to improve, more and more people switched from using taxis to using public buses.

To accommodate the growing numbers of cars in the city, and to discourage some commuters from using their cars, a new parking system was put in place. Thus, three types of parking were created under this system:

1. 15 indoor public car parks.
2. Open air public car parks
3. Zonal on-street parking (with three zones: A, B, and C)

The Zones for On-street Parking in Skopje



Source: Skopje Transport Master Plan

The parking system is ambitious and quite comprehensive. As the table below evidences, it has a clear price structure based on assumed intensity of use and based on the length of time cars can spend in the city; it has a strict enforcement policy; and, it offers preferential parking opportunities and prices for people living in the area. Drivers that wrongfully park their cars in Zone A, or those that overstay the 2-hour time limit, can expect to pay a fine of around \$30 – quite high for Macedonian standards (around 7% of the average salary in the country).

Skopje On-street Parking System

Description	Zone A	Zone B	Zone C
Price per Hour (in Denars)	25	35	45
No. of Parking Spaces	199	109	794
Time Limit (hours)	2	4	unlimited
Enforcement (penal ticket in Denars)	1,300	1,000	700
Resident Permits (Denars/month)	200	200	200
Paid Permit/month (in Denars)	5,000	4,000	3,000

As comprehensive as these parking improvements have been however, they still leave a lot to be desired. For one, the development of the parking system was not done in an integrated approach, and has not taken into consideration existent and planned public transit routes. Since traffic and public transportation are handled by two different departments there have been some lapses in communication and cooperation. Moreover, although the traffic department is in charge of the development of non-motorized infrastructure, there are no obvious efforts of integrating parking with walk and bike-paths.

A casual walk through the city also immediately reveals that the parking situation in Skopje is far from being resolved. As the images below indicate, cars are routinely parked on sidewalks, making it almost impossible for people to walk in the city center. Often people are forced to walk in the middle of the street, on busy thoroughfares. Moreover, in addition to cars that are illegally parked on sidewalks, the City has created “On-Sidewalk” parking, robbing people of the opportunity to safely walk through the city. Whereas in other cities, such as Bogota (Colombia) or Copenhagen (Denmark), more and more city space is dedicated to walking and biking, in Skopje streets seem to be engulfed by more and more cars with every passing day.

The situation is not all grim though. While congestion is becoming an ever-pressing problem, the City has taken a pro-active approach in the development of alternative modes of transportation. An extensive bike-path system has been created along the banks of the Vardar River, extending into the city center, along the main boulevards, and into several nearby parks.

Parking on Sidewalks in Parking Zone C



“On-Sidewalk Parking”



Plans have been made to extend the system even more, and to turn biking from a recreational endeavor to a legitimate way of commuting. Right now, less than 1.5% of trips in the city are made by bike.

Bike Path along the Vardar River



Local authorities rightfully indicate that convincing people to use bikes will not be an easy task, as mentalities are hard to change. However, the experience of other cities in ECA shows that this is far from an impossible task. Moreover, forward-looking cities, like Copenhagen have set a high bar to follow by other cities. By 2015, 50% of Copenhageners are expected to do their daily commutes by bike.

To encourage more people to use bikes, efforts to extend the bike infrastructure have been doubled by other measures, such as the introduction of a bike-share system. The system has been created on a pilot basis, with two stations in the center, and two stations in Aerodrom and the Old Bazar respectively. Based on the response from people, the number of bike-share stations will be systematically expanded to other areas of the city. It now costs 10 Denars (~20 US cents) to rent a bike for an hour, and when the weather is good, all bikes tend to be rented out.

Bike-share Station in the Center of Skopje



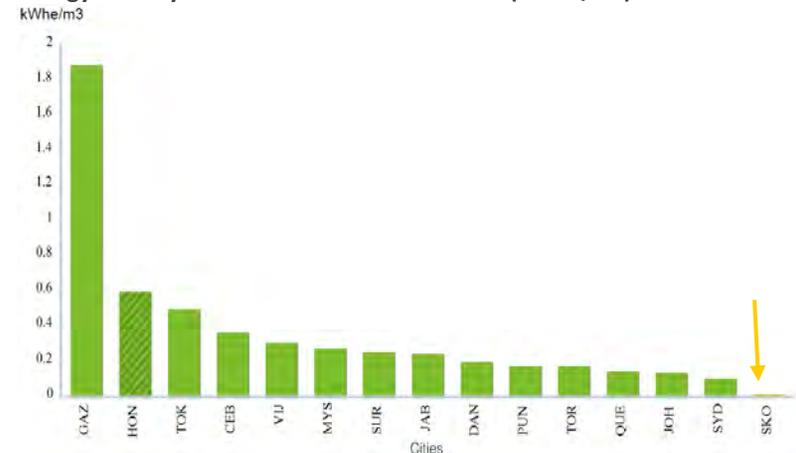
In addition to creating and expanding a bike infrastructure, local authorities have also invested in making the city center a more pleasant place for pedestrians. Several streets in the center, along with the main central plaza, have been closed down to cars, and trees and urban sculpture create an inviting environment. As more and more streets are closed to car traffic, more and more people will flock to them. With increased traffic on these streets, more and more businesses will open in the area. In fact, the main pedestrian streets in Skopje also seem to be the places with the highest concentration of people and businesses.

Water and Waste Water

The water and wastewater system in Skopje is both efficient and inefficient at the same time. When looking at the energy used to treat and pump water, the system seems to be highly efficient. It is in fact the most energy efficient water system of any city in the TRACE database (see figure below). This good performance is enabled by the original design of the system. Thus, the water network is primarily driven by

gravity (with the city's water reservoir located at a higher altitude than the city) and it uses spring water. Basically, the water goes from the source straight to people's faucets, without any mechanical treatment (with only light chlorination), and without requiring any major pumping.

Energy Density of Potable Water Production (kWh/m³)



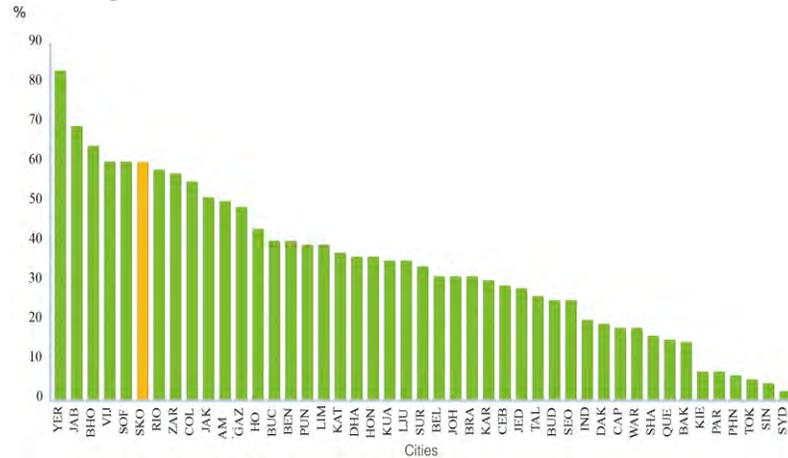
Pumps are used only for pumping water to the communities situated at higher elevations in the city. In particular, neighborhood expansion on the slopes of the Vodno Mountain have created a need for increased pumping capacity. Tall buildings, particularly the high-rise apartment blocks use their own pumps to ensure adequate water pressure up to the last floors.

While the water system in Skopje is very energy efficient, it is quite inefficient in terms of resource use. Around 60% of the water used by the system is non-revenue water – one of the highest shares of non-revenue water of any city in the TRACE database. Two main causes have led to this situation: a relatively old network, and poor household metering.

The water system network in Skopje had to be almost completely rebuilt after the earthquake of 1963. Since then, the network was continuously expanded in a drive to keep up with continuous city expansion – both in the Communist times, and in the following transition years. As the system required new additions almost every year, little attention was paid to replacing old and leaky piping. Given that the cost

of treatment and distribution are so low, there were also few incentives to improve the efficiency of the existent network.

Percentage of Non-Revenue Water



In recent years, system expansion costs have grown systematically, as the water and wastewater utility company (J.P. Vodovod I Kanalizacija) has to service lower and lower density communities, situated further and further away from the existent network. In the transition years, the area that had to be covered by the utility company doubled in size, due to suburban and peri-urban growth and due to the integration of surrounding villages in the system. For example, the energy costs required to pump water in the low-density neighborhoods of the Municipality of Saraj go up to around \$450,000 per year, but only 10% are recovered from water bills.

Around 20% of water is lost because of poor metering (with 40% lost because of technical and distribution losses). Most households have meters installed and enforcement is quite good (the utility company can access the bank accounts of those that don't pay their bills), but meters tend to be quite old and actual water consumption is not accurately tracked. J.P. Vodovod I Kanalizacija has plans to replace all water meters, and given the availability of funding they would also like to focus on a host of efficiency enhancement measures – e.g. safety-starters for pumps, frequency regulators, and a SCADA (Supervisory Control and

Data Acquisition) system. Such improvements are hoped to eliminate water delivery problems, reduce water losses by 10%, and enable energy savings of up to 30%. In addition, it is imperative that the old parts of the water network be replaced with newer infrastructure.

If the water sector requires many investments to be optimized, the wastewater sector requires a complete overhaul. As it stands, Skopje does not really have a functioning wastewater system. Local authorities indicate that the Vardar River enters Skopje with Category II level pollution and leaves the city at Category III, and sometimes even at Category IV. All of the wastewater is discharged into the Vardar virtually untreated.

There are plans to invest in a wastewater treatment plant, but the immediate needs seem to focus on the collector system. There are around 800 km of wastewater pipes, and 500 km of those do not have a parallel storm-water system. This means that heavy rains often threaten to overflow the system, and four pumps need to be used to speed-up the wastewater discharge. Improving the collector system, particularly in the newly developed areas, will take some pressure off the main system and will decrease energy expenditure – as only 2 out of the current 4 pumps would be needed.

In addition to the interventions outlined above, local authorities plan to also invest in 50 groundwater production wells, which would be used to irrigate city parks and green areas.

Solid Waste

The entire solid waste management (SWM) system in Skopje, including collection, transport, and disposal at landfill, is owned and operated by the City of Skopje. There are a number of small recycling companies, informal collectors, and national and international stakeholders that play a role in the recycling market, but, in large, SWM is a publicly run enterprise.

Up until November 2010, municipal waste collection was only done within the territory of the City of Skopje. Following that date, collection was extended to a number of suburban areas, and villages located close to the city. Since waste generation has grown continuously with

economic growth, it became imperative to extend the reach of the Skopje SWM system, as wild dumps started to proliferate all around the city.

To maintain the efficiency of the SWM system, local authorities have raised waste tariffs over the years. There are three categories of waste tariffs – residential, industrial, and commercial. Residential waste generators are charged based on the square footage of their house/apartment. On average households paid \$6.5 per month in 2011.

Not all waste is captured by the SWM company, PE "Communal Hygiene", but the around 87% that enters the system is subsequently dumped at Drisla Landfill. There is no formal recycling system in place, but there is a burgeoning informal system, there is a pilot project funded by USAID, and there are plans to introduce formalized recycling in the city.

Improving the energy efficiency of the SWM system begets a multi-pronged approach that looks at reducing fuel usage from waste transport, reducing the length and number of trips of garbage trucks, reducing the amount of waste that needs to be carried to a disposal site, and generating energy from waste (e.g. through waste-to-energy facilities, such as incinerators, or through methane capture and usage).

The fuel efficiency of garbage trucks is relatively high. A good part of the truck fleet is new, with 17 brand new trucks having been purchased with a loan from the World Bank (see image below). These trucks have good fuel efficiency, but truck drivers are not properly instructed in running trucks in an energy efficient way.

Part of the Skopje Garbage Truck Fleet



There are also a number of trucks that are not in their prime anymore (see image below). There are plans to replace these old trucks, but the focus seems to be on purchasing more trucks to supplement system needs. Before the service extension to rural areas, PE "Communal Hygiene" had difficulties collecting all the waste with the trucks it had to its disposal. Basically, trucks were running 34 routes and were working three shifts to stay ahead of demand. Following the extension, they became over-stretched, with 14 additional routes to run. In the end, they had to rent trucks to be able to service those routes too. It is estimated that 17 more trucks would be needed to run waste collection and transport in an efficient way. Right now, if a truck breaks down, other trucks have to do over-time to complete waste collection.

Old Garbage Truck



All of the collected waste gets carried to the Drisla Landfill. To optimize transport costs, most garbage trucks do not go all the way to the landfill. Rather, they bring the waste to a mobile transfer station in Vardariste. In essence, a mobile transfer station is represented by a big truck that collects the waste from several smaller garbage trucks and takes it to the landfill in just one trip (see image below for a simple transfer station model). Consolidating waste transport this way helps save energy and time, which would have to be spent if each individual garbage truck would make the full trek from the collection point to the disposal site.

In addition to the use of transfer stations, SWM operators can reduce energy expenditure from their truck fleet by optimizing collection

and transport routes. At this point Skopje does not have such a logistics system in place, and the addition of the 14 routes that serve suburban areas and surrounding villages is likely to add more inefficiency to the system in the short-term.

How a Transfer Station Works



Source: <http://www.ucitymo.org>

Reducing the amount of waste that needs to be transported to disposal sites is another way of saving energy, and recycling is the prime way to do that. Of course, collecting, transporting, and processing recycled material requires energy input and additional costs, but these costs can usually be offset by reselling the recyclables. In order to be able to sell recycled materials it is important to first identify markets for these materials. In Macedonia, the biggest market for recyclables is the market for PET bottles. Several cities in Macedonia have developed small recycling industries around PET bottles, and Skopje is one of those cities. All in all, it is estimated that around 10,000 people in Macedonia work as formal and informal recyclers, and around 4,000-5,000 of those are thought to operate in Skopje.

Apart from PET bottles, markets have been identified for paper, cardboard, metal cans, and aluminum cans. There is no market for glass bottles. Paper and cans are taken directly to scrap yards for processing and further re-selling. PET bottles have to be compacted first, because of

their large volume and small weight, before being taken to scrap yards. Most of the recyclable material is collected by informal workers. They can obtain 3 Denars (~6.5 US cents) per kg of paper or cardboard they bring in, 12 Denars (~26 US cents) for a kg of PET bottles, 10 Denars for a kg of metal cans, and 15 Denars for a kg of aluminum cans.

Cardboard Collected by Informal Recyclers in Skopje



Most of the recycled waste in Skopje is represented by PET bottles and paper/cardboard, because a private market has developed around those materials. Usually, recycling yards have a preference for these materials, because these are the easiest to re-sell, and the easiest to make a profit off of. Thus, a kg of recycled PET bottles is bought by a recycling yard at 12 Denars, and with minimum processing (just simple compacting), it is re-sold to processors for 24 Denars. The processors turn the compacted PET bottles into PET flakes, which they can use for further processing, or which they can sell in bulk on the global market – for an estimated 61 Denars per kg.

Green Tech is one of the PET bottles processors that operates in Skopje. After turning the raw material into PET flakes, they transfer those to the mother company in Romania, which in turn uses these for producing car insulation material for cars and molded plastic car parts. Green Tech buys the material from different sources. They have a compactor facility that operates directly at the Drisla Landfill, using PET

bottles collected by informal collectors from the dump site. They buy compacted PET bottles from the around 200 private recycling yards operating in Macedonia. And, they buy recyclables from Pakomak.

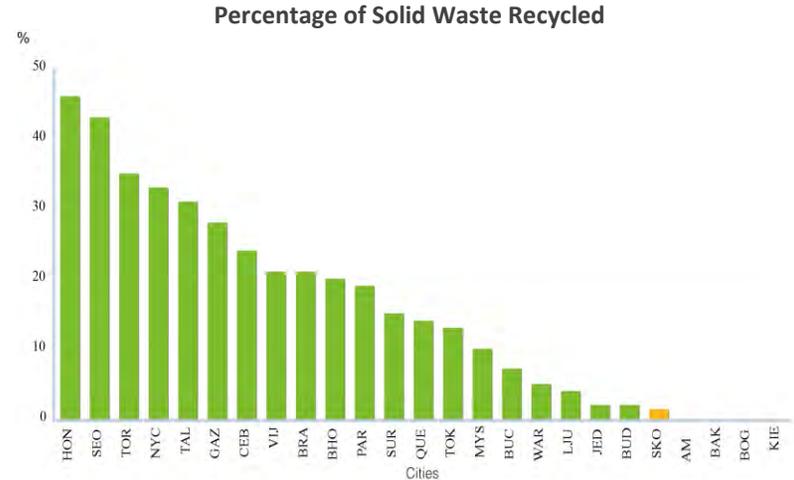
Compacted PET Bottles in the Skopje Public Recycling Yard



Pakomak is a private company, formed by Government decree, which acts as an intermediary between recycling yards and processors of recycling materials. It operates with money it receives from packaging generators in Macedonia, and uses that money to buy recyclables from recycling yards and sell it further to processors. Pakomak was basically enabled by the introduction in Macedonia of the EU inspired Law on Packaging and Packaging Waste. The law states that all companies in Macedonia that generate packaged goods, or that import packaged goods, have to recycle 5% of the packaging waste they ultimately generate – or pay for someone else to do the recycling (in this case Pakomak). For example, a supermarket that generates 100 tons of packaging waste yearly, has to either recycle 5 tons of material (5% of the 100 tons), or to pay Pakomak 100 Euro (20 Euro per ton) to do so. Most companies prefer Pakomak for the service.

In 2011, Pakomak is expected to handle around 45,000 tons of generated packaging waste, so it will have a budget of 900,000 Euro (20 Euro times 45,000 tons) to pay for its small staff and to purchase recyclables. The hope is that by the end of 2011, Macedonia will manage to recycle 5% of all waste generated in the country. In 2008, the recycling

rate was lower than 1% country-wide and only about 1.5% in Skopje. As can be seen in the figure below, Skopje is well behind other cities in the TRACE database.



While there is a lot of catching-up to do, the share of recycled waste is expected to continually rise in coming years, and to finally reach 22.5% (the EU average) in 2018 – when Macedonia is hoped to join the EU. To achieve higher and higher recycling rates, Pakomak tries to play a bigger role as a broker in the recycling market. Right now, they purchase recyclables from recycling yards at market price (e.g. 24 Denars per kg of PET bottles), and sell them to processors at below market value (e.g. 23 Denars per kg of PET bottles). In the future, however, Pakomak hopes to achieve the advantage of economies of scale and become the main intermediary between recycling yards and processors of recyclables.

On the collection side, there are efforts underway to formalize collection and improve collection rates. The City of Skopje, for example, wants to introduce separate collection at the source. USAID has successfully implemented a recycling system that aims to bring informal collectors into the formal market. The project was started in June 2011 with the distribution of 200 blue recycling containers throughout Skopje (see image below). The containers are used primarily for collecting PET bottles, and cost around \$250-\$350 per unit. 38 formal collectors have been introduced in the system, and they have been given work

equipment, ID cards, and keys to the blue boxes. They earn an income by selling the collected recyclables to the Public Recycling Yard.

USAID Financed Recycling Containers in Skopje



In the four months since the start of the program, these 38 formal collectors have sold 100 tons of PET bottles and 200 tons of paper, for around \$40,000. That means that each formal collector earned around \$265 per month – around half the average income in Macedonia (Macedonia State Statistical Office), and 24% more than what the collectors earned before. Moreover, the amount of recyclables delivered to the recycling yard in the four months since the start of the program was 200% higher than the amount received over the entirety of the past year (2010). The hope is to add 1,000 more blue boxes to the system, to bring more people from the informal sector into the formal one, and to have those formal recycle workers take ownership of the Public Recycling Yard. This way, instead of receiving 12 Denars for a kg of PET bottles, collectors could receive the 24 Denars that recycling yards currently collect. And, all they would need to double their income is a PET bottle compactor.

There is money to be made from waste, and Skopje is building a burgeoning market around recyclables. Much more money can be made from this sector if one considers that only a fraction of recyclables are actually captured. Much of the waste goes unsorted to the Drisla Landfill, and most of the recyclable materials end up being compacted and covered with soil with the rest of the waste. There are a number of collectors who work directly at the landfill, using a Green Tech compactor for PET bottles and selling the collected material directly to Green Tech.

PET Bottles Collected at Drisla Landfill by Informal Collectors



The landfill itself is better organized than any other landfill in Macedonia, but it is quite basic by international standards. It has been in operation since 1994 and has not benefited from many investments over the years. Drisla does not have an engineered lining system, it has no measures to control environmental pollutants (e.g. leachates and landfill gas), and it has no phasing system in place (e.g. a system of cells). This leads to large expanses of uncovered waste, creating a host of other problems, such as vermin, scavenging, bad odor, litter, and methane gas emissions.

The City of Skopje, with the assistance of the International Finance Corporation (IFC) is considering upgrading disposal facilities in Skopje through a Public Private Partnership (PPP) arrangement. The plans include the division of the landfill in 11 individual cells, a system for the capture

of methane gases, and potentially a waste separating plant. To make the investment more attractive to private investors, there are also discussions to increase the tipping fee charged at the landfill. Right now, the tipping fee is €11.5 per ton (there is a weigh station for garbage trucks at the entrance to the landfill), and estimates indicate that it would have to go up to around €27-€30 to make the landfill operations profitable.

Drisla Landfill



In addition to these landfill improvements, there are talks about developing a waste-to-energy facility (an incinerator) at the landfill, but first cost estimates indicate that it might be too expensive and too distant from the city (17 km). Also, the incinerator would come in direct competition with the emerging recycling industry, as it will require the same material for its successful operation.

Municipal Buildings

Municipal buildings are one service area where local authorities have been particularly active. There are numerous energy efficiency projects that have been undertaken to improve the performance of municipal buildings, and Skopje scores relatively well when compared to other cities in the TRACE database.

Municipal buildings are responsible for a relatively small share of the energy consumed by buildings in Skopje. Residential buildings are responsible for the lion share of energy consumption, with around 81.5%

of all needs, followed by commercial/office buildings with 15.3%, and municipal buildings with 3.2%. The table below gives a more detailed overview of the energy performance of municipal buildings in Skopje.

The first thing that can be observed is that educational facilities (kindergartens, primary and secondary schools) predominate in the municipal building stock, with 152 buildings out of a total of 197, and with 85% of the total floor area. The largest energy consumption in municipal buildings went to heating, and this is the one area where energy improvements in municipal buildings can bring the most dividends. In fact, the amount of energy spent on heating was five times as large as the amount of energy going to electricity provision.

Energy Performance of Municipal Buildings in Skopje

Type of Buildings	No.	Total	Electricity	Heating	Electricity	Heating
		Surface Area (m ²)	Consumption (kWh)	Consumption (kWh)	Consumption per m ²	Consumption per m ²
Educational	152	440,930	8,525,461	59,000,843	19.34	133.81
Cultural	26	21,880	853,190	2,498,564	38.99	114.19
Public Administration	11	19,145	875,763	2,706,217	45.74	141.35
Public Enterprises	8	36,007	3,962,064	6,997,499	110.04	194.34
TOTAL	197	517,962	14,216,478	71,203,123	27.45	137.47

Source: Skopje SEAP

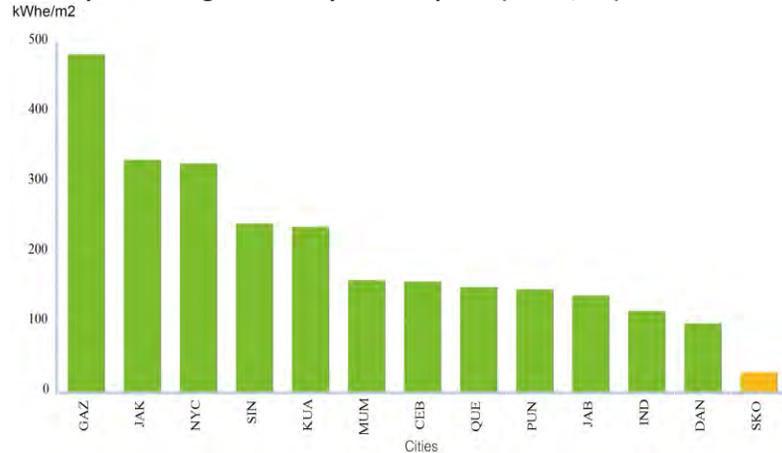
Generally, buildings in continental areas consume more energy for heating than for electricity. However, in addition to consuming less energy on electricity than on heating, municipal buildings in Skopje seem to outperform the cities included in the TRACE database.

The electricity consumed per square meter is lower than in any other TRACE city with pertinent data available. This variation can be explained by the type of municipal buildings in Skopje. Educational facilities dominate, and they tend to have lower relative energy consumption (see table above for comparison purposes), as they are not in operation all-day and all-year round. Other cities in the TRACE database may have a higher share of municipal buildings with high energy needs and year-round, 24-hour operation (such as hospitals).

Even when it comes to heating, municipal buildings in Skopje score relatively well. There is room for improvement, as many studies in the area show, but overall performance is good. In fact, improving the

thermal performance of buildings has been one area where local authorities have been most active, with a wide variety of projects being implemented.

Municipal Buildings Electricity Consumption (kWh/m²)

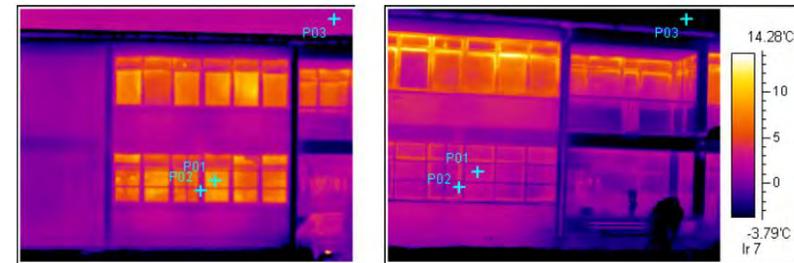


For example, the schools in Skopje squandered a lot of energy simply because heat supply was not shut off when school was not in session. Turning off heat when school was out, alone saved the City around \$150,000 per year. Simple measures like these were complemented by more complex measures. Schools in the Aerodrom municipality were equipped, for example, with automatic regulators, which only started heating supply if the temperature inside the building dropped below a set threshold. The measure cost around \$2,000, was amortized within one month, and reduced heating consumption by 30-40%.

Automatic regulators were in some cases doubled by automatic control systems, which only turned heat on when somebody was in the room. Such automatic control systems were introduced in 6 schools at a price of \$8,000 (around \$1,300 per school), enabling annual energy savings of around \$87,000 yearly. These measures and the significant cost savings were also encouraged by changes in energy regulation, which mandated that schools pay industrial prices for energy. Basically, heating companies were unwilling to deliver heating at the high volumes required by schools, for prices that were kept artificially low.

The thermal insulation of walls and roofs also showed immediate results, with a tracked reduction of energy consumption of up to 60%, and with an average investment amortization period of around 4 years. In Skopje, a lot of effort has been spent on equipping schools with more energy efficient windows. Results in this area have also been very promising. The image below, for example, gives a before-and-after picture of the thermal performance of a school where one set of windows (those in the lower left corner) were replaced. After the completion of the thermal insulation work, that set of windows had the same insulating properties as the brick wall it was part of.

Thermal Performance, before (right) and after (left) Thermal Insulation of First Floor Windows



Source: Macedonian Center for Energy Efficiency

Almost every school and kindergarten in Skopje has benefited from thermal insulation work (see image below), or are planned to be part of such a program at some point in the future. Some of the schools that generate their own heat (i.e. they have their own boilers), went a step further, improving not only energy use but also energy production. In many cases, school boilers were 50-60 years old and were highly inefficient. It was thus found that replacing the old boilers with new energy efficient ones, in tandem with thermal insulation of the roof and exterior walls, led to energy savings of up to 80%.

In addition to improvements that have benefited schools and other educational facilities, local authorities plan to do a complete overhaul of the administration buildings where they work in.

Thermally Insulated School in Skopje



Public Lighting

The street lighting system in Skopje is fairly well developed, although coverage is not universal. The City of Skopje is responsible for street lighting on main boulevards, while the 10 constituent municipalities are responsible for street lights on secondary streets found within their boundaries. This means that efforts are not always coordinated properly, and different municipalities have achieved different levels of success in making their street lighting system more energy efficient.

Improving the performance of the street lighting systems is a fairly straight forward affair. On the one hand, local authorities have to make sure to extend service to un-served or under-served areas; on the other hand, they have to make the system run as efficiently as possible – which most often means, reducing the energy consumption per light pole and reducing operations and maintenance costs.

There are no exact figures of the coverage of street lighting in Skopje. Since there are 11 public institutions (10 municipalities and the City of Skopje) that have a responsibility in this sector, the overall picture is fuzzy. Nonetheless, it is estimated that around 86% of streets in Skopje were properly covered by a street lighting network in 2011. Better street lighting is needed in some of the city's poor neighborhoods, in the growing peri-urban areas, in some areas between high-rise developments, and even in some of the city's most central areas. As can be seen in the pictures below, a central spot just off of the Makedonska pedestrian street has no formal street lighting, although public lights have been put into place there.

Street Lights not Working



This oversight may be attributed to the fact that the area, although central, is not a busy stretch in the city, and light bulbs were not replaced once they went off – either because residents or businesses in the area did not complain, or because local authorities prioritized work in areas with more traffic.

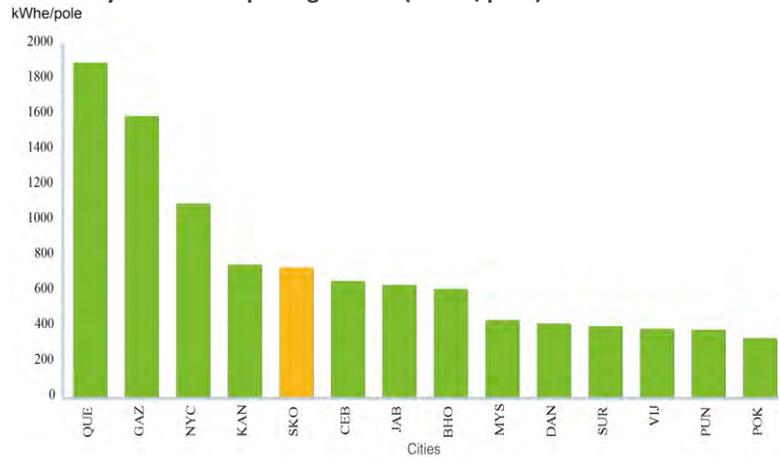
In addition to areas that are poorly lit, there are areas where lighting is not done efficiently. For example, street lights on the Goce Delchev Boulevard, one of the city's most important arteries, were still running at 1:00 PM in the afternoon – on a bright sunny day (see picture below).

Street Lights on Goce Delchev Boulevard, at 1:00 PM



In 2008, energy consumption per light pole in Skopje was higher than in many other cities in the TRACE data-base (see figure below). High consumption was driven by energy intensive light-bulbs (mostly mercury vapor bulbs), and by inefficient use of the system (as highlighted in the example above). On the other hand, consumption was mitigated by light-bulbs that went off and were never replaced.

Electricity Consumed per Light Pole (kWh/pole)



To address some inefficiency issue in the street lighting system, the City of Skopje started a major program of replacing inefficient mercury vapor bulbs with more efficient high-pressure sodium vapor bulbs. The program was commenced in 2008-2009, and by October 2011, around 60%-70% of street light on the main boulevards were replaced. The 10 municipalities that are in charge of street lighting on secondary streets also started light-bulb replacement programs, with different degrees of success.

In addition to light-bulb replacement, local authorities have started a series of innovative pilot programs. For example, several of the city outlooks on the Vodno Mountain have been equipped with solar powered public lighting. Since these areas are not high traffic, local authorities want to test these new technologies and then consider their implementation through the city at large.

Power and Heat

Most of the buildings in Skopje are connected to a district heating network. There are three district heating companies in the city, the largest of them being Toplifikacija AD – with an installed capacity of 518 MW and servicing 60,000 customers (65% of which are households). The smaller systems have installed capacities of 46 MW and 32 MW

respectively, and they service the northern part of Skopje and the city's industrial area.

District Heating Plants in Macedonia

Plants	Ownership	Installed Capacity (MW)	Network Length (km)	Heating Area (m ²)
"Toplifikacija" AD Skopje, 1965	Privately Owned	518	177.5	4,000,000
"Skopje Sever" Ad, Skopje, 2000	Privately Owned	46	8.5	220,416
"Energy Sector-ESM", Skopje, 1997	State Owned	32	11	155,000

Source: USAID. 2007. Urban Heating in Macedonia

Toplifikacija AD was quickly privatized after 1991 and now functions as a private entity with some public elements to it. As it is set-up, Toplifikacija consists of a production company (with three plants), a distribution company, and three supplier companies (East, West, and Central).

The production company generates heat with the help of three heating plants. Two of the heating plants can use both oil and natural gas for heat production, one only runs on oil. The company usually prefers to use oil for heating, because of its cheaper price. However, natural gas generates 35% less green-house gas emissions than oil, and it's considered a more environmentally friendly alternative.

In addition to the existing production capacity, plans are underway to finish a power and heat facility, which will be run by TE-TO AD – a joint venture between Toplifikacija AD and a Russian Consortium. The power and heat facility will have a capacity of 220 MW for electricity generation and 160 MW for heat production. The facility will run on natural gas, with generated heat being sold locally, and generated electricity being sold locally, regionally, and internationally. In addition to heat and electricity sales, TE-TO AD plans to supplement revenues from the sale of CO₂ certificates.

Toplifikacija AD has a participation of 20% in TE-TO AD, and will actually just buy heat from the latter, rather than helping to generate it. TE-TO will heat the water delivered from Toplifikacija, and then will be pump it in the district heating network.

While the production of power and heat is a more or less straight forward affair, the distribution of heat is less so. The district heating distribution network is old and generates technical and distribution

losses of around 23%. Heat losses from the network amount to around 12%. Right now the piping system is owned by the city and rented by Toplifikacija AD. As such, there are few incentives to invest in system upgrades. There are plans to restore full public ownership over the distribution network, but it is not clear how that will help improve the situation.

TE-TO AD Power and Heat Plant



Source: <http://www.te-to.com.mk/>

In addition to bringing the distribution system back into the public sector, there are plans to separate the three heating supply companies from Toplifikacija AD, and have them operate as independent companies. These companies would basically buy the heat from Toplifikacija and sell it further to end-consumers. They will also be in charge of collecting and enforcing heating tariffs.

The problems with how the supply system is set-up right now are manifold. On the one hand, tariffs cannot be set by Toplifikacija itself. There is a National Regulatory Commission that sets heating tariffs for the entire country. As such, heating companies have relatively little leeway in influencing revenue flows, and profits often have to suffer because of this.

Enforcing heating tariffs can also be problematic, because of the nature of the system. Since heat is delivered to substations, and then from substations to entire apartment complexes (like the one in the picture below), it is hard to disconnect individual users for failure to pay tariffs. Since heating systems in large apartment complexes are inter-

connected, cutting an individual end-user off could mean cutting the entire apartment complex off. This is obviously not the best way of solving the problems.

Toplifikacija AD usually takes bad payers to court to settle liabilities, and has an overall payment coverage of around 90%-95%. However, while enforcement seems to work fairly well, the transaction costs associated with this method of enforcement are quite high. Often people refuse to pay not because they cannot afford to, but because they feel wronged in one way or another. In 2008 alone, Toplifikacija had to deal with over 14,000 complaints.

Apartment Complex in Skopje



To be quite fair, the way the system is set-up right now, similar to other district heating networks inherited from Communist times, is not very efficient. Basically, people are charged heating tariffs according to the surface of their homes, not based on what they actually consume. Thus, a family that is gone on vacation for all of December still has to pay for heating in that month, although they didn't use any of it. Similarly, everybody in an apartment complex will receive the same amount of heat (that which is delivered by the substation) regardless of what their heating needs actually are. The only way to adjust temperature in the

cold months is to open up the windows and let some cold air in. This is not the most efficient way of organizing a heating system.

As a consequence, over the years, many people in Skopje have decided to de-branch themselves from the district heating network, and resorted to individual means of heating generation (e.g. using electricity, individual gas-fired units). In 2008 alone, over 3,100 consumers left the system. In the long-term, this will negatively affect district heating companies, as the more customers they lose, the more un-economical they become (they basically have to deliver heat below installed capacity). To address these issues, utility providers have to invest in infrastructure, upgrade systems (e.g. introduce individual metering), while keeping tariffs at a competitive level. There are talks now of attaching evaporators next to each individual radiator to determine exactly the amount of heat people consume. Such measures will also be extended to new customers, as Toplifikacija works with individual developers on branching new buildings to the district heating network.

Energy Efficiency Recommendations

The TRACE diagnostic tool allows the prioritization of investments and policies based on potential energy and cost savings. The benchmarking component of the tool enables the identification of the Relative Energy Intensity (REI) of a particular service area – i.e. how much energy can be saved based on the performance in that service area of other cities. The level to which local authorities can influence that particular service area is also an important factor in determining energy and cost savings potential. For example, if a particular service area is wholly in private hands and regulated by the central government (as is the case with the district heating system in Skopje), there is little local authorities can do about improving energy performance in that area. Moreover, since the costs are borne by a different entity, local authorities can focus on measures and actions that immediately impact their budget.

The savings potential in a particular service area is obtained by multiplying energy cost in that service area with the REI and the level of local control. Based on savings potential, service areas are prioritized, and only those are selected where meaningful annual cost savings can be achieved. Below are the priority service areas identified by TRACE in Skopje.

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	64,758,257	24.0%	0.45	7,002,709 [PRIORITY 1]
Public Transportation	9,934,599	51.7%	0.80	4,110,858 [PRIORITY 2]
Municipal Buildings	2,421,998	35.4%	0.90	773,640 [PRIORITY 3]
Street Lighting	1,688,009	38.5%	0.96	624,198 [PRIORITY 4]
Solid Waste	1,141,044	46.2%	0.86	453,431 [PRIORITY 5]

Three things deserve mentioning here. First, as can be seen in the priority table, ‘Private Vehicles’ was picked as Priority 1 for local authorities in Skopje. Even though cost savings are not immediately accrued by the locality, they are accrued by people living there. Moreover, energy efficiency improvements in the private vehicle fleet will bring benefits to the city as a whole. Another area that is similar to ‘Private Vehicles’ is ‘Residential Buildings’, and this is a sector where significant energy improvements are possible. A conscious decision was made when TRACE was developed, to not include ‘Residential Buildings’ among the group of surveyed urban service areas. The complexities of buildings, of policies in the area, and the wide diversity of the global urban built stock, make this service area hard to use for comparison and benchmarking purposes.

The second thing that deserves mentioning is that Relative Energy Intensity can be influenced by removing or adding cities for benchmarking purposes. All in all, the larger the cities database is, the more accurate the results will be. A larger database not only allows comparison with a larger number of cities, but it also enables a better selection of peers – i.e. it enables a better “apple-to-apple” comparison, with cities that are similar. Given imperfect information, we have chosen to use the entire TRACE cities database for benchmarking purposes in the case of Skopje. In some instances we have run alternative scenarios with a smaller selection of cities, and these findings will be discussed in more detail in the sub-sections below.

Third, some assumptions have to be inherently made about the level of local control in a particular service area. We looked at pertinent legislation in the field, we did an in-depth analysis of the sector itself, and we closely worked with local authorities to get an accurate portrayal of the level of local control in each service area. Changing the level of local control can dramatically affect the prioritization mechanism of TRACE. For example, if the level of local control for ‘Private Vehicles’ would have been lower in Skopje, TRACE would have picked up ‘Public Transport’ as the first priority sector.

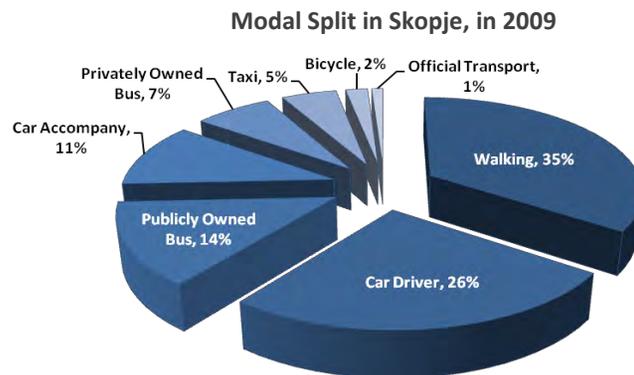
The subsections below include a more in-depth discussion of 10 recommendations from TRACE, which were considered to be particularly poignant for Skopje.

Private Vehicles

Skopje is one of the burgeoning cities in the Western Balkans. Its population and its economy have registered healthy growth in the transition years. Population and economic growth have naturally reflected themselves in a dramatic increase in the rate of private vehicle ownership. Moreover, the decline of the public transportation sector and the continuous expansion of the city have made more and more people reliant on private transportation. Given that Skopje was not designed for so many cars, local authorities now have to deal with congested streets, clogged parking lots, and increased urban pollution. Several pro-active measures have been taken to address the situation, but much remains to be done. The recommendations below are meant to build on efforts already underway in Skopje, and to help local authorities think about some things in a different way.

Development of Non-motorized Transport Infrastructure

A large number of people in Skopje already use non-motorized modes of transportation. Despite a rapid increase in private car ownership, 35% of people resorted to walking for daily commutes in 2009, while 2% used bicycles. Consequently, one of the first measures local authorities should take is to encourage those trends and build on an already good foundation.



Source: Skopje Transport Master Plan

Walking is the prime way of getting around in Skopje. It is likely that some people walk because they cannot afford other means of transportation, while others do it because it is convenient or because they prefer to. The task for local authorities is to make walking a preferred and convenient way of getting around for as many people in Skopje as possible. Such a task can be achieved in different ways.

One of the tools most often sought after by urban planners is the promotion of dense urban development patterns. The denser a city is, the smaller the distances are between destinations, and the more likely people will be to walk. Islands like Manhattan and Singapore are prime examples in this respect. They have clear natural growth boundaries which have forced vertical development and a sustainable transport infrastructure dominated by public transit and non-motorized alternatives.

While Skopje only has one natural growth boundary – the Vodno Mountain in the South of the City, it already benefits from relatively high densities, and it can continue to push dense development patterns by strategically using zoning and land use laws. For example, higher densities could be allowed in areas with particular high traffic, and around major public transit hubs. This way, non-motorized transport options can be integrated with public transport options.

In areas with high enough densities and a high enough mix of uses, people are more likely to walk from one destination to another. In such instances, local authorities should make it easier for people to walk. One of the most straight forward ways of achieving that is by investing in the proper infrastructure – i.e. walk-paths.

Skopje already has a tradition of converting streets into pedestrian-only ways. Much of the city center and the main boulevards connecting to the central plaza have been converted into pedestrian walk-ways. This has not only helped encourage people walk more through the city center, but it has also discouraged car use, and it has increased business activity in the area (with numerous shops, cafés, restaurants enjoying increased pedestrian traffic, and as such a higher customer base). Moreover, as the picture below highlights, pedestrian streets often become lively places where people meet and greet, or just spend some time away from their daily chores. As such, pedestrian streets add a lot of value to the quality of life in a city and they have become a staple of good city planning, from New York to Moscow and Beijing.

Pedestrian Street in the Center of Skopje



Local authorities should build on the successes they have already registered and think of how further investments in pedestrian streets and walk-paths could encourage more people to walk. For example, neighborhood amenities (e.g. shopping centers, sports fields, restaurants, pubs, entertainment options) should be easy to access by foot, tree planting and maintenance of green areas should create a more walk-friendly environment, and strategic land-use planning should discourage the creation of large pedestrian un-friendly spaces (e.g. big surface parking lots). Moreover, existent pedestrian infrastructure, such as sidewalks should be more aggressively protected. In many areas of Skopje, sidewalks have been completely over-run by cars.

In addition to investments in pedestrian infrastructure, the city has invested recently in the creation and extension of bicycle infrastructure. Even though the share of people using bikes is low, and even though there is some concern that people will not respond favorably to such initiatives, the experience of other cities suggests that “if you build it, they will come”. From sustainability leaders, like Copenhagen, to newcomers to the game, like Bucharest, more and more people use bikes when they are offered the proper infrastructure, and when their safety in traffic is assured.

Local authorities in Copenhagen have set the target of having 50% of daily commutes in the city be done by bike, by 2015. To achieve that target they have invested aggressively in bicycle infrastructure (with

many dedicated and higher width bike-paths, and designated parking spots throughout the city), they have introduced green-wave systems for bicyclists, they have increased traffic safety, and they have connected the bicycle infrastructure with walk paths and public transit lines. As a result of these measures, more people in Copenhagen use bikes for in-city commuting than cars.

Bicyclists in Copenhagen



Source: Niels Tørsløv. 2010. *Sustainable Urban Transport*. PPT Presentation given on May 18th, 2010 in Copenhagen.

Obviously, investments in non-motorized infrastructure should be done in an integrated way (e.g. connecting pedestrian streets to bike paths), and they should complement the existent and planned public transportation infrastructure. Whenever possible, public transit hubs should be easy to access by foot and by bike, and they should provide supportive infrastructure, such as secured parking spots for bicycles. At a minimum, integrated planning efforts should ensure that one mode of sustainable transportation does not unduly compete with another. For example, an increased share of bicyclists in Skopje should not come at the expense of public transport ridership, but rather at the expense of private vehicle ridership

Parking Restraint Measures

Parking seems to be one of the most pressing issues in Skopje right now. Not only are the city’s streets clogged with cars, but so are most of its sidewalks. Local authorities have tried to improve the parking situation in the center city by adopting a clear parking policy. However, the measure seems to have done little to de-congest the center. In some instances,

quite the contrary has happened, with dedicate sidewalks being turned into parking spaces. Pedestrians are thus left no alternative but to walk in the middle of the street.

Outside the A-B-C zones where parking measures are enforced, cars seem to also reign supreme. As the photo below evidences, people are often forced to walk in the middle of the street, with car traffic going around them. This is obviously a big safety hazard, and a factor that can severely affect the quality of life in the city. Parents, for example, don't only have to worry for their own safety, but also for the safety of their children.

Unfriendly Pedestrian Environment in Skopje



Enforcing stricter parking regulations is often hard to do, because of the expected backlash from drivers. However, it is far from an impossible task. Manhattan has one of the highest densities of wealthy people in the World, but also one of the lowest densities of parking spaces. If the wealthy of New York can do without cars and clogged sidewalks, so can the people in Skopje.

In addition to more restrictive parking regulations, local authorities should think about strategically developing a parking infrastructure that encourages more walking, biking, and public transport use. For example, many developed cities have park-and-ride facilities, especially in peripheral and suburban areas, which minimize congestion in centers cities and limit the amount of time people spend in their cars and in traffic. Such park and ride facilities could be strategically developed around major transit hubs on the outskirts of Skopje. The development

of the new light railway system in the city could also include a number of park-and-ride facilities in key locations (e.g. transit stops along high-commuter paths).

Traffic Restraint Measures

Local authorities have put in place a wide range of traffic optimization measures (e.g. roundabouts at major intersections, widening of boulevards), and they plan a number of more ambitious measures (e.g. a by-pass under the city center, and a central traffic control room). These changes have helped ease traffic in the city, but they have also, inadvertently, brought more cars on Skopje's streets. If more space on the streets is created for cars, cars will occupy it – i.e. people that might have forgone using their cars because of traffic congestion, have now fewer disincentives to do so. More cars on the streets ultimately translate into more cars on already clogged side-walks. Basically, in the battle for public space, cars are given primacy.

There is often a reticence to put measures in place that discourage the use of cars, because of the expected backlash (especially at the voting poles) from drivers. However, some of the world's cities have managed to undergo a paradigm shift in this respect. Bogota (Colombia), for example, has seen a dramatic shift from a car-oriented city to a walk-bike-bus city in less than four years. Between 1998 and 2001, mayor Enrique Peñalosa has taken cars off the city's sidewalks, has developed an extensive bicycle infrastructure, and has developed the world-renowned TransMilenio Bus-Rapid-Transit system.

One of the most important changes Mayor Peñalosa has introduced was a shift in thinking about public space. He basically considered that public spaces, like streets and sidewalks, should be organized "democratically", with the same amount of space available for people on foot, on bike, on a bus, or in a car. As can be seen in the picture below, 60 people on foot, on a bus, or on bicycles, take only a small fraction of the street space required by 60 individual cars. With this in mind, taking cars off the sidewalks and investing in bicycle infrastructure is a sign to people that, as Peñalosa mentions, a citizen on a \$30 bike is just as important as a citizen in a \$30,000 car.

In addition to creating more space for walking, biking, and for public transportation, Mayor Peñalosa has also implemented a number of traffic restraint measures. He started by implementing a car-free day in

2000, which has subsequently earned him the Stockholm Challenge Award. Every Sunday, 120 km of road in Bogota are closed to traffic for 7 hours. Moreover, in a referendum, the people of Bogota have voted to have no cars during rush hour (from 6:00 AM to 9:00 AM and from 4:30 PM to 7:30 PM) from 2015 onwards. This is quite a shift in mentality and attitudes, considering that when Peñalosa first proposed his traffic reforms for Bogota, he was almost impeached.

Street Space Occupied by 60 People in Different Transportation Modes



Such measures are not unthinkable in Skopje either. In fact, local authorities have already taken significant steps in that direction. Thus, in addition to creating more space for pedestrians and bicyclists, measures have also been taken to cement the rights of pedestrians and bicyclists in city traffic. Thus, stop lights at major crossings show the right of way as seen below. Such measures can be further buttressed by having car-free Sundays on certain streets, and by ensuring that people who walk and bike have the same right to street space as people who drive cars.



Public Transportation

After years of continuous decline, the public transportation network in Skopje is seeing a resurgence. The City has invested massively in the renewal of its bus fleet and in improving the public transport infrastructure. There are plans to create an integrated public transportation system, with streamlined routes and single-ticketing for both public and private bus operators. There are also plans for the creation of a light rail system.

Public Transportation Development

The development of the public transportation network in Skopje is one of the City's highest priorities. A Transport Master Plan has been drafted, and it includes ambitious measures, such as the development of a light rail system with four lines (see image below).

Skopje – Proposed Light Rail Lines (in red)



Source: Skopje Transport Master Plan

The Transport Master Plan is a good document, and includes most of the recommendations that could be made here. What the Master Plan is lacking however is a clear and cogent view of how different transportation modes will be integrated together. There is not a lot of talk on how park-and-ride facilities could help decongest the city center by catching the in-commuter flow on the outskirts of the city; there is little about how public transportation infrastructure, and proposed

extensions, will be integrated with walk and bike-paths, and the extensions of non-motorized infrastructure; and there is nothing about the coordination of car traffic and public transport traffic (e.g. creating a green-wave system for public transport modes, which would allow for faster bus/tram trips, by limiting the amount of time public transit modes have to wait at red lights and at intersections).

Municipal Buildings

Municipal buildings is one area where local authorities have been particularly pro-active in implementing energy efficiency measures. From simple initiatives, like shutting the heat off when buildings were not used, to more complex ones, like automatic-heat and light control systems and boiler replacements, there are a range of things that Skopje can continue to build on. Since significant progress was made in this area, it will be important for local authorities to think of how energy improvements can be scaled up to the entire city. That is, how can the accumulated experience be used to encourage households, businesses, and other institutions to improve the energy performance of the buildings they occupy.

Two immediate recommendations can be made in this respect. First, local authorities should continue to lead by example and use good practices in municipal buildings as demonstration of what can be done in the field. Second, they should put local building energy efficiency codes in place.

Municipal Offices Audit and Retrofit Program

There are a number of energy efficiency measures that have been implemented in schools, but not a lot has been done about municipal offices. Focusing on energy efficiency measures in municipal office can have a very powerful demonstration effect (particularly if they are properly advertised), and they would offer local authorities the moral high-ground for pushing more stringent EE guidelines and standards.

It has to be mentioned here that municipal buildings in Skopje seem to be doing quite well, both in terms of electricity and heat consumption, when compared to municipal buildings from other cities in the TRACE data-base. Although TRACE indicates a 35% energy savings potential, particularly in term of heat consumption, if some of the cities with a warmer climate are taken out of the benchmarking process, the savings

potential drops significantly. Basically, municipal buildings in Skopje consume less heat and electricity than almost every city with pertinent data in the TRACE database. One reason for this occurrence has to do with the fact that most of the municipal buildings in Skopje are represented by educational facilities. Since schools are used only for a part of the day and only a part of the year, their yearly energy consumption per square meter is likely to be smaller than in buildings that are used more intensely (e.g. hospitals, or administrative buildings).

A 35% energy savings potential was ultimately used because in-depth studies conducted for the Skopje SEAP have determined a very similar figure 34%. They however have not established the energy savings potential through a benchmarking process, but by estimating the energy reduction potential of certain EE measures.

When it comes to municipal offices, the City of Skopje is in a particularly interesting situation. Most of its staff works in barracks like the one in the image below.

Typical Municipal Office Building



In the 1963 earthquake, many administrative buildings were destroyed and most were never re-built. To allow a speedy city recovery, several barracks were hastily constructed in the City Park of Skopje. These were supposed to temporarily house the city's work-force until new buildings would be developed. Almost 50 years later, public officials continue to work there.

Consequently, improving the energy performance of municipal offices should closely consider the remaining lifetime of all the buildings.

Some buildings will continue to be used for years to come; some might be demolished as new, suitable spaces are created. Thus, local authorities can adopt a two-pronged approach, improving the energy performance of the buildings with a longer expected life-time, and constructing new buildings in accordance with strict EE codes.

Preliminary estimates show that simple measures can help reduce energy consumption in administrative buildings dramatically. The way these measures will be implemented should be prioritized based on expected impact and based on expected investment recovery period. For example, it makes no sense to invest in the thermal insulation of walls for buildings that will potentially be demolished within a couple of years. However, roof insulation seems to offer an almost immediate payback (see table below).

Measure	Investment Costs	Annual Savings		Period for Return on Investment
		kWh	Cost	
Insulation of Roof	\$554,270	367,361	\$384,855	1.4
Thermo Façade	\$1,013,765	120,867	\$126,623	8.0
New Windows (PVC)	\$956,173	311,993	\$326,851	2.9

Source: Skopje SEAP

Simple measures that will reduce the heat consumption of municipal offices should be doubled by innovative approaches for further energy savings. Such approaches could include automatic contracts with ESCOs, integrated energy management systems, or EE revolving funds. The results of these EE improvements could be used as showcase examples for other institutions and businesses in Skopje, and the experience gained could be funneled into the drafting of better local building codes and standards.

Mandatory Building Energy Efficiency Codes for New Buildings

Once local authorities have done their due diligence in improving the energy performance of municipal buildings, and once they have gained some experience in the field, they can consider introducing mandatory building EE codes for new buildings.

The Strategy for Improvement of the Energy Efficiency in Macedonia until 2020 makes recommendations on the improvement of building codes, but it is not clear when this will happen. *The Rulebook on Building Energy Performance* is in place since 2008, and it sets out the principles of energy audit and certification. However, all of the standards included in the *Rulebook* are voluntary, and there are few incentives to convince people to abide by them. Skopje can take the lead on that front and propose mandatory EE codes for new construction, as well as mandatory EE refurbishments for all existing public buildings.

The United Nations Economic Commission for Europe (UNECE) has compiled a comprehensive and exhaustive Action Plan for Energy Efficiency in Housing. Local authorities in Skopje can use this Action Plan as a guideline for improving the overall energy performance of the built mass in Skopje. The Action Plan can be accessed at the following link:

<http://www.unece.org/fileadmin/DAM/hlm/documents/Publications/action.plan.eehousing.pdf>

Similarly, the US Environment Protection Agency has developed a ‘Sustainable Design and Green Building Toolkit’, aimed at assisting local authorities in improving their EE pedigree. The toolkit is available at: <http://www.epa.gov/region4/recycle/green-building-toolkit.pdf>

Public Lighting

The public lighting system in Skopje is generally in good shape. Three major things are required to improve it: street coverage needs to be expanded; the existent network needs to be better monitored and maintained (e.g. ensuring that lights are turned off during the day, and making sure that light bulbs that don’t work are promptly replaced); overall energy performance of the system can be enhanced (e.g. by replacing remaining energy inefficient bulbs, using light bulbs with a longer life-span, and by introducing improved lighting timing systems). Extending the street lighting system will ultimately mean higher energy costs for local authorities, but these costs can be offset by increasing the efficiency of the existent system.

Overall, there are two major recommendations that seem to make sense in the case of Skopje. On the one hand there is a need for a better audit and monitoring system to ensure the system is running efficiently. On the other hand, lighting timing can help improve the performance of existing bulbs by adjusting use according to the intensity of the natural

light outside (e.g. higher use in the winter time and on cloudy days) and according to the time of day (e.g. lower light intensity when streets are less travelled, such as after midnight on a week-day).

Integrated Public Lighting Assessment Program

The City of Skopje, who is in charge of street lights on the main boulevards, has done an almost complete revamping of the system, replacing inefficient mercury bulbs with more efficient high pressure sodium bulbs. However, the number of light poles that come under the jurisdiction of the City of Skopje represent only around 30% of the total number of light poles in the city. The rest are maintained and managed by the 10 municipalities that make-up the city, and each one of them has tackled the issue with different aplomb. Some have been quite proactive in this field, even introducing innovative pilot project such as solar-powered street lights (see image below), while others still have a generally old and inefficient system.

Solar Powered Street Light in Skopje



The municipalities that have a dense urban fabric had more of an incentive to invest in the improvement of their street lighting network. The municipalities that have lower density neighborhoods, as well as

newly emerging developments have more areas that are poorly lit. In itself, this is another argument for promoting a dense urban development pattern. It takes only one light pole to illuminate the area around a big apartment block that houses 40 households. It can take 20 light poles to illuminate the streets in front of 40 individual detached houses.

Because the jurisdiction over the street lighting system is so fragmented, with basically 11 responsible parties, it is hard to get a full picture of network efficiency. Some street lights are left running in the middle of the day, some continue to run on inefficient light bulbs, some have dead bulbs that have never been replaced. It is therefore important to start an integrated public lighting assessment program. Such a program would not only allow a full and comprehensive analysis of the system, but it will also identify the most pressing needs and the parties responsible for addressing those needs. Ideally, every municipality and the City of Skopje would be involved in the process, although the task team assigned to assess the system need not have a representative from each jurisdiction.

An integrated assessment and common strategy are needed because street lights serve not only discrete neighborhoods (e.g. people expect their municipality to provide lights in front of their homes), but also public spaces that cross jurisdictional boundaries. Someone that starts their journey in the old city center of Skopje, walking along the Vardar River and then crossing the river to reach the National Arena “Philip II of Makedon” will experience different lighting conditions, as they are provided by the municipalities of Čair, Butel, Karposh, and Centar.

Lighting Timing

While many of the inefficient street light bulbs have been replaced, public lighting in Skopje continues to have two states of operation – 'ON' and 'OFF'. Moreover, in some cases, there seems to be no off button with lights being left to run in the middle of the day. The fact of the matter is that depending on the season and the time of the day, there are different demands for street lighting. For example, on bright long summer days, street lights may only have to be turned on after 9:00 PM. Moreover, given that few people still walk the streets after midnight

on week-days, there is no need for the same light intensity as during the high-traffic hours.

Consequently, it makes sense to introduce a lighting timing system, which automatically turns the lights on only when it is sufficiently dark outside, and which automatically dims the light after a certain hour (e.g. midnight). Lighting timing systems could also have motion-based detectors, which turn lights on only when someone is actually in the area.

Such programs can be implemented in a fairly cost effective way, and they make a lot of sense in places like Skopje, where much has already been done about improving the performance of the street light bulbs. The Annex includes a more detailed account of options in this field, as well as the experience of some cities that have successfully implemented lighting timing programs.

Solid Waste

The solid waste management (SWM) system in Skopje is in a transition period. On the one hand it is the most evolved SWM system in Macedonia; on the other hand it still has some way to go before achieving full economic, social, and environmental sustainability. Waste collection and transport is done quite efficiently, but there is a dearth of trucks, and drivers could benefit from training on fuel efficient waste vehicle operation. Disposal meets only minimal environmental standards, with no methane gas capture and uncontrolled leachate runoff. Recycling is in its incipient stages, run primarily by the informal sector, but with good promise for the future.

Although in TRACE 'Solid Waste' only came out as Priority 5, it is quite possible that this sector will weigh much heavier in terms of energy efficiency in the future. Given the potential of landfill gas to be captured and turned into valuable electricity, heat, or fuel, this is one area that deserves more attention from local authorities. Also, markets have been identified for many recyclables, and there is great opportunity to extract value from waste.

In terms of energy efficiency in SWM, there are two recommendations that make particular sense for Skopje right now: fuel efficient waste vehicle operation, and landfill gas capture.

Fuel Efficient Waste Vehicle Operation

The collection and transport of waste is organized in an efficient way in Skopje. Garbage trucks are generally new and fuel efficient; a mobile transfer station is used to consolidate waste for transport to the landfill; and collection routes are organized to minimize transport times of garbage trucks. Some of the old trucks will have to be replaced with more fuel efficient ones, but local authorities seem to already be poised to make strides in that area.

Significant energy improvements can be obtained however from better management and planning. For example, the recent expansion of the system to surrounding will require not only a fleet expansion but also better logistics. Collection routes to these outlying areas should be organized so as to minimize transport times, and they should be integrated in the existent route system. For example, if a new route lies closely to an existent route, they could be merged.

In addition to route optimization, drivers could be trained to drive in a fuel efficient way. Often, small changes in driving habits (e.g. avoiding quick acceleration, maintaining an even speed, avoiding frequent breaking, using routes without many intersections) can lead to significant fuel savings. Local authorities could consider offering drivers an incentive for more efficient driving – e.g. a percentage of the fuel savings they achieve. A number of case studies and examples of how such measures can be implemented is included in the Annex section.

Landfill Gas Capture

During decomposition, waste releases a number of gases. Methane is one of those gases, and it represents both a problem and an opportunity. From an environmental perspective, methane is one of the most potent green-house gases – once released in the atmosphere, it has a global warming potential that is 72 times higher than CO₂ in the first 20 years. From an economic perspective, methane can be converted to generate electricity, heat, or fuel.

The waste delivered to the Drisla Landfill is openly dumped and covered with a layer of compacted soil. There are no methane capture devices, and there have been several cases of spontaneous gas combustion. In the *Drisla Landfill Feasibility Study* plans have been hashed out to outsource the operation of the landfill to a private operator. The private operator will reorganize waste disposal at the

landfill around 11 individual cells, which will have leachate protection lining and methane capture devices. It is not yet clear if the methane will be used for productive purposes or if it will just be flared. Depending on gas yields and generation rates, and depending on capital and operational costs, there are different ways in which captured landfill gas could be used. For example, it could be converted into liquefied natural gas that could be used to power the city's garbage trucks. More options and examples are outlined in the Annexes.

ECA Sustainable Cities:
Improving Energy Efficiency
in **SKOPJE**
Macedonia

TRACE Study
Annexes



ANNEXES: DETAILED RECOMMENDATIONS

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ANNEX 1: 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

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

	dependent upon expensive, inefficient and infrequent public transport. See Lima case study for further details.
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 2: 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

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

necessities of non-inner city residents are considered. The success of Park & Ride is linked to availability of public transport and unavailability of cheap parking in central locations. The perceived cost should be lower than that of driving the entire 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.

SFpark 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.vtppi.org/parkpricing.pdf>

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

Water Treatment Plant, San Juan, Puerto Rico

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

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

USAID funded Ecolinks Project, Galati, Romania

<http://www.munee.org/node/62>

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

Tools & Guidance

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

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

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

ANNEX 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.

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

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

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

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/wcfcd/documents/cfd_howto.pdf

ANNEX 4: PUBLIC TRANSPORT DEVELOPMENT

Description

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

Implementation Options

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

Attributes

Energy Savings Potential

> 200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions
Improved air quality
Enhanced public health & safety

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

Monitoring

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

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

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

Case Studies

BRT system, Bogota, Colombia

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

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

through private firms, resulting in a complex but innovative management structure.

Land Use and Public Transport Planning, Curitiba, Brazil

Source: World Bank (2010). "Curitiba, Brazil -- Cost Is No Barrier to Ecological and Economic Urban Planning, Development, and Management . In ECO² 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 high-density 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: Eco² 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: Eco² Cities - Integrated Regional Urban Planning in Auckland, available online

<http://www.esmap.org/esmap/node/1227>

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

Tools & Guidance

Public Transport Authority Western Australia (2009). "Bus Priority Measures Principles and Design" A guidance document for planning bus priority methods and approaches. Available online from

<http://www.pta.wa.gov.au/PublicationsandPolicies/DesignandPlanningGuidelines/tabid/109/Default.aspx>

Transport for London (2006). "Accessible bus stop design guidance" A guidance document for designing bus stops which help make boarding easier for passengers. Available online from

http://www.tfl.gov.uk/assets/downloads/businessandpartners/accessible_bus_stop_design_guidance.pdf

ANNEX 5: 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: <ul style="list-style-type: none"> • lighting systems • air conditioning systems • heating systems • computers • server rooms and cooling of servers • appliances (water cooler, fridge, vending machines) The Municipal Offices EE Spreadsheet includes estimation methods for energy

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

	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>

ANNEX 6: MANDATORY BUILDING ENERGY EFFICIENCY CODES FOR NEW BUILDINGS

Description

This project is a city-specific green building guidelines or certification program to encourage the use of green building technologies. The guidelines can be based on previously established systems such as LEED (USA), BREEAM (UK), CASBEE (Japan), Green Mark (Singapore), Estidama (Abu Dhabi) or many others. It should focus on energy efficiency, but should also cover water conservation, urban heat island effect (green roofs), indoor air quality, and many other aspects of green buildings. The program can take many forms such as: voluntary guidelines, minimum building standards, an incentive program for private developers. The benefit of this program is to advance higher quality building design and construction and promote energy efficiency for all of the buildings in the city, saving money, saving water, and making better buildings to live and work.

Implementation Options

Implementation Activity	Methodology
Assess opportunities	Assess the climate, building types, real estate market and construction industry for green building opportunities. Evaluate other green building guidelines in the region and globally and identify the most relevant strategies
Perform cost - benefit analysis	Assess the general costs of each of the green building strategies in the specific city in terms of new construction for code-based design versus green building design strategy. Provide ranges of additional cost as well as ranges of savings and co-benefits of the strategy beyond pure financial benefits.
Draft Guidelines (voluntary approach)	Create a custom green building design guidelines that are city-specific guidelines and respond to the conditions of the city as researched above (climate, construction practices, safety, financial, market, etc.). The design guidelines can be distributed to the public and encouraged to be used voluntarily by progressive developers, designers and building owners.
Draft Incentive Program (Incentivized)	Along with the design guidelines, create a program to incentivize the construction of exceptional green building design by providing tax credits,

Attributes

Energy Savings Potential

> 200,000 kWh/annum

First Cost

< US\$100,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Efficient water use

Increased employment opportunities

Financial savings

approach)	zoning benefits, quicker approvals or other tertiary benefits that the development community will respond to.
Draft Green Building Code (mandatory approach)	If a voluntary approach or an incentive-based approach does not seem likely to succeed, and the design and construction community responds better to mandatory requirements, then reform the guidelines into the form of a code and find ways to update the local building code to include requirements of green building design. See Seattle case study as an example of best practice.
Public outreach	Distribute the draft guidelines to the real estate community, construction community, design community, and residents and citizens of the city. Along with the guidelines produce.
Enact Green Building Ordinance	With public comments integrated, a full set of technical and financial analysis completed, and potentially a small number of demonstration projects to point to, enact a law, ordinance or executive order to implement the green building guideline/incentive program/code.

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:

- kWh/m² - benchmark electrical energy consumption on a per-square-meter basis.
- kWh/m² - benchmark heating energy consumption on a per-square-meter basis.
- \$/m² - Benchmark energy cost on a per-square-meter basis for all buildings.
- Number of buildings certified under (new/other) codes.

Case Studies

Energy Efficiency Codes in Residential Buildings, Tianjin, China.

Source: ESMAP (2011). “Good Practices in City Energy Efficiency: Tianjin, China - Enforcement of Residential Building Energy Efficiency Codes”, available online from <http://www.esmap.org/esmap/node/1280>

Tianjin is one of the most successful Chinese cities in compliance enforcement of building energy efficiency codes (BEECs). Results of recent annual national inspections organized by the Ministry of Housing and Urban and Rural Development (MoHURD) indicate that compliance of BEECs in new residential and commercial buildings in Tianjin is close to 100 percent, compared to the 80 percent average across nearly three dozen large cities inspected by MoHURD in 2008. More remarkable is the fact that, in terms of building envelope thermal integrity, the currently enforced residential BEEC in Tianjin (identified as DB29-1-2007) is 30 percent more stringent than what is required by the pertinent national BEEC (identified as JGJ 26-95).

In 1997, Tianjin introduced its first mandatory residential BEEC (identified as DB29-1-97), which is equivalent to the requirements of the JGJ 26-95, the national model BEEC for cold climate regions enacted in 1995. DB29-1-97 was enforced from 1998 to 2004. Enforcement actually began on January 1, 2005; it was based on an earlier version which was updated and reenacted on June 1, 2007. This case study covered five years of enforcement of DB29-1-2007, from 2005 to 2009.

Tianjin’s efforts to go beyond national BEEC requirements marked a departure from the mostly central government-driven BEEC regulation of the past in China. Tianjin began piloting residential BEEC in the late 1980s, despite the fact that it has taken about 15 years for Tianjin to achieve a high degree of compliance. Tianjin has demonstrated the importance of the following factors in achieving BEEC compliance: (i) a well-established building construction management system, (ii) standardized and structured procedures for compliance enforcement, (iii) broad-based capacity of the construction trades to meet compliance requirements, including technical skills and availability of parts and materials, (iv) consumers’ ability and willingness to pay for the costs of BEEC compliance, and (v) local government resources, support, and commitment to implementing increasingly stringent BEECs.

Low-energy Building Standards, Münster, Germany

Source: ESMAP (2011). “Good Practices in City Energy Efficiency: Low-energy Building Standards through Sale of City-owned Land, Münster, Germany”, available online from <http://www.esmap.org/esmap/node/1170>

By mandating low-energy building standards in sales contracts of city-owned land, the City of Münster (Germany) caused a market transformation that led to 80 percent of all new buildings constructed in 2010, even those not built on city-owned land, to follow the city’s energy efficiency requirements.

Austin Energy Green Building (AE/GB), Austin, USA

<http://www.austinenergy.com/energy%20efficiency/Programs/Green%20Building/index.htm>

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

In 1991, Austin Energy Green Building (AE/GB) developed the first city-wide tool for evaluating the sustainability of buildings in the U.S. It is made up of four programs, covering single family homes, commercial, multi-family and governmental or utilities buildings. As a market transformation

program it provides technical support to homeowners, architects, designers and builders in the design and construction of sustainable buildings. Using green building rating tools specifically developed for Austin, along with the LEED and Green Globes national rating tools, Green Building's staff assist design teams to establish green building goals, review plans and specifications, make recommendations for improvements, and rate the final product on its impact to the environment and community.

AE/GB has produced \$ 2.2 million in annual financial savings from reduced energy costs to consumers. The initial investment of \$1.2 million for the project came from an annual budget (including a \$50,000 grant from the US Department of Energy). The AE/Gb has also reduced energy consumption by 142,427 megawatt hours and reduced demand on the utility's generation resources by 82.8 megawatts. These energy savings have resulted in the reduction of power plant CO2 emissions by 90,831 tons, NOx by 87.6 tons, and SOx by 17.4 tons.

Sustainable Building Action Plan, Seattle, USA

http://www.c40cities.org/docs/casestudies/buildings/seattle_green.pdf

Under the Sustainable Building Policy, Seattle requires that all new city buildings over 5,000 square feet meet new state LEED (Leadership in Energy and Environmental Design) building ratings, which measure the sustainability of buildings. The city provided financial, height and density bonuses for private projects meeting LEED. Seattle implemented programs such as the Sustainable Building Action Plan (with key strategies to promote green buildings), the Density Bonus (offering downtown commercial, residential and mixed use developments greater height and/or floor area if a green building standard of LEED silver or higher is met), and the City LEED Incentive Program (providing financial incentives for energy conservation, natural drainage/water conservation, and design and consulting fees for LEED projects). Between 2001 and 2005, the city provided incentives of over \$4.3 million for projects implementing LEED standards. The standards have produced average reductions of 35% in energy use and 6.9 million KWh/annually for LEED Municipal buildings. Other benefits from the scheme included an average reduction of 1,067 CO2e tonnes per LEED building, along with an annual average financial saving of \$43,000 per LEED building.

Green Building Guidelines, Cape Town, South Africa

[http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/DRAFT City of Cape Town Green Building Guidelines.pdf](http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/DRAFT%20City%20of%20Cape%20Town%20Green%20Building%20Guidelines.pdf)

The City of Cape Town plans to enact a bylaw by 2012 to call for environmentally-friendly building methods. The Draft Green Buildings Guidelines will form the core of the planned bylaw, actively promote resource efficient construction of new or renovated buildings in Cape Town to minimise the negative environmental impacts of the built environment, whilst maximising positive social and economic impacts. In the long-term the City will work towards design manuals and legislation to ensure the implementation of green buildings. The Green Building Guidelines document is aligned with the Green Building Council of South Africa, which has incorporated the Green Star Rating system of the Green Building Council of Australia. It is envisaged that the City of Cape Town will also incorporate the Green Star Rating system in the future. The guidelines for the implementation of green buildings are specific to Cape Town, including advice on site selection, design and construction phases, sustainable resource management, waste management, urban landscaping, human health and safety and visual mitigation measures.

Tools & Guidance

<http://www.epa.gov/region4/recycle/green-building-toolkit.pdf>

ANNEX 7: LIGHTING TIMING PROGRAM

Description

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

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

Implementation Options

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

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

	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 8: INTEGRATED PUBLIC LIGHTING ASSESSMENT PROGRAM

Description

Existing public lighting is often highly inefficient, using high energy consumption technologies, and lacking the strategic coordination of placement and operation of lighting. An audit of the existing stock as well as assessing running and maintenance operations, will help identify appropriate measures to significantly increase energy efficiency. Interventions that include new technologies and retrofitting will also increase the design life of luminaires, which reduces both the requirements and costs of maintenance. The aim of this recommendation is to enable a holistic assessment of the lighting system as a whole to identify areas for improvement across the network.

Implementation Options

Implementation Activity	Methodology
Appoint Inventory Leader	Hire, or allocate staff with the skills, experience and personality required to be able to gather a wide variety of data from many departments across the city administration. Alternatively hire an external consultant as a leader for the below activities.
Identify Inventory Requirements	Define essential and desirable information useful for a street lighting inventory database. Key data points are required to contextualize the information. Data may include: <ul style="list-style-type: none"> • Street Name and Pole Number • Pole types and Luminaries types • Lamp type and wattage and lumen output • Park lighting lamp type inventory • Monument lighting lamp type inventory • Traffic Signal lamp type inventory • Street Signage lamp type inventory
Collect Data	Hire staff positions to begin the arduous process of requesting data, receiving data, checking data, and collecting primary data by visiting street lights and other lighting features. Alternatively write an RFP and award a contract with a specific scope of work to gather energy benchmarking data for all municipal buildings.

Attributes

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

First Cost
< US\$100,000

Speed of Implementation
< 1 year

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

Analyse and Interpret Data	<p>Conduct an analysis of collected data to ensure accuracy and begin to identify opportunities. Some examples of analysis include:</p> <ul style="list-style-type: none"> • compare kWh/ pole • compare lumens / Watt for different lighting source types • compare \$ / Watt for initial cost • compare \$ of lifetime operational cost per lamp
Publish Inventory Publically	<p>The boldest statement to show leadership in Public Lighting energy efficiency is to publish energy performance data to the public, press, voters, and potential political opponents. This last stage of the program may be many years after the commencement of the program when the data shows improvements and tells a good story of progress toward efficiency in government operations. The CA could then challenge (or require as some cities have begun to do) private owners to benchmark their lighting installations and publish their results.</p>

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:

- % street lights inventoried for luminaries type and lamp type.
- % public parks and monuments lighting inventoried for luminaries type and lamp type.
- % traffic lights inventoried for luminaries type and lamp type.
- % signage lighting inventoried for luminaries type and lamp type.

Case Studies

Energy Efficiency Public Lighting Project, Vietnam

<http://www.gefonline.org/projectDetails.cfm?projID=1106>; http://www.c40cities.org/bestpractices/lighting/vietnam_lighting.jsp

The Vietnam Energy Efficiency Public Lighting Project (VEEPL) is a national 10-year program which audits, installs and promotes the use of energy efficient lighting in streets, schools and hospitals, where all costs from installation, operation, maintenance, and electricity are covered by the

national government. At a capital cost of US\$ 15 million, the program is projected to yield annual financial savings of about US\$ 13 million (based on an electricity tariff of US\$ 0.056/kWh). By means of strengthening both the technical and policy support for a transition to more energy efficient public lighting in Vietnam, the authorities are looking to set up a sustainable long-term lighting industry. Measures which have been introduced to remove barriers have included the establishing of standards which define energy-efficient public lighting and building policies; improvements made in testing capabilities of the local lighting laboratories; the education of the public about the benefits of energy efficient public lighting; and having brought private and public industry and stakeholders around the table to agree on minimum standards of energy efficiency in lighting.

Energy efficient public lighting, Gaia, Portugal

<http://www.managenergy.net/download/nr20.pdf>

Gaia Municipality enacted a study with the main objective of reducing energy consumption in public lighting across the municipal area. The project was divided into four phases. The first phase evaluated existing public lighting conditions and available energy efficient technologies. The second phase developed a pilot project to confirm the theoretical results of flux control systems. This was followed by a third phase, where a financial model for project implementation was developed. Finally the project was implemented using a third party financing model. A communication campaign was then enacted in order to disseminate the information on the project. The preliminary study found that the best technical solution was the installation of flux control systems. These typically save 20-30% of energy and increase the life span of lamps by up to 30%. The first stage of the project saw the installation of 30 flux control equipments inducing energy savings of up to US\$ 45,000. The total investment was approx. US\$ 225,000, which will lead to payback period of 5 years, not considering savings in maintenance costs.

Tools & Guidance

"Lighting the Way": A Local Government Guide to Energy Efficient Public Lighting on Minor Roads, Australian Government, Department of Environment and Water Resources. http://www.iclei.org/fileadmin/user_upload/documents/ANZ/CCP/CCP-AU/EnergyToolbox/lightingtheway.pdf

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 disposal points, eliminate vehicle backtracks and minimise long distance haulage of waste in small

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

	<p>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.</p> <p>See Trabzon, Daventry, Oeiras and Paris case studies for further details.</p>
Continued driver training and improvement	<p>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.</p> <p>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.</p> <p>This implementation activity works well with educating operators about the benefits of efficient operations.</p> <p>See General Santos City and Oeiras case studies for further details.</p>
Inform operators about the advantages of fuel-efficient operations	<p>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.</p> <p>See Maribor and General Santos City case studies for further details.</p>
Incentives: charging	<p>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.</p> <p>See Paris and Italian Local Authorities' Waste Management case study for further details.</p>

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: WASTE LANDFILL GAS CAPTURE PROGRAM

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	<p>A feasibility study establishes the technological and policy framework to implement a landfill upgrade program across the city. This should consider:</p> <ul style="list-style-type: none"> • 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 <p>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 directive to support programs such as gas capture from landfill, the feasibility study should be formulated to fit with these policy prescriptions.</p> <p>Other municipality cost centres can also benefit from the study if biogas displaces other types of fuels, e.g., biogas-powered bus fleet.</p>

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

	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 CO₂e 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?ldtin=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. KMDK 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, eThekweni, South Africa

eThekweni 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 eThekweni 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 eThekweni 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 CO₂e 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>