ECA SUSTAINABLE CITIES:

Improving Energy Efficiency in GAZIANTEP (Turkey)

TRACE Pilot

ECA SUSTAINABLE CITIES

ESMAP
Energy Sector Management Assistance Program

İLLER BANKASI

GAZİANTEP BÜYÜKŞEHİR BELEDİYESİ

Table of Contents

Executive Summary

Globally, cities account for more than 70% of green house gas (GHG) emissions. In terms of energy consumption, they generally account for some 60-80% of a country's demand directly or indirectly. This reality places cities at the forefront of the climate change and sustainability agenda. Clearly, the way cities are planned, financed, and managed will have a determining effect on sustainability outcomes and on the lives and livelihoods of city residents today and into the future.

One option is to discourage people from migrating to cities. This has been tried in the past with little effect. In fact, recent research shows that economic advancement is tied to urbanization -- no country has reached high income status without urbanizing. And cities globally are understood to account for some 70% of global GDP. Policy makers have alternatives. An approach advocated in the World Bank's Europe and Central Asia (ECA) Sustainable Cities Initiative is to identify the main drivers of energy consumption and carbon emissions and take policy and institutional measures, alongside critical investments, to proactively deal with these sustainability challenges into the future.

The ECA Sustainable Cities Initiative or SCI is designed to help cities and national governments tackle this agenda. It involves a four stage process within the SCI Framework: (i) Orientation and Awareness Raising; (ii) City-level Diagnostics; (iii) Policy and Institutional Adjustments and preparation of Sustainability Action Plans; and (iv) Financing of Sustainable Investments.

This report is an outcome of the diagnostics referred to above as "stage two" of the SCI Framework. Gaziantep is noted for a number of initiatives that already reflect city officials' awareness of energy efficiency and carbon emission challenges and some of the solutions. So the main purpose of this analysis was to provide a framework to understand critical areas where energy efficiency gains are needed and possible through a variety of interventions.

This report was prepared by a World Bank team led by Stephen Karam and comprised of Marcel Ionescu-Heroiu, Ranjan Bose, Elif Ayhan and guided by Mara Warwick. The team benefitted from the guidance and input from Wael Zakout, ECA Urban, Water and Disaster Management Sector Manager. The report documents the findings of work that began back in January 2011 with initial data gathering by city technical staff and other informed sources and with the important partnership and support of Iller Bank, the sponsor of this pilot exercise. The diagnostics are based on the application of the new Tool for Rapid Assessment of City Energy (TRACE), this being one of the first global pilots of the tool. Sponsorship for this work came in part from the Energy Efficient Cities Initiative (EECI) of the Energy Sector Management Assistance Program (ESMAP), hosted at the World Bank.

TRACE is a novel tool that quickly diagnoses inefficient energy performance across a city's systems and offers a range of potential solutions embedded with implementation guidance and case studies. The study therefore had two objectives: to provide Gaziantep Metropolitan Municipality (GMM) with recommendations to improve energy performance and to validate and test the TRACE as a global pilot.

GMM is a rapidly growing metropolitan area that has seen its population increase ten-fold over the last 40 years to an estimated 1.35 million today. This growth continues at an exceptional rate of 4.25% annually and the city's population is anticipated to reach 3 million in the next 20 years. In this context, urban form and service delivery become critical issues to deal with new growth by planning and investing in sustainable systems. The city's interest in pursuing the TRACE diagnostic underscores its commitment to achieving optimal energy efficiency. The analysis was carried out across 6 service areas or sectors – municipal buildings, public lighting, urban transport, power and heat, water and waste water, and solid waste. These were in turn assessed against the performance of a range of peer cities through a benchmarking process. This review provided a number of significant findings which helped focus activity during the early part of the study and contributed to the definition of priority sectors for further study. Key findings of the Gaziantep TRACE diagnostics included the following:

- high city-wide electricity use per capita;
- high city-wide water consumption and disproportionately high electricity consumption for water pumping;
- high city-wide utilization of public transport but equally growing ownership and use of private motor vehicles, resulting in higher operating energy intensity for mobility;
- high city-wide electricity use on public lighting; and
- very high consumption of electricity in municipal buildings.

The review established that there are several energy efficiency activities taking place in Gaziantep City currently. For example, there is an initiative to replace mercury light bulbs (used for street lighting) with sodium vapor lamps, and new LED technologies are being trial-tested. In the buildings sector, the new 2011 Energy Efficiency in Buildings Law of the Municipal Public Works and Settlement is in place, requiring that all new buildings have an energy certificate that attests adequate energy performance above a set threshold. The water utility, GASKI, is working on limiting water leakage from the distribution system (currently at 40%) and on reducing the relatively high electricity bill. The GMM has no jurisdiction over the supply of power and no recommendations were found to be suitable in this sector. In the solid waste sector, collection and transportation is contracted out to third parties and service outcomes did not suggest the need to prioritize policy changes or investments in this service area. Good practice with respect to waste management was observed in the landfill gas capture and energy generation project at the Gaziantep landfill site. Although the recycling rate is only 1%-2%, there is an active informal recycling system, with people cashing-in on valuable material collected directly from trash cans. It is estimated that around 28% of solid waste is recycled through the informal economy and is not delivered to the landfill. Transport, the major city-wide energy consumer, is proving difficult for GMM to directly influence. Much of the transport sector is either under private ownership (mini buses), licensed by national authorities or in case of infrastructure, planned and developed at a regional level.

Most of the activities currently underway in Gaziantep City were successfully identified by the TRACE tool. This report was prepared based on the TRACE results and covers the following areas in Gaziantep City.

- City background information – e.g. contextual data, key city development priorities, energy efficiency drivers, barriers, etc;
- A summary of the benchmarking results, along with an analysis of city performance and sector prioritization based on city-owned and city-wide scales; and
- A draft summary of recommendations provided as inputs to a Sustainable City Action Plan.

Of the energy efficiency recommendations currently incorporated into the TRACE, ten were deemed a high priority for the Gaziantep City. These covered the water, transport, buildings and public lighting service areas. They are as follows:

Active Water System Leak Detection and Pressure Management: In 2010, 40% of the potable water produced in Gaziantep was lost in the system due to technical losses. The share of non-revenue water was 48.5%. With the assistance of Iller Bank, GASKI (Gaziantep's Water and Wastewater Utility Company) has recently introduced a supervisory Control and Data Acquisition (SCADA) system. The SCADA system allows the adjustment of system pressure so that water leaks are limited. To double the efficiency gains that SCADA enables, GASKI should start a more extensive leakage detection program and determine investment needs for replacing old infrastructure (e.g. old piping).

Improve Efficiency of Water Pumps and Motors: The water system that provides the largest share of potable water in Gaziantep, from the Karltalkaya reservoir, has two water distribution lines, each with three pumping stations along the way. One of these distribution lines, along with the pumping stations serving it, are rather old – they were completed in the 1970s. Consequently, those pumps are not operating at peak performance. They require higher operation and maintenance costs, and they can potentially cause more damage (e.g. leaks) to water pipes. This diagnostic recommends that GASKI carry out an assessment of the costs and benefits of replacing those pumps, and, in addition, assess the viability of developing hydro-powered turbines in key areas along the system (as a way of generating some, or all of the energy the system needs).

Water Efficient Fixtures and Fittings: Considering the revenue loss from water leakage and the relatively high daily water consumption in the city (185 l/capita), water demand management measures is a critical area where action is recommended. Water efficient fixtures and fittings (e.g. valves) help to reduce water consumption by reducing the volume of water used in each application. This reduces the associated energy needed to treat and convey the required flows. Efficient fittings can help raise consumer's awareness of the link between water use and energy

consumption, and generally leads to the consumer installing additional energy efficient products. The GMM can use policies, incentives, and/or investments to ensure better water management throughout the city.

Public Transport Development: A well crafted public transport development plan cannot only lead to better city-wide energy performance by offering alternatives to private vehicle use, but it can also improve energy performance by guiding city growth in a sustainable way. If population growth continues at the present pace, the city will more than double in size in the next 20 years. Public transport planning should therefore go hand in hand with city planning, as they are mutually beneficial. For example, an integrated city development plan should allow for higher densities around public transit hubs. This will not only provide a higher ridership for public transit operators, but it will also allow a higher share of people access to an affordable means of transportation.

Municipal and City Bus Fleet Efficiency: Much of the bus fleet in Gaziantep has an average age of 18 years. It is energy inefficient, polluting, and a traffic hazard. While only a small share of this fleet is owned and operated by the GMM, the metropolitan municipality regulates the sector and could impose stricter efficiency guidelines. It could start these efforts by retrofitting or replacing municipally owned buses that are energy inefficient.

Traffic Flow Optimization: Even for cities that are not growing, traffic flow studies are important as travel patterns and preferences change constantly. Gaziantep, in addition, is expected to grow at a very fast pace. Consequently, the GMM, along with the district municipalities, should track traffic flow patterns, and continually optimize the system to avoid energy shortfalls (e.g. cars waiting longer than needed at intersections, or people choosing to commute by car because public transportation modes are too slow).

Mandating Building Energy Efficient Codes for New Buildings: Buildings are one area where significant energy savings can be achieved. The 2011 Energy Efficiency in Buildings Law in the country requires that all new buildings have an energy certificate that confirms energy performance above a set threshold. The GMM will need to put in place mechanisms to properly enforce this regulation and may wish to consider ways (e.g. voluntary guidelines, building standards, incentive programs) in which it can encourage households to go beyond these minimum requirements (e.g. the use of energy efficient appliances and fixtures).

Municipal Offices Audit and Retrofit Program: The Ministry of Public Works and Settlements is undertaking a complete overhaul of 100 Government buildings in Ankara. It aims to set an example for other public sector actors, as well as for the private sector. The GMM could consider a similar program in Gaziantep. Innovative financing schemes (e.g. using private Energy Service Companies – ESCOs) can ensure that the burden on the local budget is minimal.

Street Lighting Timing Systems: In addition to network extension (many streets in Gaziantep are poorly lit), the GMM should consider ways in which the performance of light poles can be improved. For example, light intensity can be reduced when street traffic is low (e.g. late at night), and motion detectors could turn on some lights only when there is activity on the street.

Street Lighting Audit and Retrofit*:* The bulbs that have traditionally been used for street lighting tend to be very inefficient, producing a lot of heat. They are also poorly designed, unnecessarily spreading light in all directions (including the sky above). New bulb technologies can not only significantly increase efficiency, but also extend the design life – reducing the need for investments in bulb replacement. Throughout the world, light audit and retrofit programs are recognized as being among the surest sustainable development investments cities can make. The retrofit costs are usually amortized within a year of two, and operation and maintenance costs are reduced significantly. Consequently, local authorities can chose to either finance such project directly, or they can engage an Energy Services Company (ESCO). Within Gaziantep there has been a push to replace mercury vapor street lights with sodium vapor ones. The switch has been slow, many still need replacement, and there already are a number of better technologies that can be considered. Thus, Gaziantep officials can soon think of how they can replace the sodium vapor bulbs with more energy efficient bulbs (e.g. LED).

Introduction

Gaziantep is one of the fastest growing cities in the world, and one of the most dynamic urban economies in Turkey. It serves as Turkey's gateway to the Middle East, and is one of the country's most important trade links south and east. The New York Times reported that trade between Turkey and Syria more than doubled from $795 million in 2006 to $1.6 billion in 2009, and is expected to reach $5 billion in the next three years. In 2010, the Middle East received nearly 20% if Turkey's exports, about $19.2 billion worth of goods and services, compared with 12.5% in 2004. Such expansion has also come with tremendous challenges, and local authorities in Gaziantep are interested in seeing the recent growth translate into sustainable development.

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

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

Focusing on sustainable development issues in ECA cities is particularly poignant, because they face a number of critical economic, social, and environmental challenges. ECA, for example, has some of the most polluted cities in the world. In fact, it has the highest share of pollution per unit of GDP of any other region in the world, accounting for 7.1% of the world population, 3.1% of global GDP, and 11.8% of global CO^2 emissions from fuel combustion. In economic terms, while ECA countries have registered some of the fastest growth rates in the past decades, they have also registered some of the sharpest economic declines in 2009 – underlining that much of the previous growth was not sustainable. From a social point of view, many ECA cities suffer from demographic decline and an aging population, or, as is the case of Gaziantep, they are growing at a very fast pace, giving birth to slums and informal settlements.

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

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

A Note on Methodology

Gaziantep (Turkey) represents the first pilot tackled under the ECA Sustainable Cities Initiative. The activity, so far, has included a scoping mission in October 2010, data collection enabled by Iller Bank in January-February 2011, a series of workshops organized with national and local stakeholders in March 2011, and the implementation of the Tool for Rapid Assessment of City Energy (TRACE). The TRACE diagnostic tool was selected because energy efficiency is often considered to be a "low hanging fruit" in sustainable development, with outcomes and benefits that are fairly easy to measure and monitor. This activity is expected to

yield important dividends in helping Gaziantep identify investments necessary to develop as a sustainable city.

During the early part of the study, interviews were held with a range of GMM departmental staff and representatives from a range of city agencies. Information gathered during this period enabled a classification of each sector based upon the degree of influence directly or indirectly exerted by the GMM, the potential for energy savings in the sector and relative spending on energy in each sector or service area. On the basis of these findings, a service area intervention prioritization assessment was undertaken. Although this analysis and the related interventions are subject to further development, the analysis concluded that water, urban transport, municipal buildings and public lighting service areas are priorities for further investigation and intervention.

The latter part of the study involved further interviews and site visits at the city's main water and waste water treatment facility, and at the landfill site. These enabled a detailed systematic filtering of all of the energy efficiency recommendations currently contained within TRACE, to examine their suitability in Gaziantep City. This process demonstrated that a large number of recommendations were:

- either likely to be technically and/or financially unviable;
- outside of the direct control of the GMM; or
- already being implemented or trialed.

Background

Turkey is the fastest growing country in Europe. Between 1990 and 2009 it grew at 1.53% per year, going from 56 million people to 76 million people. Most of that growth took place in cities, with the urbanization rate increasing from 59% in 1990, to 70% in 2010. Cities, particularly the regional growth centers, have grown even faster that the national average, and have set themselves apart as economic engines – attracting not only the lion share of the population, but also the lion share of new investments. Between 2003 and 2010, Turkey attracted $94 billion of foreign direct investment (FDI) – more than six times the FDI value for the previous 30 years ($15 billion between 1973 and 2002).

Population Dynamics in the Largest Turkish Cities

	Name	Population		Compounded Annual Growth
		1990	2010	
1	**Istanbul**	6,629,431	12,175,592	3.09%
2	**Ankara**	2,583,963	4,082,184	2.31%
3	**Izmir**	1,758,780	2,815,046	2.38%
4	**Bursa**	834,576	1,567,756	3.20%
5	**Adana**	916,150	1,491,066	2.47%
6	**Gaziantep**	**603,434**	**1,388,004**	**4.25%**
7	**Konya**	513,346	950,645	3.13%
8	**Antalya**	378,208	809,437	3.88%
9	**Kayseri**	425,776	796,291	3.18%
10	**Mersin**	422,357	629,224	2.01%
	TURKEY	56,086,184	75,960,383	1.53%

Source: World Gazetteer and authors' calculations

Such growth has not come without its challenges. Rapid population and economic growth have put pressure on land and environment, have strained existing infrastructure, and have triggered rising energy needs and costs. City livability has been taxed by increasing demands for services, and questions have been raised about long-term sustainability – with Greenhouse Gas (GHG) emissions more than doubling between 1990 and 2008, and electricity consumption more than tripling in the same time period. Furthermore, Turkey is expected to continue on an accelerated growth path, with an average annual growth rate of 6.7% between 2011 and 2017 – the fastest expected growth rate of any OECD country.

With this unprecedented economic and urban growth, the country is facing particular challenges on how to meet the rapidly increasing energy demand in a sustainable manner. National and local authorities have to lead the way in promoting more sustainable development patterns and encouraging a more efficient use of resources and energy. For example, by ensuring that urban energy supply is secure, reliable, and affordable, and by ensuring demand is efficiently managed, cities can optimize operating costs, improve air quality, and improve quality of

infrastructure services, while at the same time supporting economic development and climate change mitigation objectives. This requires investigating beyond the energy sector itself, to all sectors that require energy in the production of urban services (e.g. water and wastewater, transport, buildings).

Given energy's cross-sectoral nature, municipalities need to evaluate energy efficiency opportunities on both demand and supply options, across sectors – and within the urban planning framework – as well as across time to cut energy costs. While municipal officials would like to take action, the World Bank has found that they often do not know where to start. They typically require some level of technical assistance with the early first steps towards achieving cross-sector efficiencies, which include evaluating baseline energy consumption and supply options, and identifying priority sectors for promoting sustainability and achieving measurable improvements. These activities are the building blocks for developing holistic, phased urban energy policy and investment strategies.

National energy efficiency strategy

The Government of Turkey (GoT) has acknowledged that increasing energy efficiency (EE) is a national priority. Promoting EE policies can help the country achieve energy supply security, sustain economic growth, and come closer to meeting criteria of the *Aquis Communautaire* for EU integration. Inefficient energy use translates into a higher public expenditure on energy, putting pressure on national and municipal budgets. In 2008, Turkey spent $48 billion on energy imports, increasing the country's current account deficit, and making it more susceptible to external shocks and fuel price volatility.

In addition to economic and political considerations, environmental concerns play an increasingly important role. While GHG emissions per capita are still relatively low, Turkey has registered the highest increase in emissions (from 1990 to 2008) of all countries tracked by the United Nations Framework Convention on Climate Change (UNFCCC). Such changes have not gone unnoticed among the Turkish population. A recent survey indicates that 79% of Turkish citizens see climate change as a very serious problem. Furthermore, 58% consider that climate change is substantially affecting people now, and 87% think the Government has a responsibility to take steps to deal with climate change.

In 2004, the GoT has drafted the *Energy Efficiency Strategy for Turkey*, setting out to improve energy efficiency in the country by: 1) supporting central and municipal administrations to define and implement integrated energy efficiency policies; 2) encouraging energy users to reduce consumption of energy; 3) improving legal and institutional framework; 4) seeking outside funding to promote and buttress energy efficiency measures.

The Strategy considers municipalities to be one of the key areas where energy efficiency measures can have the highest impact. It is also acknowledged that a number of hurdles have to be overcome before energy savings in municipalities can be achieved. The most important of these is the lack of capacity and financial resources at the municipal level. Even if local authorities are committed to reducing energy consumption, they often don't know where to start (e.g. how to prioritize among different sectors, and what measures to resort to), and if they do, they lack the necessary funds and know-how to see these changes through.

In addition to the EE Strategy, The Ministry of Public Works and Settlement (MPWS) has recently drafted a strategy (KENTGES) that sets out sustainable development principles for Turkish cities. KENTGES is structured around 19 objectives, 42 strategies, and 100 actions, covering a wide range of issues – including energy efficiency in cities.

Three important pieces of legislation came to buttress these two strategies: the 2007 Energy Efficiency Law of the Ministry of Energy, the 2008 Regulation on Increasing on Increasing Efficiency in the Use of Energy Resources and Energy, and the 2011 Energy Efficiency in Buildings Law of the MPWS. The first two set out principles and procedures for achieving higher energy efficiency in Turkey, with particular attention given to large energy consumers, like industrial enterprises and large buildings. These are required to appoint an energy manager whose task is to improve the energy performance in the facilities under their control. The Energy Efficiency in Buildings Law requires that all new buildings have an energy certificate that attests adequate energy performance above a set threshold.

Since industry and buildings are the largest energy consumers in Turkey (e.g. 85% of net electricity is consumed in these sectors), the

legislative measures put in place tackle these directly. If properly enforced, they are hoped to tap an energy-savings potential of 30% in buildings, and 20% in industry.

To encourage energy efficiency in other sectors as well, the GoT has prepared a package of other regulatory measure, taxes, and incentives. Circular No. 2008/19, for example, requires all public bodies to replace incandescent bulbs with energy-efficient bulbs in areas that fall within their responsibility. The implementation of this circular led to the replacement of 1.8 million incandescent bulbs, reducing electricity costs for national and municipal bodies by over $27 million. The cost of the LED light bulbs ($7.6 million) was amortized in 101 days.

In the transport sector, energy efficiency is encouraged through the use of taxes on fuel. In 2010, Turkey had the second highest gasoline prices in the world, and the highest prices on diesel, at $2.52/liter and $2.03/liter respectively. As a point of comparison, in the same year, the US charged on average $0.76 for a liter of gasoline. Similar high prices are charged for electricity (with Turkey having some of the highest tariffs in Eastern Europe and Central Asia), and for municipal water use (Gaziantep charged more for water than sustainability champions like Stockholm and Amsterdam).

Urban Growth and Energy Challenges in Gaziantep

Gaziantep is among the oldest continually inhabited cities in the world – and its residents hope to preserve that legacy. Approximately 52% of the total area covered by mountains and 27% of total area is plains. While the north part of the city has the impacts of continental climate, the south parts have the characteristics of Mediterranean climate. Generally summers are hot and arid, winters are mild and rainy. Located in the central south region of Turkey, bordering on Syria, Gaziantep serves as Turkey's gateway city to the Middle East.

The city's economic structure is fairly well-balanced with modern and traditional industries (soap-manufacturing), as well as a very successful machine carpet industry (one of the largest in the world with exports of $700 million in 2006). With an emerging tourism sector, Gaziantep has attracted investment in restaurants and other tourist destinations centered around a historic castle and several traditional artisanal craft workshops producing copper and other products. Gaziantep also aims to keep pace with its larger sister cities of Istanbul and Ankara with the recent opening (2009) of the first enclosed shopping center in the city and region. This new development -- Sanko Park – underscores the regional importance of the city as it draws a significant number of shoppers from Syria. In the agriculture sector, Turkey ranks third among producers of pistachios in the world and the Gaziantep region is noted as one of Turkey's largest producing regions, accounting for 60,000 metric tons in 2007.

In the 1970s, Gaziantep had a population of around 120,000 people. By 2010, the population grew to over 1.35 million. Now the city is spread over three distinct district municipalities: Şahinbey with a population of 730,000; Şehitkamil (590,000); and Oğuzeli (17,000) (see map below). Each district municipality has its own leadership, but the city as a whole is governed by the Metropolitan Municipality of Gaziantep (Gaziantep Büyükşehir Belediyesi)[1]. According to Turkish administration law, all large conurbations (with the exception of Istanbul, which is very large) have to establish metropolitan authorities, in charge of an area 20 Km in diameter around the center of the conurbation. The district municipalities are responsible for all municipal services that are not specifically allocated to metropolitan municipalities, but they also share some functions[2].

Of the ten largest conurbations in Turkey, Gaziantep was the fastest growing between 1990 and 2010, with a compound annual growth rate 0f 4.25%. Most of this growth happened in a haphazard, un-planned manner. The last Plan drafted to guide city growth was done in 1974, when the city population was a tenth of what it is today. Zonal plans were the only tools local authorities used to control the explosive city growth. A new city plan is under works now, and it will guide city

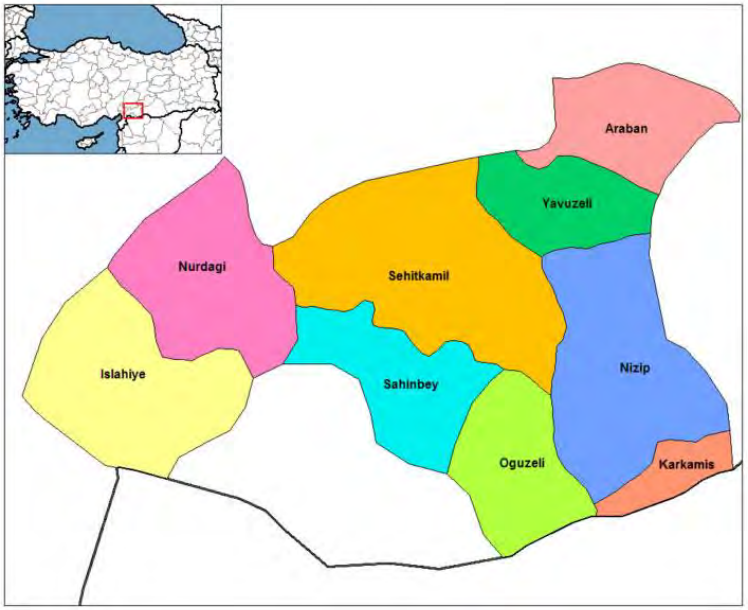
[1] In the text, when we talk about the Gaziantep Municipality, we refer to the Gaziantep Metropolitan Municipality (GMM), not the district municipalities.

[2] District municipalities are usually responsible for garbage collection and maintenance of parks, while metropolitan municipalities handle street cleaning. The metropolitan municipality prepares masterplans for the area, while district municipalities can take a lead role in preparing detailed plans. The metropolitan municipalities are usually responsible for major roads and public transportation management, while district municipalities handle local roads. Both administrative levels have a responsibility for traffic control.

development through 2030, when the population is expected to reach 3 million people.

Fast city growth puts tremendous pressure on land markets, housing markets, and public services infrastructure. It also creates energy efficiency shortfalls as new developments are largely un-coordinated (e.g. worker housing does not always go up close to industrial areas, resulting in unnecessarily high commuting times).

The Gaziantep Province



To accommodate a large incoming population, squatter settlements have risen up throughout the city, with people often building where they could find cheap available land. Nonetheless, the city's outward expansion happened in a rather compact manner, and population density within the developed area is relatively high - 3,750 people/km^2. Since many of the incoming people could not afford a private car, and since gasoline is very expensive in Turkey, suburban type developments were rare. The image below gives an idea of how the city is growing along its Southern border, where a lot of new developments go up.

Neighborhood in Şahinbey

The fast city growth has created a series of energy efficiency challenges in a number of sectors. In what follows, the report will look at six distinct municipal service areas where better energy performance can be achieved: water and wastewater, transport, municipal buildings, street lighting, solid waste management, power and heat. Addressing energy efficiency issues in these sectors can not only ensure a better environmental pedigree for Gaziantep, and save public money. It can also ensure that the city will become more economically competitive and more attractive for people and capital in the region. Gaziantep is considered to be an Anatolian Tiger and the economic gateway to the Middle East. As such, it has a significant opportunity to not only become a more sustainable city, but also become a regional centre of innovation, providing best practices for other cities in the area.

Sustainable Gaziantep

The term sustainability can encompass many things and can be used for different purposes. The TRACE tool is specifically focused on energy efficiency issues at the municipal level, and on ways in which local public intervention can contribute to making cities more sustainable. This approach is particularly tractable as it targets clear and easy to monitor outcomes (i.e. energy, and energy bill savings in a particular sector). TRACE is designed to rapidly assess energy use in a city and suggest energy efficiency interventions. There are six sectors, or municipal service areas, that the tool focuses on: water and wastewater, transport, municipal buildings, street lighting, solid waste management, power and heat. The overall and energy specific performance of these sectors was evaluated using both hard data, as well as qualitative information collected during the mission to Gaziantep.

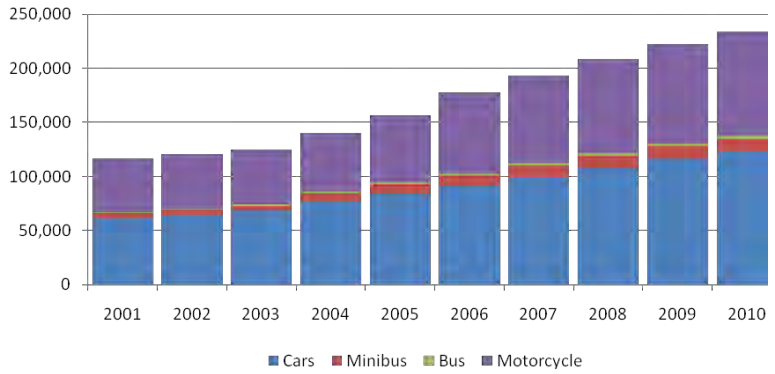
The benchmarking component of the TRACE tool is intended to assess the energy performance of a city compared to other peer cities. For each sector, 3-6 Key Performance Indicators (KPIs) have been derived to indicate energy performance either across the sector or with respect to components of the sector. The present version of TRACE contains a database of 28 KPIs collected from 60 cities geographically spread around the world. Each of the data points that make up these KPIs is collected prior to the application of the tool. The benchmarking process provides an overview of energy performance so the city can assess its relative rankings against all cities considered for comparative analysis. On-site interviews and field visits have helped give a more rounded picture of energy efficiency challenges in the city. The quantitative and qualitative information thus collected have enabled sector prioritization based on clear or estimated energy savings potential.

Transport

Rapidly increasing urbanization and even faster growth of motorization (motor vehicle ownership and utilization) in Gaziantep has brought opportunities and benefits in areas such as education, health care, social services and employment opportunities, which directly contribute to the achievement of development objectives. But it has also brought significant challenges as the city works to absorb an estimated 3 million people by 2030. A higher motorization has an impact on congestion, haphazard urban growth and land use, petroleum dependency, harmful vehicle emissions, and safety costs in terms of traffic fatalities and injuries. Besides the serious consequences on people's health and quality of life, greenhouse gas (GhG) emissions from energy use by transport are also a growing major concern.

In the past 10 years, Gaziantep's population grew by 62% while the number of motor vehicles more than doubled (see Figure 3.1). By 2010, Gaziantep had 304,344 motor vehicles (including freight vehicles) – 225 for every 1,000 inhabitants, a rate far higher than most cities with similar incomes and population size. Most of these are cars and motor cycles. The growing number of vehicles can in part be explained by the strong desire for personal vehicle ownership – a phenomenon observed virtually everywhere.

Growth of motor vehicles for passenger movement in Gaziantep



The shift from mass transit to personal vehicles will have a large effect on energy use – as well as traffic congestion, pollution, and GhG emissions. In Gaziantep municipal buses use only one-sixth as much energy per passenger-kilometer to transport people as cars, about one-third as much as motorized two-wheelers. Developing a strategic approach to motorization is therefore increasingly critical in Gaziantep. Two different, but potentially related, issues needs to be addressed: (i) there is a need to develop a more balanced pace of motorization; and (ii)

there is a need to identify a more balanced multi-modal transport network with fewer implicit or explicit subsidies.

The transport sector is responsible for the majority of city-wide energy use. A quick and rough estimate based on the transport data presented in the table below provides energy demand and expenditure on public transportation and private vehicles.

Annual Energy Use and Energy Spent on mobility in Gaziantep, 2010

Mode	Energy Use (MJ)	Energy Spent (US$)	Energy Intensity (MJ/PKM)
Public Transportation	964,257,023	53,775,872	0.32
Private Vehicles	2,770,038,147	1,999,442,747	1.30

Note: (i) Diesel price is taken as $2.03/l and gasoline as $2.52/l; (ii) All public transport modes are assumed to run on diesel fuel and private vehicles on gasoline.

Public Transportation

Buses in Gaziantep represent less than 1.5% of the city vehicle fleet, but meet over 57% of travel demand in terms of passenger kilometer travelled. However, private vehicle ownership if growing fast (faster than actual population growth), and public transport development does not seem to be able to keep up with it. Ultimately, increased private vehicle use can lead to growing traffic congestion (primarily in the down town area), to higher level of transportation energy use, to higher carbon emissions, and lower ambient air quality.

The Transport Department of the Metropolitan Municipality thus faces a double challenge. On the one hand it has to organize new transportation routes for a quickly expanding city. On the other hand, it faces a fierce competition from private vehicles. Failing to extend and upgrade the public transportation system could translate into more and more people choosing private cars and motor cycles.

Much of public transportation in Gaziantep is privately organized, which leaves less control room for the municipality. Of the around 3,029 buses operating in the city, only 22 are owned and operated by the municipality. 260 are privately owned and operated, and another 80 operate under a lease agreement with the municipality. The lines served by these private buses, as well as ticket prices they charge are set by local authorities after consultations with the operators.

The most intensive bus traffic is done for school and work. There are 1,100 school buses (900 of which are actually active), which take children to and from school every working day. There are an additional 1,300 Dolmuş, or “Blue Buses”, which take workers to and from the three large industrial areas around the city. 487 minibuses and 1,464 taxi cabs complete the picture.

Of all these, the “Blue Buses” are considered to be the most problematic by the municipality. A large share of the Dolmuş fleet is old and energy inefficient (an average of 18 years), they are polluting, and they are considered a menace to traffic safety (in Turkey, Dolmuş buses are notorious for being rather liberal with obeying traffic rules).

Dolmuş/Blue Bus

In addition, because much of city growth was not governed by a clear plan, much of the workforce lives in neighborhoods that are far from industrial areas.

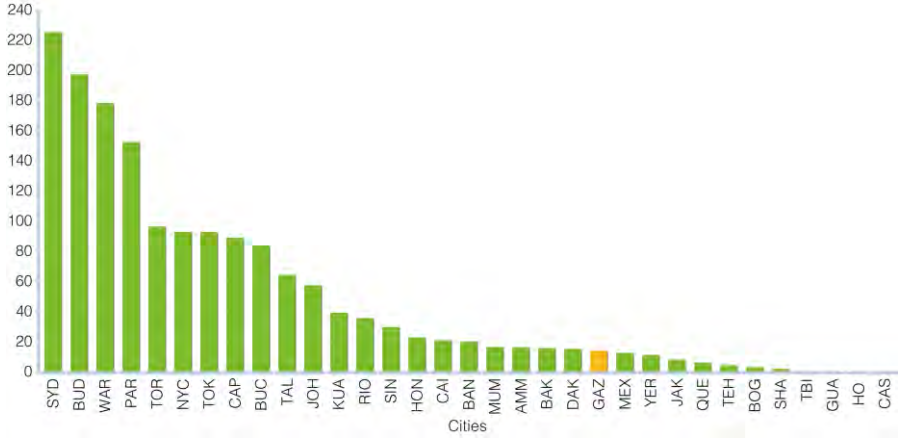
Regulating and optimizing the Dolmuş fleet is one of the main concerns of the Transportation Department, but it is a desiderate that is hard to achieve. Social and political considerations have prevented local authorities from adequately regulating this sector.

There are however other measures that the municipality are taking to address transportation challenges. One of the most recent measures is an investment in an 18 km light railway line that connects a middle income neighborhood to the city center. The railway line was inaugurated on March 1st, 2011 and there are plans to extend it by another 30 km. Currently, there are 4 trams operating on a trial basis and each tram has a carrying capacity of 220 people. These trams run at a 20-minute interval in both directions. The plan is to have a total of 15 trams operating in the system after the trial period is over.

The New Gaziantep Rail Line

In addition, the municipality is talking to the National Railway Company to lease land along the main railway line that connects the industrial areas to the railway station in the city. The land would be used to build a separate rail line meant to take over some of the daily commute load, currently done by Dolmuş buses. This measure is hoped to not only decongest roads, but also generate better environmental outcomes. When compared to other cities, Gaziantep ranks relatively low in terms of the relative length of high capacity transit lines (see figure below). Expanding high-capacity transit has been identified by local authorities as one of the key ways of making Gaziantep more sustainable.

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



In addition to these new rail lines, the municipality is also working on optimizing existent bus lines. To improve the energy and environmental performance of the local bus fleet, the municipality is planning to convert much of it to natural gas, and a pilot is already envisioned for the municipal owned bus fleet. This move would also allow significant cost savings, as gasoline and diesel prices are quite high in Turkey.

Even though the GMM operates only a small part of the public transportation fleet in the city, it has full regulatory control over all 3,029 buses in operation (in terms of their route rationalization, fare fixation, speed control, frequency, periodic fleet inspection and maintenance, and drivers training). Consequently, the level of local control was assumed to be 0.55 in the TRACE tool[3]. With this assumption the tool picked up public transportation as the second major priority area that could benefit from energy efficiency interventions.

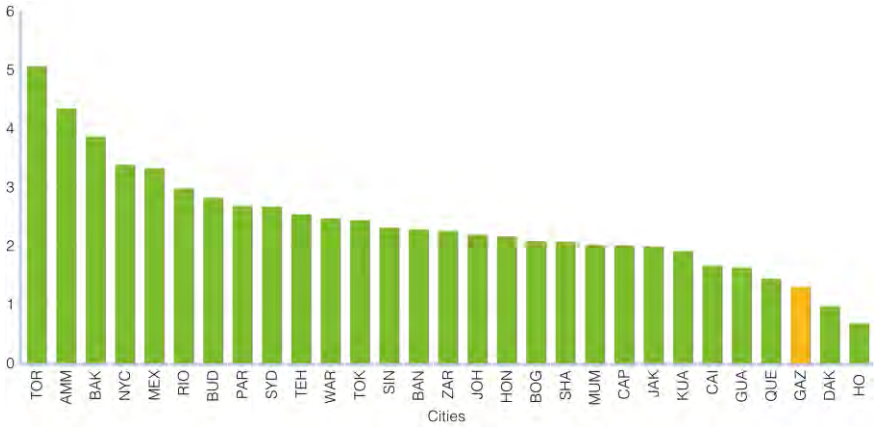
[3] The level of control varies from 0 – no control, to 1 – full control.

Private Vehicles

In terms of the private vehicle fleet, the municipality can play only a very limited role to regulate in excess of what the National Government is doing, although the extent of energy use in this sector is the highest compared to any other sector measured by the TRACE. The high fuel taxes act as a disincentive to using private cars, but they are not doubled by incentives programs (e.g. a national cash-for-clunkers program) or more stringent local control (e.g. congestion charges).

As it stands now, energy consumption in the private transportation, although high compared to other municipal service areas, is relatively low when compared to other cities. In fact, Gaziantep had one of the lowest rates of all cities with pertinent data in the TRACE database (see figure below). Nonetheless, the rate at which private vehicle ownership is growing in the city indicates that pre-emptive measures in this area would be ideal. In other words, local authorities should think about ways of preventing a transportation 'crisis', rather than responding to an already ensuing one. Moves in this direction have already been made by local authorities. There is for example a study on the use of electric hybrid cars and the establishment of a network of electric charging stations in the city. This study explores the feasibility of using such a system as an incentive for people to switch away from fossil fuels.

Private Transport Energy Use (MJ/passenger-km)



Since local authorities have relatively little control over the private vehicle fleet, the local control index in TRACE was assumed to be 0.15. With this assumption, and given the high volume of energy spend on private transportation, TRACE picked up private vehicles as the third priority area of intervention.

Water

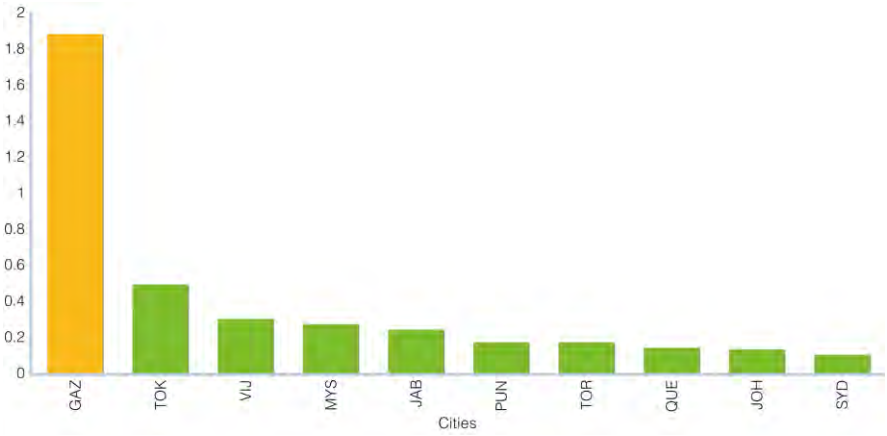
GASKI (Gaziantep Water and Sewerage Administration) is the utility company responsible for water treatment and distribution and wastewater collection and treatment services in the Gaziantep metropolitan area. TRACE considers potable water and waste water as separate items, but in reality in many cities operate these sectors under one umbrella. In most situations, water operations are used to subsidize wastewater treatment. In Gaziantep, it appears to be quite the opposite. As will be highlighted in the following two sub-sections, wastewater is so energy efficient in Gaziantep that it can be used to counter some of the inefficiency of the water system.

Potable water

In 2010, GASKI was servicing a population of 1,296,000, up from 850,000 in 2004. Not everybody receives water from GASKI (some have individual water wells), but all are branched to GASKI's sewage network. The quickly expanding city has put a double pressure on GASKI. On the one hand it had to continually expand the system (e.g. 1,500 Km of new piping were laid between 2004 and 2010), while at the same time maintaining and upgrading the existent network. System upgrades primarily focus on ways of reducing water leaks and reducing energy costs required to pump, treat, and deliver water. In 2010, about 18% of the annual GASKI budget[4] covered energy expenditures. In fact, Gaziantep has the highest energy density of potable water production of any city with pertinent data in the TRACE database – more than three times as high than the figure registered in Tokyo (Japan), and more than nine times as high than the figure registered in Sydney (Australia).

[4] In 2010, GASKI had a total operating budget of $119 million.

Energy density of potable water production (kWhe/m^3)



GASKI draws water from three main sources: the Kartalkaya reservoir (76% of all water drawn); 30 large groundwater wells (19%); and 12 in-city wells (5%). The Kartalkaya reservoir was developed by DSI (General Directorate of State Hydraulic Works), and it is located several hundred meters below the altitude of the city. This means water has to be pumped up to reach end-consumers. An alternative reservoir has been identified, which has 3 times the capacity of the current reservoir (300,000,000 m^3 as opposed to 100,000,000 m^3), and which would allow water to be transmitted by gravity - and generate hydroelectricity in the process. Whether this new source will be used in the future is still a matter of speculation, and depends on how fast the city will expand in coming years.

Getting the water from the current reservoir to the city storage tank (which has a capacity of 100,000 m^3) requires three pumping stations. These pumping stations serve two main lines – an older line, which dates back to 1974, and a newer one, which was completed in the 1990s. The pipes and the pumps that were put into use in 1974 are inefficient and require replacement with newer materials and technology.

The three pumping stations consume a lot of electricity in getting the water up to the treatment station. About 99% of the total electricity is used for pumping raw water to the storage tank for treatment. GASKI is mainly using the pumps at night time, after 10:00 PM, when energy prices are lowest. Even so, the energy costs they incur are quite high. (Annex 2 includes a break-down of energy expenditure based on the water source).

The raw water from the storage tank then gets transmitted to the treatment plant. After treatment, the water flows into a 60,000 m^3 distribution tank. From there gravity does its work until water reaches end consumers. Water losses are incurred during distribution as much of the piping is relatively old and overburdened.

Gazinatep's Water Treatment Facility

The water drawn from the 30 groundwater wells (which were also developed by DSI), requires three pumping stations to reach the city. Of all water lines, this is the most energy intensive in relative terms – 7.08 kWhe/m^3 as opposed to 1.88 kWhe/m^3 for the entire system. However, the volume of water pumped through it is relatively low, and the water itself does not require treatment. Since it is drawn from clean natural ground reservoirs, the water is simply chlorinated and sent to end-consumers.

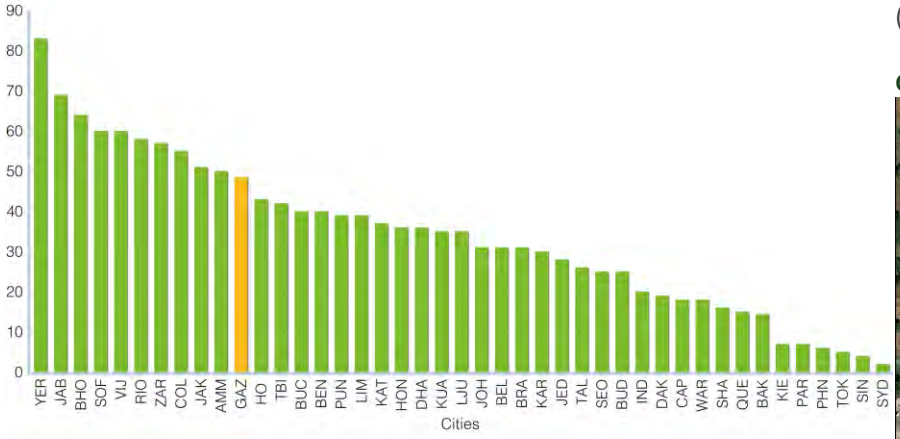
To offset the energy expenditures required to pump the water up from these two main sources, GASKI is continually working on improving the system. Recently, with the assistance of Iller Bank, it has invested in a modern computerized system, which controls pressure valves and collects system data from 160 points. It is also considering the construction of a hydroelectric plant just before the inlet to the main

storage tank, and electric turbines adjacent to the three pumping stations of the Kartalkaya main line.

As it stands, Gaziantep's water system is not expected to reach its full capacity until 2040. Thus, it is not clear if any other large investments (e.g. building a bigger reservoir driven by gravity) will happen in the near future. GASKI seems poised however to continually modernize the existent system, and improve energy performance as well as efficiency.

In 2004, the amount of non-revenue water in the system was 71% - one of the least efficient systems out of all systems counted in the TRACE database. Local authorities have however, pro-actively invested in improving system performance, repairing and upgrading physical infrastructure and streamlining operations. Consequently, by 2010, the percentage of non-revenue water dropped to around 48.5%, and it is hoped to drop even more with further system improvements. As can be seen in the figure below, there is significant room for improvement in this area.

Percentage of non revenue water (%)



To encourage efficient water usage by end-consumers, GASKI has put progressive water tariffs in place. In 2010, a household that consumed an average of 15m^3 of water per month had to pay $27.5, or $1.83 per cubic meter of water. 84% of subscribers consumed less than 15m^3/month.

Despite these significant improvements, the system is far from being efficient. 48.5% non-revenue water is still high, and the system as a whole is very energy intensive. Further improvements can be done in three main areas: source, transmission, and distribution. Following discussions with GMM officials, it is assumed that the level of local control in the water sector is 0.8. With this assumption, the TRACE has identified potable water in Gaziantep as the first priority for improving city-wide energy efficiency.

Wastewater

The wastewater system, established in 1999 and also managed by GASKI, seems to be less problematic than the water system. In fact, if in other cities water works subsidize wastewater operations, in Gaziantep the opposite seems to be the case. The wastewater treatment system does not only run efficiently (e.g. the discharge is carried down by gravity), but it also benefits from a series of innovations that basically reduce energy costs to zero. The energy density of wastewater treatment is very low (0.14 kWhe/m^3) and therefore energy use is highly efficient.

Gaziantep's Main Wastewater Treatment Facility

On the site of the main treatment plant, GASKI has developed a co-generation unit of 1.6 MW capacity that uses methane gas from sludge to produce heat and electricity. The cogeneration facility provides 60% electricity within the plant. The electricity thus generated is used to run the plant, allowing them cost savings of around $1.3 million. The

generated heat is hoped to be used in a sludge drying facility. The cost of the co-generation unit ($1.85 million) will be fully amortized in 26 months. When compared to other TRACE cities with pertinent data available, Gaziantep came out as having the most energy efficient wastewater treatment system.

While it scores high on efficiency, the 11 year old wastewater system scores low on capacity. It serves only 1 million people, and it is aided by an advanced biological treatment plant, which serves another 300,000 people. A third treatment plant is under construction, and when finalized it will cover 99% of the 1.6 million people living in the Gaziantep Province (the three district municipalities that Gaziantep City is spread over, plus another 6 adjacent district municipalities).

Even with a CA control index for wastewater of 0.9, TRACE did not pick up the wastewater sector as a priority area energy efficiency interventions, as it is already highly efficient.

Solid Waste

The solid waste management system in Gaziantep is innovative and run efficiently, albeit not without its problems. Collection and transportation, as well as disposal are completely privatized, with the municipality covering the bills of the two companies that transport the trash and operate the landfill. Collection and transportation are the two main areas where energy savings can be achieved, and captured landfill gas can help generate electricity.

In 1992, the Gaziantep administration contracted a private company to do an investment in a local regulated storage facility. The new facility was commissioned in 1996. It was the second administration in Turkey to do so, after Istanbul, and the facility was constructed with an operational life of 50 years. All three district municipalities that make up Gaziantep use this landfill, and they are serviced by 82 garbage trucks. The storage area is situated in the South of the city, and trucks have to travel an average of 10 Km from Şahinbey (the most populous district), 30 Km from Şehitkamil, and 8 Km from Oguzeli, to reach it. The capacity of garbage trucks varies – 22, 14, and 7 tons – and they put together collect about 4 million tons of trash yearly. Each incoming load is weighed before being finally disposed.

Weigh Station in Gaziantep Landfill

Up to 2009, the municipality paid around $1 million in tipping fees, to dispose of generated trash. Following that year, it entered into a partnership with a Korean company. The company offered to both operate the storage area and generate electricity from methane emissions. Landfill operating costs are to be covered by electricity sales to the National Grid, and the municipality has agreed to buy all electricity

that the Grid won't. The company has leased the landfill for 29 years, a timeline in which it hopes to amortize the investment.

If the system would operate at full capacity, it would generate around 27 MW/day. As of now however, it generates only 5.85 MW/day. Part of the reason has to do with the fact that not all engines are operational. Part has to do with the site, which is not always properly covered to avoid gas leaks.

Another cost-effective measure that has come to benefit Gaziantep SWM system is the establishment of a medical waste processing facility. A policy of the Ministry of Environment requires that all medical waste be properly sterilized and disposed off. In 2008, Gaziantep set up such a facility, at a cost of $1.5 million, of which 32% were covered by the State Planning Organization (SPO). When finished, the facility had a capacity of 21.6 tons/day. Gaziantep however produced only 4 tons of medical waste per day. To allow the system to run more efficiently, they have opened it up to other municipalities in the region. By doing so, they have increased effective processing to 10-15 tons per day, and have brought in extra revenues. In effect, it costs $33,000/month to run the operation, and the revenues that are collected from other municipalities sum up to $53,000/month.

In terms of recycling, there is a sorting station on site, but little recyclable material gets there – 1%-2%. Informal recycling, done by people who cash-in on valuable material, plays a big role in the cycle of waste. It is estimated that about 28% of waste is recycled overall.

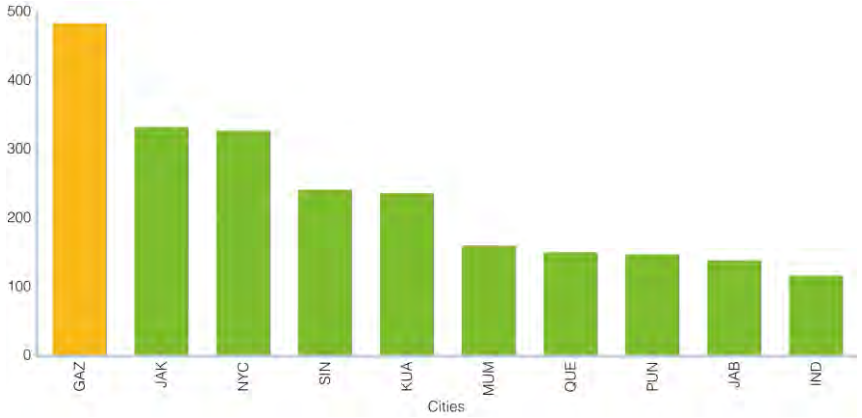
While the Gaziantep city government exerts considerable control over the contractors, energy efficiency savings through contractual changes may not necessarily produce financial savings for the city as contractors are likely to roll costs of vehicle upgrades into annual bids. Taking these into considerations and on the basis of discussions with GMM officials, even with 0.75 as the level of local control index the potential scope for energy efficiency improvement is very low.

Municipal Buildings

Local authorities own 22 buildings with a total floor area of around 190,000 m^2. These buildings had an electricity consumption of 90,250,000 KWh in 2009, and required 412,000 KWhth of heat in the same year. To cover this electricity and heat bill, the municipality had to pay US$ 13.8 million, or 4.8% of the local municipal budget.

In terms of energy expenditure, municipal buildings are the one sector that is directly under the influence of the municipality, and therefore the CA control index is considered to be 1.00. Once these numbers were run in the TRACE tool, Gaziantep came out to have the most inefficient municipal buildings of all cities with pertinent data in the database (see figure below). Consequently, this is also a sector where local authorities could achieve energy and cost savings through retrofit programs. Municipal buildings have been picked up by TRACE as the fourth priority sector.

Municipal Buildings Electricity Consumption (kWhe/m^2)



In effect, the GoT has required that all public buildings replace their light bulbs with energy efficient LED bulbs. Local authorities in Gaziantep have partially done so, but a cursory glance inside their buildings reveals that they still have some ways to go before full compliance.

In addition to simple program like these, the municipality might consider a complete energy re-vamping of the buildings within their control. The MPWS is undertaking such a pilot with 100 buildings in Ankara. The project aims to determine some of the most cost effective and innovative ways of bringing public buildings to the highest standards of the new Energy Efficiency in Buildings Law. Measures can include thermal insulation, more efficient office appliances, or card operated electric systems (which turn off automatically when nobody is in).

Public Lighting

Public lighting is another sector that is organized in a quite peculiar fashion. The system is built, operated, and maintained by TEDAŞ - the National Electricity Distribution Company. This set-up is in place since 2005, when the Treasury asked TEDAŞ to take on the task of providing street lighting in municipalities. The costs of operating the system are covered by the Treasury, not the municipalities themselves.

At the surface, one would think that local authorities would be happy to have a cost generator off their hands, but public officials in Gaziantep indicated that they are not completely satisfied with how the system is run, and they are looking forward to 2015, when they are to assume control of the sector again.

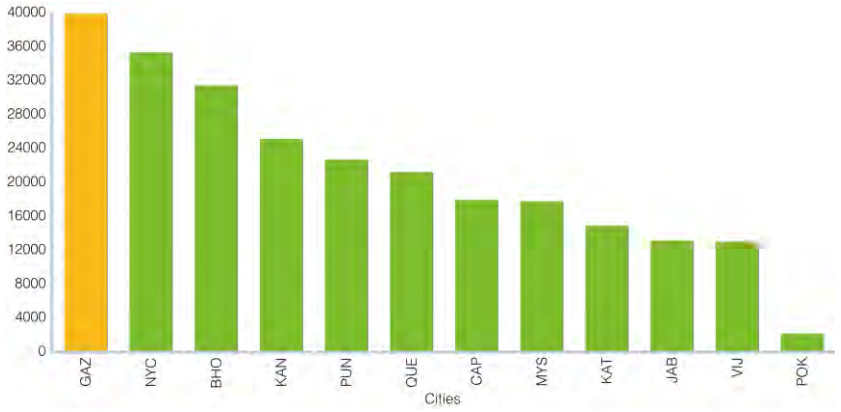
One of the main problems of having a national operator run the system is that coverage is less than ideal. As the picture below highlights, the main streets are fairly well lit, but secondary roads are generally not. TEDAŞ does not always respond promptly to the municipality's request of installing new light poles, which causes frustration locally.

Street Lighting in Gaziantep

There is however a standing agreement between the two parties, which obliges TEDAŞ to cover all sector investments in physical infrastructure that are done by the municipality. The municipality itself has to cover pertaining labor costs. This agreement was put into practice when TEDAŞ was slow to introduce light poles along the newly constructed light rail line, and local authorities had to take on the task.

Another shortcoming of having TEDAŞ running the system, and the Treasury footing the bill, is that there is no incentive for TEDAŞ to run the sector in an efficient way. Quite the contrary: since it provides the electricity needed for street lighting, it has every interest to run the costs high. As a consequence, Gaziantep has one of the most inefficient street lighting systems of the cities with pertinent data in the TRACE database (see figure below). There is the potential to save energy in street lighting by replacing inefficient lamps with efficient ones. A move was made to replace the mercury light bulbs with sodium vapor light bulbs, but the conversion is not complete.

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



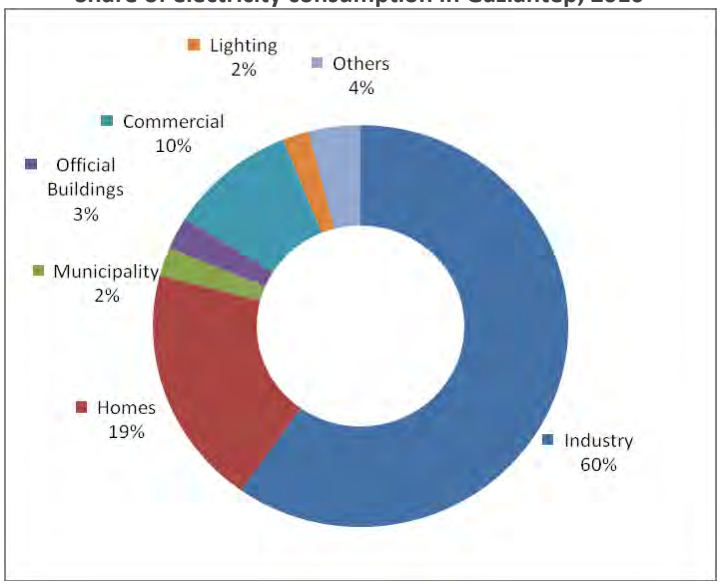
The municipality is also considering to potentially using new LED (Light Emitting Diode) technology designed specifically for street lighting. Cost savings are also sought through the replacement of 100 Watt traffic and signalization light bulbs with LED bulbs. 75% of bulbs have already been replaced, and by 2012 it is hoped that all traffic lights will be LED.

Given high level of control by the city municipality in ensuring proper street lighting in the city, a local control index of 0.90 is assumed in TRACE. The TRACE result shows public lighting as the fifth priority sector for energy efficiency interventions by local authorities.

Power and Heat

In 2010, Gaziantep Province had a total energy consumption of around 3.87 terawatt hour ($3.87x10^{12}$ watt hour). Figure 3.9 highlights the electricity break-down by end-users. The bulk of the electricity is used by local industrial facilities (60%), followed by residential users (19%), and the commercial (10%) sector. The electricity consumption in various activities covered under the public sector accounts for the remaining 10% - which is what the TRACE tool primarily focuses on. Transmission and distribution losses are relatively low in the Gaziantep Province, almost half of national T&D losses – 8.5% as compared to 17.7%.

Share of electricity consumption in Gaziantep, 2010



Gaziantep does not have a district heating system, and it does not control electricity production (done by TEIAŞ) and distribution (done by TEDAŞ). There is therefore little scope for the municipality to achieve higher energy efficiency in this sector.

There is however one program that is quite innovative and with good promise for the future. Solar water heating is pervasive in Gaziantep, and almost every residential unit is equipped with solar water heaters. These provide hot water for 6 months of the year, cut utility bills, and can potentially be converted in electricity generators. The municipality is actually looking into ways of using the existent solar infrastructure for covering more of the city's electricity needs.

Solar Water Heaters

Energy Efficiency Recommendations

The analysis performed in TRACE identifies five priority municipal service areas where significant energy savings are possible. The on-the-ground analysis confirms this selection and the prioritization. As indicated in the table below, the municipal service area that has been identified as Priority 1 for energy savings is Potable Water. It is followed by Public Transportation, Private Vehicles, Municipal Buildings, and Street Lighting. The table indicates the amount of energy spent in each of these "sectors", the Relative Energy Intensity (the percentage of energy that can be saved in each sector, based on the TRACE benchmarking), and the level of local control the municipality has over these sectors. The savings potential is calculated by multiplying the three previous columns.

Sector	Energy Consumption (US$)	Relative Energy Intensity (%)	Level of local control (from 0- no control, to 1-full control)	Savings Potential (US$) [Priority]
Potable Water	20,046,760	86.1%	0.80	13,819,468 **[PRIORITY 1]**
Public Transportation*	53,775,872	40.6%	0.55	12,015,546 **[PRIORITY 2]**
Private Vehicles*	199,442,747	36.5%	0.15	10.930,996 **[PRIORITY 3]**
Municipal Buildings	13,836,029	54.8%	1.00	7,586,851 **[PRIORITY 4]**
Street Lighting	12,999,355	51.2%	0.90	5,998,875 **[PRIORITY 5]**
Waste-water	1,194,840	5.0%	0.90	53,767
Solid Waste*	500,000	48.2%	0.75	180,803
Electricity	538,517,487	31.5%	0.01	1,701,657
Heating	-	-	-	-

*Sectors for which energy consumption figures have been estimated.

To achieve the energy savings potential in each of these sectors, local authorities have a variety of tools to their disposal. The TRACE tool contains a playbook of 58 energy efficiency recommendations applicable across all sectors analyzed above. The recommendations themselves are not meant to be either exhaustive or normative. They simply outline a number of policies and investments that could help local authorities in Gaziantep achieve higher energy efficiency standards. Following the sector by sector analysis, each individual recommendation was reviewed to establish its applicability in the Gaziantep City context. This filtering process helped focus the process on those recommendations that are both viable and practical. Some of the recommendations included in the tool were not considered because: the GMM is already engaged in the area; potential savings are minimal; recommendations are financially unfeasible.

Based on priorities identified for each individual sector a list of 41 recommendations was eventually selected. Out of those, 10 stood out as being particularly relevant for the City of Gaziantep. Implementation details and attributes of each of these recommendations are outlined in the next sections. A full list of TRACE recommendations can be provided upon request.

Water

The Gaziantep Water System has already benefited from a series of innovations, and performance has continually improved over the past years. Nonetheless, when compared to other cities, there still is significant room for improvement in this sector. On the one hand, Gaziantep has to deal with a poorly located water reservoir, which requires energy intensive pumping technology. On the other hand, it has to deal with a partially old and inefficient infrastructure, which leads to significant water losses. Consequently, improving the energy performance of the Gaziantep Water System could follow a two-pronged approach: improving energy performance of existent technology, and reducing water losses and consumption. Below are some options local authorities in Gaziantep might consider.

Active Leak Detection and Pressure Management

Despite continuous improvements in the system, GASKI is reporting 40% physical water losses (and 48.5% non-revenue), and the water that does eventually get to end-consumers requires energy intensive pumpting. An active leak detection and pressure management program, could address both of these two issues at once. Effective management of leaks cannot only help save large quantities of wasted water, but it can also decrease energy expenditure as more water gets to end consumers with the same amount of energy inputs. Pressure management can significantly reduce pumping costs by minimizing the required delivery pressure and leakage. Leakage rates can be lowered with automated controls that reduce pressure in the network, especially at night. Pressure management is generally more cost-effective than extensive repairs to numerous leaks in buried pipes, especially for extensive systems with numerous leaks that would be difficult and expensive to locate and repair.

The most common type of control automation used in water and wastewater systems is the Supervisory Control and Data Acquisition (SCADA). Such a system was recently introduced by GASKI, with financial assistance from Iller Bank. SCADA can remotely monitor and control a large array of components spread over large geographic areas, while also providing performance information on individual sites. The basic SCADA system consists of one central computer (the master terminal unit, MTU) that communicates with and controls a number of remote terminal units (RTUs) at key control points such as pumping and metering stations, plus the equipment to communicate between the MTU and RTUs. The RTU serves two functions: it uses information from those sensors connected to it to control system components such as pumps and valves, and it enables the user to access performance information on the site.

A properly designed SCADA system for water pumping saves time and money while improving service. Some of the many benefits include: complete information on pumping operation provided in real time; pump operation adjusted automatically as needed to ensure reliable water supply; the need for service personnel to visit sites for inspection, data collection or adjustments is greatly reduced; alarms are sent to the central control location in case of emergency; optimal pressure maintained in the water supply network, minimizing service interruptions; electricity consumption reduced and pump productivity increased; equipment life increased; reports generated automatically. Although the GASKI SCADA system is still its infancy, utility officials indicate that it has significantly improved the performance of the Water System.

To double the efficiency gains obtained through SCADA, GASKI should start a more extensive leakage detection program, and determine investment needs for the replacement of old infrastructure (e.g. old piping).

Improve Efficiency of Pumps and Motors

One of the main ways local authorities can increase energy efficiency in the water sector is by optimizing energy consumption in the pumping systems. This can include improvements such as matching the pump to requirements, optimizing the distribution piping, eliminating unnecessary valves, controlling pump speed where appropriate, and institutionalizing improved O&M practices. The pumping system is important, since every liter of water that passes through the system represents a significant energy cost, a cost that is magnified by every liter lost to leaks. Pumping improvements range from lower cost measures like soft starters for motors, trimming impellers (when pumps are over-sized) and re-winding motors, to higher cost measures like replacing inefficient pumps with efficient ones and installing variable speed drives. System automation saves water, energy and operation costs, improves service, and lengthens equipment life.

Aside from an initial set of efficiency measures, it is critical to institute improvements in the routine operations and maintenance protocol. Managers should develop a facility layout showing the location of all critical pumps and use it as a road map for the maintenance technicians to follow for troubleshooting, preventive inspection, cleaning, and minor adjustments. Some routine operations and maintenance procedures that increase the life of equipment as well as efficiency are: monitor the electrical system, including motors (such as motor operating parameters, power factors, peak and off-peak loads, and electricity consumption); optimize pump variables (pressure, flow, peak load, and motor starting and stopping); clean the impellers and replace as needed; periodically run the manufacturer's field test on the pumps and check the packing and lubrication of the bearings; check pumps for excessive heat, leaks, vibration and noise; maintain uniform flow profiles at pump inlets and outlet.

By adjusting, upgrading, and/or replacing the pumping technology, considerable savings can be achieved in terms of energy required to run the system. A newer and more efficient pump will also be subject to less wear and tear. This, in turn, reduces O&M costs and the potential of damage to pipelines and fittings. Pumping water at off-peak hours (e.g. filling treatment reservoirs at night, when demand is lowest) can help reduce the energy bill. GASKI has already implemented this measure, filling up its treatment reservoir when electricity costs to TEDAŞ are lowest. Thus, pumps are activated at night to fill up the tanks, and treated water is delivered to end-consumers using gravity (with little energy costs). In addition, GASKI is considering the development of hydro-powered turbines in key areas along the system (i.e. where the gravitational drop would make them efficient), to generate some of the energy it requires, and reduce its electricity bill.

Water Efficient Fixtures and Fittings

Considering the heavy revenue loss due to water leakage and the relatively high level of per capita water consumption in the city (185 l/capita/day), water demand management is another area where action could be beneficial. Water efficient fixtures and fittings help to reduce water consumption by reducing the volume of water used. This also helps reduce energy needs for water pumping and distribution.

This recommendation mainly applies to the consumption of potable water and it can be achieved in a variety of ways, using policies, incentives, and public investments. For example, in addition to using progressive water tariffs, local authorities can offer further discounts to end-consumers that have installed water efficient fixtures and fittings. Furthermore, building codes for new buildings could require that water efficient technologies are part of the initial building design. Types of energy and water efficient fittings applicable to both retrofit and new buildings include: low flow taps and showers; dual, very low, or siphon flush toilets; low flush or waterless urinals; rainwater harvesting tanks.

Local authorities can lead the charge by improving the performance of all water fixtures and fittings in municipal buildings, and by implementing innovative ideas – e.g. using harvested rain water for flushing toilets and building cooling. Even the smallest improvement can lead to big gains. For example, a toilet that is constantly running can waste over one liter per minute, or around 1,500 liters per day. Over the course of a year, such an inefficient toilet can waste over 500,000 liters. Repairing or replacing such an inefficient toilet can immediately pay for itself.

Transport

Although TRACE picked up Transport as Priority 2 in number of immediate energy savings potential, it is the sector with the highest potential of guiding future city growth in a sustainable manner. Public infrastructure investments are one of the main tools local authorities can use to encourage compact development (e.g. development around transit hubs), encourage alternatives modes of transportation (walking, biking, public transportation), and decrease local energy inputs (transport is one of the most energy intensive sectors). Gaziantep has to be pro-active in its thinking and strategically use infrastructure to guide city growth from the current 1.3 million, to the estimated 3 million in 2030. In its planning it should veer away from a static model, and instead focus on a dynamic model, in which the city is expected to change fast. Some potential avenues for action are listed below.

Public Transport Development

Public transport achieves a lower operating energy intensity and lower emissions per capita than private cars, and has the potential to provide an equitable transport network. A reduction in the number of private vehicles in circulation can lower emissions and improve air quality.

For a city the size of Gaziantep, there is a wide array of measures that can be taken to improve the performance of the public transport network. Such measures should be taken however only after careful planning. An analysis of traffic patterns, city growth patterns, and congestion points, should guide public sector investments. Local authorities should also be aware of the power public transit lines and hubs have in directing new development. For example, a light railway line will not only decongest traffic, but it will also attract new developments around it, as people seek to be closer to an affordable and convenient means of transportation. Often times, transport planning measures will influence city planning measures and vice-versa. For example, having land-use regulations that allow higher densities and a mix of uses around public transit hubs can not only create a patron base

for public transport, but it will also provide a larger share of people with easy access to an affordable mode of transportation.

Local authorities in Gaziantep have already expressed interest in expanding the city's light rail system. Part of it has already been planned out, part is still in the planning stage. One of the main drivers of the system extension is the need to better serve the main commuting lines in the city – primarily to and from the city's main industrial areas. For a city of 1.3 million (and growing) there is significant opportunity in investing in a city-wide rail system – particularly considering how small the existent network is.

In addition to expanding rail lines, local authorities have expressed interest in expanding and optimizing the bus system. One of the most important shortcomings of having a public transport system that is run primarily by private operators is that not all areas of the city will be adequately served. There is a significant incentive for operators to only run profitable routes. Consequently, city authorities in Gaziantep are looking into ways of exercising more control and improving the way the bus system is operated.

Municipal and City Bus Fleet Efficiency

The average age of the Gaziantep bus fleet is around 18 years. This means there is great scope for improving the energy efficiency of public transportation vehicles. This is achieved by ensuring that municipality owned vehicles (only 22 out of 3,029 buses in Gaziantep) meet set standards in terms of their fuel type and consumption, as well as engine maintenance.

Currently there are no maintenance procedures specifically focused on fuel efficiency. Bus fleet maintenance programs have been shown to save 10% - 20% of fuel consumption. In 2010, bus operators spent around $54 million on fuel. Improving bus fuel performance could help save more than $5.3 million yearly. This does not necessarily have to include a complete replacement of old buses, but it could focus on strategic retrofits. For example, buses in Stockholm (Sweden) have been retrofitted to run on biogas produced at the local wastewater treatment plant.

Gaziantep is already producing a significant amount of biogas at its wastewater treatment facility, and at its landfill. The biogas thus generated can be used not only to run buses, and generate electricity, but it could also be used by taxis (examples abound throughout the world – from Brazil, to Romania and Pakistan) and by retrofitted private vehicles. Local authorities in Gaziantep are already thinking about creating a network of filling stations for hybrid cars – they could do the same for cars run on biogas.

In addition to measures targeted at using alternative sources of fuel, local authorities can think about improving technical maintenance procedures for buses, such as: pressure checking, engine tune-ups, fuel additives for combustion chamber cleaning, and other simple technical fixes. In addition, a rigorous bus-driver training program can translate into behavioral change for fuel efficiency. Seemingly trivial behavioral changes addressing acceleration/deceleration rates, maximum time for engine idling, maximum speeds can have significant fuel efficiency impacts.

Traffic Flow Optimization

As Gaziantep is growing, and as its streets become increasingly congested, there is a need to continually optimize traffic flows within the city. Such a measure could follow two major outcomes. It can look to reduce the amount of time public transportation vehicles spend at intersections and the distance these vehicles travel between origin and destination (e.g. by having dedicated bus lanes and properly timing stops at intersections). On the other hand, traffic flows can be fine-tuned so that private vehicles spend a minimum amount of time in traffic. This way fuel consumption and pollution within the city are reduced considerably.

Traffic flow optimization should thus look to reduce commuting times for both public and private vehicles, but primacy in traffic should be given to public transportation modes. It seems, for example, that the newly developed light-rail in Gaziantep has the right of way at most intersections. This allows it to significantly reduce commuting times for travelers, which is one of the main ways of encouraging its increased use.

In addition to optimizing traffic for vehicles, local authorities could start to pro-actively think about how traffic can be improved for alternative modes of transportation – e.g. walking and biking. Green Wave programs that limit commuting time for bikers (i.e. by timing green lights at intersection so it is easier for bikers to have seamless trips) have been implemented in a variety of cities, from Portland (US) to

Copenhagen (Denmark). Similar programs have been implemented for pedestrians, limiting the time these have to wait for a green light at a cross-walk.

Traffic flow optimization should occur at regular intervals as cities continually change, with some areas becoming less travelled, while others become increasingly congested. Gaziantep has grown at a staggering rate in the past years. From 1990 onward it has had a compounded annual growth rate of 4.25%, almost double the growth rate of the global urban population in the same time frame (2.18%). More people mean more traffic, and more traffic requires continued optimization efforts.

Municipal Buildings

Buildings are among the biggest energy consumers in any city. In Gaziantep they consume around 20% of all electricity produced. Improving energy efficiency in buildings is thus one of the main ways to achieve all-around energy savings. National energy efficiency laws are now in place, and city authorities should take a pro-active role in enforcing those laws and retrofitting the building stock they own and maintain.

Mandating Building Energy Efficient Codes for New Buildings

In addition to national energy efficiency guidelines for buildings, city authorities in Gaziantep can choose to also cover other aspects, such as water conservation, urban heat island effect (green roofs), indoor air quality, and many other aspects of green buildings. Higher energy efficiency in buildings can be achieved by pursuing different avenues: voluntary guidelines, minimum building standards, or incentive programs for private developers. The benefit of such measures 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 in.

The US Environment Protection Agency has produced a 'Sustainable Design and Green Building Toolkit', which aims to assist local governments in improving their green building permitting framework. The toolkit is available at http://www.epa.gov/region4/recycle/green-building-toolkit.pdf and addresses the codes/ordinances that directly affect the design, construction, renovation, and operation and maintenance of a building and its immediate site.

Municipal Offices Audit and Retrofit

To set a good example for other buildings in the city, local authorities should develop an audit and retrofit program for all the offices they own. Such programs can help reduce energy bills and the carbon footprint of the CA, and they offer a good knowledge basis for upgrading and updating the city building codes. In addition, there are innovative ways of financing such projects, so that the burden on the public budget is minimal. Throughout the world, Energy Service Companies (ESCOs) have successfully been enlisted to retrofit buildings at zero cost to building owners.

ESCOs are private companies that offer to retrofit a building, ensuring improved energy performance. The cost of the investment is to be recouped from the difference between the old energy bill and the new one, over a certain period of time. For example, building owners can agree to allocate the same amount of money for the electric bill as before the retrofits, and pay the post-retrofit savings to the ESCOs. In addition to providing the know-how and hard investments, ESCOs often also maintain the new energy efficient infrastructure.

Such a program has been successfully implemented in Berlin (Germany), with over 1,300 buildings having been retrofitted with the help of ESCOs. Investments in these buildings have led to yearly energy cost savings of around $15 million – a reduction of the energy bill of 26%. Similar programs have been implemented in Bulgaria, Chile, Romania, and Slovenia.

Public Lighting

The public lighting system in Gaziantep has two major problems: coverage (many streets are poorly lit or not lit at all), and efficiency (the system is energy intensive). Extending the public lighting network can lead to a higher energy bill, but this can be offset by improvements in the way the system is operated. Such measures are particularly poignant considering that the CA is planning to take control over the system in 2015. TEDAŞ, who currently operates the system, was often slow to respond to local needs and problems.

Street Lighting Audit and Retrofit

The bulbs that have traditionally been used for street lighting tend to be very inefficient, producing little light and a lot of heat. They are also poorly designed, unnecessarily spreading light in all directions (including the sky above). New bulb technologies can not only significantly increase efficiency, but also extend the design life – reducing the need for investments in bulb replacement.

Throughout the world, light audit and retrofit programs are recognized as being among the surest sustainable development investments cities can make. The retrofit costs are usually amortized within a year of two, and operation and maintenance costs are reduced significantly. Consequently, local authorities can chose to either finance such project directly, or they can engage an ESCO to take on the task. For example, the City of Akola (India) has enlisted an ESCO to replace over 11,500 bulbs (standard fluorescent, mercury vapor, sodium vapor) with efficient T5 fluorescent lamps. The ESCO financed 100% of the investment, implemented the project, maintained the newly-installed lights, and received a portion of the verified energy savings to recover its investment. Under the energy savings performance contract, the CA paid the ESCO 95% of the verified energy bill savings over the 6-year duration of the contract. The ESCO was also paid an annual fee for maintaining the lamps and fixtures. Initial investments were estimated at $120,000 and the retrofit was completed within a 3-month period. Annual energy savings of 56% were achieved, delivering the equivalent of $133,000 in cost savings. This gave a very attractive payback period of less than 11 months.

Within Gaziantep there has been a push to replace mercury vapor street lights with sodium vapor ones. The switch has been slow (there still is a good share of bulbs that need to be replaced) and there already are a number of better technologies that can be considered. Thus, the CA could soon think of how it could replace the sodium vapor bulbs with more energy efficient bulbs (e.g. LED).

Lighting Timing

Public lighting usually only has two states of operation, 'ON' and 'OFF', and only switches between these states in the early evening and early morning. However, the demand for lighting varies significantly throughout the day, 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 while still delivering appropriate levels of lighting (e.g. to ensure safety and sense of security in public areas). 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. Light timing programs could include motion-based detectors (which turn on the street light, or increase luminosity), timers, and/or dimmers.

Such a lighting timing program has been implemented in Kirklees (UK). The innovation introduced by the Kirklees CA was to dim lights to varying levels throughout the day, instead of switching them off completely. 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. Wireless technology was installed on each existing lighting pole 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 Kirklees can save up to 30% of the electricity used annually. By replacing 1,200 lights, Kirklees CA estimates savings of approx $3 million in energy costs per year.

Annex 1

Operating energy intensity of different transportation modes in Gaziantep, 2010

Type of vehicle	No. of vehicles	Avg. trip distance	No. of trips per day	Avg. Occupancy	Fuel Efficiency	Annual fuel consumption	Annual PKM	Annual energy intensity
	No.	km/trip	Trips/d	People/vehicle	km/l	MJ/year	PKM/year	MJ/PKM
Municipal Bus	22	35	6	30	5.53	11,099,696	50,589,000	0.22
Private Bus	260	40	5	25	5	138,174,400	474,500,000	0.29
Leased Bus	5	110	1	40	2.75	2,657,200	8,030,000	0.33
Rural Bus	55	60	4	15	5.85	29,978,667	72,270,000	0.41
School Bus	900	50	4	20	8	298,935,000	1,314,000,000	0.23
Staff Bus	1,300	50	2	12	7.69	224,600,780	569,400,000	0.39
Mini Bus	487	50	6	10	7.5	258,811,280	533,265,000	0.49
Taxi	1,464	12	5	2	13.33	84,182,746	64,123,200	1.31
Car	123,424	10*	2*	2*	12.5*	2,522,786,560	1,801,990,400	1.40
Motor cycle	96,042	3.65*	2*	1.25*	40*	223,915,920	319,879,886	0.70
SUVs	822	10*	2*	2.5*	9*	23,335,667	15,001,500	1.56
Total for passenger vehicles	***224,781***					**3,818,477,916**	***5,223,048,986***	***0.73***
Small trucks	45,072							
Tractors	20,355							
Trucks, trailers and tankers	14,136							
Total for goods vehicles	***79,563***							
All together	**304,344**							

*Assumed values in absence of any data.

Source: Transport Planning and Rail Systems Department, Gaziantep.

Annex 2

Annual electricity consumption for water treatment to produce potable water, 2010

Name of the pumping station/reservoir	Electricity consumption (kWhe)	Total volume of potable water produced (m^3)	Total energy expenditure (TL)	Energy density for water pumping (kwhe/m^3)
Raw water pumping				
Kartalkaya (3 pumps)	95,971,375	68,014,583	18,102,596	1.41
Mizmilli (3 pumps)	44,456,690	19,326,150	7,387,308	2.30
Local wells and pumping stations	30,252,797	4,267,991	7,823,344	7.08
Total	170,680,862	91,608,724	33,313,248	1.86
Potable water pumping				
Kartalkaya reservoir and groundwater wells	1,794,240	91,608,724	406,460	0.02
Grand total	**172,475,102**	**91,608,724**	**33,719,708**	**1.88**

Source: GASKI

ECA SUSTAINABLE CITIES:

Improving Energy Efficiency in GAZIANTEP (Turkey)

TRACE Pilot

Annexes

ECA SUSTAINABLE CITIES

ESMAP
Energy Sector Management Assistance Program

İLLER BANKASI

GAZİANTEP BÜYÜKŞEHİR BELEDİYESİ

ANNEXES: DETAILED RECOMMENDATIONS

ANNEX 1: ACTIVE LEAK DETECTION & PRESSURE MANAGEMENT PROGRAM

DESCRIPTION

Develop a leak detection and pressure management program to minimise losses along the following systems:

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

It is anticipated that most systems would already be subject to passive leak detection, i.e. identifying leaks through visual observation, but that provides limited information and benefits. This recommendation therefore focuses on a pro-active and more thorough leak detection program to locate and repair leaks. The following techniques could be used:

- Ground microphones
- Digital leak noise correlator
- Acoustic logger
- Demand management valves, meters and zoning
- Mobile leak detection programs
- Basic acoustic sounding techniques

In addition excess pressure can be reduced by installing:

- Flow modulating valves on gravity networks
- Pump controls and/or pressure sensors to modulate a pump's relative performance to suit the daily variation in flow demand, thus maintaining maximum efficiency and minimum energy use.

A leakage detection program can facilitate the provision of minimal pressures and encourage, through less wastage, a more sustainable use of water resources. In sewerage systems, identification and elimination of leaks can also significantly reduce risk of ground contamination. Pressure management can cost-effectively reduce treatment and pumping costs by minimizing the required delivery pressure and leakage. It is particularly suited to pumped mains and may

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

Efficient water use

Enhanced public health & safety

Increased employment opportunities

Financial savings

Security of supply

require estimates of how demand changes over the day. Appropriately rated pressure reducing valves will in turn reduce the flow through leaks and the total flow that must be delivered by the pump upstream at the source/treatment works. This solution may be particularly appropriate in gravity flow networks. The key advantage of pressure management over leak detection is the immediate effectiveness. It is most appropriate where the network is expansive and features multiple small leaks that would be difficult and expensive to locate and repair.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study to assess leakage levels across the network(s). The CA should engage a team that includes network planners, water and utilities engineers and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability, as well as procurement and policy options. Options should be appraised against baseline city energy expenditure associated with water leakage; monitoring flows and demands to refine value and pump controls accordingly. Technical ability, incentives and taxes should also be given consideration.
Direct expenditures & procurement	Where the potable or wastewater network is owned or run by the City Authority, the CA pays for upgrades to the utility infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation, policies and obtaining planning permission. The main expenditure associated with pressure management will be mainly the acquisition and installation costs of the equipment (i.e. valve, control fittings).

Build-Own-Operate-Transfer (BOOT)	If the City Authority lacks ability to access capital and technical expertise, a Build-Own- Operate-Transfer (BOOT) type contracting mechanism may be deemed most suitable to implement an initiative. The Request For Proposals (RFP) calls upon bidders to implement efficiency measures and provide funding for the project, with remuneration paid through the resulting savings. This 'shared savings approach' is common in the electricity industry. The contractor is required to provide a basket of services including financing of capital, design, implementation, commissioning, operation and maintenance over the contract period as well as training of municipal staff in operations prior to handover. This sort of arrangement can be complex to set up and it can also be difficult to find an organisation willing to take on the risk associated with this form of partnership. Case Study: Emfuleni, South Africa.
Efficiency Standards	The City Authority regulates the Water Companies to meet leak reduction targets and ensure their pipes meet required standards of operational efficiency.
Community led implementation	The City Authority liaises with the local community to increase understanding of the benefits of leak detection initiatives. Simpler, less technical methods of leak detection and reporting provide a considerable opportunity for community involvement and participation. In so doing, amenity will be maximised and leaks may be identified more quickly. In turn, the baseline infrastructure may also be safeguarded against vandalism or poorly implemented operation and maintenance. This activity may be complemented by offering subsidies to those who take part or by passing on the associated monetary savings to the community through reduced water rates.

Partnering Programs	The City Authority liaises with established organisations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the pipe/pumping infrastructure. Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy-efficiency projects, promotion of technology development and deployment, and/or help to build public-private partnerships. Difficulty can arise where the partnering organisations do not have access or influence over the funds required to implement the initiatives. Case Study: Galati & Iasi, Romania; Phonm Penh, Cambodia.

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:

- % Unaccounted for water (UFW): Measures the percentage of the water lost, due to leakages, wastage, theft, mechanical errors in meters at the source or human errors in correctly recording the meter reader, out of the total treated water produced.
- % Volume of water leakage per kilometre of water main per day: Measures the average volume of water leakage per kilometre of water main per day during the reporting period.

- Length of water mains inspected for leakages: Measures the total length of water mains inspected for water leakages during the reporting period.
- Properties affected by low water pressure: Measures the total number of properties affected by low water pressure due to aged pipe network or repair works during the reporting period.

CASE STUDIES

Pilot Leak Detection and Abatement Program, Iasi, Romania

http://www.resourcesaver.com/ewebeditpro/items/O50F1144.pdf

With an EcoLinks Challenge Grant of $46,820, Regia Autonoma Judeteana Apa-Canal Iasi (RAJAC) partnered with a U.S. environmental technology provider, Cavanaugh & Associates, to develop a pilot leak detection and abatement program. The total project investment was $118,074. The program trained RAJAC personnel in leak detection, implemented a leak detection system and developed a water conservation program and public outreach campaign. This pilot leak detection and abatement study was a prerequisite for the implementation of an infrastructure program. Awareness of new technology was significantly increased through training and seminars. The company's public awareness-raising program encouraged and enhanced consumers' capacity to participate in water conservation efforts. Environmental and economic benefits were derived from the more efficient use of water and energy resources. In the short-term, it was estimated that three of the leaks identified in the pilot scheme were responsible for a water loss of 60,000 m3/year and a revenue loss of $24,000. Since the equipment used during the pilot project cost approximately $20,000 and no further significant investments were needed to eliminate the leaks, the payback period for the equipment was less then one year. This project contributes to a larger effort to improve water efficiency throughout Iasi County that will ultimately reduce water loss by 8 million m3 and provide a savings of $3 million per year, however, this level of savings, would require significant investment in the infrastructure.

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.

Pressure Management, Emfuleni, South Africa

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

The Sebokeng/Evaton pressure management project use a Build-Own- Operate-Transfer (BOOT) type contracting mechanism because the municipality had only limited access to capital and lacked the technical capacity to implement the project. The savings in water were so significant that both the municipality and contractor gained, with 80% of the savings accruing to the municipality and the remaining 20% used as remuneration to the contractor for services provided over a five year period. As the installed infrastructure is permanent in nature and has a design life of at least 20 years, the municipality will continue to achieve savings well beyond the initial five year period. The staff also benefit from access to additional expertise and training. This project reduced water losses by over 30%, saving about 8 mega-litres per year with an equivalent financial value of around $3.5 million. These water savings also translate into energy savings of around 14,250,000 kWh per annum due to the reduction in energy required to pump water. The project clearly demonstrated that the intervention of a suitable technology with a shared savings arrangement could succeed in low income communities; a private firm providing financing for technical innovation at no cost to the municipality received remuneration from sharing the resulting savings in water purchases.

Water Pressure Management Program, Sydney, Australia

http://www.sydneywater.com.au/OurSystemsAndOperations/WaterPressureManagement/index.cfm

Sydney Water has a water pressure management program to target those areas where pressure levels are well above average and there is a history of water main breaks. Excessive water pressure can lead to water main breaks and cause leaks in the city's water system. Water pressure management aims to adjust water pressure levels in the supply system to achieve more consistent pressure levels which will reduce the number of watermain breaks, improve the reliability of the water supply system and conserve water. The Water Pressure Management program is an important part of Sydney Water's leak prevention program and the New South Wales Government's Metropolitan Water Plan.

Water Supply and Drainage Project, Phnom Penh, Cambodia

http://www.adb.org/water/actions/CAM/PPWSA.asp

http://www.adb.org/water/actions/CAM/Internal-Reforms-Fuel-Performance.asp

Asian Development Bank's (ADB) Phnom Penh Water Supply and Drainage Project provided the opportunity for PPWSA, the government-owned water supply utility, to partner with ADB and demonstrate its capacity for catalyzing water sector reforms. To phase out non-revenue water, i.e. consumers gaining access to water supplies for free, PPWSA started metering all water connections. It gradually

equipped each network with a pressure and flow rate data transmitters that provide online data for analyzing big leaks in the system. They also set up a training centre to respond to in-house training needs. PPWSA renewed old pipes using state-of-the-art materials and labour from PPWSA staff. PPWSA also institutionalized performance monitoring, coming up with progress reports and performance indicators on a regular basis and annually subjecting its accounts and procedures to an independent audit. The project advocated the transfer of more managerial autonomy to PPWSA to enable it to use its own funds on maintenance and rehabilitation programs. The result of the project was that PPWSA became financially and operationally autonomous, achieved full cost recovery, and transformed into an outstanding public utility in the region.

ANNEX 2: IMPROVE EFFICIENCY OF PUMPS AND/OR MOTORS

DESCRIPTION

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

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

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

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

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

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

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US$100,000-1,000,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

Efficient water use

Enhanced public health & safety

Increased employment opportunities

Financial savings

Security of supply

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

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

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

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

CASE STUDIES

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

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

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

Improving the Distribution of Water, Fortaleza, Brazil

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

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

Economical Pumping Solutions, Lichetenau, Germany

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

Lichetenau is a small municipality with 3,600 inhabitants. Advice on water supply solutions was provided by a sales and service partner of the water pump company, ITT Lowara. This partner uses the knowledge and support of Lowara to propose more economical and innovative pumping solutions. These sorts of collaborations ensure that even the smallest water boards can achieve considerable savings through improving efficiency of water supply systems. By replacing an old pump with a variable speed version they have reduced energy consumption by around 40%. The frequency converter on the pump ensures that the flow rate can be easily adapted to that of the other pumps in the system. The pump installed has been running perfectly for more than 2 years in Lichetenau, and a recent audit at the same flow rate has shown that the pump consumes only 13.39 kW per hour, providing a saving of 8.34 kW/h against the old cast iron pump. This equates to a saving of 39%. During its service of some 5,827 hours to date, it has consumed less than 48,597 kWh. Based on a current energy cost of 0,18 Euro/kWh, the saving would be 8,748 Euros - and in environmental terms they emit less than 7,500kg/year CO2, giving Lichtenau a production of CO2 well below the federal average.

Energy Efficiency Strategies, Moulton Niguel, USA

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

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

Energy Management Program, Madera Valley, USA

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

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

Water Treatment Plant, San Juan, Puerto Rico

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

The San Juan Water District's Sidney N. Peterson Water Treatment Plant was built to be energy efficient and is operated to encourage energy and water conservation among customers and staff alike. The district even created an incentive program for its employees that rewards them with a percentage of the first year's savings from new cost-cutting techniques that they identify. A state-of-the-art facility,

the Peterson plant uses gravity flow to minimize pumping needs for a 120-mgd modular filtration system. Initial plant designs specified 15 horsepower backwash motors instead of 100 horsepower units, which reduced construction costs by 33% and lowered filtration energy requirements by 75%. A supervisory control and data acquisition (SCADA) system optimizes day-to-day performance and energy efficiency. To save more energy and money, district staff replaced standard-efficiency motors with energy-efficient motors to save $5,000 per year. They also installed variable-frequency drives on flocculation and chemical feed pump motors to save $11,000 per year and launched water conservation education, promotion, and enforcement programs. Avoided pumping due to water conservation measures saves around $50,000 per year.
USAID funded Ecolinks Project, Galati, Romania http://www.munee.org/node/62 As part of a USAID funded Ecolinks Project, the Cadmus Group assessed the city's water supply system and discovered that a series of energy conservation measures could save roughly $250,000 per year in electricity costs. Low cost measures included trimming impellers to better match pumps and motors with required flows and pressures. Moderate cost measures included leak detection and reduction and limited pump replacement. A series of pumps replacements were recommended. For one pump's 5,854 hours of annual operation, it used roughly 2,500,000 kWh. A replacement pump and motor set could save roughly $55,000 per year. For another pump with 6,000 hours of annual operation and consuming 3,000,000 kWh per year a replacement pump and motor set could save roughly $42,000 per year. Cadmus also estimated that reducing the height of the discharge would decrease the static head between the wet well in a low voltage pump station and the actual discharge. If the height of the reservoir were an average of 1 meter below the discharge and the discharge were lowered, roughly 10 percent of the pumping costs could be eliminated. The cost of the measure would include labour and minimal parts (pipe extensions). This measure would save roughly 100,000 kWh/yr or $5,000/yr.

TOOLS & GUIDANCE

Tools & Guidance
Kitakyushu Initiative: A report focusing on building the capacity of the local governments to overcome the urban environmental and water problems. http://kitakyushu.iges.or.jp/docs/sp/water/4%20Overview_Analysis.pdf
Pump Efficiency Calculator: An online calculator tool to work out exactly how much could be saved by replacing a fixed speed damped or throttled centrifugal load with a variable speed drive controlled solution.

Tools & Guidance
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: WATER EFFICIENT FIXTURES AND FITTINGS

DESCRIPTION

This recommendation will apply to:

- potable water
- irrigation networks.

Develop an incentive program and/or mandate to:

- Increase the number of local rainwater collection tanks in buildings and the reuse of rainwater (for beneficial reuse).
- Promote the installation and use of more efficient water fittings.

Types of energy and water efficient fittings applicable to both retrofit and new-build include:

- Low flow taps and showers
- Water efficient white goods
- Dual, very low or siphon flush toilets
- Low flush or waterless urinals
- Bubble irrigation that involves less water being lost through evaporation
- Rainwater harvesting tanks.

Water efficient fixtures and fittings help to reduce water consumption by reducing the volume of water used in each application. This reduces the associated energy needed to treat and convey the required flows.

Efficient fittings can also help to raise consumer's awareness of the link between water use and energy consumption and generally leads to the consumer installing additional energy efficient products.

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

Efficient water use

Improved air quality

Enhanced public health & safety

Increased employment opportunities

Financial savings

Security of supply

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study of incorporating energy efficient fixtures and fittings. The CA should engage a team that includes network planners, water, energy and utilities engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability, as well as procurement and policy options. It defines current water demand against the efficiency of the current method of provision (litres per flush, flow delivered, % leakage in pipes, usage per fitting) Technical ability, incentives and taxes should also be given consideration.
Direct expenditures & procurement	The City Authority pays for upgrades to the fixtures and fittings within government buildings directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. This lever is may not be appropriate if the City Authority does not own the buildings. Case Study: Soweto, South Africa; Preston, UK.
Legislative Enforcement	The City Authority exercises its legislative power to set obligatory fitting efficiency thresholds that must be met. The CA can influence the design of new buildings by making incorporation of water saving

	devices mandatory. It is particularly easy for the CA to lead by example by specifying inclusion of low flow fixtures and fittings in their briefs for design of new government buildings. NOTE: Energy Star standard for low-flow toilets is 1.28 gallons per flush; faucet is 1.5 gallons per minute and the International Plumbing Standard for showerheads is 2.5 gallons per minute. Case Study: Delhi, India
Partnering Programs for Residential Sector	The City Authority liaises with established organisations and/or coalitions (frequently non-profit) to gain access to their experience and expertise in order to evaluate and implement the most appropriate interventions for the situation. Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy-efficiency projects, promotion of technology development and deployment, and/or help to build public-private partnerships. Difficulty often arises where the partnering organisations do not have access or influence over the funds required to implement the initiatives. Case Study: Preston, UK
Subsidies	The City Authority instigates subsidies and scrappage allowances to incentivise customers to directly and actively engage in implementing more water efficient fittings. The City Authority will also have the choice of managing and/or promoting preferred subsidized schemes. This activity may be complemented by educating the public on the benefits of water efficient products.

	Case Study: Preston, UK; Kirkless, UK; Waitakere, NZ; Albuquerque, USA.
Raise Awareness of sustainable Products and Services	The City Authority invests in publicity and promotion of Water Efficient Products and Services to raise awareness of the products available and encourage the local community to engage with new water efficient technology. This activity may be complemented by offering subsidies or a rebate to those who are willing to invest in water efficient products. Case Study: Waitakere, NZ; Preston, UK; Leicester, UK; Albuquerque, USA.

MONITORING

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

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

- Water consumption per capita per day: Measures the average individual water usage calculated on a daily basis at the local level.
- Number of households claiming subsidies/rebates for purchasing water efficient technologies: Measures the number of households correctly claiming subsidies/rebates after purchasing water efficient technologies during the reporting period.
- Number of low flow fixtures and fittings procured: Measures the number of water efficient technologies purchased during the reporting period.

CASE STUDIES

Rehabilitation of the Water Network and Private Plumbing Fixtures, Soweto, South Africa

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

Johannesburg Water (JW) initiated Operation Gcin'amanzi (Operation Save Water),in Soweto as a multi-faceted project focusing on the rehabilitation of the water network and private plumbing fixtures alongside water metering. Once all phases are completed JW will save almost 270 million Rand (US$45 million) per year in bulk water purchases alone. The effective payback period of the project is less than 3 years. (This does not include savings from the associated reduced energy use of 175 million kWh/year)

Reducing Water Demand in Social Housing, Preston, UK

http://www.waterwise.org.uk/images/site/Research/preston%20water%20efficiency%20initiative%20-%20interim%20report%20-%20october%202008%20-%20waterwise%20with%20partners.pdf

The Preston water efficiency initiative aimed to reduce water demand in social housing. The project was instigated in April 2007 following funding by the Government of the South East (GoSE). Reigate and Banstead Council were given the responsibility of project managing and handling all financial matters concerning the project. The project involved a number of partners such as housing and environment organisations.

A package of water efficient devices was offered to each household. Raven Housing Trust visited each household to discuss the suitability of each device to the household and which devices would be fitted. Some of the devices were acceptable and practical to install to that particular household whereas others were not. The visit by Raven was followed up by a plumber visit to fit the appropriate devices and to leave full instructions and a telephone contact number.

The package of measures encompassed several aspects of saving water in the household. Areas of saving included toilets, taps, garden watering, leakage and clothes washing. These are the main areas where water is used around the home and in some cases where that usage is continuously increasing. Water savings from refurbishment (e.g. first time installation of showers rather than baths) were around 24% where as the water savings from retrofitting (e.g. installation of lower flush toilets) were around 15%.

Energy and Water Conservation Fund, Kirklees Metropolitan Council, UK

http://www.managenergy.net/products/R319.htm

In 1992, Kirklees Metropolitan Council adopted the Friends of the Earth environmental charter for local government, which aims to reduce

Carbon Dioxide emissions from KMC operations by 30% by 2005, from a 1990 baseline.

The Energy and Water Conservation Fund was set up to enable Council services to make capital investments in energy efficiency in buildings and to help attract external funding for energy projects. For most projects, the fund gives loans rather than outright grants, and they are repaid out of savings made from lower energy and water bills.

Around 10% of the fund ($100,000) was spent on water (push taps, urinal flush controls, shower controls, rainwater recovery systems, waterless urinal controls, a mat watering system at Bradley Central Plant Nursery)

Over the three-year period, energy savings of 6% were achieved. At the same time, water management measures made savings of around $190,000.

Rainwater Harvesting, Delhi, India

Measures for Ensuring Sustainability of Rainwater Harvesting, Water for Asian Cities Programme Rain Water Harvesting and Artificial Recharge to ground water: A Guide to follow. 2008.

Rapid urbanisation and population growth have resulted in Delhi facing acute water shortages and a drastic drop in the groundwater table. A number of measures are being promoted to address the falling groundwater levels. One of these measures involves a Ministry of Water Resources programme for rainwater harvesting and recharge of the groundwater system.

The Municipal Corporation of Delhi has given instruction to make rainwater harvesting mandatory in all new buildings with a roof area of more than 100 m2 on plots exceeding 1,000 m2. The potential of rooftop rainwater harvesting is approximately 125,000 litres for a plot size of 250 m2 based on an annual rainfall of 1,000mm.

If the scheme is implemented throughout the city of Delhi the additional recharge to groundwater will be around 76,500 million litres per annum. If the water level rise from this recharge is as expected, this will amount to a saving on pumping energy of US$16,000 per day. Over and above this saving on conventional water supply, there will be a very significant energy saving; in floodplains the energy saving for 1m rise in ground water level is around 0.40 kW per hour due to the reduced pumping needs.

Rebates, Albuquerque, USA

http://www.cabq.gov/albuquerquegreen/green-goals/water

Albuquerque, City Government and local companies are leading the way in developing and utilizing sustainable technology in their

buildings. Rebates of $200 per toilet are available when switching out old high flow toilets and these rebates apply to both residential and commercial customers alike. $50 rebates are available for conversion from Low-flow to high efficiency toilets.
Waitakere City Council Website, Waitakere, NZ http://www.waitakere.govt.nz/abtcnl/to/suppliers.asp The products and companies featured on the Waitakere City Council Web pages are not endorsed by the council but rather a suggested starting point for local residents to do their own research to find a product that fits their individual household requirements.

TOOLS & GUIDANCE

Tools & Guidance
Water calculator: Questions relating to your home-lifestyle to estimate how much water and energy your household uses. http://www.energysavingtrust.org.uk/watercalculator/flashcalculator
Shower calculator: The calculator shows your potential water, energy and money savings if you spent one minute less in the shower. http://www.eswater.co.uk/Showerenergycalculator.aspx
Water use efficiency: This online calculator uses the Government's methodology for assessing the whole house water efficiency of new dwellings to assess compliance against the water performance targets in Building Regulations Part G and the Code for Sustainable Homes. http://www.wrcplc.co.uk/PartGCalculator/Calculator.aspx
Energy saving calculator: Ways to start saving energy in the home grouped by initial cost and potential annual costsaving. http://www.uk-energy-saving.com/energy_saving_calculator.html

Tools & Guidance
Benchmark Water Use: The tool allows you to compare your site's water consumption with your industry's average. http://envirowise.wrap.org.uk/uk/Topics-and-Issues/Water/Water-Tools/Water-account-tool/Benchmark-your-water-use.html
Best Practice Reports: Waterwise East produced the best practice guide to support developers, housing associations, self-builders and others to deliver water-efficient new developments. http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

ANNEX 4: PUBLIC TRANSPORT DEVELOPMENT

DESCRIPTION

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

IMPLEMENTATION OPTIONS

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

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

> US$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Planning regulations & guidelines	The City Authority links development densities to public transport availability and funding. The City Authority reviews the city's zoning ordinances and considers making the following changes: Increase the permitted floor area ratio/ plot ratio on sites located near public transport hubs. In areas where it is appropriate re-zone single-use lands to allow multiple uses on the same site. Allowing higher densities of development along well-served public transport corridors creates a patron base for public transport and can be used in combination with other planning measures, such as capping parking provision to residential and office buildings, thus discouraging car use. Developers are required to show how a new development links to the existing or planned public transport network in order to gain planning permission. See the Curitiba case study for further details.
Subsidies	The City Authority subsidizes travel on public transport. In certain areas this can provide an incentive for people to use public transport.

MONITORING

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

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.

Linking development densities to public transport availability, Curitiba, Brazil

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.

TOOLS & GUIDANCE

Tools & Guidance

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

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

Tools & Guidance
http://www.tfl.gov.uk/assets/downloads/businessandpartners/accessibile_bus_stop_design_guidance.pdf

ANNEX 5: MUNICIPAL VEHICLE FLEET EFFICIENCY PROGRAM

DESCRIPTION

The objective of this recommendation is to improve the energy efficiency of municipal vehicles. This is achieved by ensuring that municipal vehicles meet set standards in terms of their fuel type and consumption, as well as engine maintenance.

Reductions in fuel use, reductions in air emissions resulting in improved air quality, and reduced carbon footprint.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Engine performance standards	The City Authority produces a procurement requirement linked to international engine performance standards, e.g. EURO series (others include US EPA or Japan's Heisei Standards), adopted by a number of countries outside the European Union, such as India and China. Whilst the standards relate to air emissions, the more stringent they are, the more efficient the engine technology is likely to be. Standards are introduced through City Authority procurement contracts as minimum requirements for all new vehicle purchases including government cars, police cars, buses, waste-collection vehicles and emergency vehicles. A feasibility study is required to determine the appropriate engine performance standard to be implemented. See http://ec.europa.eu/environment/air/transport/road.htm for further details. See the New York and Stockholm case studies for further details.
Maintenance standards	The City Authority transportation departments define regular preventative maintenance standards for owned vehicles and contracted parties, for

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

Financial savings

	example: Once a week or at each fill-up ▪ Check your oil, water, wiper fluid, engine coolant/antifreeze level, and tire condition and pressure. Monthly check ▪ Inspect transmission fluid and brake fluid, windshield wiper blades, and power steering fluid. Review condition of belts, hoses, and battery cables. Every six months or 6,000 miles ▪ Check the brake system and inspect and/or rotate tires. Review condition of clutch system (manual transmissions) and chassis lubrication. Once a year ▪ Have underbody flushing performed and service engine cooling system (which should include inspecting the radiator, water pump, fan belt, thermostat(s), radiator cap, and antifreeze). Check accelerator control system, and lubricate doors, locks, hinges, and parking brake. 15,000 miles ▪ Inspect automatic transmission. Change auto transmission fluid and filter. 30,000 miles ▪ Change spark plugs and fuel filter, inspect spark plug wire, check engine timing. (source: http://www.gmfleet.com/government/maintenance-info/maintenanceSchedule.jsp)

	City Authorities should define a maintenance program that suits their fleet profile and to ensure that owned vehicles are operating at desired performance levels. Maintenance requirements can be extended to taxis and buses, although these can be voluntary where the vehicles are not be owned by the city authority. Municipal compliance with the objective should be made public to demonstrate leadership by example. See Jakarta case study for further details.
Contingent contracts	If the municipal fleet is subcontracted to different operators, contracts can be made contingent upon the use of vehicle standards with specific minimum fuel use and performance levels set by the City Authority. See Copenhagen case study for further details.

MONITORING

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

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

- Determine KPIs: Vehicle fleet fuel consumption records, emission test records, numbers of maintenance checks undertaken.
- Survey baseline performance (fuel consumption).
- Survey ongoing performance on fuel consumed per vehicle mile.

CASE STUDIES

NYPD hybrid vehicle program, New York, USA

NYPD press release 2009-14 http://www.nyc.gov/html/nypd/html/pr/pr_2009_014.shtml

The Mayor has introduced hybrid cars for use as police patrol cars. Each vehicle produces 25-30% lower CO2e compared to conventional fuel-powered models from fuel savings, and averages twice the distance per gallon for city driving. At a cost of USD 25,391 per vehicle, the payback period for the capital investment was just over one year. Notably their deployment has been concentrated in areas which maximize their economic and environmental benefits, i.e. in precincts with large coverage areas and those which are prone to heavy stop-and-go traffic.

Clean Vehicles Program, Stockholm, Sweden

http://www.c40cities.org/bestpractices/transport/stockholm_vehicles.jsp

http://www.managenergy.net/products/R1375.htm

All municipal cars, buses and heavy trucks will operate on biofuels or at a high emission standard by the end of 2010. Run through a fleet replacement program, critical factors for success have been a common procurement of electric vehicles by Stockholm City and other cities, in order to significantly reduce prices, as well as the active encouragement of local production of biogas.

Bus inspection and maintenance program, Jakarta, Indonesia

http://www.unep.org/pcfv/pcfvnewsletter/2009Issue2/Retrofit.pdf

As part of an initiative to reduce pollutant emissions from the city bus fleet, nine bus companies developed their own internal inspection and maintenance program. The program checked the vehicles for engine malfunctions and excessive smoke and measured exhaust opacity. The program's success rested on an extensive education program which aimed at raising awareness among technicians and drivers about the environment and technical training on how to conduct a proper inspection and maintenance program. The education also included instruction on safe and fuel saving driving practices.

In total over 13,000 buses were tested in 2001 and 2002, with 89 technicians and 1372 drivers trained. Measures identified through the inspection program that could be easily fixed were cleaning air filters, adjusting fuel injection timing and injection nozzle pressure and calibrating the fuel injection pump. In some cases, air filters and fuel injection nozzles had to be replaced.

This program achieved a 30% reduction of diesel soot and a 5% decrease in fuel consumption through improved, regular maintenance practices. Another 10% decrease in fuel consumption was attained through improved driving methods. Approximately a third of the vehicles failed the inspection but over 80% of these vehicles could be repaired with only minor additional cost. The inspection test method used in Jakarta, a free acceleration emissions test to measures smoke opacity, is a simple procedure to implement that provides an indication of a gross engine malfunction.

The Jakarta program started out with just two bus companies on a voluntary basis but, by the end of the program, grew to nine bus companies as the economic benefits of inspection and maintenance became more apparent.

Contracted bus fleet, Copenhagen, Denmark

http://www.kk.dk/sitecore/content/Subsites/Klima/SubsiteFrontpage/

As part of the Copenhagen Climate Plan, the Copenhagen City Authority (CCA) has made contracts with bus companies operating within the municipality contingent in the on a reduction in 25% less CO2 emissions. The CCA does not require a particular technological solution, for example, procurement of hybrid busses. Instead, it taps into national government funding available until 2012 for pilot testing of various energy efficient transport solutions, of which increased energy efficiency of the bus fleet is one. At the time of publication of the Klimaplan (August 2009), CCA was looking to cooperate with neighbouring municipalities to initiate a trial project in relation to energy efficient bus fleets.

TOOLS & GUIDANCE

Tools & Guidance
UNEP (2009). "UNEP/TNT Toolkit for Clean Fleet Strategy Development", A step-by-step toolkit with guidelines and calculators to develop a strategy for reducing the environmental impacts of a fleet. This includes measures which improve fuel and performance efficiency of the fleet. http://www.unep.org/tnt-unep/toolkit/index.html
Energy Trust (2009). "Grey Fleet guidance", A guidance document which provides an overview for reducing the impact of a City Authority's grey fleet (privately owned vehicles used by employees on CA business). http://www.energysavingtrust.org.uk/business/Global-Data/Publications/Transport-Advice-E-bulletin-October-09-Focus-on-grey-fleet

APPENDIX 6: TRAFFIC FLOW OPTIMIZATION

DESCRIPTION

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

Encourage the efficient use of vehicles and minimise journey lengths, reducing fuel use.

IMPLEMENTATION OPTIONS

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

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US$100,000-1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Enhanced public health & safety

	reduces effectiveness. See Madrid case study for further details.

MONITORING

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

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

CASE STUDIES

Arterial 'green wave' traffic flow optimisation, Portland, USA

C40 Cities (2010). "Portland, USA: Optimizing traffic signal timing significantly reduces the consumption of fuel", available online from

http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp

The City Authority optimized traffic signal timing at 135 intersections on 16 of some of Portland's most congested thoroughfares. 'Optimization' of traffic signals consists of re-timing the traffic signals to improve their synchronization across a road traffic network. The cost of an intersection synchronization varied USD 1,000-3,000. The resulting reductions in the frequency by which vehicles accelerate and decelerate, as well as the reductions in the time vehicles spend with idling engines, yielded annual fuel savings of 1,750,000 gallons of gas. This is the equivalent of removing 30,000 passenger vehicles from the road for an entire year. The city went a further step by measuring and eliminating CO2 through the purchase of carbon credits.

Variable Message Signs, Milton Keynes, UK

Department for Transport (2010). "Case Study: Milton Keynes Integrated Traffic Management", available online from

http://www.dft.gov.uk/itstoolkit/CaseStudies/milton-keynes-integrated-traffic-management.htm

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

High-Occupancy Vehicle lane, Madrid, Spain

Monzon, A. (1999) "Managing long term congestion in HOV lanes. Effect of 2+ vs 3+ limit on the Madrid N-VI corridor", paper presented at the European Transport Conference, Cambridge, Jan 1st 1999, available online from http://www.etcproceedings.org/paper/download/2493
High environmental standards, low housing density, and high motorization rates influenced the decision of implementing an HOV lane scheme on the median of the N-VI motorway into Madrid. The cut off limit for the lane is 2+ passengers and the facility is separated from the mix-flow lanes by a concrete barrier along the whole length of it. A successful design aspect is the reversible basis on which the system operates to match peak flows, serving the inbound trips during the morning peak, and the outbound trips during the evening peak. Rather than increase ridesharing, the lanes have attracted a growth in public transport mode share (40% in the period 0700-1000 in the year following implementation), resulting in increased frequencies of services.

TOOLS & GUIDANCE

Tools & Guidance
Colorado Department of Transportation (2005). "CDOT Guidelines on Variable Message Signs (VMS)", A guidance document for the design of Variable Message Sign (VMS) messages. Available online from http://www.cotrip.org/its/whitepapers/VMSGUIDE-rev-2005.pdf
Alabama Department of Transportation (2007). "Traffic Signal Design Guide & Timing Manual" A guidance document with detailed guidelines and recommendations for the designing and timing of traffic signals in the State of Alabama. Available online from http://www.dot.state.al.us/dsweb/Traffic/pdf/AldotTrafficSignalManual122007.pdf

ANNEX 7: MANDATING 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

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

	to be used voluntarily by progressive developers, designers and building owners.
Draft Incentive Program (Incentivized approach)	Along with the design guidelines, create a program to incentivize the construction of exceptional green building design by providing tax credits, 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:

- kWhe/m2 - benchmark electrical energy consumption on a per-square-meter basis.
- kWht/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

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 $50,000grant 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

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

Tools & Guidance
http://www.epa.gov/region4/recycle/green-building-toolkit.pdf

ANNEX 8: MUNICIPAL OFFICES AUDIT AND RETROFIT PROGRAM

DESCRIPTION

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

IMPLEMENTATION OPTIONS

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

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

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

MONITORING

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

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

CASE STUDIES

Model for Improving Energy Efficiency in Buildings, Berlin, Germany
http://www.c40cities.org/bestpractices/buildings/berlin_efficiency.jsp
The City of Berlin in partnership with Berlin Energy Agency (BEA) has pioneered an excellent model for improving energy efficiency in buildings. They project manage the retrofit of public and private buildings, preparing tenders for work that will guarantee reductions in emissions. CO2 reductions of an average 26% are written into the public retrofit tenders so that winning Energy Systems Companies (ESCOs) must deliver sustainable energy solutions. 1,400 buildings have so far been upgraded, delivering CO2 reductions of more than 60,400 tonnes per year - these retrofits cost the building owners nothing - and the buildings make immediate savings.

Internal Contracting, Stuttgart, Germany
http://www.c40cities.org/bestpractices/buildings/stuttgart_efficiency.jsp
Stuttgart saves around 7200 tonnes of CO2 each year through an innovative form of internal contracting, making use of a revolving fund to finance energy and water-saving measures. The city is able to reinvest savings directly into new activities, creating a virtuous circle of

environmental improvements and emissions reductions.
EU and Display Campaign Case Studies http://www.display-campaign.org/page_162.html The European Display Campaign is a voluntary scheme designed by energy experts from European towns and cities. When started in 2003 it was initially aimed at encouraging local authorities to publicly display the energy and environmental performances of their public buildings using the same energy label that is used for household appliances. Since 2008 private companies are also encouraged to use Display for their corporate social responsibility CSR activities.
Energy Management System, Frankfurt, Germany http://www.managenergy.net/download/r164.pdf In 1996 the City of Frankfurt (Building department) entered into a contract with a private company to install and operate an energy-management system (EMS) for the city hall (Romer), Paulskirche and Museum "Schirn". The goal of the project is to reduce the costs for energy- and water as well as the CO2-emissions. Based on the annual costs of 2.6 Million DM in 1992/1993 the potential cost reductions were estimated to be approximately 320,000 DM per year. To reach these cost savings an investment of 1 Million DM for control equipment was necessary. Repayment of the invested capital will be provided from the energy savings (54%) over a period of 8 years. The remaining 46% will reduce the operating costs for the buildings.
Energy Efficient Office of the Future (EoF), Garston, UK http://projects.bre.co.uk/envbuild/index.html The new Environmental Building at Garston was built as a demonstration building for the Energy Efficient Office of the Future (EoF) performance specifications, drawn up by a number of companies representing the manufacturers, designers and installers of building components and the fuel utilities, as part of the EoF project run by BRECSU. A key part of this specification is the need to reduce energy consumption and CO2 emissions by 30% from current best practice. Air conditioning is not used in the new building - the major energy consumer in many existing office buildings. Other savings will be made by making better use of daylighting and by using the building's 'thermal mass' to moderate temperatures.

TOOLS & GUIDANCE

Tools & Guidance
EU LOCAL ENERGY ACTION Good practices 2005 - Brochure of good practice examples from energy agencies across Europe. http://www.managenergy.net/download/gp2005.pdf

Tools & Guidance
ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf
Energy Conservation Buildings Code provides minimum requirements for the energy efficient design and construction of buildings and their systems. http://www.emt-india.net/ECBC/ECBC-UserGuide/ECBC-UserGuide.pdf

ANNEX 9: STREET LIGHTING TIMING SYSTEMS

DESCRIPTION

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

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

ATTRIBUTES

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

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

CASE STUDIES

Control system for public lighting, Kirklees, UK
http://www.kirklees.gov.uk/community/environment/green/greencouncil/LightingStoryboard.pdf
Instead of switching off street lights at certain times of the day, as has been done by other CAs, the Kirklees CA decided instead to dim lights to varying levels throughout the day. This was done partly because not switching public lighting off completely during times of low activity would provide increased safety in the community by preventing crime. Retrofit systems were installed on each existing lighting pole which used wireless technology to monitor and dim the street lights. The retrofitting of these systems simply required the addition of a small antenna to the lamp heads, which plugged into the electronic ballast with no need for additional wiring. Generally the lights are switched on 100% at 7pm, thereafter dimmed to 75% at 10pm, and then to 50% at midnight. If the lights are still on at 5am, they are

increased again to 100% lighting. By dimming the lights gradually, eyes are able to adjust to lower lighting levels, and the dimming is barely noticeable. The remote monitoring system also provides accurate inventory information and enables street lighting engineers to identify failed lamps quickly and easily. This reduces the need for lighting engineers to carry out night scouting and has also reduced other on-site maintenance costs. A dimming of lights as implemented in Kirklee can save up to 30% of the electricity used annually. By replacing 1,200 lights, Kirklee CA estimates savings of approx USD 3 million in energy costs per year.

Intelligent outdoor city lighting system, Oslo, Norway

http://www.echelon.com/solutions/unique/appstories/oslo.pdf

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

Motorway intelligent lights retrofit, Kuala Lumpur, Malaysia

http://www.lighting.philips.com.my/v2/knowledge/case_studies-detail.jsp?id=159544

The project implemented a lighting solution for highways leading to Kuala Lumpur International Airport. The total length of the dual carriage highway covers 66 km.

The main requirement for the project was that each individual lamp along the entire 66 km stretch of highway should be independently dimmable. This called for a network linking all 3,300 positions to a central control facility. There was also a need for greater maintenance efficiency while ensuring optimal visibility without compromising on visual comfort on the road.

An intelligent lighting system that uses telemanagement control was employed. Telemanagement makes it possible to switch or control every individual light point in the system from a central PC. It also enables specific dimming profiles adjusted to suit conditions on the road for different lamps, instant reception of failure messages, and the creation of a database where all system data is stored. It allows a significant reduction in energy consumption in addition to the 45% savings as a result of the use of dimming circuits.

TOOLS & GUIDANCE

Tools & Guidance
N/A

ANNEX 10: STREET LIGHTING AUDIT AND RETROFIT PROGRAM

DESCRIPTION

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

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

ATTRIBUTES

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

IMPLEMENTATION OPTIONS

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

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

MONITORING

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

- $/km - Benchmark annual energy cost on a per liner km basis.

- Lumens / Watt - average efficacy of illumination for the current operational city street lighting inventory.

CASE STUDIES

ESCO street light retrofit, Akola, India
Source: Energy Sector Management Assistance Program (ESMAP) (2009). "Good Practices in City Energy Efficiency: Akola Municipal Corporation, India - Performance Contracting for Street Lighting Energy Efficiency"
The Akola CA enlisted an ESCO to replace over 11,500 existing street lights (standard fluorescent, mercury vapor, sodium vapor) with efficient T5 fluorescent lamps. The selected contractor financed 100% of the investment cost, implemented the project, maintained the newly-installed lights, and received a portion of the verified energy savings to recover its investment. Under the energy savings performance contract, the CA paid the ESCO 95% of the verified energy bill savings over the 6-year duration of the contract. AEL was also paid an annual fee for maintaining the lamps and fixtures. Initial investments were estimated at USD 120,000 and the retrofit was completed within a 3-month period. Annual energy savings of 56% were achieved, delivering the equivalent of USD 133,000 in cost savings. This gave a very attractive payback period of less than 11 months.

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

Street Lighting LED Replacement Program, City of Los Angeles, USA
Clinton Climate Initiative, http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative/i/cci-la-lighting
A partnership beween Clinton Climate Initiative (CCI) and the city of Los Anglese, this project will be the largest streetlight retrofit undertaken by a city to date, replacing traditional streetlights with environmentally friend LED lights. It will reduce CO2 emissions by 40,500 tons and save $10 million annually, through reduced maintenance costs and 40% energy savings.
The Mayor of Los Angeles and the Bureau of Street Lighting collaborated with CCI's Outdoor Lighting Program to review the lates technology, financing strategies, and public-prive implementation models for LED retrofits. CCI's modelling and technology analysis, as well as its financial advisory, serves as key reference sources for the development of this comprehensive retrofit plan.
The phased nature of the project allows the city to re-evaluate its approach on an yearly basis. This gives enviable flexibility to the municipality when selecting contractors and the street lighting systems for upgrade. Los Angeles also capitalised on its government status to attract financial institutions offering favourable loans and funding mechanisms as these institutions were looking to establish positive

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

TOOLS & GUIDANCE

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